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Shift Handover After Buncefield

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Post Piper Alpha, 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 uses the Buncefield oil storage depot explosion and fires as an exemplar incident, briefly reviews the current state of knowledge on handover against on and offshore major hazard sector needs and compares the two sectors' needs. The review concludes that there has been little new original research on handover, although there has been some application to new domains such as patient safety. Going forward, the paper identifies the main gap for the on and offshore major hazard industries as being 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. Finally, recommendations are made for the way forward for both the on and offshore sectors.

1. Introduction and background

Failures in shift communication, including shift handover, continue to contribute significantly 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, 1990) 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 Chemical Safety Board's investigation report of the BP Texas City refinery accident (USCSHIB, 2007). Safety critical communication is involved in practice in a much broader range of activities, (see e.g. the HSE's Inspectors toolkit (HSE, 2005a)) but here the focus is on shift communication and specifically changeover.

1.1 Shift communication and shift handover

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 in high hazard operations. 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, 2005b). For offshore, this would also include communication between key functions offshore and on the beach.

Shift handover is one of three key elements in a shift changeover, typically including: 1) A preparation period by the outgoing shift; 2) Shift handover, where both the outgoing and incoming shift communicate so that task-relevant information is reliably exchanged; and 3) Subsequent cross-checking by the new shift. Effective shift handover requires the accurate and reliable communication of task-relevant information between shifts (and with other relevant groups such as day maintenance and management) to ensure continuity and safe working. (Adapted from HSE, 1996).

Key features of an effective handover include: conducting individual handovers face to face, with the relevant information available (such as logs, registers, computer displays); two-way active dialogue between incoming/outgoing personnel that facilitates adequate clarification through e.g. questioning, explanation; awareness of company standards for handover, individual and team performance standards, higher risk or potentially difficult handovers. Higher risk handovers include: 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. (Adapted from HSE shift handover Webpages (HSE, Undated Webpages)).

1.2 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, Undated Webpages). 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-h shift may last up to 30 min, 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 1.2 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, 2006a).
However, although 12-h 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).

2. Review of other sectors

A review of publicly available research and guidance was carried out by the authors (and see Wilkinson and Lardner, 2012). The results are summarised here. A search of CET articles (2002-2012) was included but no articles on shift handover were found.

2.1 Research and guidance

The available research is very limited on shift handover. 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, undated webpages). In addition to the above papers, there is also an audit method developed by The Keil Centre for HSE (HSE, 2006b) for offshore application, and an extract from an Inspectors Toolkit (HSE, 2005a). 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, and human factors specialists on this issue.

2.2 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; Lardner, 1999). 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.

2.3 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 sources and there is better – if still limited - evidence of transfer here.

2.4 Offshore and onshore differences

Onshore practice in the major hazard industries - subject to the Control of Major Accident Hazard Regulations 1999 (amended 2005): implementing SEVESO 2 in the UK (COMAH, 2005) - 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 d tours offshore; a 12-h 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-h 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 e.g. 8- or 10-h 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 (there is an industry trend 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.

2.5 Other Sectors

The other sectors are reviewed in detail in the earlier paper (Wilkinson and Lardner, 2012) and are summarised here. They include patient safety/nursing, nuclear power, air traffic control and aviation maintenance (including spacecraft mission control) and shipping. While there is good practice in other comparable sectors, the focus varies, application is limited and the research and guidance is usually developed from the Lardner and HSE sources. One more recent space sector paper - on best practice in shift communication based on the Mars Exploration Rover mission - confirms this: 'The Europeans have long been at work in this field, and Lardner provides an excellent review of the shift handover literature in European off-shore 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.' (Parke and Mishkin, 2005). This confirms both the thoroughness and continuing relevance of the original research, and also the key domains of interest, though Patient Safety and Shipping have been added here. The paper offers a very useful handover checklist which, while focused on the handover needs for an extended space mission with a remotely-operated vehicle, also confirms that the key issues for handover remain much the same.

3. Buncefield

In analysing the available evidence during the HSE investigation for the Buncefield Major Incident Investigation Board (Buncefield, 2008), the first author's conclusions were the following (further supporting detail is available in (Wilkinson and Lardner, 2012)):

- Effective arrangements for shift changeover, including handover, were not in place.
- Shift changeover was inadequately structured, variable and informal.
- Proportionate policy, standards or procedures for changeover had not been set.
- The key information required for communication at handover had not been adequately determined.
- Such arrangements as were in place were in any case inadequate.
- Changeover was heavily skewed towards the more active pipeline activities i.e. towards the Finaline pipeline owned and run by Total rather than the other two major pipelines run by the British Pipelines Authority (BPA).
- There were however some elements of apparent good practice in place for changeover. For example, face-to-face communication at handover and use of handover logs. 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.

- 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.
- Any reduced alertness and increased fatigue potentially resulting from the 12-h shift system *(*HSE, 2006b*)* was made worse by other fatigue and shiftwork issues present at the terminal. This allowed potential for 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 i.e. higher risk handovers e.g. specifically the involvement of relatively inexperienced staff in key changeovers before the incident.
- An increased likelihood of error was identified in the investigation on the four preceding shift handovers e.g. they all coincided with relatively busy periods of activity on the pipeline.
- There were other significant shift communication and changeover failures e.g. between shifts and maintenance and operational management.

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 and tank 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.

4. 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. In addition to the information available in the many Buncefield reports (Buncefield, 2008), this paper aims to make the key information more specifically, usefully and widely available. 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).

So it is recommended 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 such a review. An earlier paper (Wilkinson and Lardner, 2012) also contains some specific good practice points from comparable sectors and a useful checklist.

In addition, it is recommended that the offshore sector should consider how to secure more consistent crew-change changeover; recognise more explicitly that 12-h shifts and extended same-person handovers can increase the likelihood of some error types e.g. mistakes; continue to work on assuring good shift-shore communication; review current procedures and related arrangements for changeover to ensure they reflect guidance and good practice; and identify and secure higher risk handovers.

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