Learning from incidents, accidents and events

LEARNING FROM INCIDENTS, ACCIDENTS AND EVENTS

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FOREWORD

A number of industry commentators have noted that the energy and allied industries still need to improve in learning lessons from incidents. This view is prompted by the reoccurrence of similar events, and by evidence of the difficulty of achieving long-term changes in behaviour and working processes following incidents. Ideally, learning from incidents (LFI) should be a critical part of ensuring continuous business and operational improvement.

In 2008 the Energy Institute (EI) published *Guidance on investigating and analysing human and organisational factors aspects of incidents and accidents* (first edition). This provided guidance on ensuring human and organisational factors (HOF) are considered in addition to technical causes when investigating incidents, and was produced because of the recognition that these factors were often given insufficient attention.

In addition to insufficiently probing HOF within the investigation, research has indicated additional challenges at several stages in the LFI process, including: reluctance to report incidents due to fear of disciplinary action; lack of time and resources dedicated to helping people understand and make sense of lessons; overload of investigation recommendations and failure to agree actions with all the involved parties, and failure to check that implemented changes have actually addressed the underlying causes and have reduced risk.

In recognition of these and other challenges, the EI's Human and Organisational Factors Committee (HOFCOM) was tasked by the EI's Technical Partner Companies (comprising many of the major energy companies), together with the Stichting Tripod Foundation (STF), to update and broaden the original 2008 guidance document.

Learning from incidents, accidents and events (first edition) supercedes the 2008 publication and now covers the whole LFI process, from reporting and finding out about incidents through to implementation of effective learning resulting in changing practices.

The main objectives of this publication are to:

- act as the initial 'go to' resource for LFI, but pointing to other more detailed resources as necessary;
- inform on current good practice for all key phases of the LFI life cycle; and
- focus not just on accident/incident investigation but also learning.

In addition, the central objective of the 2008 publication has been retained, i.e. to guide the reader in understanding the HOF causes of an incident through appropriate investigation approaches.

This publication has been produced with the help of three industry stakeholder workshops organised by the EI and held in September, October and November 2014. The workshops focused on reporting, investigation and broader learning respectively. Workshop attendees included representatives from major energy companies, regulators, infrastructure providers, consultancies and academic institutions (over 20 organisations in total).

Little progress with LFI is possible without strong management commitment. Section I Executive summary is intended to inform managers of the essential features of LFI and explain concisely why it is needed.

Suggested revisions are invited and should be submitted through the Technical Department, Energy Institute, 61 New Cavendish Street, London, W1G 7AR. e: technical@energyinst.org

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I EXECUTIVE SUMMARY

I.1 OVERVIEW OF LFI

Developing an effective process for LFI will provide an organisation with a critical tool for managing its risks. Inadequate LFI processes have been cited as contributory factors in major accidents such as the space shuttle accidents, Piper Alpha, Macondo and many others. An effective LFI process will use multiple opportunities for learning to make optimising changes that lead to a lower risk, more stable, business environment.

LFI is a process whereby employees and organisations seek to understand any negative events that have taken place and then take actions in order to prevent similar future events (Lukic, 2013). However, many aspects of the LFI process can also be applied to learning from positive events to help feed an organisation's continuous improvement loop.

The LFI process should lead to changes in equipment, behaviours, processes and management systems, such that risk is reduced in an effective and sustainable manner. Achieving this is *not* just about generating and disseminating information about incidents from which learning *might* take place. Rather it should involve giving people the time and resources to reflect on and make sense of the information communicated, enabling them to make the changes necessary to reduce risk. It also involves the organisation embedding and monitoring changes so that, even if people leave the organisation, sustained measures to prevent incident re-occurrence stay in place.

The main LFI phases necessary to deliver the required changes (see Figure I.1) are:

- **Reporting** incidents and **prioritising** for investigation: as well as formal reporting, it is recognised that incidents can also come to light through informal discussions. This is covered in more detail in section 3.
- **Investigation:** this includes initial fact finding and information gathering, and the subsequent analysis of the information to determine what happened and why (see sections 4 and 5).
- **Recommendations and actions:** the recommendations from an investigation should be translated into actions which are tracked, implemented and verified (see section 6).
- **Broader learning:** the implementation of actions arising from an incident investigation will typically lead to localised changes. In order to ensure that the changes will be broader geographically and sustained for the long term, broader learning should be achieved. This is described in section 7. Broader learning includes learning from the incidents of other sites and organisations and sharing information with them. However, importantly, following communication of incidents, people should be given time and resource to 'reflect' on incidents and incorporate lessons into their own work. The result should be systematic changes to equipment, management systems, behaviours and processes, driven through by the relevant teams, to ensure learning and sustainable change.
- **Evaluation:** this final phase is regarded as two-fold; evaluating whether effective learning has taken place following an incident, and whether the LFI process itself can be improved (see section 8).

Following incidents, these phases serve as building blocks to ensure effective and sustainable change that reduces the risk of incidents occurring in the future.

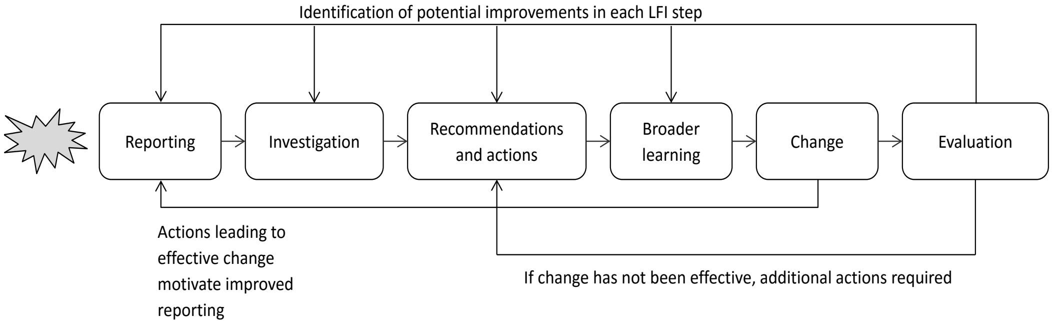

Figure I.1: LFI process model

Whilst the phases are presented as discrete, feedback loops between the phases help determine whether the LFI process thrives or withers. For example, an active reporting culture will generate the raw material for LFI. If actions leading to effective change are taken, that will encourage additional reporting. If change is not effective and, in the worst case, individuals are simply blamed, reporting is likely to decline and formal LFI will cease. At the evaluation phase, feedback loops identify if additional actions are required in response to an incident and help an organisation 'learn how to learn' by identifying potential improvements in the LFI processes. The importance of the latter evaluation loop has been highlighted by research (Drupsteen, Groeneweg and Zwetsloot, 2013) that reveals that, across the industry, significant learning potential is being lost in every phase.

There are a number of blockers to learning discussed in this guidance document. These can lead to a situation where an organisation neglects the potential lessons from lesser severity incidents (accident precursors) and only learns when a major accident actually happens. This is inherently an unstable approach likely to lead to states of higher overall risk.

The LFI blockers for each phase are highlighted in table I.1. Guidance on how to overcome these blockers is provided in the relevant sections of this publication. A coordinated approach to making improvements in each LFI phase should be taken to avoid exposing weaknesses elsewhere. For example, any improvements made to investigation practices should take place before trying to secure an increase in reporting, to ensure that maximum value is obtained from the LFI process.

Table I.1 Blockers to learning

LFI phase	Blockers
Reporting	– Fear of being blamed or embarrassed – Belief that nothing will be done in response to a report – Concern from contractors that their contract may be jeopardised – Apathy – People do not understanding what to report – Complex reporting systems – Insufficient weight given to potentially high learning events – How to classify and prioritise reported incidents. Are theones selected for investigation those with the most potential for learning?
Investigation	– Insufficient management commitment – Lack of personnel trained/competent in investigation – Reluctance of personnel to provide full story; worry of being blamed or incriminating others – Lack of comprehensive identification of underlying causes and 'single (root) cause seduction' – Difficulty of establishing why people did something: they themselves might not know – Lack of early learning: the time to produce a final report can be lengthy and the temptation can be to postpone wider learning until all the facts are known definitively
Recommendations and actions	– Recommendations are not accepted by line management – Recommendations are not accepted by frontline personnel – Insufficient weight given to underlying causes in developing recommendations – Insufficient checks that recommendations will effectively reduce risk – Too many, or loosely worded, recommendations – Recommendations do not address the main risk issues or all relevant causal levels – Backlog of actions build up

Table I.1 Blockers to learning (continued)

LFI phase	Blockers
Broader learning and evaluation	– Difficulty in identifying who should be learning – Common methods of sharing lessons are often passive and provide over-simplified summaries lacking in context – The investigation report is difficult to understand – Insufficient opportunity to reflect and make sense of communicated information – Actions not taken to embed learning – Legal constraints on sharing incident information widely – Difficulties in relating to other organisations' incidents, especially when they are in a different industry – Embedding change for the long term can be difficult given normal corporate memory loss – Difficulty in evaluating if effective learning and change has occurred

A key message that emerges from the examples and case studies in this publication is that leadership and management commitment at all phases of the process are important for making LFI effective, whether this involves setting up comprehensive reporting systems or implementing the necessary actions from incident data analysis. Linking senior managers to LFI also reduces the risk that LFI is seen as the narrow responsibility of incident investigators or the safety, health, environment and quality (SHEQ) department.

1 INTRODUCTION

1.1 BACKGROUND

A number of industry commentators have noted that the energy and allied industries still need to improve in learning lessons from incidents. This view is prompted by the reoccurrence of similar events and by evidence of the difficulty of achieving long-term changes in behaviour and working processes following incidents. Ideally, LFI should be a critical part of ensuring continuous business and operational improvement.

In 2008 the EI published *Guidance on investigating and analysing human and organisational factors aspects of incidents and accidents* (first edition). This provides guidance on ensuring HOFs are considered in addition to technical causes when investigating incidents, and was produced because of the recognition that these factors were often given insufficient attention. A recent publication from the Society of Petroleum Engineers (SPE) states that this is still the case (*The human factor: process safety and culture*):

'Researchers, human factors professionals and others [. . .] believe that real learning from incidents has been hindered by a tendency to 'blame the human', or to treat 'human error' as an acceptable final explanation of why an incident occurred.

Despite the best efforts of many companies [. . .] going 'beyond human error' is still relatively uncommon in many industries, including the oil and gas industry.

The key is to pursue a deeper understanding of why 'human error' occurred, and especially the organizational/cultural factors that 'set up' the human for failure.'

In addition to insufficiently probing HOF within the investigation, research has indicated additional challenges at several phases in the LFI process, including:

- reluctance to report incidents due to fear of disciplinary action or the perception that reporting does not lead to any change;
- lack of time and resources dedicated to helping people understand and make sense of lessons;
- overload of investigation recommendations and failure to agree actions with all the involved parties, and
- failure to check that implemented changes have actually addressed the underlying causes and reduced risk.

In recognition of these and other challenges, the EI's HOFCOM was tasked by the EI's Technical Partner Companies (comprising many of the major energy companies), together with the STF, to update and broaden the original 2008 guidance document. *Learning from incidents, accidents and events* (first edition) updates and supersedes the previous 2008 publication, and now covers the whole LFI process, from reporting and finding out about incidents through to implementation of effective learning resulting in changing practices.

1.2 WHAT IS LFI

In this publication, LFI is understood to be a process whereby employees and organisations seek to understand any negative events that have taken place and take action to prevent similar future events (Lukic, 2013). Such events include near misses, which enable successful interventions to be analysed and learnt from, as well as learning from what has gone wrong.

While LFI is often discussed in the context of safety, it includes any failure of control with the potential to impact a business. These impacts could be, but are not limited to, environmental, health, production, system availability, damage, quality, etc. Thus, LFI should be understood to be relevant to all these aspects throughout this publication.

Following a significant incident, organisations produce a range of responses, suggesting that the phrase 'we have learnt from this incident' can mean different things to different people. For example, it could mean any of the following:

a) That the team of investigators has investigated an incident, and understand how and why it occurred.
b) That several people in an organisation now know how to prevent it happening again.
c) That an organisation has implemented a set of changes (for example in equipment and personnel behaviours) which will prevent this event happening again.
d) That an organisation has implemented a set of changes which will prevent this event, and similar events, happening again and even learnt about its processes and practices for LFI.

Bullets a - d could be seen as representing a range of learning potential. It would be expected that bullet 'd' would lead to a significantly larger and sustained risk reduction than if bullet 'a' alone were achieved. In this publication, the ideal LFI process is regarded as one which leads to changes in equipment, processes or behaviours such that risk is reduced in an effective and sustainable manner.

LFI is therefore not just about investigation or generating and disseminating information about incidents from which learning might take place, but it will also involve people having opportunity to reflect and make sense of that information, and actually taking action to reduce risk. It involves the organisation embedding changes so that even if people leave, measures to prevent incident reoccurrence stay in place. A key point about LFI is that it should occur within individuals, teams, an organisation, and between organisations. All of these are covered within this publication.

For convenience, the phrase LFI is used in this document to cover learning from accidents, incidents and events. An accident is considered to be an event that results in injury or damage or general loss, whereas an incident has the *potential* for injury, damage or loss and hence includes near misses. For further definitions see Annex B. The term 'incident' is predominantly used in this publication and refers to both accidents and incidents unless otherwise specified.

It should be noted that there are other methods as well as LFI for learning from operational experience, such as task observation, inspections and audits. Lessons from these techniques are also necessary for risk management, but they are not the subject of this publication.

1.3 THE BENEFITS OF LFI

There can be various 'blockers' to learning (discussed in this publication) that can lead organisations to neglect the potential lessons from lesser severity incidents (e.g. near misses, precursors, barrier failures) which could have escalated into major accidents (MAs), and only learn when a MA actually happens. This is an inherently unstable approach likely to lead to states of higher overall risk as illustrated in Figure 1. If the only changes an organisation makes are in response to learning from major accidents (LFMA) rather than the broad range of potential incidents, as represented in the accident pyramid in Figure 1, this will typically lead to large disruptive changes following such MA events in which risk will be reduced by large expenditure in new safety related equipment, with high associated capital expenditure (CAPEX) costs and reduced plant availability. Over the longer term however, the memory of these low frequency events may weaken and risk could increase unnoticed as the warning signs (or 'weak signals') offered by smaller incidents are not being effectively processed.

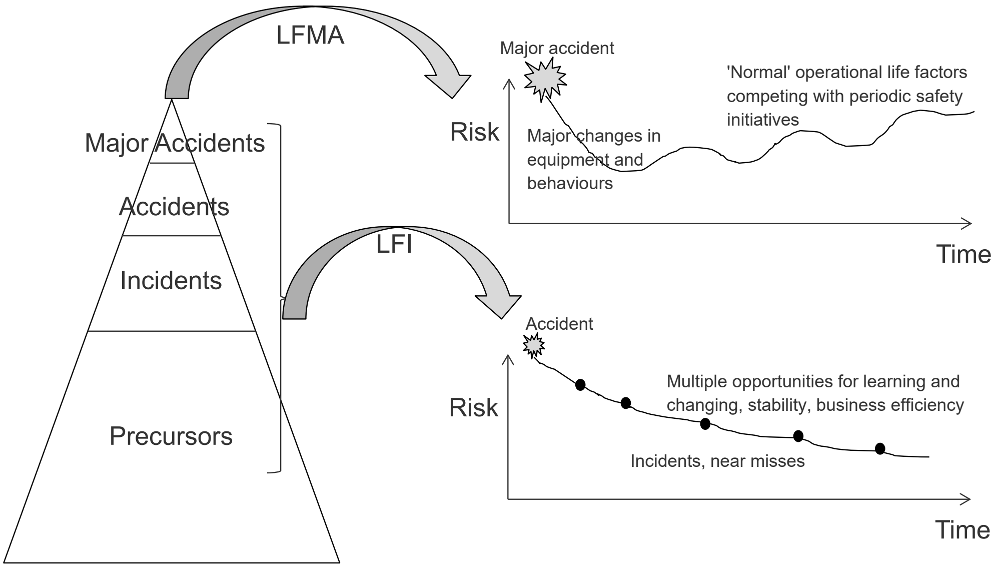

Figure 1: Benefits of LFI

An effective LFI process should make use of multiple opportunities for learning leading to a lower risk, more stable business environment as the organisation makes smaller, optimising adjustments in response to LFI. As an illustrative example, following the 1988 Piper Alpha disaster, the hydrocarbon release (HCR) system was developed to learn from higher frequency loss of containment incidents as opposed to learning only from major fires and explosions.

Many public inquiry reports have noted how weak signals of problems or incident precursors have been repeatedly missed. The LFI processes set out in this guidance document should help to detect those signals and reduce the risk of major losses.

Although a well-working LFI process should ultimately represent a cost-effective approach, the phrase 'near-misses offer free lessons' (which is sometimes heard amongst safety professionals), referring to the aftermath of events that do not cause injury or damage, is potentially misleading. It is not possible to learn effectively from incidents without dedicating resources to this process. In particular, time and effort should be invested to help personnel make sense of the information produced by investigations. This topic has been the subject of research funded by the EI (Lukic, Littlejohn and Margaryan, 2012) and the practical outputs of that research are discussed in 7.4 and 7.7.

1.4 OBJECTIVES AND SCOPE OF GUIDANCE

1.4.1 Objectives

The main objectives of this publication are to:
- act as the initial 'go to' resource for LFI, but pointing to other more detailed resources as necessary;
- inform on current good practice for all key phases of the LFI life cycle; and
- focus not just on accident/incident investigation but also learning.

In addition, the central objective of the 2008 publication has been retained, i.e. to guide the reader in understanding the HOF causes of an incident through appropriate investigation approaches.

1.4.2 Scope

For clarity, this publication is focused on LFI rather than learning from other types of operational experience, such as task observation, safety walkarounds, inspections and audits. However, the process and techniques in this publication are in many cases also applicable to learning from these others types of operational experience.

Incidents could be related to safety (personal and process safety), health, environment, property or equipment damage, loss of production, quality, security, business interruption or organisational reputation.

All phases of an incident are relevant for LFI. This includes incident causation but also later phases of an incident including emergency response. However, prevention is often more valuable and reliable than mitigation and emergency response.

1.5 BASIS FOR GUIDANCE

The guidance in this publication has been produced with the help of three industry stakeholder workshops organised by the EI and held in September, October and November 2014, which focused on reporting, investigation and broader learning respectively. Workshop attendees included representatives from major energy companies, regulators, infrastructure providers, consultancies and academic institutions (over 20 organisations in total). The outputs from the workshops have helped augment the guidance and literature that are already available (see references in Annex A) and ensured that the guidance is based on existing good practice.

1.6 POTENTIAL USERS OF THIS PUBLICATION

It is in the nature of LFI that there will be a broad range of potential users, including:
- incident investigators in operating companies, authorities or consultants;
- LFI coordinators in the operating companies and their contractor organisations;
- those who commission an investigation;
- persons who use the recommendations from the investigation to decide what changes are needed (line managers, designers, consultants);
- those involved in helping individuals learn (including training professionals);

- those involved in long-term knowledge management (e.g. designers of incident databases), and
- researchers in incident investigation and safety who may obtain insights from this good practices overview.

It is recognised that little progress with LFI is possible without strong management commitment. Thus section I Executive summary is intended to inform managers of the essential features of LFI and explain concisely why it is needed. Mature LFI processes will ensure that managers are better informed and able to determine appropriate actions for managing risk effectively.

2 OVERVIEW OF INCIDENT CAUSATION AND LFI

2.1 OVERVIEW

This section provides the background required to understand the subsequent sections in this publication. Two main models are presented in this section, namely the following:

– An incident causation model: by illustrating the multiple causal levels of a typical incident, ending ultimately with management system, leadership and cultural issues, the model highlights the main factors that an incident investigation should be trying to uncover.
– An LFI model: this is based on the main building blocks of LFI identified in existing studies. In each building block there are potential challenges or blockers to learning. The guidance in subsequent sections provides practices to help overcome these learning blockers.

In this section, some of the main concepts which underpin LFI (namely organisational and individual learning, management systems, culture, and legal considerations) are also briefly introduced. Cross-references to more detailed explanations are provided.

2.2 INCIDENT CAUSATION MODEL

The incident causation model used in this publication is structured around a generic model of failures and is illustrated in Figure 2. It consists of the following:

– A barrier model, also known as a 'Swiss cheese' model. Barrier models are widely used and represent an organisation's defences between a source of harm (e.g. a fuel source) and an undesirable outcome (e.g. injury due to a fire) as a series of barriers or layers, represented as Swiss cheese (with holes to indicate breaches in barriers). These barriers are often structured in the form of preventive and mitigation measures.
– Links between each barrier and sets of progressively deeper causal factors (a 'causation path'). These are represented in Figure 2 as:
    – immediate causes, also known as direct causes;
    – performance influencing factors (PIFs), also known as performance shaping factors (PSF) or preconditions, and
    – underlying causes, also known as root causes, latent failures/causes or systemic causes.

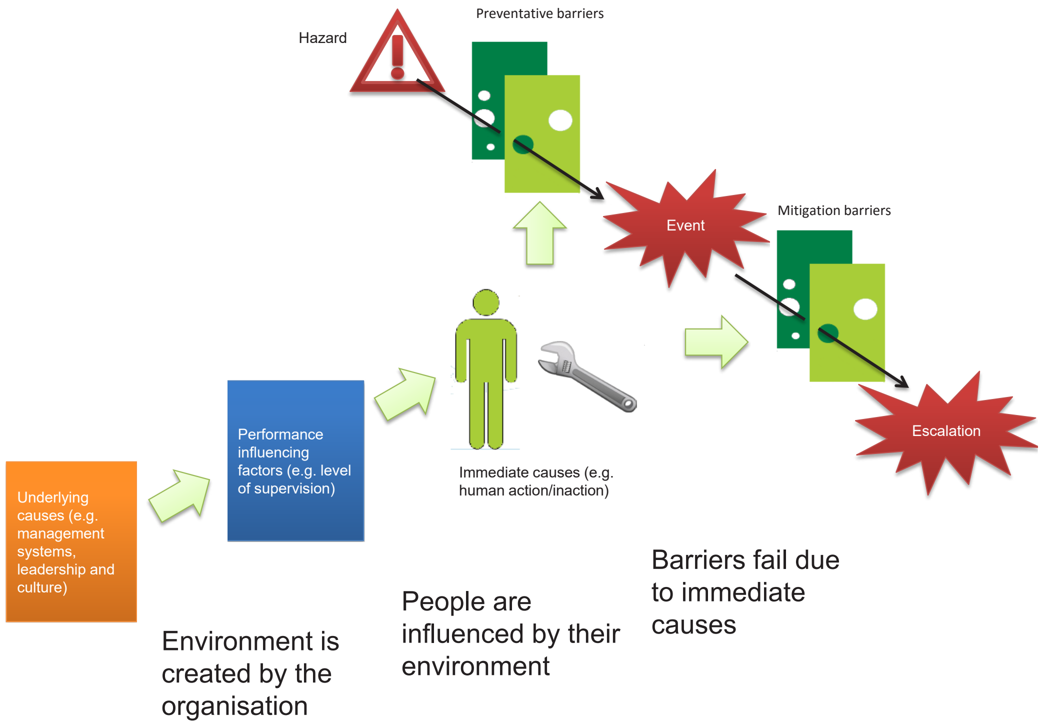

Figure 2: Incident causation model

2.2.1 Barriers

Barriers may be physical barriers (fences, guards, bunds, protective clothing, safety devices) or 'administrative' barriers (checking procedures, permits-to-work, supervision). For example, a pipe is depressurised and drained prior to removing a pump; a drip tray is placed under the pipe in case of leaks; also, the permit-to-work requires a second fitter to ensure that the pipe is isolated and drained and to sign the permit-to-work when he has completed the check. From the example in this section, it is clear that there are two types of barriers: those designed to prevent incidents and those designed to counteract or reduce the consequences of an incident.

It should be noted that a person’s understanding of what constitutes a barrier may depend on what analysis or risk assessment methodologies they are familiar with. For example, some would describe a general measure as a barrier (e.g. a procedure), whereas others would only consider a specific measure to be a barrier (e.g. the specific action the procedure requires the operator to perform and how that will prevent an incident).

If the barrier is ineffective, then an incident ensues.

2.2.2 Immediate causes

As illustrated in Figure 2, barriers are considered to fail (or be ineffective) due to immediate causes. These are events where an action (or inaction), or decision, by a person reduces the level of control over a task; such 'operational disturbances' or 'unsafe conditions' could result in an incident. For example, a small pump was being lifted by a sling attached to an eyebolt on the pump. This was a 'blind lift' and the load snagged causing the eyebolt to fail and the pump to drop several feet. The decision to use the eyebolt to lift the pump and the decision to conduct a blind lift were both 'substandards acts', leading to the operational disturbance of lifting the load in this manner. Immediate causes are often unsafe/substandard acts – these are the human behaviours that lead to barrier failures. Often, an immediate cause is the human action that directly led to a barrier failure (opened the wrong valve, pressed the wrong button, did not respond to an alarm, etc.), or the human decision/action that created an operation disturbance or unsafe condition (failure to address corrosion, leading to failure of a component, installation of a faulty fuse that only created a problem several months in the future, etc.). Immediate causes may also be less proximal actions or decisions made by managers or designers weeks, months, or years before an incident (see 2.2.5). For example, the immediate cause of an alarm failure may be with the design of the alarm.

It should be recognised that there is a variety of 'human failure types' (commonly called human error) that lead to unsafe actions. These are commonly split into errors (slips, lapses, mistakes) and non-compliances/violations (of which there are several). In general, errors of these types result in either:

- an error of omission: something is not done that needs to be done, or
- an error of commission: something is done but is done incorrectly.

(In addition, it should be noted that an error of commission such as operating the wrong device would also involve an error of omission because the device that should have been operated is not operated.)

The type of human failure is often only known once the PIFs are known.

2.2.3 Performance influencing factors (PIFs)

Having identified immediate causes, including relevant human action or inaction, it is then possible to identify factors which are likely to have influenced performance.

PIFs are sometimes referred to as psychological precursors (the state of mind of the person which influenced the type of unsafe/substandard act carried out) and situational precursors (the working conditions that led to the state of mind). It is not possible to know a person's state of mind at any given time but certain factors could affect a person's state of mind more than others: time pressure, lack of competence, etc.

Examples of PIFs include the following, grouped by whether the PIF is something to do with the task at hand, the person, or the organisation (taken from EI, *Guidance on using Tripod Beta in the investigation and analysis of incidents, accidents and business losses*):

- Task:
  - Inadequate or incorrect tools or equipment (can lead to slips of action).
  - Procedures that are unclear, incorrect, ambiguous, or do not align with usual working practices (can lead to rule-based mistakes or violations).
  - Working environment conditions that are noisy, dark, hot, untidy, etc. cause sensory errors (which in turn can lead to lapses or knowledge-based mistakes).
- Personal:
  - Insufficient knowledge or insight to undertake a task (can lead to knowledge-based mistakes).
  - Reduced attention from being preoccupied (can lead to slips and lapses).
  - Over-energetic attention to task; macho behaviour; 'can-do' attitude, over confidence, complacency, stubbornness (can lead to violations).

– Organisation:
  – Poor motivation by supervisor failing to promote a positive attitude (can lead to violations).
  – Failure to adequately train personnel (can lead to knowledge-based and rule-based mistakes)
  – Production goals, superiors, work schedules, inadequate resources creating undue time pressures (can lead to violations by short cuts being taken).

'The relationship between [PIF] and immediate cause is not direct causal but probabilistic. That is, it is not certain that the influence created by the [PIF] caused the sub-standard act [the immediate cause] but only that it increased the likelihood for it to happen' (EI, *Guidance on using Tripod Beta in the investigation and analysis of incidents, accidents and business losses*). Immediate causes can be the result of *multiple* PIFs.

2.2.4 Underlying causes

Finally, underlying causes that created the environmental conditions and gave rise to the PIFs should be identified and understood. Underlying causes are often faulty organisational decisions, leadership or culture. Within this model, decisions made within the organisation about how to manage all the tasks carried out are the ultimate root cause of incidents and accidents. These can create the conditions from which errors later emerge. Such conditions include: poorly defined systems for selection or design of plant and equipment; inadequate processes for training of personnel; ineffective supervisory practices or resource provision; inaccurate communications methods used; poor team structuring etc. Underlying causes often stem directly from inadequacies with the safety management system, such as lack of policy or requirements to manage certain aspects of the operation, and so are likely to relate to deficiencies in the management system itself (e.g. procurement or human resources), leadership or organisational cultural. Deeper underlying causes may be the factors that affect those management decisions (such as the regulatory environment), but this is a level of complexity that is not often reached in investigation, as such factors are often beyond the control of organisations.

2.2.5 Differences in terminology and models

As LFI is a complex topic, there are understandably differences in the terminology and models different practitioners use. For example, some only consider human actions that immediately precede the incident to be immediate causes, and instead consider human actions that were made weeks or months prior, such as installing a faulty fuse, to be underlying causes (i.e. the causes of the incident are categorised in terms of chronological proximity to the incident). Others still consider such ‘distant’ human actions to be immediate causes, reserving underlying causes for organisational aspects that, in turn, can cause many different types of incidents (i.e. the causes of the incident are categorised in terms of logical proximity to the incident). This publication uses the latter definition, but it is important to ensure the organisation uses consistent terminology so that people share the same understanding.

2.2.6 Drilling down

Investigating the progressive causal layers can be seen as a process of repeatedly asking 'Why?'. For example, for an incident involving the accidental release of product, these layers could be:

– Barrier: valve prevents release of product.

– Immediate cause: operator opens wrong valve.
– PIF: Operator is fatigued, makes wrong decision.
– Underlying cause: organisation does not have a system for assessing the impact of changes to shift patterns; supervisors not trained to consider fatigue when setting shift patterns.

This process of drilling down to underlying causes can enable an investigation to go well beyond simply attributing an incident to 'human error', and it becomes clear that investigations that do not get further than identifying the human error have only investigated as far as the immediate causes. It should be noted that it is possible to conduct an investigation without focusing on HOF; however, such an investigation will likely only serve as a technical investigation (i.e. to understand the component and technological failures of an incident, common with initial aircraft accident investigations) and will not be able to identify the immediate or underlying causes of the incident (at least as the terms are understood in this publication) without knowledge of HOF.

If an organisation addresses the underlying causes of the failures identified, this is likely to have a longer term impact on reducing the likelihood of not just this event reoccurring but other potential events linked to the inadequate management system element. On the other hand, addressing such organisational causes can take significant time. Thus it has been argued (Peuscher and Groeneweg, 2012) that a balanced approach is required that addresses barrier failure as well as the underlying organisational causes.

Major accident hazard (MAH) organisations' management systems are generally 'barrier based' as they rely on defence in depth. If there has been a significant event then usually multiple barriers will have failed or been absent. This model is therefore well suited to illustrating and visualising the multiple causes present in most significant events. Even if a barrier model is not included explicitly in a formal incident investigation technique, 'barriers' in a general sense will still receive consideration in an investigation; hence the model in Figure 2 is of general applicability.

2.3 LFI PROCESS MODEL

Organisations will likely have a number of processes in place for LFI. Based on various research studies, Figure 3 presents a generic LFI process model in order to illustrate the various steps required for effective LFI. The main LFI building blocks considered in this guidance are the following:
– **Reporting** incidents and **prioritising** for investigation: as well as formal reporting, it is recognised that incidents can also come to light through informal discussions. This is covered in more detail in section 3.
– **Investigation:** this includes the initial fact finding and information gathering, and the subsequent analysis of the information to determine what happened and why (see sections 4 and 5).
– **Recommendations and actions:** the recommendations from an investigation should be translated into actions which are tracked, implemented and verified (see section 6).
– **Broader learning:** the implementation of actions arising from an incident investigation will typically lead to localised changes. In order to ensure that the changes will be broader geographically and sustained for the long term, broader learning should take place. This is described in section 7. Broader learning includes learning from the incidents of other sites and organisations and sharing

information with them. Following broader communication, systematic actions should be driven through by the relevant organisations to ensure learning and effective change.

– **Evaluation:** this final phase is regarded as two-fold; evaluating whether effective learning has taken place following an incident, and whether other LFI processes can be improved (see section 8).

Following incidents, these phases serve as building blocks to ensure effective and sustainable change that reduces the risk of incidents occurring in the future. Each phase of the LFI process is expanded upon in the relevant chapters. The LFI process model can be used to identify opportunities for learning throughout the incident life cycle. Organisations can use the model to ensure LFI initiatives are integrated in ways that support overall effective learning.

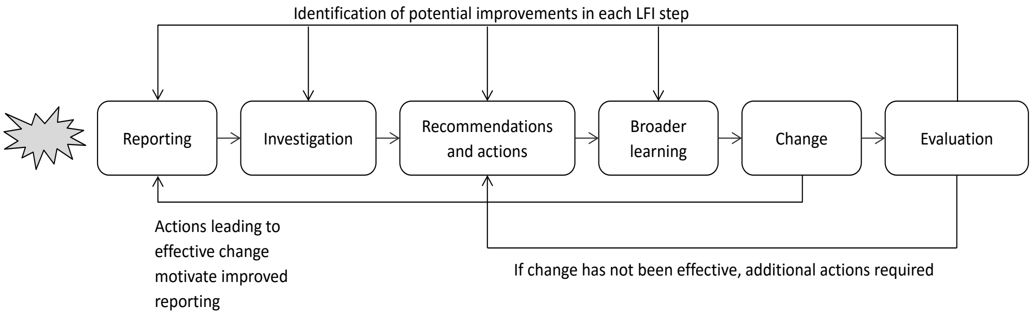

Figure 3: LFI process model

2.3.1 Feedback loops

The feedback loops in Figure 3 are of key importance in determining whether the LFI process thrives or withers. An active reporting culture will generate the raw material for LFI. If lessons are learnt within an organisation, that will encourage additional reporting. If lessons are not learnt and, in the worst case, individuals simply blamed, reporting is likely to decline and formal LFI will cease.

The evaluation feedback loops are two-fold. Evaluation after an incident should determine whether the change has been effective, i.e. whether learning has really taken place. If not, additional actions should be planned and implemented. Additionally, higher level evaluation helps an organisation 'learn how to learn', by identifying potential improvements in the LFI processes. The importance of this evaluation loop has been highlighted by research that reveals that, across industries, significant learning potential is being lost in every phase (Drupsteen, Groeneweg and Zwetsloot, 2013). This is somewhat surprising given that good practice guidance has been available on traditional features of LFI such as investigation techniques for some time. However, it is clearly important to address all the LFI phases in this publication and expand traditionally under-represented topics related to broader learning and evaluation.

Despite the linear representation of steps in the LFI model, it should be noted that opportunities for early learning do arise even before an investigation report has been finalised and published. Examples of this are presented in this publication.

2.4 INDIVIDUAL AND ORGANISATIONAL LEARNING

Whilst organisations are made up of individuals, individual learning and organisational learning are distinguishable.

2.4.1 Individual learning

It is generally accepted that adults learn best in the workplace through participation and 'doing', with plenty of social interaction. In addition, learning that encourages *reflection* (particularly self-reflection on the relevance of lessons learnt on an employee's own practice) is more likely to result in deeper learning and improved practice.

Research within relevant industries (e.g. Lukic, Littlejohn and Margaryan, 2011) has revealed that, in order to learn, individuals:

- Need to understand the context of incidents, and time should be allocated for reflection on lessons and sense-making.
- Need encouragement from the organisation to challenge the status quo and reflect on whether current practices could be made safer.
- Benefit from more active engagement, for example, turning incidents into scenario-based group training sessions.
- Will be affected by who delivers the learning information. The quality and credibility of the individuals delivering the information are critical. For example, learning from a peer who has been involved in an incident might be more effective than hearing something second-hand from a supervisor or manager.

Much of the discussion about individual learning is in the context of frontline staff. However, LFI is at least as relevant for managers and technical personnel, and this should be catered for.

The user experience of LFI should be considered. Figure 4 shows two extreme paths for individuals through the LFI process, for illustration only. Clearly the green path is likely to encourage a more effective LFI process than the red path. No organisation will set out to design an LFI experience as negative as the red one; however, in an organisation where mutual trust is low, and where little LFI evaluation is occurring, it could be possible for a system to exhibit many of these characteristics.

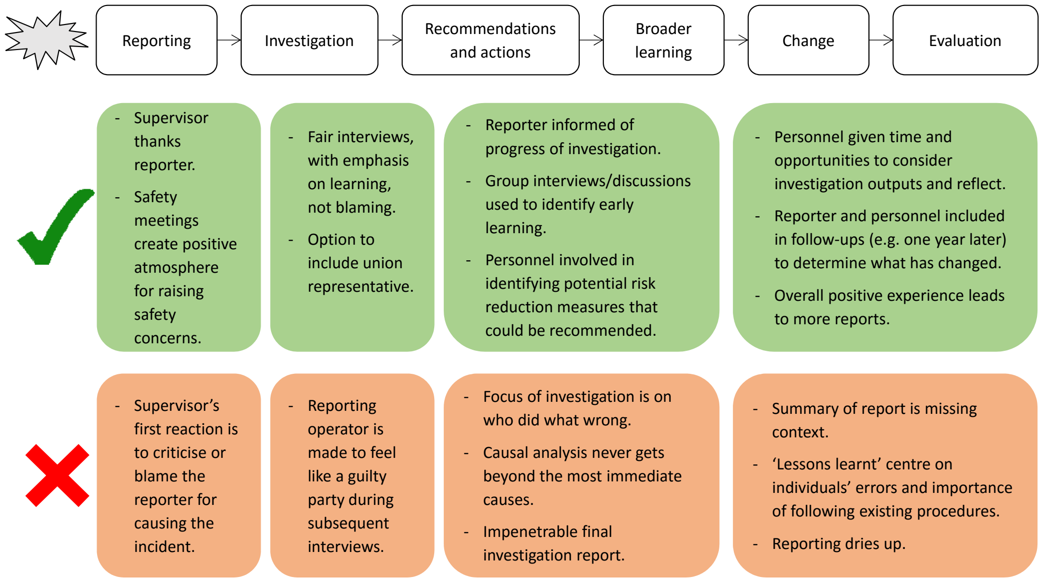

Figure 4: Examples of the user experience of LFI

2.4.2 Organisational learning

Organisational learning involves embedding the lessons from incidents in the organisation itself, not only in the individuals who make up that organisation. Hence one would expect learning to result in changes to plant and equipment and to policies and procedures, training, competence assurance, supervision, resourcing priorities, and other management systems (and the reasons for the changes recorded). In this ideal, learning will become permanently embedded in the organisation and be sustained long after those involved in the incident have left the company.

Figure 5 illustrates how LFI should work in relation to increasing organisational knowledge. The figure represents a 'before LFI' and 'after LFI' scenario. In both scenarios it is considered that knowledge relevant to an incident could be known or unknown to the organisation and known or unknown to an individual within that organisation. This leads to four possible states which are characterised as shown in Figure 5. Over time, as information from incidents is effectively learnt from, the amount of corporate information known to the organisation and to individuals will grow, partly due to the better capture of 'private' information known only to certain individuals. The effective sharing of this corporate information will reduce the number of employees who have significant 'blind spots' (that which the organisation knows but individuals do not) and shrink the information gaps that exist both in the organisation and individuals.

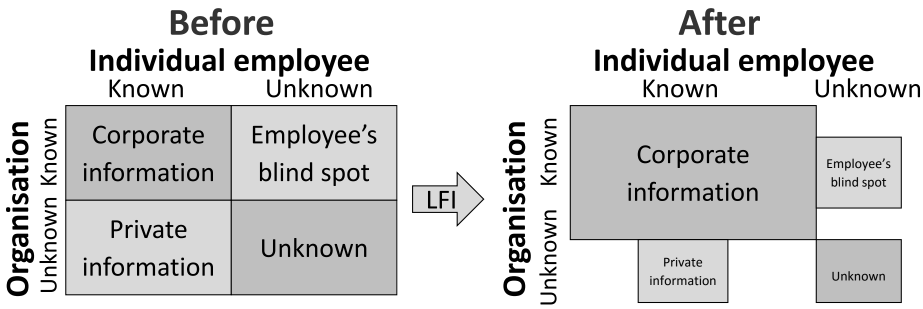

Figure 5: Increasing the pool of organisational knowledge through LFI

In the context of LFI, key aims for an organisation should be to ensure the following:

– Having increased organisational knowledge, sustainable actions are then taken to reduce risk.
– The right culture is in place such that the user experience is a positive one (see Figure 4).
– The investigation is deep enough that relevant causes, including management system inadequacies, are identified and understood so that effective change can be planned.
– Stakeholders have been identified and their learning needs understood. Who should be involved in LFI extends beyond picking an investigation team. Understanding which stakeholders can influence and shape the learning process has been shown to be critical (Lukic, Littlejohn, and Margaryan, 2012).
– Sufficient resources are dedicated to support individuals in the active learning that is noted as most effective in this section. In particular, for a message to be successfully communicated, it should be both transmitted *and* received. The reception and implementation end of the learning cycle is often under-resourced or even ignored entirely.
– Openness, transparency and sharing of information, rather than unclear requirements and the hoarding of knowledge.

2.5 MANAGEMENT SYSTEMS

LFI has a two-way connection to management systems. As noted in 2.2, problems with management systems can result in underlying causes of incidents. LFI should therefore be a key contributor to a successful operating management system. Figure 6 shows a typical operating management system (OMS) framework from IOGP (IOGP Report 210, *Guidelines for the development and application of health, safety and environmental management systems*). Incident reporting and investigation have traditionally fitted within the 'monitoring' element contributing to the continuous improvement loop. However, the broader view of LFI set out in this guidance document can be seen to link more widely to the following:

– Plans and procedures: some of the actions arising from incident investigations can be readily implemented (e.g. procedural updates) but others could relate to deeper, underlying causes that may take some time and effort to resolve. Such actions would typically be included in a SHEQ or business unit plan.
– Organisation, resources and capability: some of the recommended action from an investigation may require significant changes to the organisation or resources. In addition, LFI will involve awareness sessions and training related to lessons learnt from incidents. It will also be an input into knowledge and learning management related documents and databases.

– Risk assessment and control: information about incidents can be fed into risk assessments and risk assessments can help structure incident investigations (e.g. providing insights into relevant barriers).
– Assurance, review and improvement: the evaluation phase of LFI contributes to continuous improvement through reviewing whether learning and effective change has taken place after each individual incident, and assists in the wider review of OMS systems illustrated in Figure 6. LFI should be a critical part of making the feedback loop real, rather than an abstract management system concept.

Figure 6: A model for an operating management system, from IOGP Report No. 510

A key message that emerges from the examples and case studies in this publication is that leadership and management commitment at all phases of the process are important for making LFI effective, whether this involves setting up comprehensive reporting systems or implementing the necessary actions from incident data analysis. Linking senior managers to LFI also reduces the risk that LFI is seen as the narrow responsibility of incident investigators or the SHEQ department.

Practical management activities should be done to set up LFI in an organisation. These will include the following:
– Establishing a written policy concerning reporting, investigation and learning lessons.
– Defining the roles, responsibilities and specific activities to be carried out by personnel involved in LFI.
– Building an atmosphere of trust and respect (to encourage reporting and active participation).
– Developing procedures and guidelines for LFI with input from an organisation's relevant LFI personnel, i.e. investigators, trainers, and knowledge management experts.
– Providing the resources necessary for training and organising LFI.

– Establishing performance indicators of effective LFI and measuring these against this (see 8.4).
– Periodically reviewing and evaluating LFI.

2.6 SAFETY CULTURE AND ORGANISATIONAL CULTURAL MATURITY

A short, and therefore well remembered, definition of safety culture is 'The way we do safety around here' (CBI, *Developing a safety culture*). It has also been described as 'How people behave when no one is looking'. Detailed information about safety culture can be found in IOGP Report No. 435, *A guide to selecting appropriate tools to improve HSE culture*.

LFI initiatives should be appropriate to the cultural maturity of the organisation. For example, the attitude to confidential reporting will vary in different cultures. In a low maturity setting, confidential reporting may be seen as a first step in trying to kick-start reporting; an increasing number of confidential reports will be seen as positive, demonstrating greater engagement. In a high maturity organisation, confidential reporting might not often be used, as the internal reporting systems are well trusted and used, but it may be retained as an option; an increasing number of confidential reports in this context could be a sign that trust has diminished in a part of the organisation.

Creating the right culture for LFI involves leaders in an organisation promoting an environment that will create the positive user experience illustrated in Figure 4. This will involve leadership commitment to LFI and leadership behaviours such as providing positive responses to 'bad news', openness and demonstration of trust.

Developing an appropriate approach towards reported incidents is particularly relevant (GAIN, *A roadmap to just culture: enhancing the safety environment*). A company should establish a distinction between acceptable (non-culpable) and unacceptable (culpable) behaviour so that appropriate action can be taken to prevent a recurrence. Based on an understanding of HOF, unintentional unsafe acts (i.e. honest errors, routine and situational violations) are seen as opportunities for organisational learning. Conversely, deliberate, intentional unsafe acts (i.e. reckless non-compliance, criminal behaviour, substance abuse and sabotage) are dealt with accordingly, with the required level of sanction.

The link between LFI and cultural maturity means that it is difficult to be definitive with respect to what a specific organisation should implement. Thus, in some of the subsequent sections, a number of LFI approaches which have been found useful are outlined, and it is expected that an organisation will select measures appropriate to its situation. If LFI initiatives are introduced at the right time and in the right way they can provide a major boost to the culture of an organisation and improve risk management, as demonstrated in many of the examples in later sections.

2.7 OVERVIEW OF LEGAL ISSUES

Legal advice can act as a blocker to sharing and learning the lessons from accident and incident investigations. There are potentially very significant benefits associated with sharing information as noted in 1.3. However, there are also risks, as illustrated in Figure 7 (adapted from Hazards Forum Newsletter, Issue No. 84), in terms of potential legal liabilities and prosecution. This can sometimes make it difficult for organisations to learn if information is being deliberately suppressed or kept confidential (or limited in some other way) in order to protect against prosecution.

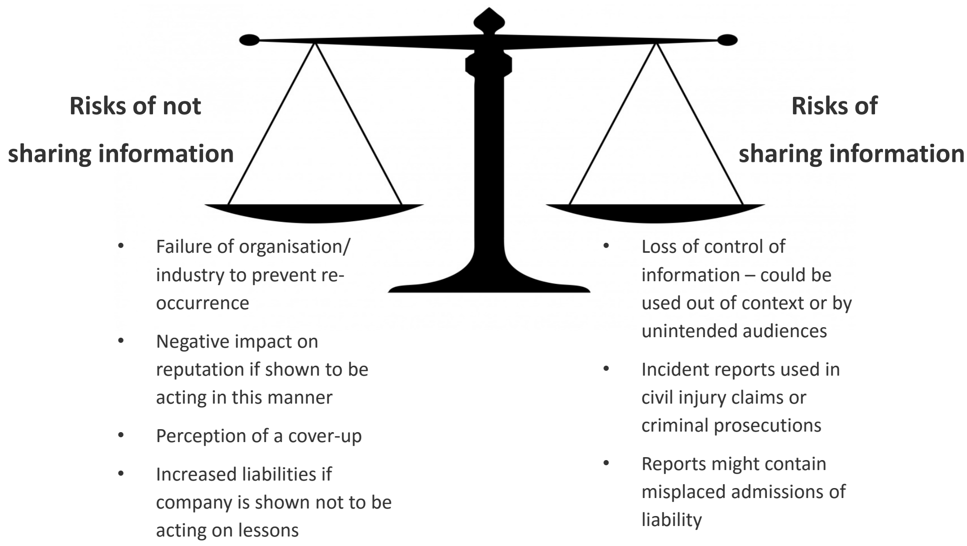

Figure 7: Balancing the risks and benefits of sharing incident information

Thus an organisation should weigh up the pros and cons of sharing information and decide what is in the best interests of the business. Practical approaches to addressing legal constraints include the following:

1. Establish a productive relationship with the legal department

The legal team should be engaged at an early stage when setting up LFI processes so that they can understand what are the aims of LFI and what the overall organisation is attempting to achieve in terms of sharing incident information. Advice about the legal risks can be provided at this early stage. Then there is time to devise a process (e.g. using agreed report templates, avoiding problematic terminology (cause, failure, etc.)) that is the optimum compromise of sometimes competing concerns. This will help avoid last minute frustrations and wasted efforts. One commentator stated that engaging the legal team in this way greatly helped, and the legal team actually felt better placed to defend the organisation against legal action if the need arose because of their better understanding of the incident and its causes.

2. Use alternatives to releasing full causal information about an incident

Release purely factual information about what happened (this can raise awareness that an event has happened and of basic facts, although this will not lead to all possible lessons being shared).

Be clear on what information is needed to learn. A recipient may have enough to learn the lesson from just a description of the hazard, how it can be realised and what precautions are necessary. Many hazards will be common to the industry. It may not be necessary to describe exact details such as locations, incident chains, consequences, etc.

Turning lessons learnt quickly into good practice guidance which can help others learn shouldn't carry the same liability risks.

Share information about near misses and precursors where there are generally fewer legal complications than in accidents.

3. **Write as if the information will be made public**
   Be mindful of how reports are written. Avoid emotional or judgemental language and adjectives. Think how words could be misinterpreted if used in another context outside of the organisation.

4. **Make learning a priority when legal privilege is applied**
   In some countries legal/ litigation privilege may allow an organisation to control the flow of information[2]. Privileged documents are immune from ordinary disclosure requirements. They do not have to be disclosed as part of either civil or criminal investigations and proceedings. There will usually be legal tests to determine what can be deemed legally privileged (including the investigation report itself).

   Where there is a genuine risk of prosecution/civil litigation, a company may decide that legal privilege is necessary. When managed appropriately this may not impede learning and may even allow for deeper investigation, but it can restrict the speed and availability of information. Work with the organisation's legal team to ensure learning is made available in a timely fashion.

5. **Establish an incident response protocol**
   To help an organisation manage the risk balancing described in Figure 7, an organisation should have in place a documented, tried and tested incident response protocol incorporating legal privilege over internal investigations when appropriate, and access to required legal advice in the event of an incident that is likely to give rise to criminal proceedings.

6. **Be prepared to challenge legal advice**
   There could be a bigger picture associated with sharing incident information of which legal advisors are not aware. A healthy debate concerning the pros and cons for the business can help to optimise the final decision.

[2] The laws associated with legal privilege vary between countries.

3 REPORTING AND PRIORITISATION

3.1 OVERVIEW

This section focuses on maximising the potential for learning by generating the necessary learning 'raw material' and prioritising it for effective use in the next LFI phases.

Figure 8 shows a schematic for a reporting and prioritisation process. Incidents are likely to come to light via formal reports and by informal means such as safety concerns raised at safety meetings. All these reports should be recorded. If the reporting system is mature, there should be sufficient recorded incidents such that they need to be classified and prioritised. The prioritisation process can be used to determine the investigation level and the resources allocated to the investigation. Positive feedback from later LFI stages, i.e. evidence that actions have been implemented to prevent reoccurrence, may encourage further reporting.

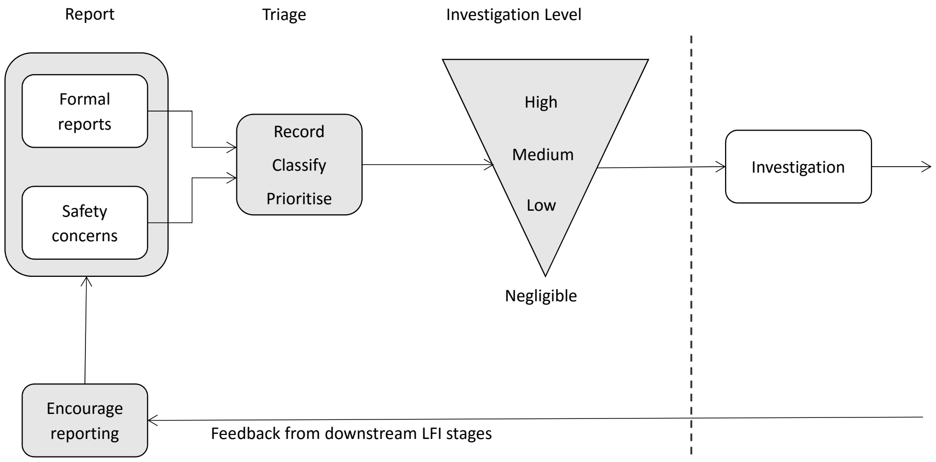

Figure 8: Incident reporting and prioritisation

3.2 REPORT

3.2.1 What incidents should be reported?

When an event is detected, it should be formally reported and recorded. However, deciding what events should be reported can be a challenge. There are often different perceptions within an organisation about what constitutes a reportable event. Therefore an organisation should:

– Define clearly what needs to be reported, ensuring that the definition includes near misses and precursors which will provide valuable learning, but does not become so wide that it becomes unwieldy.
– Train personnel in what needs to be reported using a wide range of illustrative examples.

Accident and external reporting requirements, for example in the UK the *Reporting of Injuries, Diseases and Dangerous Occurrences* regulations 2013 (RIDDOR), are generally well understood (HSE INDG453, *Reporting accidents and incidents at work*). External reporting may include stakeholder as well as regulatory reporting requirements. Even if the regulations are not known in detail by everyone in an organisation there will usually be a general awareness that such events need to be reported.

Differences in the understanding of what needs to be reported usually arise at the level of 'near misses' and lesser severity events. To develop a common understanding of the term, a company should develop a list of examples it believes to be reportable near misses (CCPS, *Guidelines for investigating chemical process incidents*). Examples of process-related incidents include the following:

- excursions of process parameters beyond pre-established critical control limits;
- releases of less-than-threshold quantities of materials;
- activation of protection such as relief valves, interlocks, rupture disks, blowdown systems, vapour release alarms, and fixed water spray systems, and
- activation of emergency shutdowns.

Examples of personal safety near misses include:

- trip hazards not leading to injury;
- unsecured ladders or faulty scaffolding, and
- absence of PPE.

In determining what should be reported, an organisation should try to find an appropriate balance. Making requirements too broad may dilute the power of learning from actual events and overwhelm the reporting and analysis system, but being too narrow may mean that important learning opportunities are missed. Research has indicated that at least 20 events per actual accident need to be reported to drive organisational learning (Bridges, 2000); thus having all the workforce understand what events should be reported is clearly an important step in ensuring effective LFI.

EI *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation* provides additional examples of incidents an organisation should report.

Some organisations also attempt to make personnel aware of what barriers site management rely on to control risk, and hence the events that frontline staff are expected to report. This involves creating a dialogue between management and frontline staff and creating a common awareness of barrier management. The reporting of failed barriers represents a relatively sophisticated approach to developing reporting criteria.

3.2.2 How should incidents be reported?

Organisations should consider a variety of mechanisms to ensure that all can participate in reporting, i.e. via a paper form, using an online system or reporting verbally. Alternatively, direct voice communication can allow rapid tuning of information and the use of semi-structured discussion can lead to high quality, richer data. Typically such systems are phone-based, with dedicated trained operators, or web initiated with call-back.

Example of a reporting system

The railways system CIRAS (Confidential Reporting for Safety) is a well-established example of a direct reporting system.

http://www.ciras.org.uk/

A report can be submitted by phone, text, online or hard copy form and then a member of the CIRAS team will get in touch and discuss the reported health and safety concerns. A written report will be prepared on behalf of the reporter. CIRAS will make sure the report does not contain any information that can identify the reporter. They then send the report to the relevant rail company for a response.

Once CIRAS receive the company response they will then provide the reporter with a copy. Events with high learning potential are published in the CIRAS newsletter.

Whatever system is used, reporting should be easy and rewarding (or at least not painful), there should not be negative feedback and the user should not have any anxieties that they will end up with lots of extra work.

Reporting should be rapid to ensure that an investigation is started as soon as possible after the incident. People have a tendency to forget events, 'reinvent' history or unduly influence each other by discussing an incident before it can be properly investigated.

All employees should be familiar with the procedure for incident reporting; training should be provided to ensure this is the case.

There should be a culture of mutual trust between workforce and management. The system should be perceived to be fair (see 2.6). Confidential reporting may be considered where the culture of trust and fairness is not yet established or to support other reporting mechanisms (see Table 1).

Table 1: Cultural maturity and attitudes to confidential reporting (adapted from CIRAS newsletter, Issue 51, May/June 2014)

Level of maturity	Typical attitudes to confidential reporting
Low	Confidential reporting might be distrusted by managers. Alternatively it could be encouraged by management as a first step in engaging with frontline staff and trying to increase the number of reports.
Medium	Confidential reporting is generally regarded as a valuable way of engaging staff in safety, demonstrating that they can report safety concerns and near misses securely.
High	Confidential reporting may be rarely used as internal systems are well trusted. However, the system is retained and valued as it is recognised that not all people may feel comfortable using internal systems. Confidential reporting could also help identify departments where internal systems are not working as expected.

To assist in reporting to external bodies, the format and timing of all external notifications should be identified and incorporated as part of a company's normal incident response procedures. Proper notifications can then be made quickly and accurately when an incident occurs.

The typical contents of an initial report (example template) are shown in EI *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation*. Some organisations also identify which barriers have failed in the initial report, but this implies a relatively high level of training in, and awareness of, risk management.

As noted, not all incidents will be formally reported immediately. Information may come to light in different ways, such as via safety meetings, mess room conversations, and toolbox talks, etc. In order to ensure that these are also used to learn, they should be recorded and integrated with the formal reports.

3.3 TRIAGE

3.3.1 Initial response

For more serious incidents there can be an overlap at the initial notification stage with the emergency response system. An organisation should develop procedures or checklists for the following:

– For those earliest at the scene of an incident to ensure their own safety and the safety of others.
– To preserve and protect information, especially of a perishable nature, for example, take photographs of the site/equipment, names of witnesses, instrument readings, etc. (see 4.5 for more on information gathering).

There should also be procedures in place covering response times for investigators; for example, following a fatal accident, investigators will be on site within 24 hours.

Initial response actions effectively form the beginning of the investigation, for example, recording what has happened and when.

In the case of certain types of incidents (for example, fatal incidents or public transport incidents), there will be a legal framework that needs to be applied. This tends to restrict the right of organisations to interview, may restrict access to the site of the incident and normally defines the concept of primacy (who is in charge) of one particular organisation for that incident. In some cases, there is a requirement to enable interested parties to access information identified by a lead investigator. The result of this is that separate protocols may be needed for these types of incident.

3.3.2 Prioritisation

It is not possible to conduct in-depth investigations (deep dives) into all reported incidents. An organisation should make best use of constrained investigative and learning resources. To achieve this, organisations adopt classification schemes designed to achieve a 'triage' type process. The classification level will often link to investigation levels (capability and number of investigators) and sometimes to the rigour of the investigation techniques employed. These levels may also determine how the incident is used subsequently in terms of broader learning.

There is no perfect one-size-fits-all system of classification. Traditionally, classification systems fit an incident into severity (actual or potential) categories. However, alternative approaches include the following:

- Take into account the probability of reoccurrence and hence use a risk-based approach (see the following examples).
- Assign investigators based on the nature and complexity of the incident, rather than its severity. Complexity may be judged against a number of parameters: organisational interfaces, type of process systems, etc.
- Determine how much additional learning could come about through a deeper investigation.
- Take account of how many barriers should have been in place and which ones have failed. This is a relatively sophisticated and potentially demanding approach.

In practice, there will be grey areas in every classification scheme, i.e. lack of clarity into which level an incident should be classified. During an investigation new information or reanalysis may lead the team to change the initial classification.

Example of a proportionate response classification scheme

Rail Safety and Standards Board (RSSB, *Investigation guidance - Part 2: Development of policy and management arrangements*) lays out a proportionate response model which is used in the rail industry and employs a three-stage filtering process:

1. Determine the credible worst outcome. Examples are provided to guide the user to ratings from negligible to high.
2. Evaluate the effectiveness of the safety barriers (again from negligible to high). Stages 1 and 2 are combined in a matrix, similar to the classification matrix in the following example, to determine an initial level of investigation (low, medium or high) or, if an incident is considered of negligible risk, whether it should be just recorded and not investigated.
3. More senior managers then consider wider factors (such as similar previous events, how to gain the maximum safety benefit for the organisation) to determine the final level of investigation.

Thus this is a risk-based, proportionate approach, but one which allows additional flexibility for taking account of broader learning opportunities.

Example of a risk-based classification scheme (EI *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation*)

A suggested matrix for classifying incidents is shown here for health and safety events. This divides incidents into three levels, incidents (I), serious incidents (SI) and very serious incidents (VSI). EI *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation* notes that this matrix should be calibrated to meet the needs of an organisation.

Similar matrices cover incidents with consequences for the environment or a company's reputation and for business interruption and financial costs.

Example Consequences

- Fatalities, major fire-explosion, gas leak
- Permanent disability, fire, minor gas leak
- Lost time injury, RIDDOR reportable
- Medical treatment injury, minor fire
- First aid treatment, limited plant damage

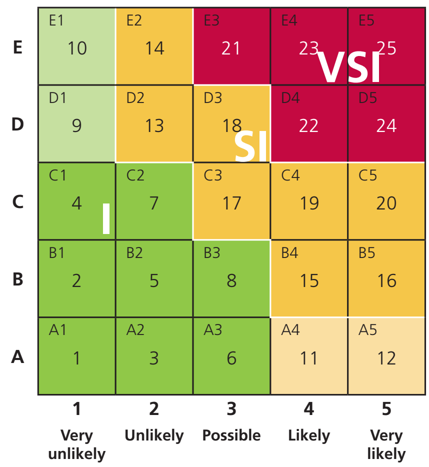

Figure 9: Risk matrix

An alternative risk-based scheme is shown in HSE HSG245 (*Investigating accidents and incidents*).

Some schemes classify only on the consequence axis of this matrix, i.e. the actual or potential severity of outcomes, not the likelihood.

While a risk-based classification scheme will generally represent a proportionate treatment of incidents, some organisations have also followed different, or complementary, approaches:

- One organisation chose to investigate every tenth reported incident regardless of the classification level. Partly this was to act as quality assurance on the prioritisation process and partly to train enough personnel in incident investigation.
- Similar to this approach, an organisation could choose to conduct deep dives on a random basis to determine if the formal prioritisation process is identifying those incidents from which significant learning can be extracted.
- Some organisations have considered classifying incidents in an alternative manner more specific to the incident type, for example classifying dropped objects by estimates of kinetic energy.

Given the uncertainty and subjectivity that will inevitably exist around classification, it is important to provide training and plenty of examples so that the classification scheme selected can be consistently followed.

3.4 DEFINING THE LEVEL OF INVESTIGATION

The classification levels developed in 3.3.2 are generally linked directly to levels of investigation. Alternative rule sets recommended by the HSE, EI and RSSB are shown in Table 2.

Applying rule sets in an overly prescriptive manner can lead to inappropriate decisions. For example, risk matrices can be difficult to apply consistently as individual incidents can be reasonably placed in several cells of a matrix. Thus, decision makers should be allowed flexibility to apply different investigation levels if they think it is warranted. This open-minded attitude should be carried over into an investigation, for example, if an incident is more complex than first thought the investigation level may change, as could the required resources and methods used to analyse it.

Table 2: Example rule sets for determining investigation levels

HSE, HSG 245	**EI, *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation***	**RSSB, *Investigation guidance - Part 2: Development of policy and management arrangements***
Minimal – the relevant supervisor will look at the event and try to learn lessons to prevent reoccurrence.	–	Negligible – supervisor records event.
Low level – short investigation by the relevant supervisor or line manager into the circumstances and causes.	Incident – investigated by local supervisor.	Line manager level.
Medium level – a more detailed investigation by the relevant supervisor or line manager, the health and safety advisor and employee representatives.	Serious incident – investigated by independent investigator.	Line manager level potentially with support.
High level – team-based investigation involving supervisor or line managers, health and safety advisors and employee representatives. It will be carried out under the supervision of senior management or directors.	Very serious incident – investigated by independent senior manager.	Experienced investigator and team of experts.

3.5 ENCOURAGING REPORTING

Encouraging and sustaining increased reporting are likely to require multiple approaches. These will include:

- demonstrating that valuable use is made of the reports;
- making the user experience positive;
- creating a trusting atmosphere, and
- targeted use of rewards.

The best demonstration that valuable use is being made of reports is when personnel can see effective changes being made to prevent the reoccurrence of incidents (as illustrated in the LFI feedback loop in Figure 3). If personnel see reports being used to help reduce risk they are likely to report more. By contrast if something has been reported several times personnel will learn to live with it and that becomes an accepted norm.

The importance of making incident reporting a positive experience has been emphasised already in Figure 4. The initial reaction of the supervisor is crucial: it should be 'thank you', but often it is not. The organisation should strive to create the type of environment that encourages such reaction. However the event is reported (e.g. verbally or online), an organisation should provide timely feedback and keep the reporter updated on progress and when something changes. If practical, an organisation should involve the person reporting the incident in developing the solution, on the basis that they will be more likely to implement it and report again in the future.

Another important factor in determining whether reporting will be fit for purpose to drive LFI will be whether the majority of employees perceive there to be a fair process in place.

Example of incentivising reporting

Within a train operating company (Basacik and Gibson, in press) no action was taken if a driver released the doors on the wrong side at a station if they reported it. Action was only taken if this happened and it was not reported but was subsequently discovered. This effectively incentivises reporting and dis-incentivises non-reporting. In the case of non-reporting, an organisation should try and discover the reason; it may have a systematic cause that needs to be addressed.

The use of financial rewards or prizes should be carefully considered within an overall package of measures to encourage reporting. They can drive inappropriate behaviours but if used carefully they can be an effective incentive, as demonstrated in 3.6.2.

3.6 CASE STUDIES

3.6.1 Chiltern Railways' 'Close Call' campaign. How to build a strong reporting culture

3.6.1.1 Understand the blockers to reporting

The Health, Safety, Quality and Environment Executive in Chiltern Railways used informal discussions with frontline staff (e.g. chatting in the mess room) to promote openness with reporting, make the staff aware that Chiltern Railways had a genuine concern for the safety of its employees, and to find out why frontline staff did not always report near misses. Three main issues were discovered. Staff felt there was:

– Too much paperwork. Completing the correct forms was time-consuming and sometimes impractical for operational roles that are not based at computers.
– Peer pressure not to report, and some feared being seen to 'shop their friends' (get their friends into trouble).
– Some confusion or misunderstanding about what constitutes a 'near miss'. Additionally, there was a lack of understanding about why it is important to report a near miss when 'nothing actually happened'.

3.6.1.2 Implement change

The Close Call campaign was launched across Chiltern Railways in September 2013. The campaign’s aim was to improve near miss reporting across the company. The campaign was underpinned by several tactics to improve near miss reporting:

– 'Near misses' were rebranded as 'close calls'. There was some misunderstanding about what constituted a near miss so it was reconceptualised as a close call. A close call is defined as an event that had the *potential* to cause injury, loss or damage. Under different circumstances this event could have ended with more serious consequences.
– The reporting process was made easier, more straightforward and less time-consuming for the staff. Staff are no longer required to fill in forms to report a close call and a special confidential telephone service was set up for the staff to use.
– Timely feedback was given to staff. Using the intranet, a log was made accessible to all staff so that they could see the reported close calls and follow-up actions.
– All staff were informed about the messages of the campaign. Line managers received various training materials and safety briefing procedures. Mugs and flasks with examples of close calls were given to all staff (Figure 10).
– It was made clear to all staff that the safety department would listen to reports from staff at every level and that their input was vital for the success of the campaign.
– Reporting was made into a positive experience for the reporter.
– The company began to actively reward and praise its staff for reporting close calls.

Figure 10: Close call mug

Close call reporting was emphasised to be a way of protecting colleagues from future harm and injury. This message was communicated through casual discussions, and staff began to think 'I’m looking after my guys – I’m reporting this', rather than fearing they were getting colleagues, or themselves, into trouble.

3.6.1.3 Result

Over the five months during the build-up and the launch of the campaign, near miss reporting increased by a factor of 17. When the campaign was officially launched in September 2013 there was a further increase in near miss reporting and Chiltern Railways are now averaging approximately 70 near miss reports per month, compared to 13 near misses reported in the previous 12 months (a near 70x increase).

To sustain the frequency of close call reporting and maintain a healthy reporting culture, the campaign will be relaunched annually to remind staff about the benefits of close call reporting. These campaign relaunches will provide a good opportunity for managers to give feedback to all staff about how their close call reporting has helped to reduce risk across the company in the past year. This feedback should include statistics that show how effective close call reporting has been at improving company-wide safety, and personal examples of close call resolutions.

3.6.2 Q8Oils near misses promotional campaign 2013/2014

3.6.2.1 Overview of campaign

The goal of the campaign was to increase awareness of the importance of near miss reporting and increase reporting through use of targeted communications, coaching and rewards.

Communications included: the production of posters in different languages located widely outdoors and indoors, including non-HQ offices and operative sites (e.g. sales offices); near miss report forms made available in hard copy in dispensers; and a campaign video played on both local Q8Oils televisions/screens and on the intranet.

Safety, health and environment (SHE) focal points met with different teams to provide appropriate coaching concerning the campaign and the processes for near miss reporting.

3.6.2.2 Use of rewards

Prizes were allocated, not based on frequency of reports but on the basis of which reports had led to the biggest safety or business improvement for the organisation. This evaluation was made by SHE and management team representatives.

3.6.2.3 Result

Following this campaign near miss reporting increased globally by 32 % compared to the previous year.

3.7 BLOCKERS AND POTENTIAL ENABLERS FOR REPORTING OF INCIDENTS

Table 3 summarises what are judged to be the most significant blockers to effective reporting, along with potential enablers.

Table 3: Blockers to effective reporting and potential enablers

Blockers to effective reporting	Enablers for reporting
Fear of being blamed or professionally embarrassed; peer group pressure	– Long-term engagement and commitment to a fair reporting system (see 2.6). – Making the user experience a positive one. In an ideal world the initial reaction of the supervisor to a report should be 'thank you' but often it is not. – If culture is immature, consider confidential reporting.
Belief that nothing will be done in response to report	– However the event is reported (e.g. verbally or online), provide timely feedback and keep the reporter updated on progress and when something changes. – If practical, try and involve reporters in developing the solution, on the basis that they will be more likely to implement it and report again in the future. – Provide feedback at end of LFI process to demonstrate that reports lead to effective changes.
Concern from contractors that their contract may be jeopardised	– Ensure contractors are protected from contractual penalties for reporting and are encouraged to participate in LFI processes (see 7.3.1).
Not understanding what should be reported (lack of awareness about what is important)	– Develop a list of examples that illustrate high-learning-value incidents, particularly near misses. – Train personnel on the examples. – Use safety meetings to capture and communicate near misses that were not previously identified. – Try and develop common understanding of important incident barriers and important safety performance indicators. – Avoid tendency to focus efforts on high frequency personal risks at the cost of low frequency major hazards.

Table 3: Blockers to effective reporting and potential enablers (continued)

Blockers to effective reporting	Enablers for reporting
How to classify and prioritise reported incidents. Are the selected ones those with the most potential for learning?	– Ensure there is an effective risk-based approach to prioritise incidents that also takes account of learning potential. – All classification schemes (whether based on actual severity of outcome, potential severity, risk of reoccurrence, learning potential, etc.) have strengths and weaknesses. Do not become too constrained by definitions and boundaries (e.g. concerning near miss, incident, accident, dangerous occurrence etc.). – Random deep dives can act as a quality control check on the classification scheme. They can also be used to train up investigators and test the overall LFI process.
Apathy – not understanding the value of reporting, instead seeing reporting and investigations as taking unnecessary time and effort which should be avoided	– Ensure that the reporting process is straightforward and that extra follow-up workload is not allocated to those reporting. – Make the case for reporting, i.e. it is about 'looking after colleagues'. – Provide incentives for reporting, e.g. prizes for reports that lead to the largest safety/ business improvements. – Provide disincentives for non-reporting, e.g. no disciplinary action is taken if an event is reported, but action is taken if an event is not reported but subsequently discovered.
Complex reporting systems	– Make sure the reporting system does not require too much from the reporter. – Avoid multiple systems that confuse the reporter and that require repeated data entry. – Review the system from user's perspective – is reporting a positive experience?

4 INVESTIGATION: FACT FINDING

4.1 OVERVIEW

The main steps of incident investigation are shown in Figure 11. The first step is to gather facts concerning the incident. This step is also known as information or evidence gathering. The next steps are to analyse the gathered information and determine what has happened and why. This involves making hypotheses which are either discarded when information comes to light which contradicts the hypotheses or retained for further consideration. Although fact finding, analysis and validation of hypotheses are shown as discrete activities, in practice they are part of an iterative, overlapping process and they could be combined. Finally, the investigation should be clearly reported to feed effectively into the subsequent stages of LFI.

For clarity, this section discusses planning and initiation of the investigation phase, and fact finding. The steps of analysis through to reporting are covered in section 5. The overall investigation process as set out in Figure 11 applies to investigations at all levels (as covered in section 3); however, some of the specific details would not be required for a simple investigation.

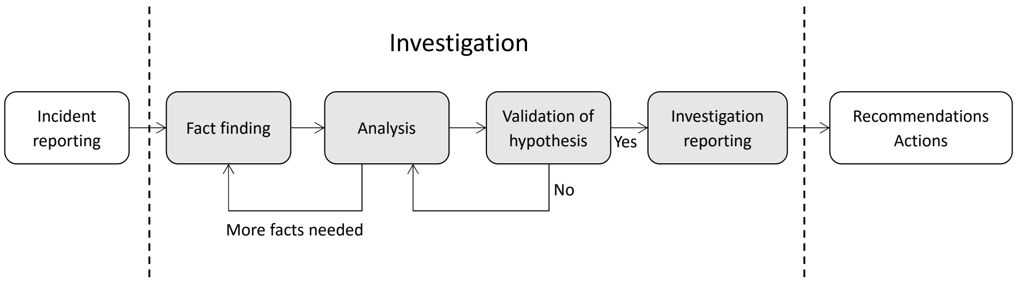

Figure 11: Investigation

The topics in sections 4 and 5 are well covered in the following references, among others:

- HSE HSG 245, *Investigating accidents and incidents*
- RSSB *Investigation guidance - Part 2: Development of policy and management arrangements*
- RSSB *Investigation guidance - Part 3: Practical support for accident investigators*
- CCPS *Guidelines for investigating chemical process incidents*
- EI, *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation*

Hence these sections make use of cross references where appropriate.

4.2 INVESTIGATION INITIATION

Establishing a terms of reference (TOR), also termed remit, helps to define the scope and depth of the investigation. Investigator involvement in the development of the TOR can be beneficial. Typical TOR require the investigation to cover the following (RSSB, *Investigation guidance - Part 2: Development of policy and management arrangements):*

- level of investigation;
- determination of events leading up to the incident;
- immediate and underlying causes;
- documentation of analysis;
- recommended system improvements;
- reporting of urgent safety problems requiring early remedial action;
- completion timescale, and
- a well-structured and accessible report covering these.

Developing templates for TORs should ensure consistent application of good practices. Clear TORs are particularly important for small organisations which need external investigation resources (e.g. stating whether assistance is required with close-out of actions). The typical TOR requirements cited should be extended to cover LFI, for example, considering what went right (successes) as well as what went wrong, converting the report into incident summaries for safety meetings or developing training scenarios based on the event.

At this stage the affected organisation should establish an incident owner with the accountability to ensure that it is investigated according to the TOR.

4.3 INVESTIGATION RESOURCES AND COMPETENCES

The organisation should ensure that appropriate training is provided to develop the competence of the nominated investigators. The training should address all aspects of incident investigation and issues of leadership and team skills. An organisation can make use of CCPS, *Guidelines for investigating chemical process incidents* to help it define the investigation, leadership and team skills that investigators will require.

For more complex investigations, an organisation should ensure that sufficient numbers of suitable personnel are identified and nominated to take on the role of incident investigators. Persons chosen to be investigators should have sufficient experience of the operation, good analytical skills and interpersonal skills, and have an inquisitive nature. A register of available trained investigators, who can be called upon to carry out independent investigation of serious and very serious incidents should be maintained. It may be advantageous to establish a rota whereby specified individuals are the nominated- or duty- investigator for a defined period; this can be a practical solution to resource constraints, although it should be ensured that investigation skills are sufficiently practised to maintain competence.

Other investigations may be carried out by the local supervisor/line manager or their delegates. Consider independent investigation leads if the actions of the supervisor or line manager may have been contributory factors.

A common learning constraint identified in section 1 is lack of depth with respect to HOF analysis. All investigation teams should have at least a basic level of competence in HOF. This should be sufficient to recognise where additional help is required on human factors issues. This is difficult on the basis that 'you don't know what you don't know', but this publication should help investigation teams to determine if they have sufficient knowledge of human factors to make this decision. RSSB, *Investigation guidance – Part 2: Development of policy and management arrangements* provides an illustrative HOF syllabus.

As well as training courses other means of ensuring investigators' competence include:
- investigating enough events (including near misses) to ensure skills are maintained;
- including them in independent reviews of other incident investigations;

- involvement in table top exercises and assessing them during these exercises;
- providing refresher training to suit the levels of investigation;
- competence testing, and
- obtaining qualifications linked to incident investigation courses.

Normally a lead investigator chosen for more serious or more complex incident investigations will be independent from the operation or facility where the incident occurred. Appointment of supporting staff will be dependent on the nature of the event and company resources. The selected lead investigator may require support, especially if they are a line manager with limited experience in investigations and they are under pressure of time. Technical expertise may also be required from inside or outside the organisation, for example, fire/explosion experts or materials experts.

Whether an organisation consistently allocates sufficient resources for investigation is a significant indicator of its priorities. Releasing investigators sufficiently from their day-job responsibilities involves a cost, but one that should be recouped in the long term from reduced losses due to reoccurring events.

Some organisations may have minimum requirements for the size of an investigation team based on the incident classification, e.g. a fatal event will be investigated by a team of four, a lost time injury (LTI) by a team of typically two, a reportable injury by a local manager and a first aid injury by a local supervisor. It should be noted, however, that as an investigation proceeds, new lines of enquiry or increasing complexity may require the investigation team to grow in size, or to seek input from specialists.

Example – RSSB's Human factors training modules for investigators (RSSB, *Investigation guidance – Part 2: Development of policy and management arrangements*)

The RSSB's human factors awareness course has been developed for incident investigators and those with an incident investigation role. The course is run over two days and focuses on the analysis of incidents and accidents from a human factors perspective. It clarifies the process of identifying underlying causes using practical examples and case studies from a range of safety critical industries. It provides an introduction to human factors analysis techniques and the application of these to the incident investigation process.

The course content covers:

Section 1: Introduction to human factors.

Section 2: Understanding human performance (observe; understand; decide; act).

Section 3: Human error and violations (types of error; types of violation).

Section 4: The individual (distraction; fatigue; physical and mental well-being; work-related attitudes; experience).

Section 5: The job and workplace (equipment; workload; communication and teamwork; practices, process and information; work environment).

Section 6: The organisation (culture; supervision and management; knowledge and skills; change).

Section 7: Putting it into practice (investigative techniques; developing recommendations).

In the case of a very simple incident, the basic investigation steps remain the same but they are generally scaled back.

For anything other than a very low-level incident, a person will find it a challenge to conduct an investigation alone. An individual does not have the benefit of developing hypotheses through brainstorming possible chains of events or causes. A single person should also guard against individual biases. For example, an individual's specialism could cause them to focus on certain lines of enquiry. Alternatively, recent investigations may skew an investigator's approach. In some cases a single-person-investigation may be necessary but the investigator should be aware of potential problems, and it should be ensured that there is adequate peer review of the investigation report.

As noted in this section, sometimes outside assistance from third parties will be required to provide resources, experience and an independent view. This is often the case for smaller companies, serious or complex incidents, or when stakeholder management is critical. Having clear TORs may assist in obtaining the right resources.

4.4 PLANNING

It is difficult to provide definitive guidance concerning planning and scheduling, because incidents vary so much in terms of scale and complexity. Some simple low complexity/low severity events may need little formal planning and may require only a few hours to complete. Major incident investigations on the other hand can extend for weeks and months.

Assuming an event is not of very low complexity/low severity, a planning checklist can be helpful, such as the one adapted from CCPS, *Guidelines for investigating chemical process incidents*:

- defining priorities and the scope of the investigation;
- identifying support and supplies;
- developing information-handling procedures;
- establishing communication channels both within the company and with outside groups;
- establishing interfaces, e.g. with other parties and other investigations (contractors, legal, insurance, etc.), precedence and authority in multi-party investigations;
- plan for conducting witness interviews;
- plan for documentation, and
- summarising findings and recommendations in a report.

In some cases the investigation methodology itself will have such checklists built in (see section 5) which assist in the planning process.

In the case of an investigation team, as opposed to a single investigator, an organisation should clearly establish who has responsibility for which activities in the plan. It should make sure that tasks are allocated appropriately, i.e. matching tasks to the skills and strengths of the team members.

Research among a range of companies (Drupsteen and Hasle, 2014) indicated that one cause of dissatisfaction with investigations is a perception that they can be rushed to fit artificial deadlines, rather than establishing the full causal picture and, hence, appropriate recommendations. Thus, investigation schedules should be realistic and allow for all the steps in Figure 11 to be carried out thoroughly and to a high quality.

An orientation visit can be useful to firm up the plan and establish the physical boundaries of the investigation. A site visit at some stage in the investigation is critical for understanding[3].

It is also important to establish an investigation room for serious incidents. There will be lots of information to handle, collate, process and visualise on charts, so sufficient space is needed.

For further information on planning and team resourcing it is recommended to consult CCPS guidance (*Guidelines for investigating chemical process incidents*), chapters 2 and 7.

4.5 INFORMATION[4] GATHERING

During the information gathering the investigator is looking to establish in broad terms (HSE, *Investigating accidents and incidents*):

- what happened;
- who or what was affected and to what extent;
- what were the conditions like;
- what was the chain of events (what happened just before the event and just before that);
- what was going on at the time, and
- was there anything unusual/different in the working conditions etc.?

Good practice guidelines for information gathering and preservation are set out in HSE, *Investigating accidents and incidents*, CCPS, *Guidelines for investigating chemical process incidents* and RSSB *Investigation guidance Part 3: Practical support for accident investigators* e.g. how to make effective use of photography and video.

There is also merit in identifying whether there have been previous incidents at the site, and if so, obtaining the associated investigation report to provide useful insights.

The CCPS guidelines identify five types of information:

1. **People:** examples include discussions with, or written statements from, witnesses, participants, or victims.
2. **Physical:** examples include mechanical parts, equipment, stains, chemicals, raw materials, finished products, results of analysis of parts, and chemical samples.
3. **Electronic:** all electronic format data are included in this category. Examples include operating data recorded by a control system (both current and historical), controller set points, and email. Email may provide a record of what and how people were thinking when decisions relating to the incident were made. This can be an important and powerful source of information.
4. **Position:** this is the depiction of locations of people and physical data such as valve positions, tank levels, and explosion fragments and debris. Position data are related to both people data and physical data.
5. **Paper:** examples include operating logs, policies, procedures, alarm logs, test records, and training records.

The different types of information have strengths and limitations with respect to the investigation aims. Some examples of these are shown in Table 4. By combining the five

[3] An organisation may not always have the control to ensure a site visit, e.g. where regulatory investigations take precedence.

[4] ‘Information’ has been used rather than the commonly used alternative ‘evidence’. Evidence can be regarded by some people as linking to finding blame or establishing a basis for prosecution.

different sources, the limitations in any one source can be effectively compensated for (see CCPS, *Guidelines for investigating chemical process incidents* for a fuller list of strengths and limitations).

Table 4: Example strengths and limitations of information sources

Information source	Example strength	Example limitation
People	Good at noticing the unusual	Imperfect recollection
Physical	Equipment likely to have records that describe its original condition	May be severely damaged in the event
Electronic	In a modern system there might be a huge amount of electronic data available	Can only record what it was designed to do
Position	Can allow reconstructions and simulations	Positions might be moved as part of rescue and recovery
Paper	Paper relating to events a long time prior to the incident might be valuable	Records may be incomplete

The five sources also have different characteristics in terms of fragility (e.g. people forgetting) and likelihood of degrading with time. The investigator should identify time-sensitive data as a priority (e.g. software data, metallurgical items prone to oxidation) and take steps to collect or preserve this information (e.g. taking photographs, conducting interviews in a timely manner).

In terms of the control of collected information:
– information should be logged and catalogued carefully and systematically;
– a simple spreadsheet to record details can be useful, and
– information reference numbers can be used on storyboards to provide an audit trail and highlight where there are information gaps.

For serious incidents it may be necessary to establish formal chains of custody (i.e. who has been in charge and what protective measures taken) to show that information has been preserved.

For further information on gathering information it is recommended to consult the CCPS guidance, *Guidelines for investigating chemical process incidents,* chapter 8. For special requirements for testing failed equipment cross-refer to CCPS, chapter 8.4 including physical tests.

4.6 INTERVIEWING

When drawing up a list of bystanders/witnesses and those to be interviewed, investigators should look more widely than the immediate participants in the incident and determine, for example, how other shifts conduct the task of interest and whether they have experienced problems.

Good practice guidance concerning setting the right tone for the interview, types of questions to ask, and style of questioning are covered extensively in CCPS, *Guidelines for investigating chemical process incidents* and RSSB, *Investigation guidance Part 3 Practical support for accident investigators*.

The following points should be noted:

- A witness's memory may degrade over time, so interviews should be conducted in a timely fashion.
- Accurate records of interviews should be kept, although verbatim accounts may not be necessary. Such records will help to avoid the influence of memory loss and contamination through conversations with others. Recordings can be used but this can lead to witnesses becoming unwilling to share, and are time-consuming to transcribe.
- By introducing the interview as an opportunity to prevent reoccurrence this is a motivation to personnel to prevent others suffering injuries or loss.
- Discourage asking 'why did you do it?' – the motivation is not that helpful. People often may not know why they did a certain action. Ask more neutral questions such as 'take me through what happened'.
- Conducting an interview while walking around the location can be more productive than 'behind closed doors'.
- There are easy to use structured interview techniques (cognitive interviewing) that help witnesses to recall information accurately.
- With traumatic incidents witnesses may find it difficult to give their account. It is important to be supportive and refer them to further help if they want it.
- Be careful in the use of language, repeatedly stress it is about 'learning'.
- Naming interviewees: consider whether you need to name anyone when you are investigating. It will help with disclosure if no-one is named in reports and some legislation specifically prohibits the use of witnesses names.
- Be mindful of things unsaid. Personal problems and impending redundancy have been given as examples which were not mentioned in initial interviews but which emerged subsequently as causal factors. Give space for such things to emerge in the interview and provide contact details so that interviewees can come back afterwards with this type of follow-up information.

While it is common to interview personnel singly to try and develop a clear picture of what has happened, consideration should also be given to using group-based interviews at some stage in the investigation. This approach can be useful in helping to develop recommendations to deal with identified causal factors and in promoting learning from the event at an earlier stage than traditionally occurs.

4.7 EARLY LEARNING

As some investigations can become quite lengthy, it is good practice to look for opportunities for early learning within an organisation. An extreme example of early learning was during the emergency at the Fukushima Daiichi nuclear reactors following the devastating tsunami of 2011. Operators in one control room controlling two of the nuclear reactors were learning lessons in real time based on events in another control room responsible for two of the other units on the site which had suffered a hydrogen explosion. Three teams from each of the control centres were located in the same emergency response room. Such early learning was very dependent on the relatively long duration of the incident and the co-location of multiple control centres. However, it flags up the potential for early learning which other organisations could be looking to exploit.

4.7.1 Urgent actions

During the initial part of the investigation it may become apparent that actions need to be taken before detailed causes are known. If an identical or a similar system is being operated at another site, for example, a safety alert (flash alert) may need to be issued. Even if longer-term measures are planned, an organisation should consider informing other parts of its business of the basic facts to allow them to assess and mitigate in the short term.

An organisation should also be able to respond to such safety alerts coming from other sites or other organisations. This is discussed further under external methods for communicating lessons in section 7.

Generationsafe
A new approach to safety

Lifting Rope failed lowering empty kit bag
HSEQ RED Alert Part 1

Details
A hook recently became detached from a rope hauling kit whilst an empty lifting bag was being lowered from the yaw section of a LINCS O&M turbine.

The decision has been made to recall all current hauling kits shore and quarantine for further inspection and replacement (if required).

Key learning point
The hook can become loose when under a NO LOAD condition, allowing the central core of the rope to slide free of the outer plastic sheath. Over time, this allows the hook to become detached.

Good order **Beginning to fail** **Complete failure**

Summary: The supplier of the lifting equipment and manufacturer of the rope are being consulted to agree the best way forward to resolve this issue as soon as possible.

For more information please contact:
Part two will be issued to share findings once the investigation is complete.

centrica energy

Figure 12: Example flash report/incident alert

4.7.2 Communication of initial findings

In some investigations there can be a need or an opportunity for issuing interim reports with initial findings. With reference to Figure 2, potential solutions for fixing the barriers may be proposed in such interim reports. Potentially this could provide an opportunity for early learning. Identifying and fixing the underlying causes might take further analysis and involve longer-term learning.

In some cases, issuing alerts with basic facts can allow people to make their own assessment as to the relevance of the findings to their situation.

The aviation industry is generally good at issuing timely interim reports and bulletins that enable the industry to begin risk reduction in advance of the final report.

Example illustrating early communications from Air Accident Investigation Branch (AAIB) special bulletins

AAIB special bulletin S1/2014 on the crash of an AS332 L2 Super Puma on 23 August 2013 into the North Sea was published on 23 January 2014 prior to a final investigation report. It contained a safety action concerning the emergency breathing systems (EBS), namely:

Safety action

The AAIB has approached the main helicopter operators flying in support of the UK oil and gas industry, whose passengers are equipped with a hybrid EBS. Whilst operation of the hybrid EBS should be covered in initial and recurrent training, it is not explicitly described in the pre-flight safety briefing.

The operators have undertaken to amend their pre-flight briefing material to include information that the hybrid system contains its own air supply which is discharged automatically, making the system usable even if the wearer has not taken a breath before becoming submerged.

http://www.aaib.gov.uk/cms_resources.cfm?file=/S1-2014%20G-WNSB.pdf

4.7.3 Returning to production/service

Another form of early learning concerns the decision to return to production or service. Although the actual decision to restart depends on equipment availability, repairs being completed, and line management, the investigation team may also have identified requirements or criteria that need to be met before resuming operations. These requirements may be informed by the information gathering and initial analysis. For example, early identification of the immediate causes of barrier failure may enable restart with certain short-term operational constraints or limitations.

4.7.4 Including frontline staff in investigations

HSG245 notes that accident rates in organisations that include front-line staff in investigations are about half that of those that do not. As well as helping to incorporate front-line expertise into the investigation, this approach is another route for spreading early learning out into the wider organisation.

5 INVESTIGATION: ANALYSIS

5.1 OVERVIEW

In this section the remaining steps from Figure 11 are covered, i.e. analysis, hypothesis validation and investigation reporting. Different approaches to investigation analysis are described but they all have the common goal to understand causal factors in sufficient breadth and depth that effective recommendations for change can be identified.

Investigation analysis techniques can help to structure known facts and findings and identify unknown information that will require further collection and analysis. This can help to increase transparency and make it clear how investigation results were obtained. However, ultimately analysis techniques are 'servants' and not the 'masters'; the skill and experience of the analyst is more important than the technique selected.

In a recent literature review of papers relating to identifying incident causes (Drupsteen and Guldenmund, 2014) it was shown that underlying causes, including organisational and managerial factors, are often not addressed in investigations. This is a critical weakness in the LFI process making effective learning much more difficult.

Guidance is provided in this section on broad approaches to analysing what happened and why (5.2). By combining techniques into an overall framework and applying the good practice set out in this publication the aim is to generate outputs that:

- are systematic and defensible;
- are consistent across different investigations;
- are understandable and engaging;
- have clear timelines/sequences of what happened;
- present multiple causes logically and identify immediate and underlying causes, including HOF causes, and
- are traceable and auditable.

In this way an organisation maximises the chances of developing a good understanding of an incident and what can be learnt for the future.

The broad approaches presented in 5.2 can be supported by specialist techniques (e.g. HOF incident and analysis tools, as well as technical methods such as metallurgical analysis) to form an effective toolkit to address the range of incidents that may be encountered.

This section also addresses the validation of hypotheses (5.2.2.6) and the reporting of the investigation (5.3). A case study is presented in 5.4 to illustrate typical investigation processes. Blockers and enablers relevant to all steps in investigation are summarised in 5.5.

5.2 APPROACHES TO INCIDENT CAUSAL ANALYSIS

5.2.1 What happened

In determining what happened the use of a storyboard-based technique (e.g. sequentially timed events plotting (STEP)) is commonly used to build up the sequence of events and a timeline (see). Such techniques help provide a visual picture of what happened and act as a point of focus for an investigator or an investigation team. Sticky notes can be created as information is gathered (e.g. following an interview) and used to fill in the storyboard. This will also help show the areas where information is currently missing.

CCPS (*Guidelines for investigating chemical process incidents*), BSI (*Root cause analysis*) and EI (*Guidance on investigating and analysing human and organisational factors aspects of incidents and accidents* first edition (superseded), Annexes A and B, available as a web link) provide descriptions of storyboard and sequencing techniques.

5.2.2 Why it happened

There are a very large number of analysis techniques that are used to help determine why an incident occurred. EI (*Guidance on investigating and analysing human and organisational factors aspects of incidents and accidents* first edition (superseded), Annexes A and B, available as a web link) provides an initial introduction to many of these. A survey by IOGP (Walker et al, 2012) indicated a number of techniques which are most commonly used by some energy companies, including TapRoot, Tripod Beta, Topset, SCAT, Apollo and others.

Many companies use multiple techniques either for different levels of incident consequence or different incident types (CCPS, *Guidelines for investigating chemical process incidents* and Walker et al, 2012). It should be noted that not all techniques are comparable in scope, i.e. some are more focused on the investigation (the information gathering) and others on the analysis (the causes), and techniques can therefore be complementary. Combining techniques into a framework or toolkit has advantages in terms of ensuring appropriate investigation for the full range of incidents.

Each of the broad approaches described in this section provides a structure for analysis of collected facts and helps identify where there are gaps in the collected information. All of them can be used to analyse HOF. Whether the use of a technique during a specific investigation achieves the desired goals is often a function of the skill of the analyst.

Whilst it is possible to group the various types of techniques in a number of ways, the categorisation following is based on CCPS, *Guidelines for investigating chemical process incidents*, EI *Guidance on investigating and analysing human and organisational factors aspects of incidents and accidents* first edition (superseded, Annexes A and B available as a web link) and the EI stakeholder workshops, and can help the reader understand the distinguishing features of different techniques.

5.2.2.1 Logic-based trees/charts

A number of techniques build logic trees or charts to identify causes of an incident. Typically the final incident is shown as an event at the top or on one side of the page and a tree of causes is constructed (deduced) based on collected information and logic. The tree is based on a 'why-because' process of questioning, and helps to define relationships between causes and effects. Often there are logic gates that set rules on how different causes interact (AND gates and OR gates). This process can effectively show progressive layers of causes similar to the diagram shown in Figure 2. Figure 14 and Figure 15 show an example chart and tree. It should be noted that while fault tree analysis was not designed for incident analysis it is commonly used in investigations.

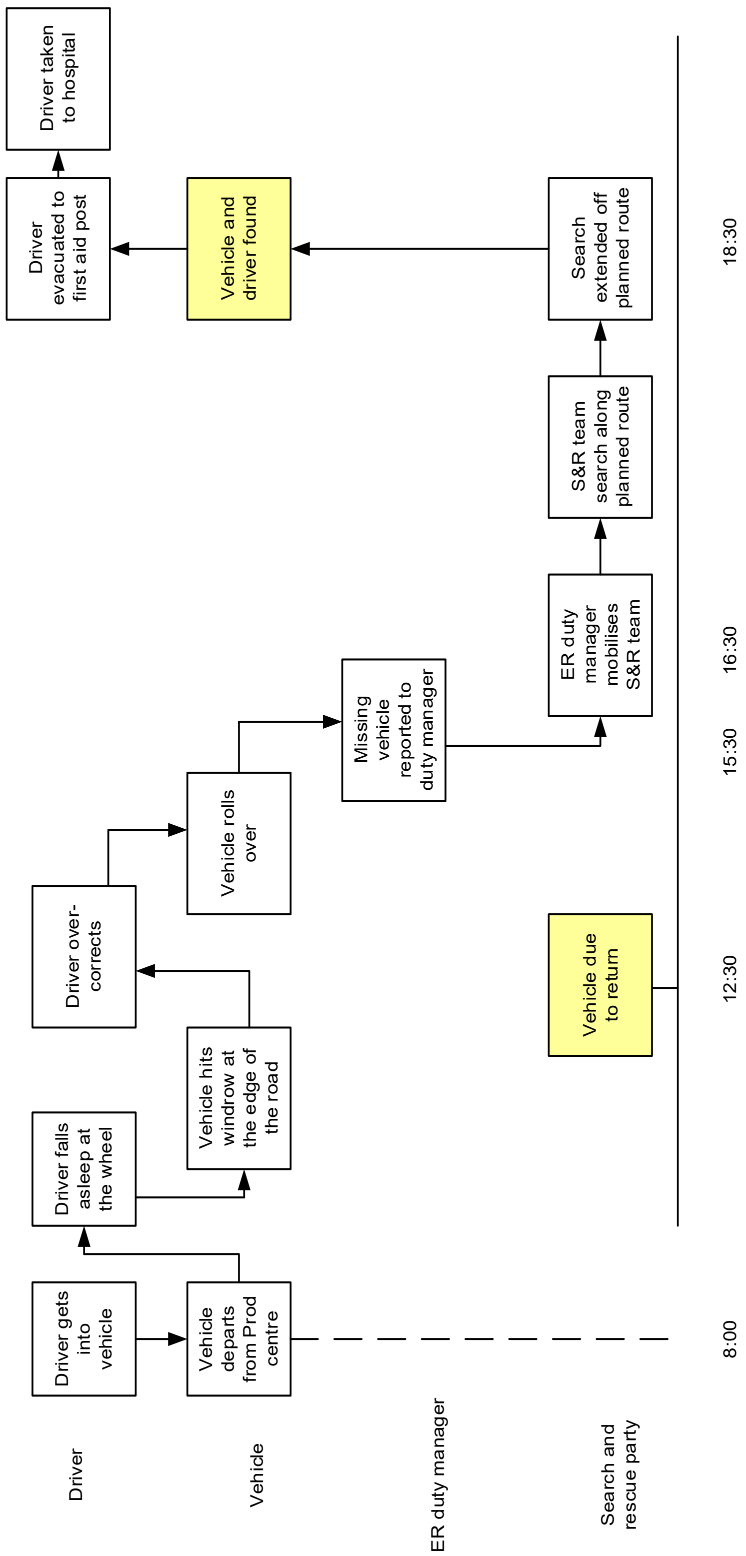

Figure 13: Illustrative timeline and storyboard *(Guidance on using Tripod Beta in the investigation and analysis of incidents, accidents and business losses)*

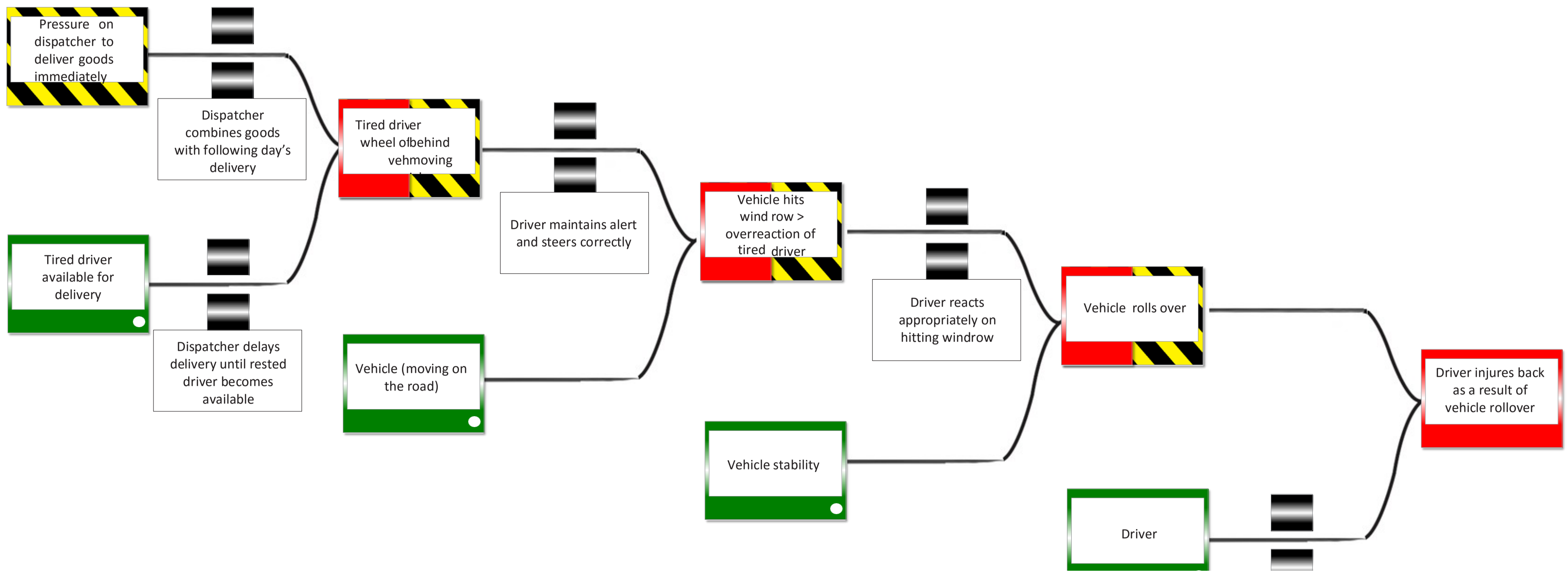

Figure 14: Example Tripod Beta 'core diagram' (logic tree plus barriers, but causation paths removed for clarity)

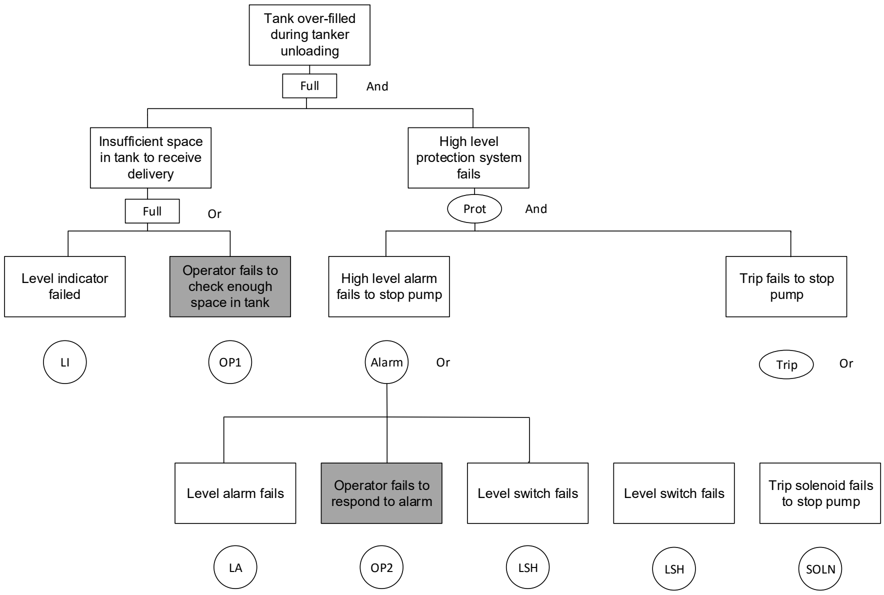

Figure 15: Fault tree of tank over-filling

Trees and charts can allow an analyst to work through to the underlying causes of an incident. They are often combined with checklists (see in this section) to prompt the analyst to consider a suitably comprehensive range of possible causal factors. When combined with timelines and storyboards they provide visual representations that aid creative analysis and aid communications internally within the team and with external parties. A more detailed list of the main strengths and limitations of tree- or chart-based techniques is given in Table 5.

Table 5: Strengths and limitations of logic tree-based techniques

Typical strengths
– Flexibility: trees can generally be split into segments allowing detailed analysis of the most interesting parts specific to that incident. – Visual representation can be helpful in promoting group involvement and communicating to others. – Trees clearly show the multi-causal nature of significant incidents and may help the team understand how these causes have interacted. – The process of developing the trees encourages the exploration of deeper levels of causal factors. – Trees can show multiple hypotheses and help investigation teams see other ways that an incident could have occurred. This could be especially important for subsequent learning, helping to prevent occurrence of similar events as well as reoccurrence of the identical event. – The reasoning behind such trees should be checkable using formal logic.

Table 5: Strengths and limitations of logic tree-based techniques (continued)

Potential limitations
– Barriers, immediate causes, PIFs, or underlying causes may not be specifically identified, making targeting actions difficult. – Generally most effective in the hands of trained and experienced users. – Because of their rigour, may be reserved for the more serious incidents. – Some specialist training may be required, e.g. on rule sets to be applied. – These techniques are expansive and they can result in finding a lot of potential causes because there is no direct linkage to control failure. This in turn can result in many recommendations, not all of which are significant in terms of causation. – Because they do not depend on a checklist, may be more difficult to categorise and trend findings across multiple incidents.

5.2.2.2 Barrier-based techniques

Many organisations use barrier-based analysis techniques to represent the various safeguards protecting against serious incidents. As noted in 2.2, barrier models are well matched to MAH industries which rely on defence in depth (see Figure 2).

Barriers can be physical (e.g. over-pressurisation protection), actions (e.g. valve closure) and procedures/systems of work (e.g. permit to work). The rules for what can constitute a barrier vary between organisations; rules should be harmonised and applied consistently within an organisation. During investigation, available risk assessments within safety cases and safety reports can be used to identify what barriers should have been in place. Once these have been identified the analyst determines whether the barriers were effective, failed, were inadequate or missing entirely (and can even identify new barriers, making the analysis a business improvement opportunity). Thus, successes will be highlighted as well as failures.

Having categorised barriers in this manner, the causes of failures or inadequacies will be sought. Checklists can complement the barrier approach in determining causes.

As with logic-based trees, barrier models provide a useful visual aid to analysts and can be readily linked to wider control of risk through the management of barriers. Table 6 summarises more details of their main strengths and limitations.

Table 6: Strengths and limitations of barrier-based techniques

Typical strengths
– Engaging visual representation. – Barrier diagrams show the multi-causal nature of significant incidents. – Can help establish the breadth of the incident before the team go too deep with any single component. – Help identify what went right (successes) as well as what went wrong (failures). – Links each underlying cause to a barrier failure rather than a general link to the incident. – Generally, the organisation will have used barrier thinking in their risk assessments; hence there should be material in safety cases/reports which can be readily applied in the investigation. – Barriers can be combined with logic trees (e.g. a tree can be applied to one or multiple barriers) and checklists. – Barrier analysis can help identify corrective actions that may be relatively quick to implement.
Potential limitations
– Such techniques require training and if an organisation is not familiar with barrier-based approaches to risk, e.g. bow tie analysis, this is a large step in thinking. – Different analysts could construct different sets of barriers for the same system/incident; because they do not depend on a checklist, may be more difficult to categorise and trend findings. – Because of their rigour, may be reserved for the more serious incidents.

5.2.2.3 Checklist-based techniques

A large number of organisations use checklists or structured prompts in some form within incident investigations. This category includes the use of pre-defined trees. Checklists are generally based on extensive collective experience, e.g. drawn up by groups of experienced personnel or based on analyses of incident databases. As such they will represent events that are beyond what a single analyst is likely to encounter even in a whole career and hence can be a valuable resource.

An example of a checklist is the table of potential PIFs from *HSE Core Topic 3: Identifying human failures*, reproduced in Annex C. This checklist helps an analyst consider what factors relating to the job (signage, task, working environment, etc.), person (fatigue, competence workload, etc.) and organisation (communications, manning, culture, etc.) could have influenced the chain of events identified in 5.2.1.

Table 7 summarises the main strengths and limitations of checklists.

Table 7: Strengths and limitations of checklist-based techniques

Typical strengths
– Can transfer good practice and learning from previous incident investigations. Some checklists are based on many years of incident experience across MAH industries. – Can provide helpful support to a team, which can be particularly valuable for less experienced analysts (provides ready-made questions/ prompts). – Aids consistency within investigations and this, in turn, allows for better trend analysis (e.g. frequency of incidents involving defined factors). – Incident investigation checklists can help planning, acting as an *aide-mémoire*, ensuring that relevant items are considered. – Checklists can be broken down into convenient categories, e.g. technical, hardware/ software, procedural, HOF, etc. which can help check for completeness and are useful for communications with others. – Typically easier and faster to use than logic trees or barrier-based techniques. – Checklists can readily be combined with other tools (e.g. HOF checklists supporting logic trees or barrier-based models) and can be used to facilitate group-based sessions.
Potential limitations
– Comprehensiveness of checklists can vary greatly. – They can have a constraining effect and prevent wider (lateral) thinking. – They may cause an investigator to lead a witness down a defined route. – Should not use the checklists related to 'why' too early; make sure the 'what' is fully understood first. – Some checklist language can appear to imply blame which is clearly against the culture necessary for LFI. – They can be biased, e.g. towards technical causes or towards blaming the individual within HOF checklists. – Checklists may highlight many other problems and shortcomings that did not directly cause or contribute to an incident. This in itself may not be a limitation in terms of wider learning but it may distract effort away from the short-term goal of preventing reoccurrence. – Checklists may be easier for inexperienced users, but are not a substitute for analyst skill.

A number of techniques combine the three broad approaches above, e.g. Kelvin Top-Set® and TapRooT® combine trees and checklists, B-SCAT combines barriers and checklists, and Tripod Beta combines aspects from all three.

5.2.2.4 *System theory techniques*

These types of technique are not in widespread usage within industry, but are the subject of academic research. Examples of these types of techniques include functional resonance analysis method (FRAM), AcciMap, and systems theoretic accident modelling and processes model (STAMP). System theory approaches look at the linkages between different actors within an incident. Actors may be individuals, but may also be aspects of the organisation at various levels (e.g. processes, staff level, management level), the regulator and government policy. Because these techniques have been largely confined to research, little can be said of their effectiveness and advantages over other techniques for learning from incident, although they may be helpful for revealing findings that other techniques are unlikely to uncover, such as government policy.

5.2.2.5 HOF causal analysis

When conducting a HOF analysis of an incident, consider the following:

- Do not try to prove exactly why people did what they did. It is more productive to focus on the influencing factors (PIFs) that made the event more likely. When considering PIFs, the analysis will often deal with the balance of probability rather than absolute, clear causation.
- Look at HOF successes as well as failures (see 4.2 to build this into the TOR) in order to expand learning potential.
- HOF issues should be addressed in simple language and not academic terminology.
- Link HOF issues to a hierarchy of controls for improvement actions (see 6.2.2). Within this hierarchy of controls include consideration of non-technical skills (NTS) that could be improved (see IOGP, *Crew resource management for well operations teams* on additional guidance for NTS).
- For lower level events, some organisations make use of checklists with a range of pre-determined potential underlying causes to make cause identification easier and more consistent (e.g. at supervisory level). However, it is important to review whether such methods actually generate information of sufficient quality to be useful for learning as this is often not the case.

5.2.2.6 Hypothesis validation

It is to be expected that some information may not be readily available or necessarily clear-cut and may be incomplete, inconsistent, contradictory, ambiguous, misleading or false.

It is important not to rule out causes just because evidence is initially weak. If in doubt, weak signals should be explored further. This is especially relevant to process safety hazards. It is also important to determine the extent of a causal factor through sampling.

A useful rule of thumb is to accept information leading to a conclusive finding if it is supported from at least two independent sources. This is not always possible and the analyst may have to decide whether to use a single source as conclusive proof. Single findings can be tested by asking those involved in the incident if they agree or disagree with it.

Listing the source of each finding will facilitate conflict identification and resolution. In general, where any assumptions are made, these should be explicitly stated in the investigation report.

One approach to helping to clarify or resolve alternative hypotheses is to construct a finding/hypothesis table (see CCPS, *Guidelines for investigating chemical process* incidents for more details).

Table 8: Mapping known findings against hypotheses (adapted from CCPS, *Guidelines for investigating chemical process incidents*)

Hypothesis	Findings or Conditions					
	A	B	C	D	E	F
1	**?**	**+**	**?**	**+**	**+**	**-**
2	**?**	**?**	**+**	**+**	**+**	**?**
3	**NA**	**?**	**?**	**+**	**+**	**-**

Legend: (+) the finding supports the hypothesis; (-) the finding refutes the hypothesis; (NA) not applicable - the finding is not related to this hypothesis; (?) not enough information is available to decide on this finding.

5.3 INVESTIGATION REPORTING

It is good practice to develop a template for investigation reports and to have this checked by the legal department. The template should take account of good practice guidelines for report structure (see RSSB, *Investigation guidance Part 3: Practical support for accident investigators* and the template in EI *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation*). The report does not need to be an exhaustive description of the investigation itself. This can become excessive and distracting. Separate report templates for different investigation levels can help make sure authors include relevant information that will be more recognisable to readers.

To accompany the template an organisation should define good practices that help make a report a good tool for learning, for example:

- Consider who the readers are and what they need from the report.
- Use visual aids to make the report accessible, e.g. use diagrams to show where people were, photographs of area/equipment.
- Use short sentences and keep technical language and explanations in an appendix.
- Include a list of similar incidents to lend weight to the findings of an investigation report and put it in a broader learning context.
- Consider other formats to complement a written report, e.g. presentations, slides, videos; how can the information be best communicated?

Details from the report should also be captured as key words and fields for use in databases to allow trending and pattern recognition (see section 8).

5.4 CASE STUDY

5.4.1 Overview of incident

At about 0115 hours on a Thursday morning in the spring of 2007, a fire occurred at an atmospheric pipe still (crude distillation) (APS) unit at a refinery. There were three fatalities and one person was injured as a result of the fire.

These four individuals were contractors who had been carrying out de-blinding work at the APS unit in which five blinds, previously installed for the conduct of maintenance work, were being removed after completion of the maintenance work.

Schematics showing the relevant equipment and blind locations are provided in figures 16 and 17

The incident occurred when the contractor crew was working on the last of five blinds to be removed (blind E on the schematic). It is estimated that more than 760 litres of condensed hydrocarbon and water were released from the flange at blind E, which subsequently ignited from an unknown source below the work area.

Emergency response was immediate, with APS shutdown commencing at 0116 hours. The fire was extinguished by 0224 hours.

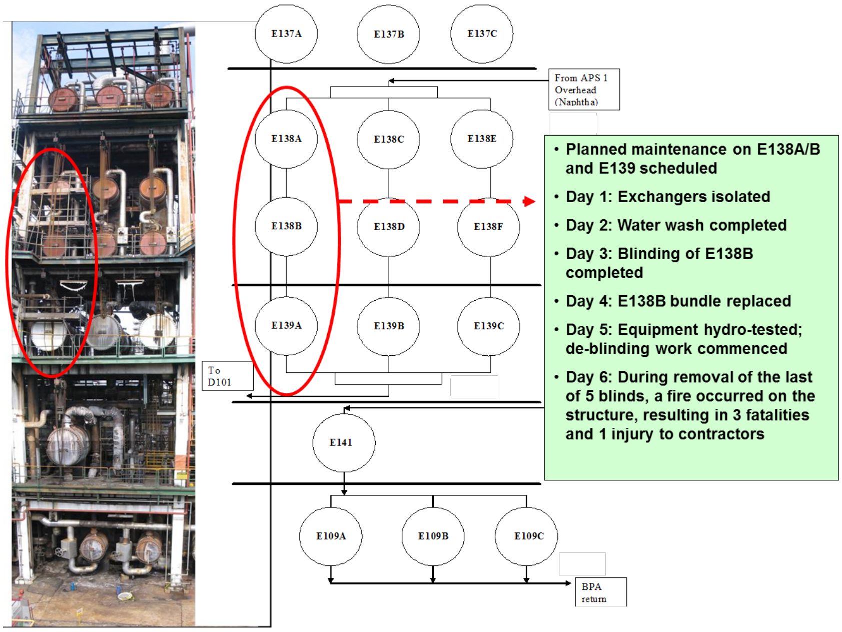

Figure 16: Heat Exchanger Structure

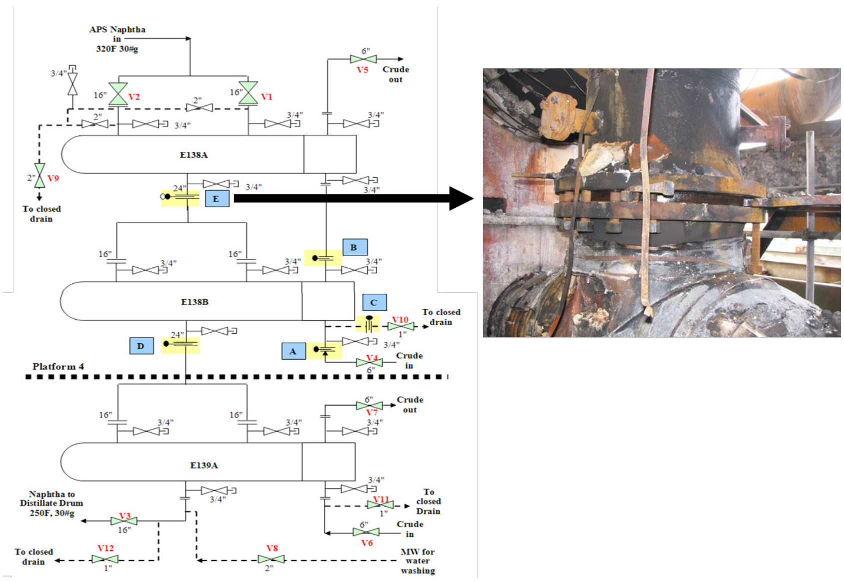

Figure 17: Schematic Layout of E138A/B and E139

5.4.2 Summary of investigation

Suitably qualified and independent investigators were assigned to report back to management with recommendations to prevent a reocurrence. The investigative techniques used reflected the following key principles:

– Establish the sequence of events with significant times and conditions defined (see Figure 18 for illustrative charts).
– Find out as far as reasonably practicable the reasons 'why' actions were taken or omitted (techniques include interview, documentation reviews, radio traffic recordings, expert witnesses/local subject matter experts, why-based techniques).
– Identify 'causal factors' (CF[5]) – those acts or omissions that if completed would have prevented the incident occurring.
– Determine influences and underlying causes relating to each causal factor, which in turn enable effective corrective actions to be developed.
– Make recommendations that allow line management to develop SMART actions to prevent a recurrence. Assign action owners and links to the global safety management systems.

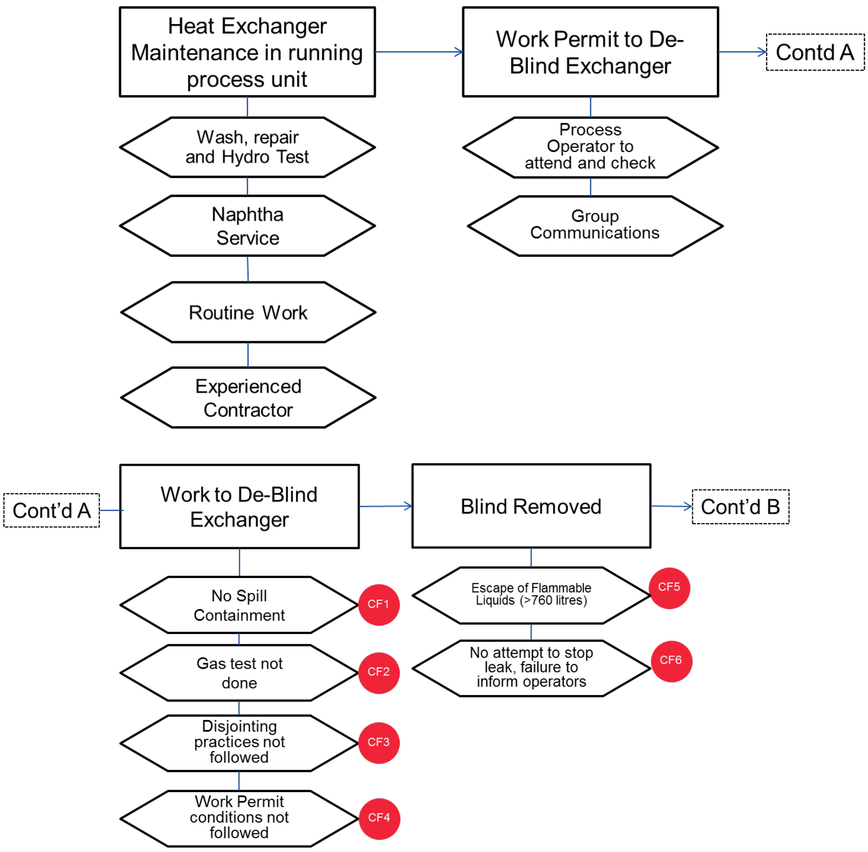

Figure 18: Charting sequence of events, associated conditions/status and causal factors

5.4.3 Immediate causes and recommended actions

Table 9 lists the identified immediate causes together with a sample of the underlying causes and recommended actions.

5 Referred to as immediate causes in rest of this case study

Table 9: Summary Analysis

<table>
<tr><th>Immediate causes</th><th>Influences/underlying causes[6]</th><th>Sample of actions[7]</th></tr>
<tr><td>CF1 – No spill containment</td><td rowspan="6">In the past, procedures had not been followed and no incident had occurred.
Lack of hazard awareness of contractors around disjointing task.
Lack of assurance that global equipment disjointing practices are being followed.
Lack of controls around contractor compliance with permit conditions.</td><td rowspan="6">Provide hazard awareness for contractors at refineries worldwide covering disjointing tasks among others.
Revise guidance for providing assurance that global equipment disjointing practices are being followed.
Enhance process operator work permit control in order to provide necessary checks prior to work commencing. Make process operator presence a prerequisite for work to proceed.</td></tr>
<tr><td>CF2 – No gas test</td></tr>
<tr><td>CF3 – Disjointing practices not followed</td></tr>
<tr><td>CF4 – Work permit conditions not followed</td></tr>
<tr><td>CF5 – Process/work conditions were not adequately evaluated prior to breaking the flange</td></tr>
<tr><td>CF6 – Work continued after liquids were released</td></tr>
</table>

5.5 BLOCKERS AND POTENTIAL ENABLERS FOR INVESTIGATION OF INCIDENTS

Table 10 summarises what are judged to be the most significant blockers to effective investigation, with potential enablers.

Table 10: Blockers to effective investigation, and potential enablers

Blockers to effective investigation	Enablers for investigation
Insufficient management commitment	– Release staff from normal duties so that they can carry out investigations to sufficient standard. – Encourage investigators to identify underlying causes even when these point to organisational and management system issues. – Encourage board / corporate level interest in LFI.

6 Some assumptions arise due to inability to confirm with the personnel involved.
7 Note these have been simplified and hence do not necessarily follow a SMART format (see 6.3).

Table 10: Blockers to effective investigation, and potential enablers (continued)

Blockers to effective investigation	Enablers for investigation
Lack of personnel trained/ competent in investigation (e.g. lack of competence in structured analysis techniques or understanding HOF)	– Develop investigator capability through selection, training and assessment (see 4.3). – Obtain assistance from another part of organisation or outside body. – Set up easy to use templates/ checklists that enable a non-specialist to determine underlying causes for non-complex incidents. However, be realistic about what less-resourced investigations can achieve; prevent non-specialists providing low quality data on underlying causes that bias the investigation and prevent robust trend analysis. – Provide HOF training for investigators. A basic HOF competence should help supervisors in day-to-day operations as well as incident investigation. – Use review panels to check investigation findings, including recommendations.
Reluctance of personnel to provide full story; worry of being blamed or incriminating others	– Establish the right atmosphere in interviews; it's about learning, not blame. – Use approaches that make the interviews less intimidating, e.g. walk around the site with the personnel during initial discussions and consider the pros and cons of interviewing groups of personnel together (this can have powerful learning potential).
Lack of comprehensive identification of underlying causes and 'single (root) cause seduction'	– Establish systematic and objective processes for gathering information so that the findings will be well founded and can be linked to the collected information. – Aim to understand correctly **what** happened through the sequence of cascading loss of control events, **how** it happened through the various barrier systems which were not effective, and **why** the barrier systems were not effective because of human and organisational behaviours and influences. – See training/ competence issues detailed in this table.
Difficulty of establishing why people did something: they themselves might not know	– Recognise that the investigation is not about proving categorically why something happened; it is about learning. Focus on what made this event more likely to happen (e.g. were fatigue factors a potential influence?). – Discourage asking 'why did you do it?': the motivation is not that helpful, and vulnerable to hindsight or reinterpretation. Ask more neutral and open questions such as 'Take me through what happened'.
Lack of early learning: the time to produce a final report can be lengthy and the temptation can be to postpone wider learning until all the facts are known definitively	– Send out incident alerts or interim reports. – Possibly run sharing learning sessions (see 7.4) in parallel to formal investigation. – Include frontline personnel in investigation teams.

6 RECOMMENDATIONS AND ACTIONS

6.1 OVERVIEW

This LFI phase translates the investigation findings into effective actions that will prevent the reoccurrence of similar incidents. Figure 19 shows the main steps in this phase. Recommendations are developed (6.2) and line managers should convert these into actions which are SMART (see 6.3) and which reduce risk to a level which is as low as is reasonably practicable (ALARP). Other operational feedback mechanisms (such as audits, task observations, staff surveys) may have also indicated issues that require corrective actions. These actions should be implemented and closed out (6.4). The results from this stage will feed forward into broader learning and change. Feedback from the broader learning and evaluation phases may lead to the identification of further actions. Blockers and enablers relevant to this phase are summarised in 6.5.

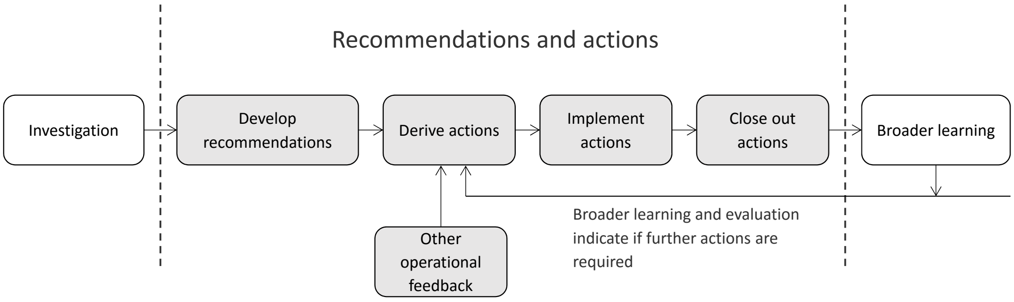

Figure 19: Recommendations and actions

It is recognised that addressing recommendations following an incident can be a major area of weakness. There may be long lists of unclosed-out actions existing sometime after an investigation report is finalised, or a tick box approach to implementing ineffective measures (e.g. rebriefing a team on a procedure).

To address these potential weaknesses line managers should be involved in the development or review of recommendations so that they buy-in to them. Equally front-line personnel should be involved in discussing potential risk reducing measures so that their expertise is fed into recommendation development.

Prioritising recommendations can prevent an organisation becoming overloaded with resultant actions (especially when actions are also being generated through reviews, audits, safety tours, etc.). Investigation recommendations should be translated into SMART actions to make them easier to address and close-out. Periodic reviews of actions should be used to check that actions are closed out in a timely and robust manner.

6.2 DEVELOPING APPROPRIATE RECOMMENDATIONS

6.2.1 Who should be involved

Line managers have an important role during the development of recommendations. As a minimum they should be consulted with to ensure that they understand the rationale for the recommendations and have a chance to comment on issues such as practicality and priorities. This consultation should be aimed at improving acceptance of recommendations and preventing misunderstandings when the draft investigation report is issued.

An organisation should consider whether the investigator or investigation team are the best people to be developing recommendations. The necessary expertise for this is more likely to lie with the line managers who understand the business and, ultimately, who will implement the actions. In The Netherlands it has become the practice for national investigation bodies to stop their report at the findings stage and hand over to the responsible line managers of the involved organisations to develop recommendations and actions to address the findings. Putting the onus on the line managers in this way has led to a higher rate of actions being closed out appropriately.

In developing recommendations it is good practice to also involve local personnel, who have frontline experience and also subject matter experts, who would typically have a deeper understanding of the issue at hand. As well as developing better risk reducing measures, this should also help establish buy-in of the resulting actions. Discussing options with appropriate stakeholders will lead to more credible recommendations and greater understanding of what needs to be done.

In developing recommendations it is very helpful to know if issues associated with the incident have been experienced and addressed before. To this end, some industries have made use of panels of retired experts who were willing to review incidents on the basis of 'giving something back' into the industry. Tapping into such large accumulations of knowledge can lead to rapid recognition of issues, appropriate recommendations and cross-references to incident reports that are not easily tracked through more formal means. These expert panels should be supported by knowledge management systems (e.g. incident databases as described in section 8).

6.2.2 Rationale for recommendations

6.2.2.1 Linkages to findings and barriers

It is usual to link recommendations to findings so that the rationale is clear. There should be at least one recommendation for each of the failed or ineffective barriers and underlying causes. If a barrier has failed, rather than automatically trying to develop a new barrier, the reasons why the existing barrier did not succeed should be understood and corrected. Suitable actions should be taken to fix failed barriers before production is restarted.

In the case of HOF causes of barrier failure, understanding the human failure types in the event can identify what measures are likely to be effective. Table 11 indicates what classes of recommended measures are likely to be effective for different HOF failure types. Improving training, for example, is unlikely to have a big impact on reducing slips and lapses, whereas it could potentially have an impact on mistakes. In contrast, reducing distractions through a less cluttered workplace or removal of extraneous activities could have a significant effect on slips and lapses, but is unlikely to be so relevant to violations.

Table 11: Mapping effective recommendations against human failure classification (adapted from Shorrock and Hughes, 2001)

Recommendations – improvements in:	Slips	Lapses	Mistakes	Violations[8]
Control/ display design	✓	✓	✓	✓
Equipment/ tool design	✓			✓
Memory aids		✓		
Training			✓	
Work design	✓	✓		✓
Procedures	✓	✓	✓	✓
Supervision	✓	✓	✓	✓
Reducing distractions	✓	✓	✓	
Environment	✓	✓	✓	✓
Communications	✓	✓	✓	✓
Decision aids			✓	
Behavioural safety			✓	✓

6.2.2.2 Applying a hierarchy of control

The rationale for recommendations can also be improved by applying logical hierarchies for reducing the risk of reoccurrence. The following hierarchy of additional risk controls has been proposed in *HSE Core Topic 3: Identifying human failures* and could be applied to incident investigation recommendations:

- Can the hazard be removed?
- Can the human contribution be removed, e.g. by a more reliable automated system?
- Can the consequences of the human failure be prevented [or mitigated], e.g. by additional barriers in the system?
- Can human performance be assured by mechanical or electrical means? For example, the correct order of valve operation can be assured through physical key interlock systems or the sequential operation of switches on a control panel can be assured through programmable logic controllers. Actions of individuals should not be relied upon to control a major hazard.
- Can the Performance Influencing Factors be made more optimal, (e.g. improve access to equipment, increase lighting, provide more time available for the task, improve supervision, revise procedures or address training needs)?

Such a hierarchy relating to plant process changes, equipment improvements, enhanced operational environment, revised procedures, better supervision and training, etc. can help organisations apply changes that are likely to be effective in the long term.

6.2.3 Prioritisation and review

It is helpful to be able to understand the relative priority of each recommendation or action and how these stand relative to other issues that need to be addressed. Ideally each recommendation or action generated by an incident investigation should be prioritised, providing an assessment of the level of risk which is mitigated by the implementation of each recommendation, and consequently, the level of risk which will remain if the recommendation is not implemented, see EI *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation*.

Risk matrices of the type discussed in 3.3 can be useful in demonstrating how risk levels could be changed by implementing different recommendations. A qualitative approach to looking at the potential benefits of implementing recommendations and issues of practicability can be found in the EI *Guidance on human factors safety critical task analysis (SCTA)*. In a minority of cases, when a recommendation will entail large costs but could lead to large safety benefits, a quantified cost benefit assessment (CBA) may be necessary to decide whether or not to implement a proposed safety measure. Such assessments can be useful to help demonstrate that the risk of a repeat occurrence is ALARP.

Investigation recommendations should be reviewed by professional leaders (discipline leads) and technical authorities before the draft report is issued. Careful reviews of recommendations can help to check that they really would eliminate the causes of the incident while being reasonably practicable, cost effective and within the control of the organisation. As noted in 2.7, and where appropriate, a legal review should also be carried out.

As part of feasibility assessment, some organisations have established review panels for recommendations to ensure that they will be beneficial and that they are practical. These panels are given the authority to accept or reject recommendations. Documentation should be produced explaining why a recommendation was rejected or modified.

It is good practice to consider whether workstreams set up after previous incidents are already addressing findings from the latest investigation. Thus, rather than producing new recommendations, the investigation may want to check whether these other workstreams are sufficient and produce a linking recommendation (e.g. 'review schedule of workstream X to ensure timely completion'). Additionally it may be possible to group recommendations from multiple incidents to help rationalise the flow of resulting actions.

6.2.4 Standards for recommendations

Organisations should have standards or procedures for developing recommendations to ensure consistency between investigations and effective resulting actions. The following guidance should be covered:

- Word the recommendation as a single stand-alone item that includes an explanation of why it is made (i.e. linkage to a finding).
- Wording should be free of emotive or judgemental language.
- Avoid wording that is vague and open to interpretation (see Table 12)[9].
- Ensure that recommendations are not only directed at immediate causes but that underlying causes and management systems are also addressed (see Table 12).
- Be clear on who is responsible for a recommendation and which part of the organisation it applies to.
- Make the intent clear in the recommendation. It may be best to specify the desired outcome (e.g. the performance standard for a barrier) and leave it to the organisation to determine the best actions to achieve that outcome.
- Avoid wording that can sound authoritarian or overly prescriptive. While a SMART format is suitable for actions (see 6.3), for other recommendations more latitude can be allowed so that appropriate actions are developed.
- Emphasise if there could be broader learning for the organisation/industry from a recommendation.

8 Extra guidance on handling violations is provided in the Hearts and Minds guidance *(Managing rule breaking, The toolkit)*
9 Standards on wording are also applicable for investigation reporting.

Table 12: Example recommendation improvements

Findings	Poorly directed and worded recommendation	Better worded recommendation	Additional recommendation
Several steps in the procedures seem to be missing, e.g. purging, blocking in reactant A and disconnection.	Rewrite the operating procedures.	Conduct a step-by-step review of the reactor charging operating procedures with a multi-disciplinary team and update the procedures as necessary.	Review the management system for writing and reviewing procedures, ensuring that personnel with the required competence are involved and that procedure review cycles are specified.

Having established organisation-wide standards for recommendations, recipients of recommendations should enforce these standards and be prepared to send recommendations back should they not fulfil the standard. Periodic verification of the appropriateness of recommendations should also be conducted.

One particular problem for organisations can be handling recommendations that are likely to take a long time to close out. If something is likely to take more than 6-12 months to implement, the investigation team should consider this carefully and highlight this before it is entered into a tracking system. Additional guidance identifying how to determine whether the recommendation is closed-out could be helpful for these long-term issues. An example of this could be when the investigation has been unable to cover a topic and wants to recommend, for example, a wider review of task execution competence. Such a recommendation should be carefully worded so that close-out is possible.

6.3 DERIVATION AND ALLOCATION OF ACTIONS

As noted in 6.2, there should be a formal process for line managers to translate investigation recommendations into actions to be implemented. This will involve the following:

– Line management review of the recommendations to ensure that they are understood. Depending on the level of involvement of line managers in an investigation, clarifications with the investigation team may be required. Feasibility studies and safety or HOF analysis may also be needed as described in this section.
– Translating the recommendations into actions. One recommendation may lead to multiple actions (e.g. a short-term and a longer-term response). Actions should be SMART, i.e. (RSSB, *Investigation guidance part 3: Practical support for accident investigators*).
  – Specific – a clear description of what is required and who is responsible. Each action should address one recommendation or issue.[10]
  – Measurable – so that the level of implementation can be tracked.
  – Attainable – non-attainable recommendations should not be accepted but challenged.

[10] Even if the recommendation is non-specific and addressed at the desired outcome the actions should be clear and follow the format above.

  - Relevant – the action should address the intent of the recommendation, relate to the circumstances of the incident and be targeted to prevent reoccurrence.
  - Time-bound – timescales for stages and completion will allow monitoring to closure.
- Ensuring ownership and agreeing responsibilities and timescales with action owners.
- Obtaining commitment to allocate the required resources and funding for implementation of the agreed actions.

In determining the feasibility of recommendations that involve significant changes, it may be necessary to carry out a safety analysis to check that additional risks are not being introduced or risks simply transferred elsewhere. This is likely to be covered by an organisation's management of change system. In addition, HOF analysis of proposed recommendations may be required to determine if people may react or adapt to recommended changes in an unpredicted (and unsafe) manner.

Following an incident, as well as addressing the recommendations for modified or additional controls, personnel and organisations may also need to unlearn old practices and break past habits. This may require the development of additional actions or be part of the broader learning described in section 7.

It should be checked that the derived actions do not duplicate actions that are already in the system, or that the system is becoming overloaded with unachievable or unnecessary actions.

6.4 ACTION IMPLEMENTATION

6.4.1 Implementation and close out

The tracking of actions is a vital part of the investigation output, as the failure to address recommendations from previous investigations has been seen as a precursor to many major accidents. Senior managers should provide oversight of action implementation to ensure that appropriate resources are made available to match the risks involved. It should be clear when an action is complete. Specific criteria may be set and information provided to demonstrate that the criteria have been met. Further criteria and measures should be set to demonstrate that actions have been effective (see 6.4.2 and section 8).

A number of challenges to closing-out actions appear widespread, as demonstrated in the following examples:

- The original recommendation was developed by a person remote from the action party and the action party does not understand the context. Therefore they do not 'buy in' to the change. This could lead to repeat deferrals of actions or changing interpretations of actions.
- The fact that staff may have to do something differently following an incident is not usually a positive experience. People need to be prepared to accept that what they believed was 'good practice' may not now be the case. This challenge to people's perceptions should be recognised as an issue when planning implementation. It may require extensive communications before everyone is convinced and implementation can start.
- There are likely to be practical problems in implementing changes, e.g. if human machine interface (HMI) weaknesses have been revealed there will be a need to procure new equipment, develop new standards, review other sites' HMIs, etc. all of which could involve long timescales. Widespread or longer-term actions may be better rolled up into higher level plans so that they can be appropriately monitored and resourced.

– There can be the belief that closing out investigation actions is the responsibility of the SHEQ department. Ownership should be established early and the owners consistently held to account.

Many organisations track overdue items at management meetings; however, this tends to focus attention on the items that have already gone overdue. Some organisations set targets of no more than a predefined number of overdue items. A good practice is to provide management information on items before they go overdue and track close-out in a more proactive manner.

6.4.2 Follow up

Actions can be framed to be easily closed-out, rather than leading to effective change. Thus, in order to ensure that implemented actions are effectively addressing the investigation recommendation, additional controls should be in place:

– Verification should be required to determine whether the actions continue to be followed, even when actions have been closed-out in an action tracking system.
– Periodic reviews should take place to check the effectiveness of the actions. This can be difficult to achieve in practice. One method could be the use of interviews to determine how the learning from incidents has been incorporated into practice (also see method in 8.2).
– Performance indicators should be set up to monitor the effectiveness of actions and how well recommendations have been addressed. This is covered in 8.4.

Examples of rationalising the number of recommendations and actions

An oil and gas company reanalysed about 20 serious accidents that had occurred over a period of three to four years using a barrier based approach. The investigations had collectively produced hundreds of recommendations. The structured review identified five common underlying causes and all the recommendations were consolidated into five workstreams.

In another example a steel smelting organisation managed to rationalise a large and ineffective action register down to just five corrective actions; for each of the five actions, the organisation developed realistic plans for implementation and closure. In addition, the organisation asked its investigators when developing future recommendations to determine ways to measure if the interventions had been successful. The process of thinking about 'how to measure success and failure' is seen as an important part of generating effective recommendations.

6.5 BLOCKERS AND POTENTIAL ENABLERS FOR EFFECTIVE RECOMMENDATIONS AND ACTIONS

Table 13 summarises what are judged to be the most significant blockers to effective recommendations and actions, with potential enablers.

Table 13: Blockers to effective recommendations and actions, and potential enablers

Blockers to effective recommendations and actions	**Enablers for recommendations and actions**
Recommendations are not accepted by line management	– Involve line management in the review of the recommendations so they understand the context and have the opportunity to question the investigation team on the value of the recommendations. – Ask line management to define the recommendations, with investigators approving them (line managers may be more motivated to implement resulting actions; but on the downside, they may be tempted to make recommendations that are easy to action rather than leading to long-term improvements).
Recommendations are not accepted by frontline personnel; there can be a perception that actions that come down from management/investigators following an investigation are divorced from understanding of what is happening day-to-day	– Involve frontline personnel in discussing potential risk reducing measures and developing recommendations. – Hold briefing sessions with frontline personnel at which draft recommendations are presented and discussed.
Too many, and loosely worded, recommendations	– Prioritise recommendations based on risk assessment. – Review the process for creating recommendations to check they eliminate the causes of the event while being reasonably practicable and within the control of the organisation. – Give guidance on recommendation wording (ideally provide examples of good and bad wording). – Convert recommendations into SMART actions.
Insufficient weight given to underlying causes in developing recommendations	– Check that there are recommendations that link to the different causation levels in the failure model. – Ensure that recommendations are appropriate to the relevant human failure type (e.g. if failure was due to a slip, extra training would probably not be an appropriate recommendation).
Insufficient checks that recommendations will effectively reduce risk	– Check that recommendations are risk proportionate and that they will not inadvertently increase risk (linked to management of change process). – Apply logical hierarchies of risk reduction to recommendations. – Use review boards and subject matter experts to assess recommendations.
Backlog of actions build up (not just from incident investigations but also from audits, safety tours, etc.)	– Reduce the numbers of recommendations by combining into workstreams. – Proactive management of action close-out, and control of deferral of actions. – Leadership should allocate sufficient resources to closing-out actions (particularly priority actions). – Audits and follow ups of investigation recommendations.

7 BROADER LEARNING

7.1 OVERVIEW

The processes described in the previous sections will lead to changes that reduce the risk of an incident reoccurring, but those changes will generally be constrained in some way, for example, being localised within the company or perhaps effective only in the short term. To ensure sustained effective change, broader learning is necessary.

A phrase that is often used in the context of broader learning is 'dissemination of lessons'. However, it should be emphasised that broader learning is not just lesson dissemination; dissemination is necessary but is not sufficient. Broader learning involves people having time to reflect, put the information into the context of their own work environment and make sense of the information disseminated. As a result they are more likely to change their behaviour and reduce the risk of a similar incident happening. Broader learning (or learning in general) should result in a measurable change to equipment, behaviours, processes and management systems, that will prevent repeat, similar or even different incidents.

Broader learning involves:
- Reaching more people in the organisation who may be affected by the same problems and risks revealed in the investigation (i.e. a wider geographic or functional reach within the organisation).
- Affecting people in the longer term, perhaps long after the memory of the incident has dissipated.
- Applying the learning to a broader range of incidents (similar and dissimilar).
- Learning about the LFI processes themselves as well as incident causation and prevention.
- Reaching and influencing people outside the organisation.

The broadening effect of these aspects on LFI is illustrated in Figure 20.

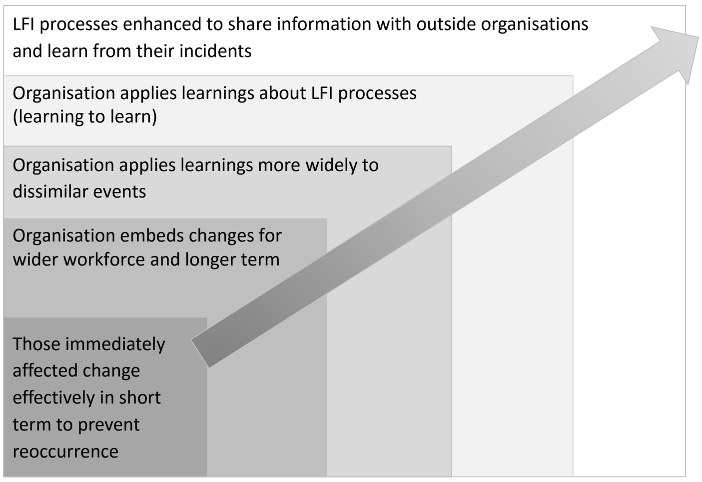

Figure 20: Representation of broader learning

To deliver this broader learning the organisation should ensure the steps in Figure 21 are conducted. Following on from the steps in section 6, organisations affected by an incident should identify what broader lessons need to be drawn (7.2). These should be effectively communicated to relevant stakeholders (7.4). But whilst communication is an important first step, real learning takes place as a result of later steps. Those stakeholders should receive this information and make sense of it, including putting it into the context of their own work situation (reflection) (7.5). The affected organisations should then identify and implement appropriate actions such that changes become embedded and sustained for the long term (7.6) i.e. a change to equipment, behaviour, processes and management systems. Part of this broader learning involves reviewing multiple incidents to understand common underlying causes that are impacting across the business activities; this is further addressed in section 8 together with blockers and enablers applicable to broader learning.

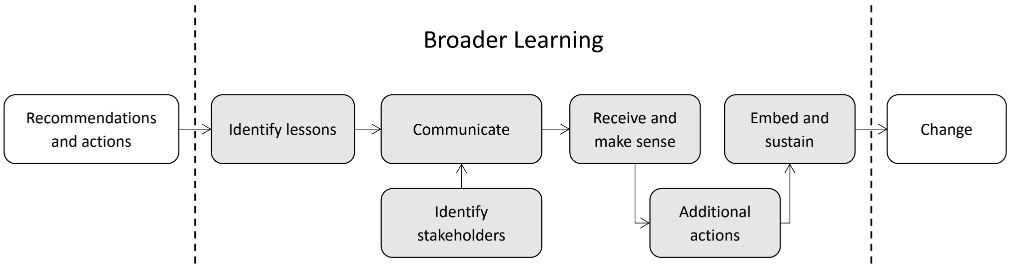

Figure 21: Steps in broader learning

There is a key role for the leadership of an organisation in this stage of LFI. Senior managers should state and demonstrate that LFI is important, highlight the benefits and make the necessary resources available to ensure that additional actions are implemented. They should embed the expectation that the organisation and the personnel have only learnt from an incident if they are doing something differently.

7.2 IDENTIFYING LESSONS

Following an investigation, two broad strategies to identifying lessons should be used:

1. Top down or expert identification: for example, leadership reviews of investigations and quarterly reviews of high potential (HiPo) incidents using a cross-disciplinary team or a learning committee.
2. Participative identification typically involving:
   – Encouraging people to identify for themselves what the lessons are. This involves reflecting on the event and finding information that is relevant.
   – Coaching activities such as facilitating sessions at which key questions are discussed: how can something like this happen to us, what is our equivalent to this?
   – Sessions in which a scenario based on an incident is presented and the team works through the example. This tests people's knowledge of their systems.

In identifying lessons, an organisation should be looking at technical issues and behaviours. Similar behaviours could be relevant in a completely different type of facility or even a different industry. A hierarchy, such as that described in 6.2.2.2, can assist in the identification of relevant lessons and potential risk-reducing measures.

7.3 IDENTIFYING STAKEHOLDERS

A range of practices can be helpful in identifying stakeholders and determining how best to communicate with them. In listing potential stakeholders it is important to consider both those inside, and those external, to the organisation (see examples in Table 14). Once a comprehensive list of stakeholders has been generated the SHEQ leads for LFI should document the likely interests of the stakeholders in an incident, potential communication mechanisms that could be effective and key messages, i.e. what people will take away. This can be captured in matrices such as Table 14.

Table 14: Illustrative stakeholder identification matrix

Stakeholders Internal = I External = E	**Their potential interests in incident**	**Potential communications mechanisms Active = A Passive =P**	**Key messages**
Technical specialists (I)	Novel ignition source identified	Briefing note (P)	Review existing risk assessments in light of novel information
Operators (I)	Actions and decision making of control room operators	Facilitated session involved scenario building and reflection (A)	Importance of NTS
Regulators (E)	New or emerging risk	Workshop for the industry to which regulators are invited (A)	Sector (including regulators) need to address this new issue

7.4 METHODS FOR COMMUNICATING LESSONS

7.4.1 Internal communications methods

A wide variety of techniques is currently used to communicate incident lessons within organisations. In the toolbox illustrated in Figure 22, some can be used in a personal (face-to-face) situation, others will typically be used to reach personnel remotely and others can be multi-use. Alongside such routine mechanisms, the use of special events can help provide regular boosts to the profile of LFI.

The following practices can enhance use of these techniques:

– Use older incidents to encourage discussions. They do not usually have the associated political or emotional problems that recent incidents have and may have enduring lessons that have stood the test of time. The use of older low frequency/high consequence events can help make use of experience that has led to sustained changes to companies.
– Develop a standard template for sharing lessons and communicating with other operating units. A summary format with space for a picture and text covering

causes, corrective actions and lessons learnt can assist the communication process and creates the expectation that information will be shared. It should be noted that the use of templates can lead to the LFI process becoming too formulaic, but overall the advantages usually outweigh this problem.

– Organise a communication session about a type of hazard and how it could turn into an incident. This can be valuable and less contentious than focusing on a historic example.

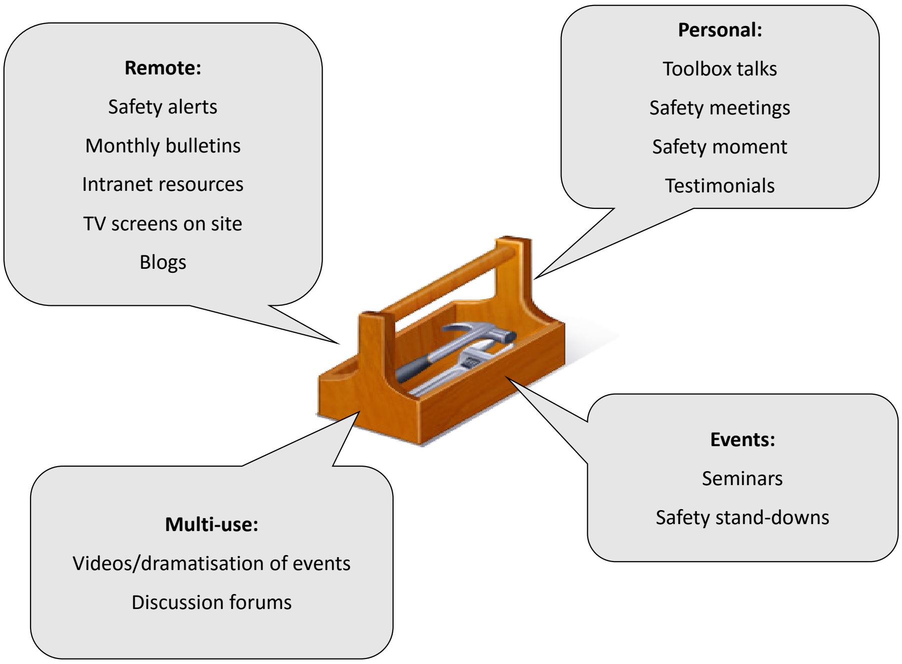

Figure 22: Toolbox of communication techniques for LFI

– Consider more innovative methods of presentation. One organisation converted their monthly bulletin of incidents into a comic that was sent to all the organisation's sites around the country. This format was much more attractive for readers. In the UK rail industry the RSSB produces the magazine Right Track which adopts a story telling, novelistic style to incident descriptions, which is more engaging than typical safety alerts.

– Use testimonials with care. The experience of some energy organisations has been that personal testimonials from those directly involved in an incident have only a limited short-term impact. However, others have found that they can raise awareness and be a valuable part of an overall package of improved incident communication. A two-way dialogue between the audience and personnel involved in an incident will be more effective than a monologue alone.

As well as the formal techniques discussed above, information about incidents will be communicated informally between personnel. Such informal learning, especially if between peers, has the advantage of potentially being more open with less concern about being blamed. The main limitation of informal learning is that information is often not shared across a site or between multiple locations. In addition, it does not become embedded into the relevant management systems.

It can be a challenge to communicate learning at the time when it is most needed, and to communicate incident information with contractors. Good practices concerning these challenges are set out as follows:

Examples of delivering the learning at the right time

Supervisors have a key role in ensuring that personnel are aware of learnings from past incidents. They can make use of, and be supported by, the following mechanisms:

1. Tool box talks (TBT) that are specific to the task at hand.
2. Key wording of safety alerts and linking these to the permit to work (PTW) system so that they are attached to relevant permits that are issued. This is especially useful for infrequent tasks (reminders about previous incidents are less effective for day-to-day tasks.)
3. Central library system of incidents that can be easily accessed.

Examples of sharing lessons with contractors

The following approaches have been found to be productive in communicating incident information to contractors:

1. Appoint a buddy manager, accountable for contractor performance, who reviews safety processes, attends meetings, visits worksites and shares information.
2. Ensure that incident information is passed to contractors. This apparently simple task is not always done, e.g. due to IT access issues, lack of relevant terminals etc.
3. Provide an intranet site specific to the contracting community.
4. During quarterly performance reviews, include a ‘sharing session’ covering incidents.
5. Specify requirements for incident reporting, investigation and LFI in the contract.
6. Integrate relevant management systems or ensure that contractor systems are of an equivalent standard.

The approach may vary according to the size of the contractor (e.g. a small contractor may not be able to invest in substantial new systems).

With all these techniques, it is important not to assume that providing access to information means that personnel will be actively learning. See 7.4 and 7.5.

7.4.2 External communications methods (including to other industries)

7.4.2.1 Obtaining and using information from external sources

Appropriate contact should be maintained with groups that may provide information on relevant incidents that have occurred in other parts within the organisation, and those that have occurred in other organisations. Typically these groups will be organisation committees and industry associations, together with journalists from trade and safety journals (EI, *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation*).

In some energy-related industries there are already well established networks and initiatives for sharing such information:

– An example of an effective global initiative using operating experience in the nuclear industry is run by the World Association of Nuclear Operators (WANO). Incident data are collected and analysed and results communicated in various formats for operators’ use:
  – Reports covering the principal contributors to significant events and providing recommendations that members are expected to implement to prevent similar events at their plants. WANO peer review teams evaluate the effectiveness of stations’ actions to implement these recommendations.
  – Training presentations to help members communicate the content of incident reports to their plant staff.

   - Specially formatted briefing sheets for use in pre-job briefings to prepare personnel for specific tasks. The reports highlight relevant industry operating experience, key lessons learnt and questions to encourage a detailed discussion of the planned task to ensure thorough work preparation.
   - CEO updates describing important events and trends that utility CEOs are encouraged to discuss with their nuclear executives and oversight organisation.
- An example of a national-level initiative is the United Kingdom Petroleum Industry Association's (UKPIA), Assuring Safety initiative. A key part of this initiative is sharing information and learning from this in a collaborative manner. As well as sharing and learning within the petroleum industry, UKPIA has learnt some very important lessons from information shared by other sectors. For example, UKPIA has used input from both the rail and nuclear industries in a study to strengthen human factors performance (Hazards Forum Newsletter, Issue No. 84).
- An example of a committee is the G9 Offshore Wind Health and Safety Association, which is comprised of members of European offshore wind operators. This group facilitates the sharing of incident data, safety alerts and lessons learned among its member companies, and produces good practice guidance, via the EI, to common issues.

For those sectors where such initiatives have not yet begun, additional research may be required to obtain a useful flow of external events. Fortunately there are many excellent sources of incident information such as the IChemE's *Loss Prevention Bulletin*, the US Chemical Safety Board (CSB) which has excellent animations and visualisations of incidents, the CCPS's *Process Safety Beacon*, and Step Change in Safety incidents. The G9 Offshore Wind Health and Safety Association publishes incident information (via the EI) as does Energi Norge. A register of external bodies and websites should be maintained which has such valuable incident information. By searching through these sources LFI personnel can identify what is new and interesting and feed this into the learning process in their organisations.

It is good practice for an organisation to format relevant external incidents in the same style as their internal incidents. Effectively this can increase the potential for learning by treating external events as seriously as internal events (*Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation*).

7.4.2.2 Sharing information externally

The external channels described in 7.4.2.1 can be used by an organisation to communicate information about its incidents to the outside world. However, other methods have also been found to have a significant positive impact as described in the following examples:

Examples of other methods of external communications

Industry briefing workshop

There was a fatal accident in the Gulf of Mexico on a rig, operated by contractors, maintained by other contractors, under the project manager of another contractor. The work permit system failed and the maintainers were welding onto a supposedly safe line, but this ignited and caused a connected tank to explode, leading to four fatalities.

Following the investigation the rig owner held a public meeting and invited all in the industry, especially contractors, to come and learn from this incident. An important lesson for the welding contractor was the need to revamp its procedures to no longer assume that other contractors had verified isolations – they needed to verify isolations themselves.

Sharing with regulators

Another potentially effective mechanism for sharing information across an industry is through discussions with regulators. In December 2012 there was a failure on a jack-up rig while berthed at a shipyard in Singapore, causing the main hull of the rig to list to one side. This led to minor worker injuries and a detailed accident investigation. The rig owner carried out detailed technical briefings to the regulators of three European states to explain to them the details of the accident (a complex software caused event).

7.5 RECEIVING AND MAKING SENSE OF COMMUNICATED INFORMATION ('REFLECTING', 'CONTEXTUALISING' OR 'SENSE-MAKING')

Although many organisations disseminate large amounts of incident information, less attention is given to ensuring that this information is received and translated into the desired changes. Research (Lukic, Littlejohn and Margaryan, 2012) indicates that for change to occur the opportunity should be provided for individuals to reflect on the incident details, make sense of what has happened and put it into the context of their own work situation. This reflection opportunity should ideally incorporate more active forms of learning than, for example, computer-based training, and whilst reflection can be thought of as a separate phase in the LFI process, in reality there may be opportunity to conduct reflection (or at least consider the ways to provide reflecting opportunities) at various points in the LFI process.

A number of relevant principles have been published in a toolkit by the EI (Hearts and Minds *Learning from Incidents*):

1. Learning is demonstrated by a change in practice. Therefore we cannot say an individual has learnt unless we have information that things are being done differently.
2. To change practice employees have to relate knowledge about an incident to their own work situation (e.g. job role, practices and workplace).
3. People learn by actively engaging with information. Even though an individual has received incident information, he/she might not have learnt.
4. Some knowledge is written, but much only exists as 'culture'.
5. Some knowledge is difficult to write down and is best learnt on the job through regular interactions with persons who are respected and trusted.
6. Learning should be two-way. Information should flow from the organisation to the individual and group knowledge should inform the organisation.

These principles of learning can be considered at each stage of the LFI process in order to help identify where broader learning is possible. For example, section 7 provides guidance on creating recommendations; clearly it is important to consider a number of the principles when doing so; for example, how will it be measured that change has taken place and what type of knowledge are we trying to change (procedures, or cultural knowledge)?

Employees, including managers, should be encouraged to critically examine the learning points contained in the LFI information, offer input and feedback and consider the relevance of the learning points and recommendations to their own work.

This phase can sometimes be constrained by the format of the information disseminated. In order to encourage people to read incident information it can be simplified and the context removed (e.g. there may not be enough space in a summary report to include all the important factors that may have influenced how a task was executed). This can then make it more difficult for people receiving this information to understand why an event has occurred and draw valid lessons for their own work situation. This reinforces the importance highlighted in 7.3 of identifying stakeholders as well as lessons early in the process so that the most appropriate method and format for communicating incident information is chosen. It may be that one incident is converted into multiple forms of communication (e.g. a short safety alert to raise awareness, a discussion item for a toolbox talk to cover detail, a technical note for technical authorities, etc.).

Another consideration is that, by providing a lot of detail about an incident this can inadvertently make it easy to rationalise the event away as something that does not apply, e.g. if a plant does not use a catalyst a lesson around confined space entry might be dismissed. Low information scenarios and broad questions (e.g. 'what hazards are in this confined space') can be more engaging than ones where all the answers are given.

Active and engaging forms of communication do not necessarily need to be resource intensive. The following example of how to share learning is from an international oil and gas company and should not require excessive resources. However, lesson sharing should be planned for in terms of budget allocation and personal goals, and KPIs used to encourage appropriate use of active learning sessions.

To further enable active learning it is important that supervisors and others who will be asked to lead such sessions receive appropriate facilitation skills training. The second example given here illustrates how one international oil and gas company has developed online training to give supervisors and managers the skills to facilitate a reflective learning session with their team.

Example of how to share learning (from an international oil and gas company)

The following guidance is given to people (e.g. supervisors, managers) to help them plan and conduct a learning session.

Planning to share learning

- What do you want people to learn? Keep key learning points in mind as you design your learning, and make sure they are relevant to your audience.
- Ask before telling. Use open questions to prompt thinking and encourage learning. Encourage people to share their own relevant experience and contributions.
- Use what/when/where/who/how questions. Beware of 'why' questions, which can lead people to apportion blame to those involved at the expense of focusing on learning. Instead ask 'what could have caused those involved to do this' to reveal factors which may have influenced the behaviour.
- Provide enough information for the person leading the conversation to emphasise the learning points.
- When documenting, use straightforward, clear language and simple diagrams where possible.
- When sharing skills, think about how people can practise to embed what's been learnt into their role.
- Think about how supervisors and line-managers can reinforce and encourage the application of learning.
- Structure the conversation as described in Table 15.

Table 15: Structure of conversation

Step	Contents	Possible questions for the end of this step
What was happening?	Describe the scenario **before** the incident or event happened, preferably up to an important decision point in the event	– What would you do next? – What standards apply here? – How do we manage this? – What would happen next at our site?
What happened next?	Describe how the incident or event unfolded	– Do you have similar examples or stories? – What should have happened here? – Who has had an experience like this?
Why did this happen?	Explain the findings of the investigation	– What are the standards? – How do we help people to meet the standards? – What else does this make you think of? – How might we know if this was about to happen?

Table 15: Structure of conversation (continued)

Step	Contents	Possible questions for the end of this step
What can we do to follow up?	Describe one or two ideas	– What else could we do? – What do we need to follow up? – What would help us? – Who here is going to do something different? – How can we get confidence in our approach? – How are you going to use this? – How do we make sure we don't forget this?
Summary	Summarise the key learning points that you established	– How will you talk about this to other people?

Example of reflective learning facilitator training

One international oil and gas company has created a 50-minute online training module called *Reflective LFI engagements* (made available via the EI). The course aims to provide basic facilitation skills and instructions on how to run a reflecting session (e.g. during a meeting or toolbox talk), complete with videos of good and bad examples, information on when and how to run a session, the types of questions to ask during the session to get the team engaged (e.g. 'How can something like this happen here?'), and how to conclude the session. It also contains a short quiz and resources to help someone plan a session. The company plans for all supervisors, and in time, contractor supervisors, to undergo this training. The intent is that supervisors will make use of learning alerts and conduct short reflecting sessions, such as before starting a new or unfamiliar task.

http://heartsandminds.energyinst.org/toolkit/learning-from-incidents2

7.6 EMBEDDING AND SUSTAINING LEARNING IN AN ORGANISATION

7.6.1 Management system improvements

In an ideal world the changes that take place following an incident become embedded in an organisation so that, even if the personnel most closely associated with the incident leave the company, the improved practices are sustained. Achieving this ideal is clearly a major challenge. It is often difficult to detect the influence of incidents on a company after several years have elapsed.

Applying a risk control hierarchy that addresses plant process, equipment and workplace environment changes, as well as procedural, supervision and training changes (see 6.2.2) is one part of achieving long-term changes. In addition, embedding changes into an organisation's management systems is an important part of achieving sustained improvements and guarding against the tendency for loss of corporate memory. Table 16 provides a number of examples of long-term changes to management systems that could be expected following an incident and its investigation.

Table 16: Using LFI to improve management systems

Management system elements	Example changes to embed and sustain improvements following incidents
Training	– Incorporate lessons from incidents into training, including site induction. – Awareness training for contractors introduced into organisation-wide programmes (see case study in section 5). – Training on NTS (IOGP, Report No. 501).

Risk assessment	– Review and update risk assessments following an incident.
	– Improve the links between LFI and risk assessment, e.g.:
	  – During the early stages of an investigation find out if a relevant risk assessment has been conducted and, if it has, see if it can throw light on the sequence of events, the way the system has or has not operated and see whether any risk-reducing measures proposed by the risk assessment had been implemented.
	  – Ensure that risk assessments take account of past accidents/incidents that have happened internally to the organisation (and externally if feasible).
	  – Development of hypotheses during investigations should take account of risk assessment scenarios with similar characteristics and can use consequence modelling techniques (e.g. fire and explosion modelling) to inform hypotheses.
	  – Risk assessment methods can be used to evaluate and prioritise the recommended measures from an investigation.
	  – Sharing and exchanging personnel between investigation and risk assessment teams is beneficial both in terms of exchange of ideas on use of methodologies as well as making efficient use of time and resources.

Operating procedures	– Update relevant procedures across the organisation. – **Record the rationale behind changes to procedures/instructions** (e.g. within the document itself) so that changes arising from incidents are maintained through heightening awareness at a direct level.
Safety documentation and knowledge management	– Link LFI to continuous improvement sections of safety reports and safety cases. – Develop a database of recommendations and actions following incidents and a record of what changes were made, and why, following incidents. – Put in place systematic processes to allow people to 'pull' information prior to starting operations, but also for the company to 'push' relevant information towards relevant people (e.g. SKYbrary from the aviation industry, http://www.skybrary.aero).

The examples in Table 16 are relatively specific. In practice, an incident, and the subsequent LFI process, can reveal potential improvements across many management systems, e.g. management of change, procurement, human resources, etc. The evaluation phase of LFI can also reveal potential improvements in the learning process itself (see section 8).

7.6.2 Organisational arrangements for learning

Organisational learning in a large company will occur at different levels, for example:

- A local representative is likely to be responsible for feeding back lessons from an incident to affected personnel, contractors and other facilities on the site.
- A corporate/group/regional manager may be responsible for sharing lessons between different operating units and shaping corporate LFI policies.

Learning from incidents is no different from any other change process that companies go through, and should be viewed as the same. Too often it is considered the role of the SHEQ department to develop a separate LFI process. Organisations should take a more holistic view and look at current information-sharing networks to communicate LFI. A good example is the Engineering Network in the global airline industry. Engineers working on a particular aircraft type are in contact with each other, and learning is rapid and effective because it is delivered by peers, not by a separate SHEQ department.

Typical organisational mechanisms for encouraging learning from incidents include appointing learning 'leads' and setting up learning forums or networks. Networks and conferences play an important role as the sharing of information and agreement for actions can happen in a decentralised way. In addition, organisations should integrate incident/ LFI-related information into a knowledge-management system and look at the potential benefits of integrating or linking safety management, knowledge management and learning management systems.

Another good practice in terms of organisational learning is using more experienced employees, who have experienced LFI, to help revise and extend key procedures, manuals etc. prior to their release or retirement. Some organisations also make use of retired staff to assist in reviews of incidents (see 6.2.1).

7.7 CASE STUDIES

7.7.1 Hearts and Minds *Learning from incidents* tool

The EI has developed a practical toolkit to help organisations conduct broader learning. The tool is based upon an initial PhD research project (Lukic, Littlejohn and Margaryan, 2012) conducted at Glasgow Caledonian University, which was followed by a further study and piloting of the tool at a number of organisations working in the energy and healthcare sectors.

The tool, which is itself a booklet, contains information about the LFI process, as well as instructions for running workshop exercises exploring the LFI process as a whole, as well as exploring individual parts of the process, including conducting workshop sessions to encourage 'reflection'. The tool also includes a questionnaire and 'hints and tips' – guidance on how to improve each phase of the LFI process.

Workshop 1: the LFI process

This workshop, which lasts four hours or longer, is meant to be run occasionally (e.g. once per year) and will involve managers and others responsible for, or heavily involved in, LFI. The workshop tasks a group of people with identifying and reviewing the organisation's LFI activities and mapping these against each phase of the LFI process. The group then conducts a gap analysis to determine where the weaknesses are, such as phases where there are no activities, or where linkages between activities have been missed. A questionnaire can be distributed within the organisation to determine how well 'learning' occurs at each phase of the process, with the data used as input into the workshop. Lastly, the group prioritises a number of the problems/ gaps identified and brainstorms solutions and actions to help tackle those problems. The intent is that the workshop is used as a starting point from which to improve the LFI processes in the organisation.

Workshop 2, 3 and 4: Engagement exercises

Whereas workshop 1 is aimed more at managerial level, the remaining three workshop exercises have a more operational focus. Each workshop engages a group of people (for example frontline workers) with an incident, and focuses on a specific phase of the LFI process: workshop 2 focuses on creating 'incident alerts', workshop 3 on communication, and workshop 4 on 'reflection' (which broadly aligns with the identify lessons, communication, and receive and make sense (and additional actions) steps in Figure 21, respectively).

Workshop 2 tasks a group of participants (perhaps those who were close to an incident) with reviewing an incident report, understanding what happened and why, and creating a short 'incident alert', along with recommendations, that can then be distributed to relevant people in the organisation.

Workshop 3 tasks a group of participants with selecting an incident alert (perhaps one created in workshop 2), reviewing its quality (and in the process getting an understanding of the incident), and then brainstorming who the alert will be relevant to and what are the best ways to communicate the incident (i.e. not just through email but other formal and informal communications mechanisms).

Workshop 4 tasks a group of participants (likely a team and their supervisor) with reviewing an incident alert that has been communicated in the usual way (perhaps before beginning a new project). The facilitator (e.g. the supervisor) describes the incident, what happened and how. The team then discuss how the findings can be applied to their own work, how similar problems can happen, what barriers are in place (and how effective they are and how they can fail), what additional protections they will put in place, what processes they will do differently, and what actions they will take to ensure a similar incident doesn't happen to them.

8 LFI EVALUATION

8.1 OVERVIEW

In this section LFI evaluation is considered at two levels:

– whether effective learning has occurred following an incident (or group of incidents), and
– whether the LFI processes are adequate.

Both types of evaluation require collection and analysis of data (see Figure 23). If effective learning is deemed not to have taken place following analysis of data, additional actions should be identified and implemented to further reduce risk. Examples of such evaluation are provided in 8.2 (following a single incident) and in 8.3. (following multiple incidents). Collected data can also be used to feed KPIs relating to the LFI processes; this can help identify potential improvements in the LFI phases described in previous sections (see 8.4). Blockers and enablers applicable to evaluation are summarised in 8.5.

Evaluation could be seen as a continuous process running through the whole of LFI. For simplicity it has been shown as one phase; however, the need for evaluation after each of the steps of LFI should be addressed.

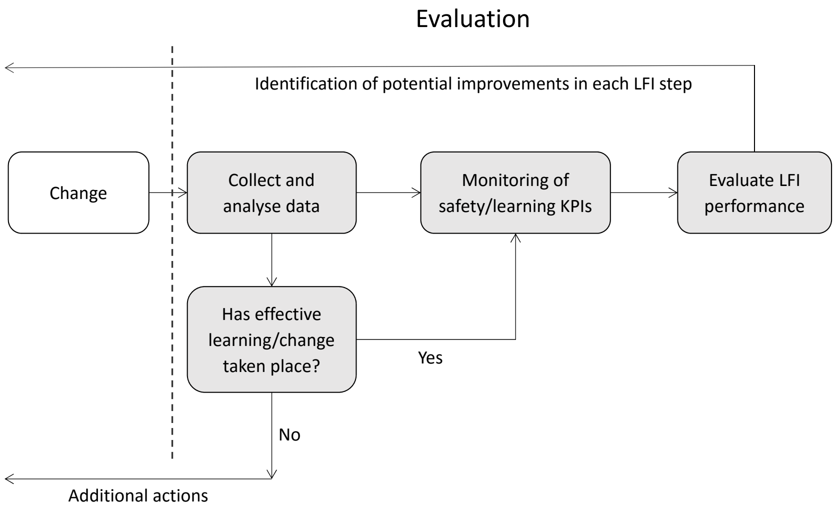

Figure 23: Evaluation Steps

8.2 DETERMINING WHETHER EFFECTIVE LEARNING HAS OCCURED FOLLOWING AN INCIDENT

The following activities should be used to help evaluate whether effective learning has occurred following an incident:

– Active reviews of whether the investigation has identified underlying causes at sufficient depth; whether the investigation tells a convincing story and whether the recommendations are being addressed in a meaningful manner (i.e. not just a 'tick-box' exercise).

– Information should be sought that an organisation has in fact gone beyond simply communicating lessons, but has identified and made organisational changes or technological changes (e.g. fitting sub-sea isolation valves after Piper Alpha). The issue of whether resource allocation has changed is a particularly salient example.
– Active measurement of whether learning has occurred via evaluation sessions such as described in the following example:

Example of how to evaluate organisational learning

Background

Following a serious maritime incident the affected shipping company initiated an investigation and put in place actions that addressed immediate and system causes (Lardner and Robertson, 2011). Following this, however, the organisation wanted to know how well broader lessons had been learnt and whether 'something like this could happen again?'. This need to test organisational learning led to the development of a scenario-based evaluation technique.

Description of method

The aim was to evaluate how well 20-30 onshore managers in the company had learnt lessons from the incident. A realistic scenario was devised which contained all the key decision-making elements of the incident but was disguised by referring to different equipment, operations and geographic location.

Embedded within the scenario were 12 key decisions and actions which were considered critical in the original incident's causation. The scenario was analysed via a series of 'organisational capability' workshops.

Outputs

The table below shows the results from the evaluation. The shaded cells represent incorrect answers and effectively identify gaps in the organisation's learning. The results showed that there were still important gaps despite the traditional means of learning lessons that the company had used.

Table 17: Group scenario responses – shaded cells indicative of gaps in organisational learning (Lardner and Robertson, 2011)

Persons	**Critical decisions**					
	1	**2**	**3**	**4**	**...**	**12**
1						
2						
3						
4						
...						
23						
Total correct	**18**	**22**	**5**	**0**	**...**	**18**

As well as helping to evaluate the organisation's learning, this method also provided an active form of learning for the participants.

8.3 COLLECTION AND ANALYSIS OF DATA ON MULTIPLE INCIDENTS

Even at the simplest level, collecting information on multiple events can provide powerful insights into whether learning has taken place. Senior personnel should be able to build up an accurate overview of events through, for example, quarterly formal reviews of incidents at one or more sites. Such simple approaches rely on having the right people involved in the review at the right frequency, rather than access to sophisticated databases. Grouping incidents with common issues can reveal that a detailed analysis ('deep dive') is required even though individual events may have been deemed of insufficient severity or risk to prompt an investigation.

Many organisations and industry bodies have put efforts into developing incident databases. Some energy stakeholders have raised the caution that there are many 'data graveyards', where significant effort has gone into developing classification schemes and taxonomies but without a well-used end product. A comprehensive user-needs-analysis should be carried out for database design, taking account of all the relevant stakeholders. If an incident database is primarily designed around the person entering the data this can lead to frustrations for those wanting to extract information, and if it is mainly designed to produce monthly reports for managers this does not necessarily promote learning.

Some classification schemes to promote consistent coding of important incident descriptors and causal factors do appear to be well-used. An example of those factors used by the IOGP is given in Table 18.

The IOGP database allows causal analysis of subsets of accidents, e.g. one can look at the dominant causal factors behind land transport accidents. This can help identify patterns of events and factors that assist identification of additional risk-reducing measures, sometimes at an industry level.

There are, however, typically limitations to data entry and coding of events. For example, a review of incidents in the European Commission's Major Accident Reporting System (MARS, first established by the EU's Seveso Directive 82/501/EEC in 1982), illustrated that the relationships between incident causes and managerial weaknesses are often not registered in the database (Drupsteen and Guldenmund, 2014). This could either be because these underlying factors were not identified in the incident investigation, they did not fit into the designated classification scheme, or they were omitted when the database entries were made. Where such categorisations are used it is good practice to use clear linkages to controls and systems that prevent incidents, rather than abstract sounding categories.

Table 18: IOGP list of causal factors (SPE/APPEA, Walker and Fraser, 2012)

People (acts) The 'people (acts)' causal factors involve either the actions of a person or actions which were required but not carried out or were incorrectly performed. There are four main categories, with an additional level of detail under each.	**Process (conditions) classifications** Process (conditions) causal factors usually involve some type of physical hazard or organisational aspect outside the control of the individual. There are four major classification categories, with an additional level of detail under each of the major categories.
Following procedures: – Violation intentional (by individual or group) – Violation unintentional (by individual or group) – Improper position (in the line of fire) – Overexertion or improper position/ posture for task – Work or motion at improper speed – Improper lifting or loading **Use of tools, equipment, materials and products:** – Improper use/position of tools/ equipment/ materials/products – Servicing of energised equipment/ inadequate energy isolation **Use of protective methods:** – Failure to warn of hazard – Inadequate use of safety systems – Personal protective equipment not used or used improperly – Equipment or materials not secured – Disabled or removed guards, warning systems or safety devices **Inattention/lack of awareness:** – Improper decision making or lack of judgement – Lack of attention/distracted by other concerns/stress – Acts of violence – Use of drugs or alcohol – Fatigue	**Protective systems:** – Inadequate/defective guards or protective barriers – Inadequate/defective personal protective equipment – Inadequate/defective warning systems/safety devices – Inadequate security provisions or systems **Tools, equipment, materials, products:** – Inadequate design/specification/ management of change – Inadequate/defective tools/ equipment/materials/products – Inadequate maintenance/inspection/ testing **Work place hazards:** – Congestion, clutter or restricted motion – Inadequate surfaces, floors, walkways or roads – Hazardous atmosphere (explosive/ toxic/asphyxiant) – Storms or acts of nature **Organisational:** – Inadequate training/competence – Inadequate work standards/ procedures – Inadequate hazard identification or risk assessment – Inadequate communication – Inadequate supervision – Poor leadership/organisational culture – Failure to report/learn from events

As an alternative to trying to code events according to pre-defined taxonomies, free text describing incidents and associated factors can be entered and then analysed using suitable tools. This type of analysis appears to be becoming more popular and can reveal useful insights as illustrated by the following example:

Example of analysis of multiple occupational injury records

A national infrastructure company analysed its extensive database of incidents to determine trends and patterns. A commercial software for generating 'word clouds' was used as one tool to analyse free text fields in batches of up to thousands of records. The software counts the occurrence of words and displays those with a high frequency as larger in the pictorial output. The example below focussed on manual handling injuries. It helped highlight the relative contribution of back injuries caused by lifting equipment into and out of vans.

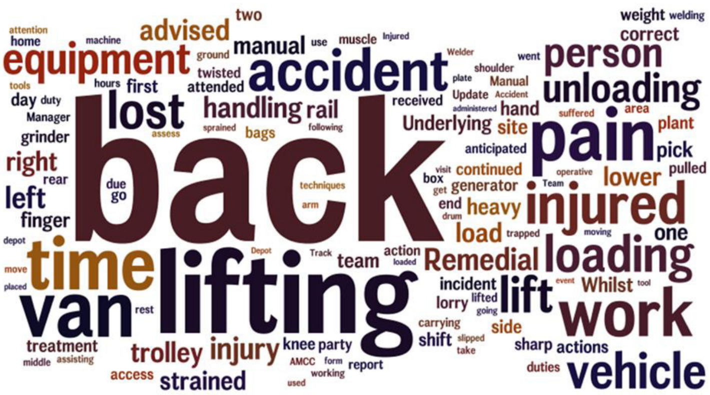

Figure 24: Example of use of word counting analysis

In addition to the example in figure 24 there are other visual ways of presenting information on multiple events. Categorising and analysing incident data by barriers enable an organisation to understand the relative strengths of their safeguards (see Figure 25). By drilling down into the weaker barriers and understanding common causal factors between multiple incidents, analysts are able to identify and propose additional measures. In addition, by studying barrier successes the analyst can learn how to sustain their strengths.

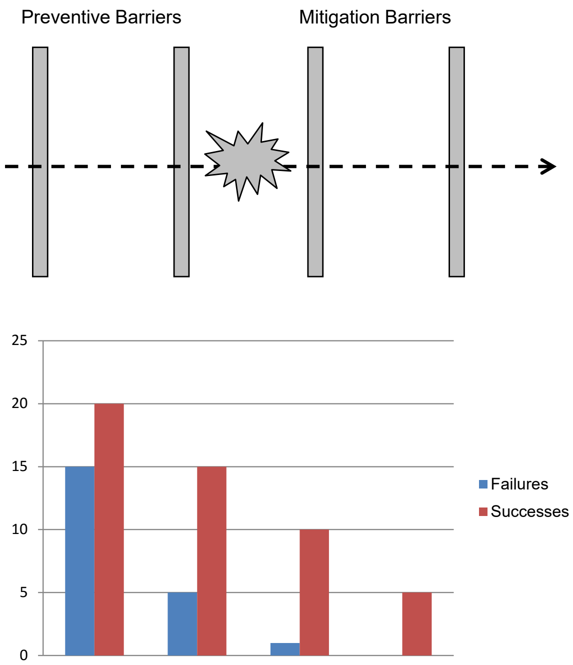

Figure 25: Relative strength of barriers

To actually reduce risk, this will involve combining the sorts of data analyses described in this section with an implementation plan of actions. The example given here illustrates how data analysis of a large number of accidents helped to identify risk-reducing measures which were then implemented with impressive life-saving benefits.

Example of data analysis to derive life-saving rules

An international oil and gas company analysed several hundred fatal accidents between 1995 and 2006 for causes and measures that could have prevented the fatality. 12 'life-saving' rules were identified which it was estimated could have prevented up to 75% of historical events if they had been fully implemented. A global campaign was launched to make all operating companies and contractors aware of these rules, involving 500 000 people in total. Non-compliance was taken very seriously and led to thorough incident investigation. The company tried to learn from all non-compliances so that initiatives were put in place to remove the causes of the violations, rather than simply focusing on the violation itself. There was strong commitment from the top of the organisation, and consistent application of the rules. Data analysis is not the solution on its own; efforts across the whole organisation were required. These led to a statistically significant reduction in injuries and fatalities with at least 30 lives saved, from an average of 37 fatal accidents per year between 2000 and 2008 down to six in 2011 (SPE/APPEA, Peuscher and Groeneweg, 2012), with sustained and continually improving performance over subsequent years.

Figure 26: Shell/IOGP life-saving rules

By analysing trends in multiple incident data, additional insights can be gained into the effectiveness of post-incident actions. However, care should be taken that statistical significance is properly accounted for.

Additional good practices related to multiple data analysis include the following:

- Use information from incident databases to inform incident investigations and add weight to investigation findings. Such data can show that an incident is not a one-off. It can also indicate that an organisation has not effectively learnt lessons before.
- If there is a small amount of data and large numbers of incident categories there could be few events in each sub-category, and then no discernable pattern. For small amounts of data, use broader categories to help ensure a statistically significant result.
- In many cases an organisation may have limited data and statistical confidence will be low. In such circumstances the best an organisation may be able to do is to conclude that 'the data suggest that. . .'. However, possible weak signals should not be dismissed and it may be possible to combine such data with expert judgements and other evidence.

- When analysing data, apply quality control checks, e.g. have they been collected in a consistent manner? Reporting levels may change over time or between different business units. Care should be taken if the data have been collected over an extended period as the relevant operations or equipment may have changed considerably.
- Tie in incident data analysis to complementary systems, e.g. staff surveys, to look for patterns.
- Apply appropriate language when presenting incident data analyses. Many people, whether on the front line or on the management board, do not engage with heavily mathematical language. There is little point presenting all this information if the decision makers do not understand it.
- Link such data analyses to risk assessment models (for example bow-tie models) to help integrate LFI with forward looking risk analysis.

8.4 EVALUATING THE EFFECTIVENESS OF LFI PROCESSES

Similar to how organisations are developing KPIs to measure the effectiveness of overall risk controls, some organisations are beginning to use measures relating to the quality of LFI processes.

Table 18 provides illustrative examples (some taken from EI *Guidance on meeting expectations of EI Process safety management framework Element 19: Incident reporting and investigation*). Many of these relate to the effectiveness of LFI processes, for example, the percentage of actions arising from investigations which are overdue. Others are related to the degree of learning that has occurred and others to the impact on risk-based measures such as incident rates or KPIs.

Table 18: Example LFI indicators

LFI phase	LFI performance indicators
Reporting	Reporting rates of near misses (categorised by severity). Number of field observation reports, e.g. tests of whether personnel are aware of reporting arrangements. Number of observed non–compliances with incident reporting arrangements. Number of confidentially reported incidents.
Investigation	% of incident investigations which have specialist investigators on teams. % of incidents which identify immediate causes, PIFs and underlying causal factors relating to organisational and managerial (O&M) factors. Incident investigation reports overdue. Observed non–compliances with incident investigation arrangements. % of incident investigations which have been peer reviewed.
Recommendations/ actions	% of open incident investigation recommendations or actions overdue. Number of recommendations per incident for a defined severity level (both excessive or too few recommendations could indicate a problem). % of recommendations relating to underlying O&M factors.
Broader learning	% of active scenario-based training sessions versus plan. % of incidents which have been converted into safety alerts or training case studies.
Evaluation	% of incidents followed-up after one year. % of actions checked for effectiveness after one year. % of incidents where LFI teams performed self-evaluations. Scores from organisational learning evaluation exercises such as described in 8.2.
Overall	Repeat incidents would be an important indicator of failing to learn lessons. Incident rates categorised by severity. KPIs versus targets (general measures of safety management system rather than LFI in particular).

As with any evaluation or measurement programme there is the potential for unintended consequences from the act of making measurements. In the case of LFI, for example, measuring could lead to the extra reporting of relatively trivial incidents which may overload the system. Overall reviews of the LFI process should be used to ensure that such problems are detected and corrected.

As well as evaluating LFI via the performance indicators in Table 18, it is also valuable to periodically step back and consider whether the overall goal of reducing risk is being delivered by the LFI system. This may require significant adaptations to the overall LFI framework rather than minor alterations to one phase.

8.5 BLOCKERS AND POTENTIAL ENABLERS FOR BROADER LEARNING AND LFI EVALUATION

Table 19 summarises what are judged to be the most significant blockers to effective broader learning and LFI evaluation, along with potential enablers.

Table 19: Blockers to effective broader learning and evaluation and potential enablers

Blockers to effective broader learning and evaluation	Enablers for broader learning and evaluation
Difficulty in identifying lessons and relevant stakeholders	– Leadership and technical review of investigations to identify lessons for wider communication. – Stakeholder identification: knowing the audience helps identify what parts of investigation/lessons will be most relevant, and also provides ideas for modes of communication.
Common methods of sharing lessons are often passive and provide over-simplified summaries lacking in context	– Make use of interactive sessions: use an incident to develop locally relevant scenarios that can be run as team sessions to identify causes and risk-reducing measures. – Train supervisors in facilitation skills to run such sessions. – Do not confuse providing access to incident information with 'learning'.
Investigation report is difficult to understand; it is a detailed account of the investigation rather than a concise report on what needs to be learnt	– Include a summary that can be readily used and shared. – Define principles/good practices that help make a report a tool for learning, e.g. use of diagrams to show where people were, photographs of area/equipment, short sentences, keeping detailed technical language/explanations in an appendix, etc.
Insufficient time or opportunities to reflect and make sense of material from investigations	– Leaders should clearly demonstrate the value placed on LFI and be prepared to allocate sufficient resources. – Build active learning sessions into schedules of safety meetings and toolbox talks.
Legal constraints on sharing incident information widely	– Legal team should be engaged early so that they can understand what is trying to be achieved with LFI and they can advise on the legal risks. There is then the opportunity to devise a process that is the best compromise of the competing concerns. – An organisation should have in place a documented and tried and tested incident response protocol incorporating legal privilege for internal investigations when appropriate, and access to legal advice in the event of an incident that is likely to give rise to criminal proceedings. – Focus on hazards rather than specific incidents in the case of communicating contentious events. – Turn lessons learnt quickly into good practice guidance, which can help others learn but without carrying the same liability risks.

Table 19: Blockers to effective broader learning and evaluation and potential enablers (continued)

Blockers to effective broader learning and evaluation	Enablers for broader learning and evaluation
Difficulties in relating to other organisations' incidents, especially when they are in a different industry	– Make use of these in safety meetings and encourage personnel to relate them to their workplace, possibly using the interactive session/scenario approach outlined in 7.4. – Convert external incident alerts into the same format as used for internal events.
Embedding change for the long term can be difficult given normal corporate memory loss	– Trend incident data over a longer term. – Use LFI-experienced employees prior to their release or retirement to help revise and extend key procedures, manuals, etc. – Ensure that the dissemination and communication activities within broader learning are developed by the organisation into embedded changes (changed plant, practices, procedures, capabilities, etc.) that effectively prevent incidents reoccurrence. – Ensure that LFI is embedded into change processes in the management system and that the rationale for the change is documented and widely understood. – Provide links between a past incident and changes, e.g. provide a reference to that incident in the rewritten procedure. – Provide a database of recommendations/actions from incidents and what changes have occurred. – Improve integration and interfaces between safety management systems and the broader organisational or industry-wide knowledge management systems. – Provide training in past accidents/incidents. – Improve the link between risk assessment and LFI (e.g. ensure that risk assessments take account of past accidents/incidents that have happened internally and externally).
Difficulty of assessing whether an organisation has learnt from an incident or a set of incidents	– Use active review and evaluation sessions such as described in 8.2. – Develop techniques for analysing multiple incidents so that patterns and common causal factors can be identified and used to generate effective risk-reducing measures and to trend risk over the longer term. – Support evaluation sessions and trend analysis with performance indicators relating to the LFI process and risk levels.

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ANNEX B
GLOSSARY OF TERMS, ABBREVIATIONS AND ACRONYMS

B.1 ABBREVIATIONS AND ACRONYMS

AAIB	Aircraft Accident Investigation Board
ALARP	as low as is reasonably practicable
APS	atmospheric pipe still
BSI	British Standards Institution
CAPEX	capital expenditure
CBA	cost benefit analysis
CCPS	Center for Chemical Process Safety
CEO	chief executive officer
CF	causal factor
CIRAS	Confidential Reporting for Safety
CSB	(US) Chemical Safety Board
EBS	emergency breathing system
EI	Energy Institute
EU	European Union
FAI	first aid injury
FRAM	functional resonance analysis method
HAZOP	hazard and operability study
HCR	hydrocarbon release (database)
HiPo	high potential (incident)
HMI	human machine interface
H(O)F	human (and organisational) factors
HOFCOM	EI Human and Organisational Factors Committee
HQ	headquarters
HSE	UK Health and Safety Executive
I	incidents
ICAO	International Civil Aviation Organization
IChemE	Institute of Chemical Engineers
IOGP	International Association of Oil and Gas Producers
IT	information technology
KPI	key performance indicator
LFI	learning from incidents
LFMA	learning from major accidents
LOC	loss of containment
LTI	lost time injury
MA(H)	major accident (hazard)
MARS	major accident reporting system
MTI	medical treatment injury
NA	not applicable
NTS	non-technical skills
O&M	organisational and managerial (factors)
OMS	operating management system
PIF	performance influencing factor
PPE	personal protective equipment
PSF	performance shaping factor

PSM	process safety management
PTW	permit to work
QA	quality assurance
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013
RSSB	Rail Safety and Standards Board
RWI	restricted work injury
SCAT	systematic cause analysis technique (superseded by barrier (B) - SCAT)
SHE(Q)	safety, health, environment (quality)
SI	serious incident
SMART	specific, measurable, attainable, relevant, time-bound
SOP	standard operating procedure
SPE	Society of Petroleum Engineers
SSIV	subsea isolation valve
STAMP	systems theoretic accident modelling and processes model
STEP	sequentially timed events plotting
STF	Stichting Tripod Foundation
TBT	tool box talk
TOR	terms of reference
UKPIA	UK Petroleum Industry Association
VSI	very serious incident
WANO	World Association of Nuclear Operators

B.2 TERMS

accident	Any unplanned event that actually results in some unwanted effect to people, the environment, assets, reputation or other business objective.
barrier	Any risk management measure which reduces the probability of a hazard being realised or reduces its consequences. Also known as control or defence.
event	An unplanned and unwanted happening involving the potential for harm or damage.
hazard	Anything with the potential for human injury or adverse health, damage to assets or environmental impact. See *risk* and *risk assessment.*
human error	System failures attributable to people but not including *violations*.
human failure	A term used to collectively refer to both errors and violations.
human-machine system	A system in which technology and human beings have specific functions but work together towards common goals.
immediate cause (of an incident)	An action or omission by a person, or group of people, that causes a barrier to fail. An immediate cause occurs close to the failed barrier in time, space or causal relationship and negates the barrier.
incident	An event, or chain of events, which cause, or could have caused injury, illness and or damage (loss), e.g. to people, assets, the environment, a business or third parties.

lapse	When a person forgets to do something due to a failure of attention/concentration or memory.
legal privilege	Relates to protection that may be applied to the disclosure of communications between a professional legal adviser (a solicitor, barrister or attorney) and their clients.
major accident hazard	Hazards with the potential for major accident consequences, e.g. ship collisions, dropped objects, helicopter crashes as well as process safety hazards. Major accidents are potentially catastrophic and can result in multiple injuries and fatalities, as well as substantial economic, property, and environmental damage.
mistake (synonymous with cognitive error)	When a person does what they meant to do, but should have done something else. This is not necessarily a *violation* but part of the action taken could involve rule-breaking or similar non-compliances.
near miss	An event, or chain of events, which could have caused injury, illness and or damage (loss), e.g. to people, assets, the environment, a business or third parties.
non-compliance	See *violation*. Also called non-conformance.
performance influencing factor (PIF)	The detrimental influences on people, and their resulting state of mind, that increase their likelihood of inadequate performance. Also termed performance shaping factor (PSF) or precondition.
risk	The level of risk is determined from a combination of the likelihood of a specific undesirable event occurring and the severity of the consequences (i.e. how often is it likely to happen, how many people could be affected and how bad would the likely injuries or ill health effects be?). The likelihood of human injury or adverse health, damage to assets or environmental impact from a specified hazard. Note that other risk definitions include a reference to the severity of the consequences – injury, damage etc. See *hazard* and *risk assessment*.
risk assessment	The process of assessing the risk of exposure to a particular hazard in a specified activity. See *hazard* and *risk*.
safety critical system	Any part of an installation whose failure could contribute substantially to a major accident or whose purpose is to prevent or limit the effects of such accidents.
slip	When a person does something but not what they meant to do.
underlying cause (of an incident)	The organisational deficiency or anomaly creating the PIF that caused or influenced the commission of an immediate cause.

violation (synonymous with circumvention)	A type of human failure when a person decided to act without complying with a known rule, procedure or good practice. The word may have connotations of wrongdoing and alternatives such as *non-compliance* or circumvention are also used.

Note: organisations differ widely in their use of some of these terms, for example, the words 'incident' and 'accident' are often used to mean the same type of event. In this publication (for brevity), where the word 'incident' is used on its own, unless otherwise stated, it should be taken to refer to an incident or an accident.

ANNEX C
PERFORMANCE INFLUENCING FACTORS

Table C.1: Performance influencing factors *(adapted from HSE Core Topic 3: Identifying human failures)*

Job factors
– Clarity of signs, signals, instructions and other information – System/equipment interface (labelling, alarms, error avoidance/ tolerance) – Difficulty/complexity of task – Routine or unusual task – Divided attention – Procedures inadequate or inappropriate or unavailable – Preparation for task (e.g. permits, risk assessments, checking) – Time available/required – Tools appropriate for task – Communication, with colleagues, supervision, contractor, other – Working environment (noise, heat, space, lighting, ventilation)
Person factors
– Physical capability and condition – Fatigue (acute from temporary situation, or chronic) – Stress/morale – Work overload/ underload – Competence to deal with circumstances – Motivation vs. other priorities
Organisation factors
– Work pressures e.g. production vs. safety – Level and nature of supervision / leadership – Communication – Staffing levels – Peer pressure – Clarity of roles and responsibilities – Consequences of failure to follow rules/procedures – Effectiveness of organisational learning (learning from experiences) – Organisational or safety culture, e.g. 'everyone breaks the rules' – Change management

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