Benchmarking Human Factors in the Process Industries

Jamie Elliott BSc, Sarah Grindrod BEng CEng FIMechE and Paul Sirett C Psychol, HFL Risk Services Limited, Freeman House, Orbital 24, Oldham Street, Denton, Manchester, M34 3SU

To understand how well human factors are being managed in the UK onshore process industries, HFL Risk Services brought together a group of 10 organisations operating sites which fall within the scope of the COMAH Regulations. The sites were benchmarked on their management of a range of human factors topics. On site workshops involving a multi-disciplined team of personnel from each organisation were facilitated by human factors experts from HFL. The question set used was based on the UK Health and Safety Executive's Human Factors Inspectors' Toolkit.

It was found that, whilst many organisations considered human factors to some extent during retrospective accident investigations, few were proactively assessing safety critical tasks to prevent human failure in the first place. Deficiencies were also found under the topics of procedures, competence and safety culture.

There was wide variation of the scores within each topic showing that there is opportunity for poorly performing organisations to learn from the high performers. Common areas of strength and opportunities for improvement are described. Many organisations fell well short of meeting recognised good practice indicating that more needs to be done to integrate human factors into process safety management.

Keywords: Human Factors; benchmark; competence; investigation; human reliability; procedures; safety culture

Introduction

Human factors are widely accepted as an important part of safety management in major hazard industries such as rail, aviation, nuclear and defence where it is standard to consider human factors as part of new projects and on-going operation. The UK Health and Safety Executive (HSE) first published HSG48 Reducing Error and Influencing Behaviour, "the key document in understanding HSE's approach to human factors" over two decades ago (HSE, 1989). However, the UK onshore process industries such as chemicals, pharmaceuticals and oil & gas have not yet widely integrated human factors practices into their operations.

In recent years the HSE established a team of human factors specialists, produced a website with guidance on a range of human factors topics, and began conducting specific human factors inspections of sites which fall under the Seveso Directive, implemented in the UK by the Control of Major Accident Hazards (COMAH) Regulations. This has played a part in driving operators of COMAH sites to start to take greater consideration of human factors.

HFL Risk Services Ltd are one of the UK's leading process safety consultancies and have worked with a significant proportion of UK COMAH sites. HFL recognised that many COMAH sites are just beginning their human factors journey and are unsure what they need to do or where they should focus their effort.

Most sites are conducting some activities which fall under the term human factors, such as producing operating procedures to help operators perform their roles, however, our experience suggests that not all aspects of human factors are being addressed sufficiently.

With this in mind, HFL invited a group of 10 COMAH sites to participate in a study to benchmark their management of a range of human factors topics. This followed on from previous process safety management benchmarking studies conducted by HFL in the UK, Europe and globally.

Objectives

The objectives of the benchmarking study were to provide the participating organisations with:

- An introduction to human factors
- Gap analysis against HSE expectations
- Benchmark against other organisations
- Examples of good practice within each of the topics assessed.

For the participating organisations, it was expected that the third of these objectives, the benchmark relative to other organisations would be considered particularly valuable. To some extent, organisations operate their sites in a vacuum. They can read published process safety guidance but this is often high level, objective setting, and does not always provide practical solutions. They also receive input from the regulator (the HSE) who will communicate their expectations through advice or enforcement action, but again this is often in terms of high level objectives. This is set in the context of the UK's "goal setting" health and safety legislation. The law requires companies to do what is "reasonably practicable" to reduce risks. There is no prescriptive standard saying what is reasonably practicable, companies have to work it out for themselves, and the regulator or ultimately the courts will subsequently come to their own view about whether the company have done enough.

Operating companies therefore have the challenge of determining how to meet the objectives set for them. They wish to achieve these objectives in a proportionate manner. For example, if they are told to put in place a competency management system, how many person-hours is it reasonable to devote to this? Solutions ranging from tens of hours to tens of thousands of hours could be envisaged. Going further than is required or achieving the objective in an inefficient way can have a significant impact on the bottom line of the business. From this perspective, understanding how other organisations are responding to the same challenges is very useful.

Approach

Following two pilot studies, the approach described below was adopted. A one day on-site workshop was conducted with each participating organisation, facilitated and recorded by human factors specialists from HFL. At each site, workshop participants included key members of the management team as well as front line staff. For some organisations a separate workshop session was held with front line staff in order to check that there was not a disconnect from key perceptions held by the management team, mainly associated with the topics of safety culture, competency assurance and procedures.

Each workshop team was asked a set of questions based on the HSE HF Inspectors' Toolkit (HSE, 2005). Five of the 11 topics in the toolkit were covered, as identified in bold in Table 1 below.

Table 1: HSE HF Inspectors' Toolkit Topics

Core Topics	**Competence assurance**
	Human factors in incident investigation
	Identifying human failure
	Reliability and usability of procedures
Common Topics	**Safety culture**
	Emergency response
	Maintenance error
	Safety critical communications
Specific Topics	Alarm handling and control room design
	Managing fatigue risks
	Organisational change and transition management

The reason for assessing five topics was to allow the study to be completed in a single day. This minimised the cost of the assessment in terms of facilitation, but more significantly in terms of the time required from organisations' personnel to attend the workshops. The topics chosen were the four "core topics" plus safety culture, which was expected to be the most relevant of the "common topics." It was expected that organisations scoring highly on these topics would have systems and practices in place to identify for themselves whether the other topics are significant for the major accident hazards they have on site, and whether they have any gaps which need to be addressed.

Guidance notes were prepared for each question in the toolkit, to allow scoring to be carried out. For example, on the topic of human factors in accident investigations, for the question "Are investigations carried out by multi-functional teams, including operators where appropriate?" the following guidance was developed:

a) No investigations carried out after accidents/incidents.

b) Investigations carried out after accidents/incidents but not by multi-functional teams and does not include operators.

c) Investigations carried out by multi-functional teams and includes operators.

d) Investigations are available to all staff. The findings from investigations are acted upon and all relevant staff are consulted with before implementing the findings.

The guidance details varying levels of performance for each question allowing a score to be allocated to each response depending on where the response was judged to fall on the scale. The scores from each question were combined to give a score for the topic.

All organisations were provided with individual feedback shortly after the workshop. This was to allow a further two way discussion and ensure that the assessment conclusions were perceived as fair and correct.

Once all of the assessments were complete, the participating organisations were brought together for a seminar to discuss the overall results and share best practice in human factors.

Overall Results

The overall results of the human factors group benchmark are shown in Figure 1 below.

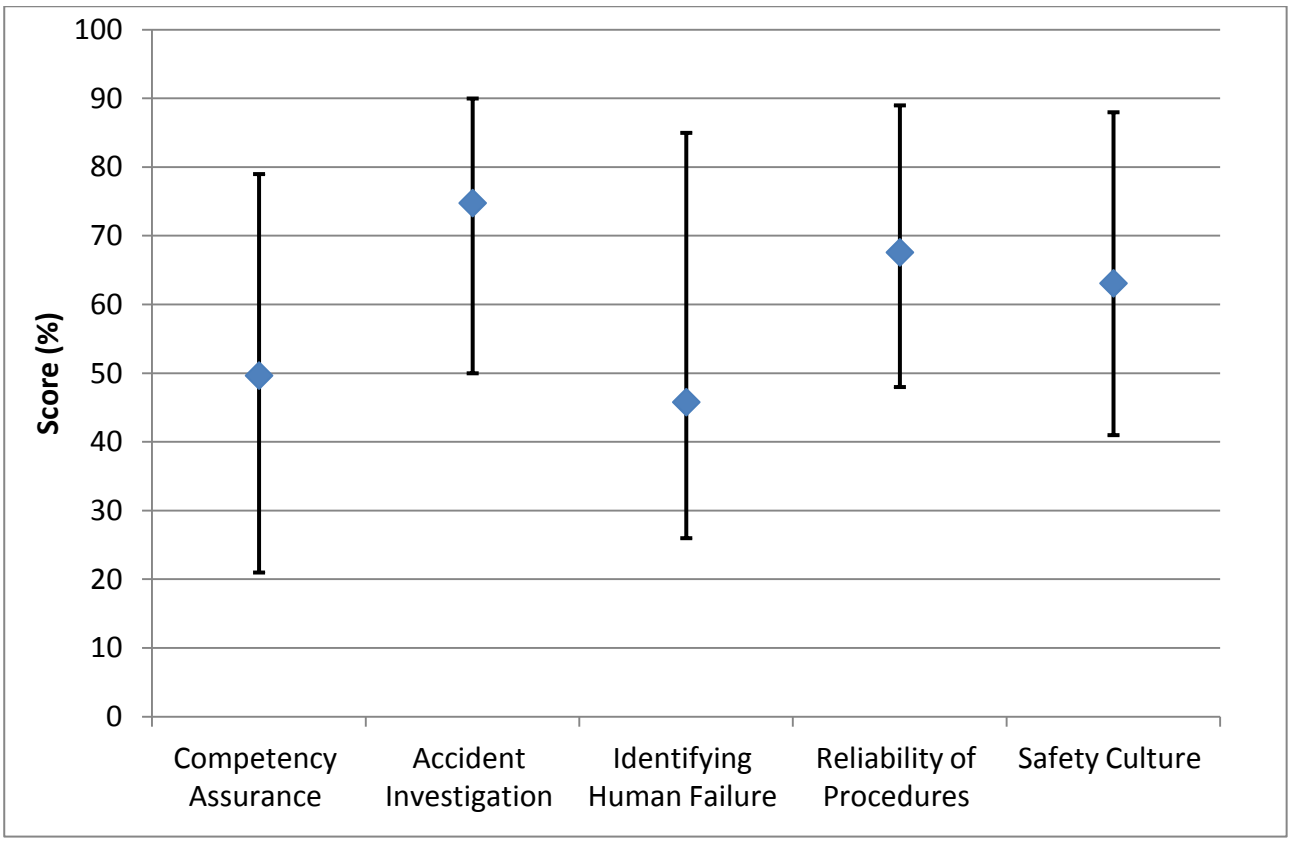

Figure 1: Overall results. The diamond shows the average score and the line shows the range of scores for the group.

Accident investigation was the topic with the highest average score. All of the organisations recognised that accidents need to be investigated and all have formal processes in place to do so. The topic of identifying human failure had the lowest average score as most organisations had not explicitly identified and assessed safety critical tasks in a proactive manner utilising accepted techniques. The other topics returned intermediate to high values. As can be seen in Figure 1, there was wide variation of the scores within each topic showing that there is opportunity for poorly performing organisations to learn from the high performers.

Figure 2 below shows how each participating organisation varied across the topics.

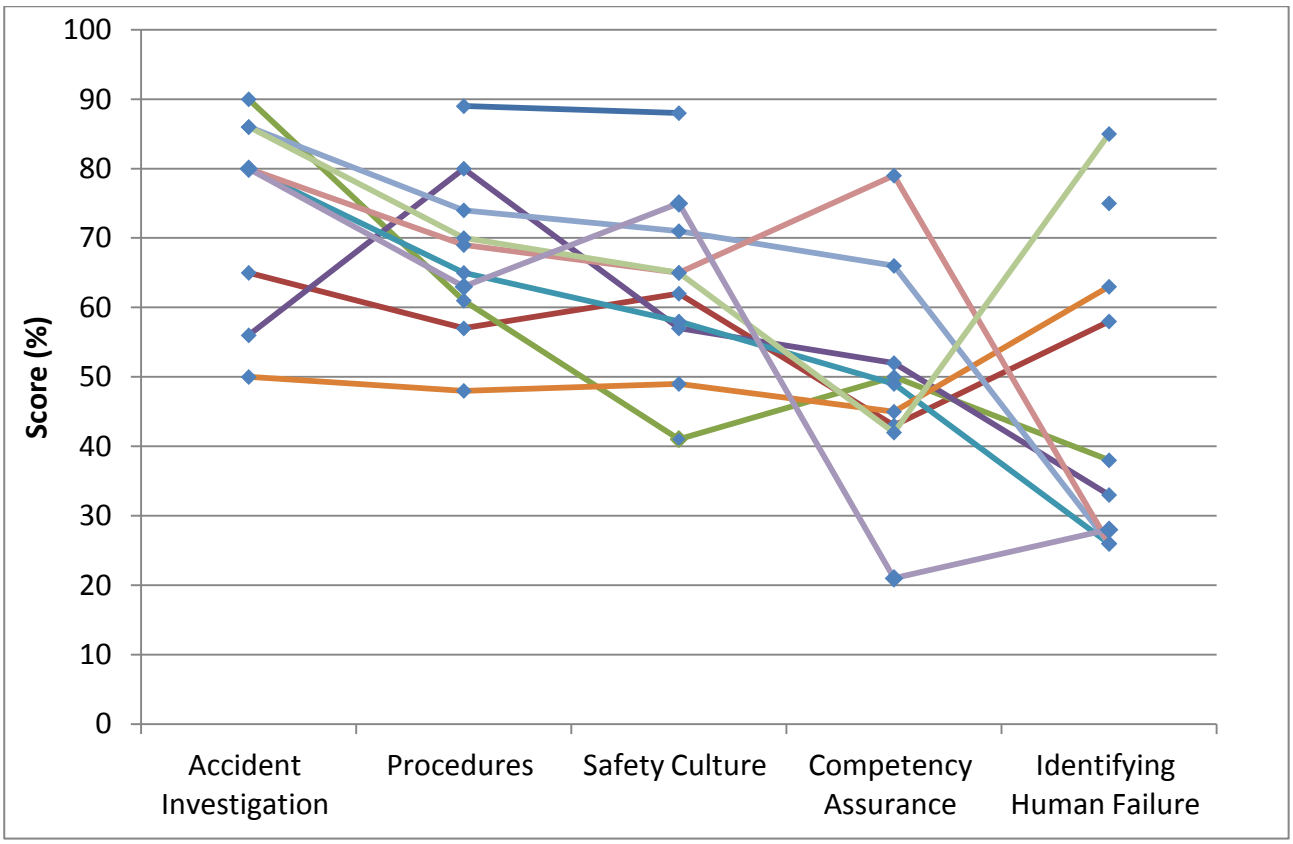

Figure 2: Results Distribution. Each line represents one participating organisation

In Figure 2 the topics have been ordered from the highest average score (*Accident Investigation*) to the lowest average score (*Identifying Human Failure*). It can be seen that some organisations score consistently across the first four topics. For example the same organisation was ranked third for these four topics. Other organisations had varying scores, for example the organisation that score highest for *Accident Investigation* scored lowest for *Safety Culture*.

On the last topic of *Identifying Human Failure* there was little correlation between an organisations score and its scores on other topics. This can be explained by the fact the six of the ten had not attempted any form of proactive identification of potential human failures, and so achieved low scores. By contrast, all organisations had made efforts of some kind in the other topics.

Results by Topic

Competence Assurance

For this topic, as well as the HF Inspectors' Toolkit, good practice is defined by the HSE's 5 stage/ 15 principle model of competence management which HSE are currently inspecting COMAH sites against (COMAH CA, 2011).

For many organisations their Competence Management System (CMS) amounts to not much more than a list of training courses, with little structure to the decision making process of who should go on what courses. Competence assessment is left up to line managers, who, particularly for new operators and maintenance technicians, decide whether someone is competent to work without extra supervision. On-going competence assessment is often limited to appraisals or performance development reviews, which are not competence based or linked to Major Accident Hazards.

Some organisations showed improvements upon this because they had some of the additional elements expected of a full CMS such as:

- Systematically defined competencies,
- In-house, process and major hazard specific training,
- Trained trainers,
- Written assessments of knowledge,
- Practical assessments of knowledge, skills and ability to follow a procedure.

None of the organisations assessed had developed a system which could be considered close to a fully integrated CMS. Elements which were missing from most organisations' CMS were:

- Assessment using a variety of techniques,

- Competence management for supervisors, managers and design engineers, linked to process safety (annual appraisals do not meet this requirement),
- Periodic re-assessment of competence,
- Key performance indicators (KPIs) to determine the effectiveness of the CMS,
- Senior leadership ownership and oversight.

The transition from a training system to a fully integrated CMS will require considerable investment for many UK COMAH sites. There are two key elements to the business case for making this investment. Firstly, there are many examples of high profile accidents caused by lack of competence which had serious effects on businesses as well as causing fatalities to the workforce, for example Esso, Longford (Hopkins, 2000), Texas City (CSB, 2007) and Hickson & Welch (HSE, 1994). Secondly, the competence of the workforce is a key competitive advantage for UK and European manufacturing sites, versus those in developing economies. Investing in competence management will maximise this advantage.

Human Factors in Accident Investigation

The HSE Inspectors' Toolkit indicates the key organisational mechanisms that need to be in place to conduct a robust accident investigation. This starts with a policy describing the use of multifunctional teams in order to identify the root cause.

All benchmarked organisations had a formal written policy for accident investigation. This outlines the investigation responsibilities and reporting requirements. In all cases, a member of the management team conducts the investigation by referring to and completing an investigation pack. This includes; completing an accident record, conducting witness interviews and obtaining photos when appropriate to do so. Multi-functional teams were used where appropriate. In all cases the management team recognised that accidents can have more than one cause. A list of immediate and contributory factors were detailed on the incident forms for some organisations. In all cases, a lot of effort is placed into accident investigation and the key processes were in place to drive the investigation. However, human factors in accident investigation or human factors awareness training had not been received by the management team in all cases.

The main shortfall for all organisations was the quality of the investigation in obtaining the root cause. In all cases, the investigation could have gone further in asking why the accident had occurred. In a few cases, the root cause was detailed as simply "human error" or not identified at all.

Situational violations rarely happen unless there are consistent routine violations, such as corner cutting and other poor safety habits creeping in to daily business practices. When this is the case, staff have given themselves and others permission to lower standards and therefore when additional pressures, such as workload, time constraints, poorly design equipment etc. are apparent, it is more likely that situational violations will occur. None of the organisations involved with the benchmark study went far enough in determining the root cause when a routine or situational violation occurred. Therefore, the investigations did not adequately address routine violations or wider cultural issues and therefore it is possible that there remained inappropriate behaviours in some parts of the business.

In all cases, the management team will need to ensure that the technical quality of reports are reviewed being mindful that the root cause has been identified. In addition, there is sufficient evidence to suggest that organisations need to militate against routine violations and ensure that there is a good safety culture. This will need to be handled as a wider cultural change programme, as part of a continued effort to better integrate human factors.

Identifying Human Failure

Human failure has been recognised as a common contributor to Major Accidents. This topic relates to organisations being proactive in identifying human failure by identifying and prioritising safety critical tasks and then conducting formal task analyses and human reliability analysis (HRA). It is considered best practice to have a rolling HRA programme in place so that deficiencies can be identified and appropriate actions implemented. Improvement actions should be monitored and assessed for effectiveness on an on-going basis.

All organisations were aware of the hazards on site and have policies and procedures in place to protect against human error. All organisations had conducted HAZOPs on some if not all safety critical operations and had an ongoing HAZOP programme in place. Only two organisations had been trained in the qualitative HRA technique and had begun a rolling HRA programme.

Most management teams were aware of the difference between intentional and unintentional errors. However, most organisations had not provided formal human factors awareness training for the management team or frontline staff. Most organisations had no direct experience of applying human factors analysis to safety critical operations. Therefore, there was very little in-house competence and relevant experience available to these organisations to carry out HRA.

The main shortfall was that human factors issues have not been addressed through a proactive explicit human factors analysis, in terms of conducting task analyses followed by qualitative HRA. As the key element of the HRA technique is the consideration of performance influencing factors (PIFs) most organisations had not considered PIFs and how these make human error more or less likely. Indeed, it was seen that unless HRA or human factors awareness training had been received, understanding and identifying PIFs was difficult for benchmark participants to fully conceptualise. It can be concluded that most organisations have not done enough to reduce the likelihood of human error in process operations and have not optimised PIFs ensuring best practice is applied in specific areas.

Reliability and Usability of Procedures

Reliable and useable procedures are key in avoiding rule based and knowledge based mistakes. The HSE provides guidance in terms of layout and formatting to ensure procedures are easily readable and understandable (HSE, 2004). Guidance is also available on organisational mechanisms or processes that need to be in place to ensure compliance to procedures.

All organisations had procedures in place for COMAH safety critical activities, including the management of contractors. Some organisations had developed procedures over time rather than through risk assessments. However, where this was the case, the organisations had identified this as an issue and had begun conducting risk assessments such as HAZOP. No organisations had informed the development of safety critical procedures by task analyses and HRA and so the reliability of the procedures were questionable.

All organisations provided access to procedures either electronically or paper based. However, in some the intranet search facility was ineffective given the large amount of procedures that could be identified. In addition, access was in some cases provided via a manager's office, implying access may not have been available in all situations.

Most organisations were found not to be following best practice in terms of layout and formatting. These shortfalls were;

- Key safety reasons were not detailed next to the task step
- System or process information was mixed in or detailed immediately underneath the key task step
- Safety critical task steps not identified
- No visual aids
- No flow charts
- Cluttered pages full of text
- Inappropriate messages that implied prioritisation of production over safety

It can be concluded that the reliability and usability of safety critical procedures can be enhanced by ensuring that HRA is incorporated into the development of procedures on a consistent basis. When updates are made to these procedures, informed by HRA output, simple changes to format and layout will significantly enhance the reliability of safety critical procedures.

Safety Culture

Culture has been described as "the way we do things around here" (Deel and Kennedy, 2000). Many things can influence the culture of an organisation and individual initiatives and activities can be used to change the safety culture over time. Those at the top of the organisation have a big influence on safety culture so their visible commitment is important. The HSE HF Inspectors' Toolkit provides guidance on the key mechanism that are required to drive and maintain safety culture.

All organisations had a global SHE policy document for line managers to interpret in order to drive the safety culture. However, in the majority of cases the policy did not overtly define the level of commitment to develop safety culture and there is no specific safety culture policy. Only one organisation had a specific safety culture policy.

Process safety commitment was reported to be a high level priority for most organisations. However, in some cases workshop discussions indicated that safety may be more aligned to HSE led initiatives as opposed to there being an inherent safety commitment. There was the perception by front line staff in a few organisations that some safety standards are cut to save money. As indicated through the review of incident reports there may be routine violations or wider poor safety culture behaviours displayed in some parts of the businesses which remain unaddressed. As these remained unidentified and not addressed appropriately through incident investigations, it suggests that some of the organisations have wider cultural issues to address through a cultural change programme.

In all cases safety related communication appeared to be strong with there being a number of mechanisms such as; weekly brief, output of management meetings disseminated to front line staff, and process safety performance indicators (PSPIs) monitored by the management team. It was seen that only a couple of organisations did not develop and monitor PSPIs. However, most organisations do not regularly measure the attitudes and perceptions of managers and front line staff to explore if messages are being interpreted as intended or indeed if there is a misperception or difference in attitudes between managers and operators, maintainers and technicians. Due to this, no organisations could report exactly what sort of culture they had as it was based on best guess, given the lack of direct measurement.

There was generally a blame free culture in most organisations and there appeared to be effective mechanisms in place to learn from accidents. In addition, in all cases it appeared that front line staff were empowered to stop work should they be concerned about safety.

To conclude, organisations did have a focus on safety but all organisations can be doing more in terms of process safety. All organisations had key organisational mechanisms in place to drive safety culture and reported that safety was a high priority. However, in real terms it appears more can be achieved. The main shortfall was that there was no specific safety culture policy that outlined the key activities and roles and responsibilities of staff that would be responsible for driving safety culture and in the majority of cases there had been no attempt to measure safety culture.

Conclusion

The study has found that, of the organisations benchmarked, many fell short of meeting recognised good practice in the five human factors topics assessed. Common areas of strength and opportunities for improvement have been described for each topic.

Awareness needs to be raised within organisations managing major accident hazards of the importance of human factors in the context of process safety management. This needs to be followed by policies and systems for managing human factors, with suitable management oversight. This can be enabled by developing staff competence in human factors including general awareness for all those involved in process safety as well as providing more specialist expertise where required. This will enable the process industries to achieve the high levels of process safety performance required when managing major hazards.

References

COMAH Competent Authority, 2011, Inspection of Competence Management Systems at COMAH Establishments. Operational Delivery Guide.

Deal T. E. and Kennedy, A. A., (1982, 2000) Corporate Cultures: The Rites and Rituals of Corporate Life, Harmondsworth, Penguin Books, 1982; reissue Perseus Books, 2000.

Health and Safety Executive, 1994, The Fire at Hickson & Welch Limited. A report of the investigation by the Health and Safety Executive into the fatal fire at Hickson & Welch Limited, Castleford on 21 September 1992, ISBN: 0 71 760 702 X, 1994.

Health and Safety Executive, 2004, Revitalising Procedures, Free information Sheet www.hse.gov.uk/humanfactors/topics/procinfo.pdf, accessed November 2013.

Health and Safety Executive, 2005. HSE Inspectors Tool Kit: Human Factors in the Management of Major Accident Hazards.

Health and Safety Executive, (1989, 2005), Reducing Error and Influencing Behaviour HSG 48.

Hopkins, A., 2000, Lessons from Longford: the Esso Gas Plant Explosion, ISBN 1864684224, CCH Australia Limited.

CSB (US Chemical Safety and Hazard Investigation Board), 2007, Final Investigation Report on the BP Texas City Refinery Explosion and Fire.