INSPECTORS TOOLKIT

Human factors in the management of major accident hazards

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Contents

Section 1: Aim of the guidance

BACKGROUND

Human factors is a relatively new area for many companies. The lack of a clear understanding of the issues means that companies often do not include human factors in their safety management system (SMS). Some aspects of human factors have always received attention e.g. training (although often without targeting the competencies required for the control of major accident hazards) but they have rarely been deliberately managed as part of an integrated SMS or with the rigour that their contribution to the risk requires.

Previous HSE research (RR149/2003) indicates that HSE is viewed as a credible source of advice and that companies are receptive to the concept of human factors to the point that it is perceived as being "an essential part of major accident prevention".

The lack of effective management of human factors has been a contributory factor in the causes of many major accidents including Piper Alpha, Esso Longford, Zeebrugge, Ladbroke Grove, Texaco Milford Haven, Chernobyl, Bhopal and Grangemouth (see Appendix 1 for details).

Section 2: Planning and undertaking the inspection

How to use this guidance

This guidance is **not** intended to be read from cover-to-cover, start-to-finish. Rather it is intended as a set of structured working notes introducing human factors at major hazard sites, some of the key topics within the subject and outlining how these can be examined at the sites.

Similarly the question sets included in this guidance do not need to be completed fully for each and every question. For many of the topics a selection of the questions will be sufficient and the more detailed elements only required in some cases.

Included within this guidance are the following sections:

- **Section 1:** aims of the guidance.
- **Section 2:** how to use the document, selecting the topic(s) to be examined, planning and undertaking the visit.
- **Section 3:** introduction to human factors, including types of human error and likely problems.
- **Sections 4 – 6:** information on ten topics (core, common and specific) including an introduction, key points to examine, guidance on good practice, enforcement steer and where to go for further guidance. Also included for each topic is a question set.
- **Section 7:** details of the human factors guidance available.
- **Section 8:** glossary explaining some of the key human factors terms.
- **Appendix:** Human factors and Major Hazards.

Why examine Human Factors?

Human factors have a very wide scope in major hazard work – often referred to as 'the thread' that runs through the safety management system, the organisation for safety, and the culture of a site.

Studies have shown that up to 90% of accidents are attributable to some degree to human failures. Appendix 1 illustrates how the failure of people at many levels within an organisation can contribute to a major disaster. For many of these major accidents the human failure was not the sole cause but one of a number of causes, including technical and organisational failures, that led to the final outcome. It is also worth noting that the prevention of major accidents depends to a large degree upon human reliability at all COMAH sites, no matter how automated.

Which topic?

Human factors is often seen as a rather nebulous concept and so it is convenient to break the subject down into a series of discrete topics. The topics chosen for inclusion in this project have emerged from the experience of the Human Factors Team, over a number of years, as those which have most often been raised by Regulatory Inspectors as requiring specialist input. Failures in these areas are also often identified as being important contributory factors in the causes of major accidents. These topics have been accepted by industry as the key ones for which improvements are needed. The topics range from broad, high level issues e.g. staff competence, to those covering detailed specific subjects e.g. fatigue risks and alarm handling.

Some direction can be given to assist Inspectors in deciding which topics will be of most benefit to examine at a specific site, but due to the wide range of topics, and of sites, this guidance cannot be prescriptive.

There are four core topics which are likely to be fundamental to all sites (the Level 1 topics) with a further four topics expected to be common to most sites (Level 2 topics). The remaining topics (Level 3), although important, will only be applicable to selected sites and at certain times in the longer-term business cycle.

Level 1: Core topics		
1.1	Competence assurance	*Fundamental to good human factors arrangements at all sites*
1.2	Human factors in accident investigation	
1.3	Identifying human failure	
1.4	Reliability and usability of procedures	
Level 2: Common topics		
2.1	Emergency response	*Relevant human factors subjects at most sites*
2.2	Maintenance error	
2.3	Safety critical communications	
2.4	Safety culture	
Level 3: Specific topics		
3.1	Alarm handling and control room design	*Important human factors issues but only for some sites at some times*
3.2	Managing fatigue risks	
3.3	Organisational change and transition management	

The inspection of one or two of the Level 1 topics will, at any site, provide a good insight into their ability to manage human factors issues.

It is recommended that if little is known about the current situation at a site then it is most appropriate to examine Level 1 topic(s). The choice of a Level 2 topic would normally be based on some intelligence about the topics relevant to the site. Level 3 topics should be considered when intelligence is available to show that the topic is relevant at this time e.g. it is known that the site intends to reduce staffing levels on a plant or concerns from Trade Unions about fatigue from poor shift patterns.

The choice of which topic to examine will be based on the nature of the activity at the site and the level of process automation, e.g. with highly technical automated plant then topics such as emergency response or alarm handling will be critical, but for those with a high level of manual operations, such as some batch reactors, then reliable procedures and good communications will be more relevant. When choosing the topic(s) the key is to identify how the site prevents major accidents and the role people have in these systems.

Planning an inspection

The overall process of planning and undertaking the site inspection is shown in Figure 2.

Pre-visit documentation

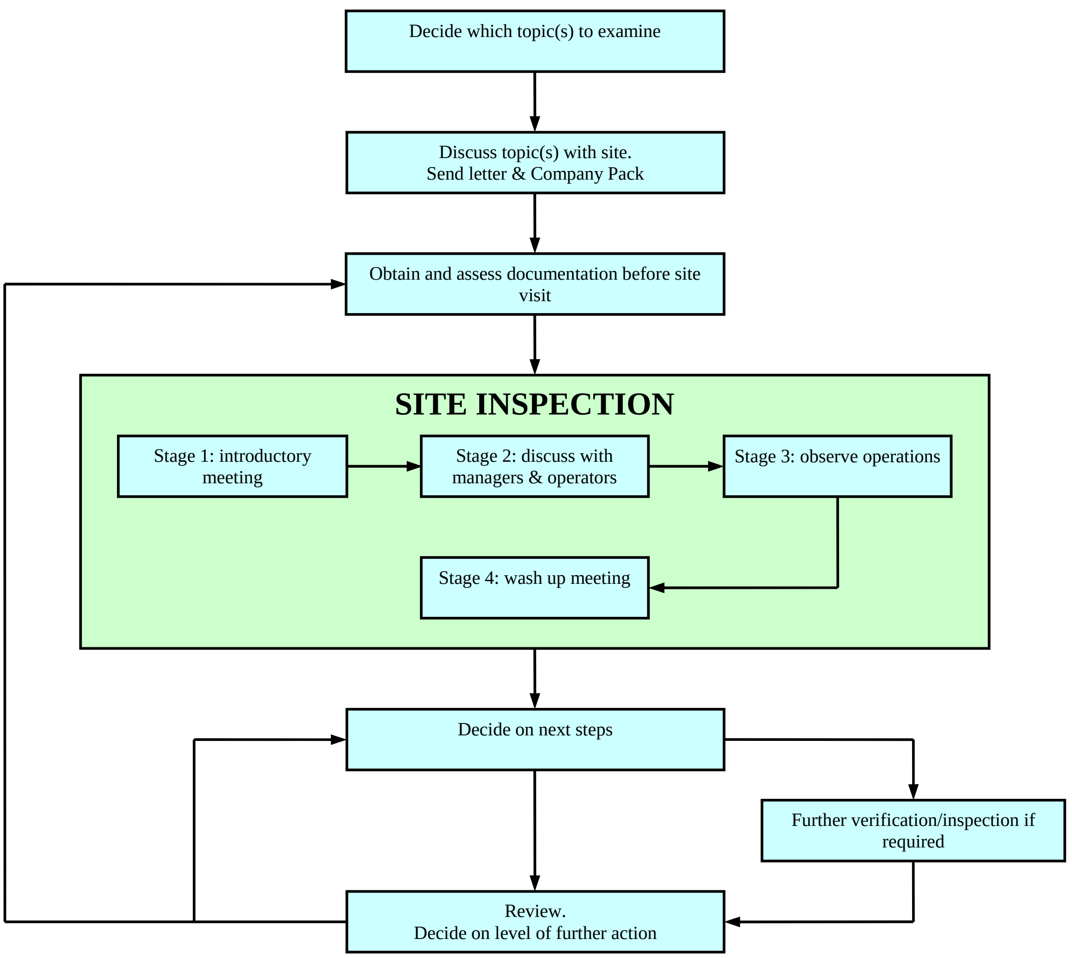
It would be useful for the site to provide copies of the following documents approximately one month prior to the visit for assessment by the Inspector:

- The site's Major Accident Prevention Policy,
- Any risk assessments relevant to the human factors topic(s) to be examined,
- Any other documents relevant to the human factors topic(s) to be examined,
- Any other documents that demonstrate the consideration of human factors issues in the site's safety management system.

In addition to the general documents listed above there is likely to be specific documents for the topic(s) being examined. Guidance on the types of documentation to request prior to the visit are contained in the individual topic sections.

It would be expected that the site visit would follow a similar structure to an audit visit, although over a much compressed time period, that is, the visit would have the following stages, represented in Figure 2.

Figure 2: Inspection planning



Stage 1: meeting with site management team to explain the purpose of the visit, introduce the subject of human factors and the topic(s) to be examined and to answer any questions the site may have.

Stage 2: discussions with the appropriate line managers and operators to find out the level of understanding of the topics at the site, to examine how they have attempted to implement control measures and to assess how successful these appear.

Stage 3: if appropriate to the topic(s) being examined, to inspect what occurs in practice e.g. if examining procedures, to observe a task occurring or if examining alarm handling then to get the control room staff to talk you though the monitor screens, mimics, alarm logs etc.

Stage 4: a wash-up meeting to explain our findings and to discuss what action is now required. The site may be asked to produce a timed action plan to not only improve the management of the topic(s) examined during the visit, but also to plan a longer term improvement in human factors, for example by examining other topics included in this guidance. If the meeting does not include a TU Safety Representative then a separate meeting will be needed to explain the findings to them.

Figure 4 can be used to assist in deciding and recording the level of management of human factors at the site – the site is rated from 0 to 4 on each of the five components of the management system.

Figure 4: What is your impression of the management of human factors at this site, judging by this inspection?

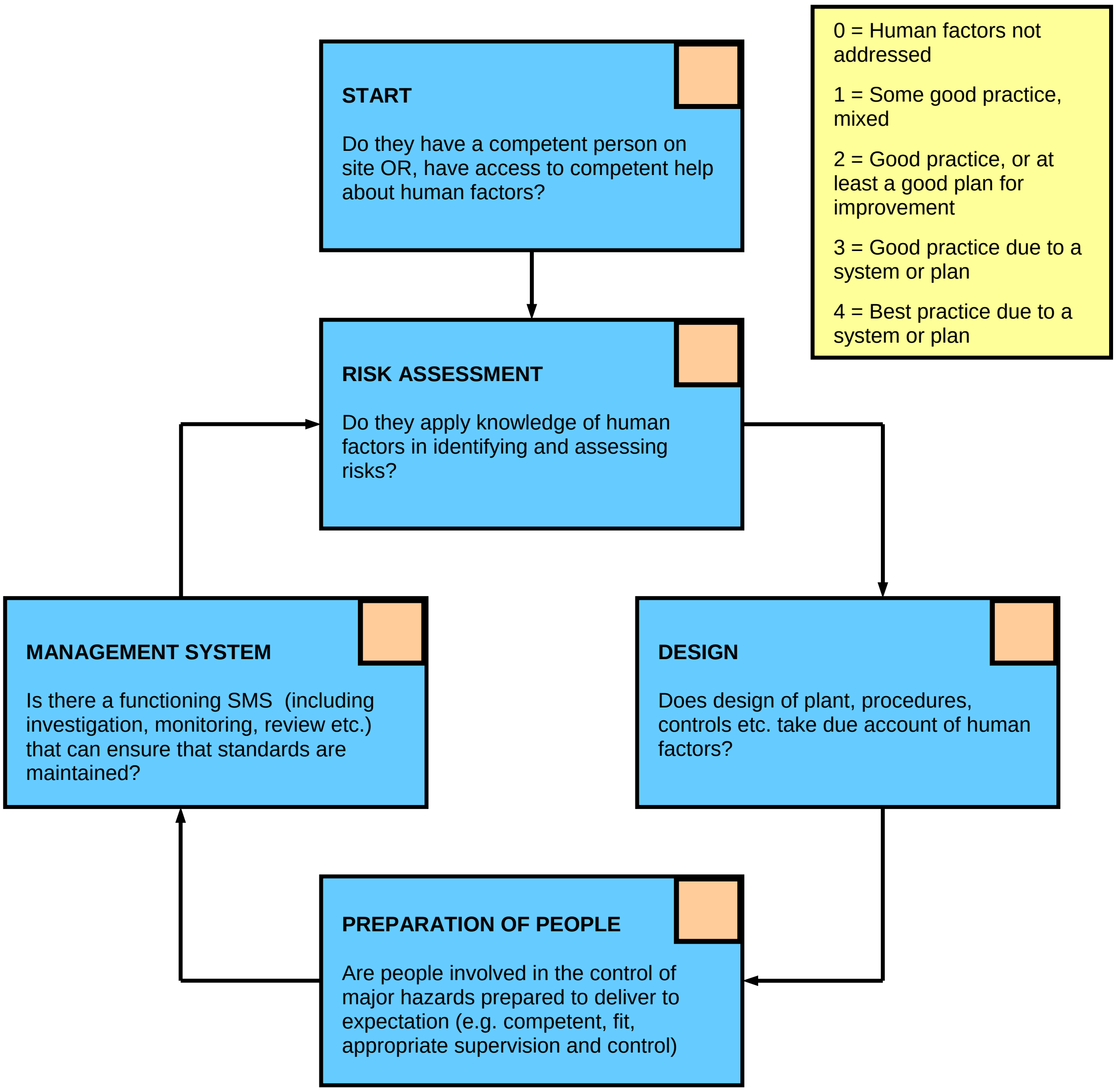
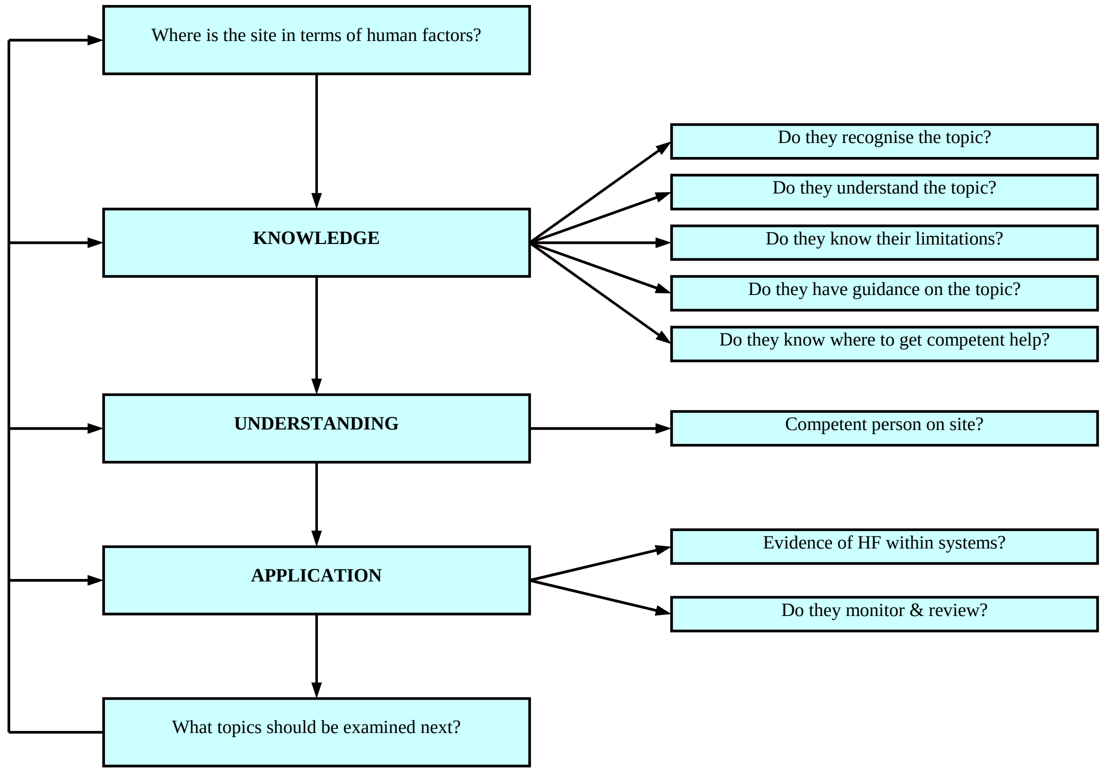


Figure 3: Assessment of 'Human Factors Maturity' at the site



ACTION	PRIORITY 1= must do, or take equally effective action 2 = recommended action
NEXT STEPS	
LONGER TERM ACTIONS	

Proportionality of the measures

When examining any of the human factors topics discussed in this guidance it is important to remember the principle of proportionality. If a site, even a major hazard one, is simple and straight forward, for example the bulk storage of LPG (without cylinder filling) in an isolated location, then the arrangements in place to manage the topics should similarly be simple. For more complex sites, for example chemical manufacture using very toxic gases, these will require more in depth, robust and well structured arrangements.

Enforcement considerations

The options for enforcement should be in accordance with the HSC enforcement policy and supported by the Enforcement Management Model (EMM). The HID Human Factors Team has carried out a substantial number of field visits and provided associated support for advice and enforcement (including expert witness work to support prosecutions). There has also been significant field activity on human factors topics.

Areas where notices have been successfully used by Regulatory Inspectors with support from the Human Factors Team include: organisational change, hours of work, workload and staffing, competency assurance and human factors risk assessment for batch reaction processes. There have been no appeals on notices issued to date.

Typically, enforcement should be considered (following EMM principles where appropriate for MAHs) where there is:

- A significant risk gap between the relevant necessary measures and standards for controlling or implementing them;
- An actual risk of recurrence of human failure following an incident (or near miss);
- Evidence of a potential serious risk from a human factors issue which could lead to an incident;
- Awareness and expertise is lacking on site to deal with a substantive human factors issue where a significant risk gap has been identified.

Section 3: Introduction to human factors

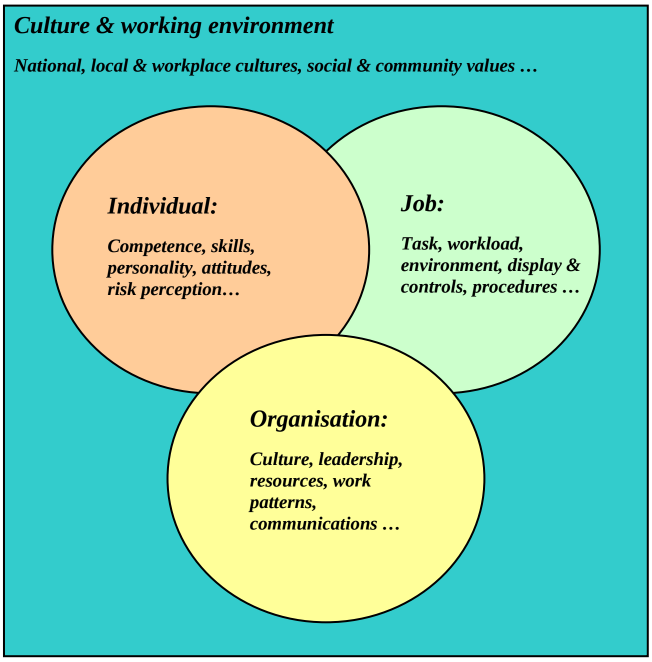
What we mean by human factors

Reducing error and influencing behaviour (HSG48) is the key document in understanding HSE's approach to human factors. It gives a simple introduction to generic industry guidance on human factors, which it defines as:

> *'Human factors refer to environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety'*

This definition includes three interrelated aspects that must be considered: the job, the individual and the organisation:

- **The job**: including areas such as the nature of the task, workload, the working environment, the design of displays and controls, and the role of procedures. Tasks should be designed in accordance with ergonomic principles to take account of both human limitations and strengths. This includes matching the job to the physical and the mental strengths and limitations of people. Mental aspects would include perceptual, attentional and decision making requirements.



- **The individual**: including his/her competence, skills, personality, attitude, and risk perception. Individual characteristics influence behaviour in complex ways. Some characteristics such as personality are fixed; others such as skills and attitudes may be changed or enhanced.

- **The organisation**: including work patterns, the culture of the workplace, resources, communications, leadership and so on. Such factors are often overlooked during the design of jobs but have a significant influence on individual and group behaviour.

In other words, human factors is concerned with what people are being asked to do (the task and its characteristics), who is doing it (the individual and their competence) and where they are working (the organisation and its attributes), all of which are influenced by the wider societal concern, both local and national. People are involved in the working system because of a number of strengths: for example, versatility in providing a link between a number of tasks, knowledge and judgement, ease of communicating with and eliciting a response. Hence, human acts and omissions can play a role in the initiation, mitigation, escalation and recovery phases of an incident.

Human factors interventions will not be effective if they consider these aspects in isolation. The scope of what we mean by human factors includes organisational systems and is considerably broader than traditional views of human factors/ergonomics. Human factors can, and should, be included within a good safety management system and so can be examined in a similar way to any other risk control system.

Categorising human failure

It is important to remember that human failures are not random; there are patterns to them. It is worth knowing about the different failure types because they have different causes and influencing factors and as a consequence the ways of preventing or reducing the failures are similarly different.

There are three types of human failures (unsafe acts) that may lead to major accidents:

Unintentional errors:

- **Errors (slips/lapses)** are “actions that were not as planned” (unintended actions). These can occur during a familiar task e.g. omissions like forgetting to do something, which are particularly relevant to repair, maintenance, calibration or testing. These are unlikely to be eliminated by training and need to be designed out.

e.g. changing down into 3rd gear when you intended (correctly) to change up into 5th.

- **Mistakes** are also errors, but errors of judgement or decision-making (“intended actions are wrong”) - where we do the wrong thing believing it to be right. These can appear in situations where behaviour is based on remembered rules or familiar procedures or unfamiliar situations where decisions are formed from first principles and lead to misdiagnoses or miscalculations. Training is the key to avoiding mistakes.

e.g. making a poor judgement when overtaking, leaving insufficient room to complete the manoeuvre in the face of oncoming traffic.

Intentional errors:

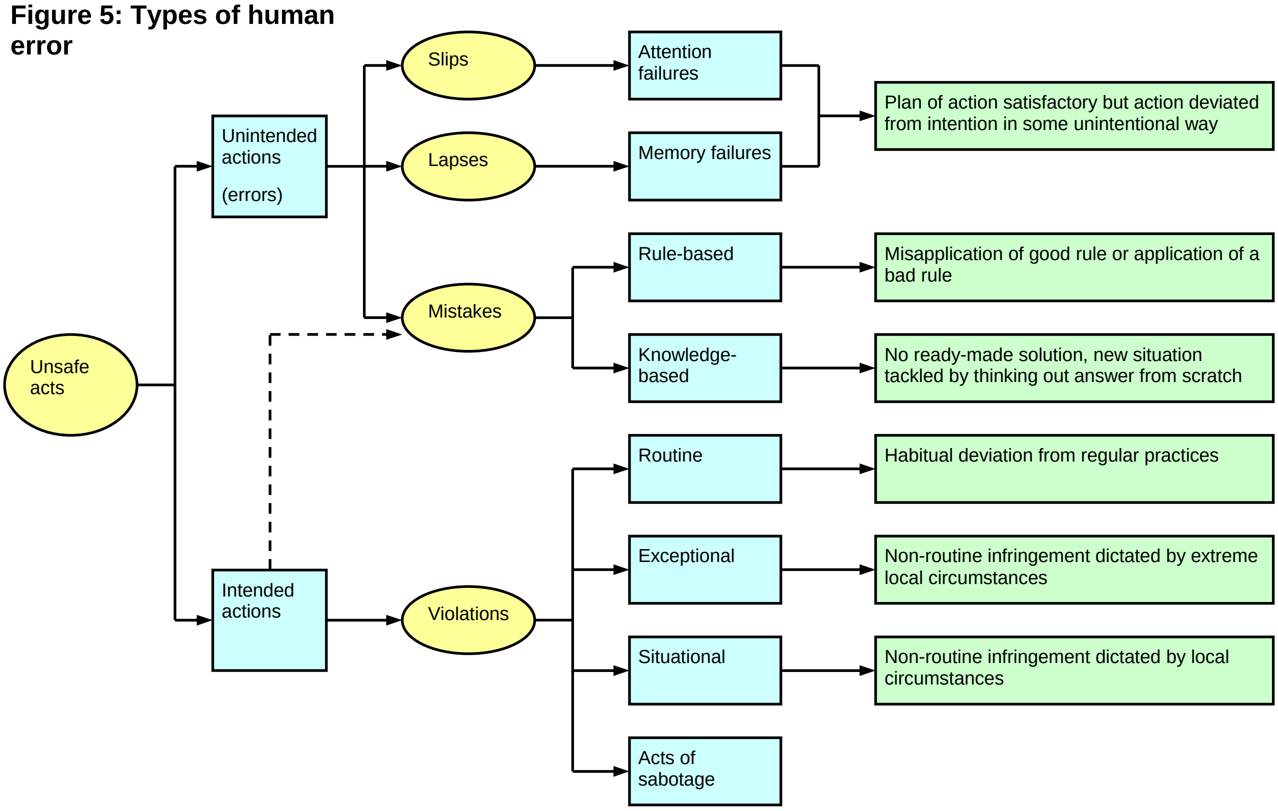
- **Violations** differ from the above in that they are intentional (but usually well-meaning) failures, such as taking a short-cut or non-compliance with procedures e.g. deliberate deviations from the rules or procedures. They are rarely wilful (e.g. sabotage) and usually result from an intention to get the job done despite the consequences. Violations may be situational, routine, exceptional or malicious as outlined below.

e.g. speeding when you are late for an appointment.

- **Routine violations:** a behaviour in opposition to a rule, procedure, or instruction that has become the normal way of behaving within the person's peer/work group.
- **Exceptional violations:** these violations are rare and happen only in unusual and particular circumstances, often when something goes wrong in unpredicted circumstances e.g. during an emergency situation.
- **Situational violations:** these violations occur as a result of factors dictated by the worker's immediate work space or environment (physical or organisational).
- **Acts of sabotage:** these are self explanatory although the causes are complex - ranging from vandalism by a de-motivated employee to terrorism.

There are several ways to manage violations, including taking steps to increase their detection, ensuring that rules and procedures are relevant/practical and explaining the rationale behind certain rules. Involving the workforce in drawing up rules increases their acceptance. Getting to the root cause of any violation is the key to understanding and hence preventing the violation.

Figure 5: Types of human error



The likelihood of these human failures is determined by the condition of a finite number of 'performing influencing factors', such as distraction, time pressure, workload, competence, morale, noise levels and communication systems. Given that these factors influencing human performance can be identified, assessed and managed, potential human failures can also be predicted and managed. In short, human failures are not random events.

The key message here is that human errors and rule breaking are largely predictable and therefore, can be identified and, most importantly, managed. We seek to encourage industry to tackle error reduction in a structured and proactive way, with as much rigour as the technical aspects of safety and make it an integrated part of their safety management system.

Managing human failures – common pitfalls

There is more to managing human failure in complex systems than simply considering the actions of individual operators. However, there is obvious merit in managing the performance of the personnel who play an important role in preventing and controlling major incidents, as long as the context in which this behaviour occurs is also considered.

There are several mistakes that major hazard sites commonly make when assessing human performance. These include:

- Treating operators as if they are superhuman, able to intervene heroically in emergencies,
- Providing precise probabilities of human failure (usually indicating very low chance of failure) without documenting assumptions/data sources,
- Assuming that an operator will always be present, detect a problem and immediately take appropriate action,
- Assuming that people will always follow procedures,
- Stating that operators are well-trained, when it is not clear how the training provided relates to major accident hazard prevention or control and without understanding that training will not effect the prevention of slips/lapses or violations, only mistakes,
- Stating that operators are highly motivated and thus not prone to unintentional failures or deliberate violations,
- Ignoring the human component completely, failing to discuss human performance at all in risk assessments, leading to the impression that the site is unmanned,
- Inappropriate application of techniques, such as detailing every task on site and therefore losing sight of targeting resources where they will be most effective,
- Producing grand motherhood statements that human error is completely managed (without stating exactly how).

Managing human failures – three serious concerns

The misconceptions discussed above can be summarised into three areas of concern, where major hazard sites do not adequately address human factors issues, which are:

Concern 1: An imbalance between hardware and human issues and focusing only on engineering ones,

Concern 2: Focussing on the human contribution to personal safety rather than to the initiation and control of major accident hazards and

Concern 3: Focussing on 'operator error' at the expense of 'system and management failures'.

Concern 1: hardware vs human issues and the focus on engineering

Despite the growing awareness of the significance of human factors in safety, particularly major accident safety, the focus of many sites is almost exclusively on engineering and hardware aspects, at the expense of 'people' issues.

For example, a site may have determined that an alarm system is safety-critical and have examined the assurance of their electro-mechanical reliability, but they then fail to address the reliability of the operator in the control room who must respond to the alarm. If the operator does not respond in a timely and effective manner then this safety critical system will fail and therefore it is essential that the site addresses and manages this operator performance.

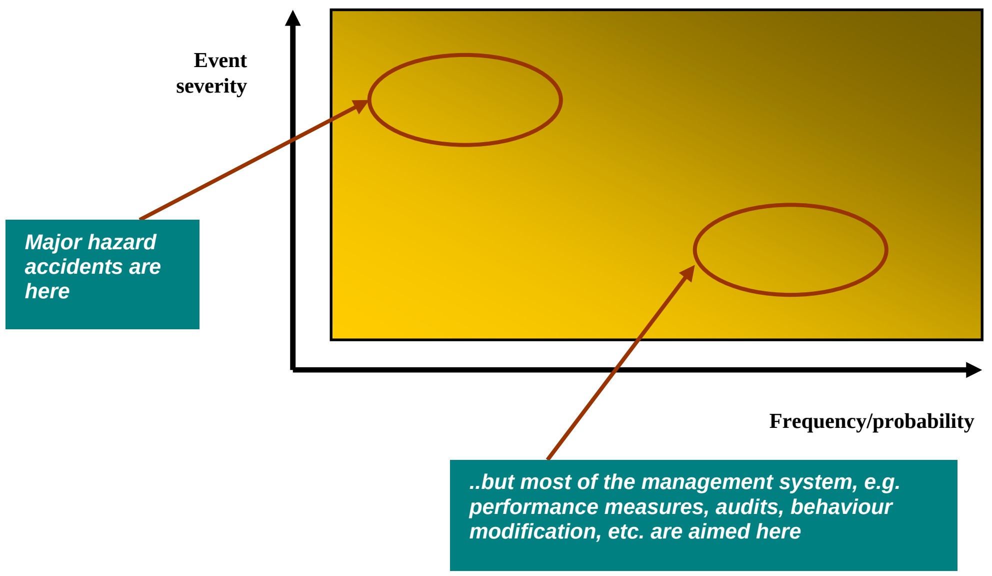
Due to the 'ironies of automation'[1], it is not possible to engineer-out human performance issues. All automated systems are still designed, built and maintained by human beings. For example, an increased reliance on automation may reduce day-to-day human involvement, but increases maintenance, where performance problems have been shown to be a significant contributor to major accidents (see reference 15).

Furthermore, where the operator moves from direct involvement to a monitoring and supervisory role in a complex process control system, they will be less prepared to take timely and correct action in the event of a process abnormality. In these infrequent events the operator, often under stress, may not have 'situational awareness' or an accurate mental model of the system state and the actions required.

Concern 2: focus on personal safety

There needs to be a distinct focus in the management system on major hazard issues, as the following diagram shows what is often the case:

Figure 6: Major accident vs personnel safety



[1] Bainbridge, L. (1987). Ironies of automation. In New Technology and Human Error. Edited by Rasmussen, J., Duncan, K. & Leplat, J. John Wiley and Sons Ltd.

The majority of major hazard sites still tend to focus on occupational safety rather than on process safety and those sites that do consider human factors issues rarely focus on those aspects that are relevant to the control of major hazards. For example, sites consider the personal safety of those carrying out maintenance, rather than how human errors in maintenance operations could be an initiator of major accidents. This imbalance runs throughout the safety management system, as displayed in priorities, goals, the allocation of resources and safety indicators.

For example, 'safety' is measured by lost-time injuries, or LTIs. The causes of personal injuries and ill-health are not the same as the precursors to major accidents and are not an accurate predictor of major accident hazards, which may result in sites being unduly complacent. Notably, several sites that have recently suffered major accidents demonstrated good management of personal safety, based on measures such as LTIs. Therefore, the management of human factors issues in major accidents is different to traditional safety management.

In his analysis of the explosion at the Esso Longford gas plant, Hopkins (2000)[2] makes this point very clearly:

> *"Reliance on lost-time injury data in major hazard industries is itself a major hazard."* and,
>
> *"An airline would not make the mistake of measuring air safety by looking at the number of routine injuries occurring to its staff".*

Clearly, a safety management system that is not managing the right aspects is as effective in controlling major accidents as no system at all.

Performance indicators more closely related to major accidents may include the movement of a critical operating parameter out of the normal operating envelope. The definition of a parameter could be quite wide and include process parameters, staffing levels or the availability of control/mitigation systems. Many performance indicators will be site specific but examples are given below:

- Effectiveness of the training program;
- Number of accidental leakages of hazardous substances;
- Environmental releases;
- Process disturbances;
- Activations of protective devices;
- Time taken to detect and respond to releases;
- Response times for process alarms;
- Process component malfunctions;

e.g. if there is frequent operation of a pressure relief valve then cause of the pressure rise needs to be established and action taken

[2] Hopkins, A. (2000). Lessons from Longford: The Esso Gas Plant Explosion. CCH Australia Ltd

- Number of outstanding maintenance activities;
- Maintenance delays (hours);
- Frequency of checks of critical components;
- Number of inspections/audits;
- Emergency drills;
- Procedures reviews;
- Compliance with safety critical procedures;
- Staffing levels falling below minimum targets;
- Non-compliance with company policy on working hours.

e.g. is the maintenance of safety critical equipment being undertaken as planned and if not what is done about it.

e.g. are the right drills being carried out in the right places, do they cover suitable scenarios, are all shifts involved, etc.

It is critical that the performance indicators should relate to the control measures outlined by the site risk assessment. Furthermore, they should measure not only the performance of the control measures, but also how well the management system is monitoring and managing them.

The Esso Longford report discussed above contains a particularly insightful section on the use, and misuse, of performance indicators at a major hazard site.

Concern 3: focus on the front-line operator

In general, most safety activities in complex systems are focussed on the actions and behaviours of individual operators – those at the sharp end. However, operators are often 'set up' to fail by management and organisational failures, a point adeptly made by Reason (1990)[3]:

> *"Rather than being the main instigators of an accident, operators tend to be the inheritors of system defects created by poor design, incorrect installation, faulty maintenance and bad management decisions. Their part is usually that of adding the final garnish to a lethal brew whose ingredients have already been long in the cooking"*
>
> (Reason, *Human Error,* 1990)

Following the investigation of major incidents, it has become increasingly clear that the role of management and organisational factors must be considered, rather than placing responsibility solely with the operator. However, audits rarely consider issues such as the quality of management decision making or the allocation of resources. Furthermore, "safety culture" is seen as being something that operators have and it has been found, following the investigation of major accidents, that management have not acknowledged that the development and maintenance of a safe culture lie within the bounds of their responsibility.

[3] Reason, J. (1990). Human Error. Cambridge University Press, Cambridge. ISBN 0 521 31419 4.

> "*If culture, understood here as mindset, is to be the key to preventing major accidents, it is management culture rather than the culture of the workforce in general which is most relevant. What is required is a management mindset that every major hazard will be identified and controlled and a management commitment to make available whatever resources are necessary to ensure that the workplace is safe*."
>
> (Hopkins, *Lessons from Longford*, reference 2)

Feedback from audits carried out by the Human Factors Team on major hazard sites often reveals areas that require attention in the management system which have not been identified (or reported) in previous audits. Audits of management systems frequently fail to report bad news. For example, following the Piper Alpha offshore platform fire it is reported that numerous defects in the safety management system were not picked up by company auditing. There had been plenty of auditing, but the inquiry reported that:

> "*It was not the right quality, as otherwise it would have picked up beforehand many of the deficiencies which emerged in the inquiry*"
>
> (B Appleton, *Piper Alpha,* 1994)

Clearly, in addition to the performance of operators on specific tasks, there is also a human dimension to the decisions made and actions taken in the management of safety itself (for a fuller discussion, see Hurst, 1998[4]).

[4] Hurst, N.W. (1998). Risk assessment: The human dimension. Royal Society of Chemistry. Cambridge. ISBN 0 85404 554 6

Section 4: Core topics

Core topic 1: Competence assurance

Introduction

The key issue for sites is to consider the competence of staff in relation to the control of MAHs and how this is identified, assessed and managed as part of a competence assurance system. When designing a competency system the sites need to be clear about what part people play in the prevention of major accidents and what part training and competency play in this. MAH competency needs to be appropriately linked to the MAH hazard and risk analysis and key procedures. The aim is to assure safety critical tasks, and associated roles and responsibilities.

Key areas to examine

- *Focus on MA prevention:* competency arrangements shouldn't just be aimed at personal safety issues or 'one off' COMAH training. The site should be clear about the part that people play in the prevention of major accidents and the part that training and competency play in this.
- *Competency for all roles:* competency for MA prevention is necessary at all levels of the organisation, not just the front line.
- *Standards:* there should be standards set for competency at all levels, and these should be site and process/job specific.
- *NVQ/SVQs:* the role and scope of SVQ/NVQs is often not properly understood and operators may assume that completion of generic VQs is sufficient for competency. There will always be gaps at site/process level which need to be addressed by more specific training even for tailored VQs.
- *Procedures:* competency and training arrangements need clear links to safety critical procedures.
- '*On-the-job' training:* this should be as well-structured as the theory/process training and with specific links to MA prevention. Trainees need specific training/learning objectives (e.g. in a training plan) for this.
- *Resourcing:* training is often under-resourced and competency may not seen as an ongoing activity.
- *Foreseeable operational modes:* training is required not just for normal operation but also for abnormal/upset, emergency and maintenance conditions. These less frequent events may need more rigorous, training and competency arrangements than for day-to-day operations.
- *Competency includes experience:* after formal training staff may be deemed 'competent', but to become fully competent they need to use the training and to become comfortable and confident with it, i.e. what we really mean when we say competent includes adequate experience.
- *Proportionality:* assessment of the training needs to be proportionate to the hazards and risks concerned (e.g. by use of adequate testing, passmarks, performance checks) and verification needs to be made.

- *Validation and Evaluation:* training also needs to be adequately validated ('Did this training deliver what it was supposed to?'), evaluated ('Is this the right kind of training for our needs?') and recorded.
- *Trainers and assessors:* they need to be trained in their roles, and, equally importantly, they need to be credible (experienced, knowledgeable and with sufficient process understanding) to the workforce.
- *Reassessment and refresher training:* arrangements should be in place to check and monitor task performance, reassess competence in key areas and provide appropriate refresher training.

Inspection points:

- Assess documentation and records.
- Talk to trainers and assessors, and new employees (operators) or those in training.
- Focus on safety critical tasks & key MAH roles.
- Ask how on-the-job (i.e. process/job-specific) training is structured.
- Work with existing training department if possible to encourage ownership, ongoing commitment and in-house expertise.
- Are there standards for competency at all levels, and that are site and process/job-specific?
- Ask about how range of training needs covered e.g. normal, upset, emergency and any use of simulators (for complex plant and upsets).
- Consider maintenance & technical training.
- Quality of the trainers.
- The role of refresher training.
- Site's auditing themselves on the effectiveness of the training arrangements.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
    - Training records for a selection of personnel involved in the control of MAH
    - Records of audit/review of the competency assurance system.

Enforcement and advice

- The HID approach should focus on ensuring there is a thorough understanding and analysis of the MAH elements of the job and tasks concerned, and that these are linked to training. In general we are looking for evidence that:
    - There is a structured and continuous process in place which is firmly linked to the MAHs on site, and to identified safety-sensitive roles, responsibilities, tasks and procedures.

  - There are adequate arrangements, resource and commitment in place to maintain competence.

- Improvement Notices have been issued on establishing a competency framework during a major business process re-engineering and following a major incident.

Guidance

- *Reducing error and influencing behaviour*, HSG48 (reference 1)
- *Developing and maintaining staff competence: railway safety principles and guidance (part 3 section A)* HSG197 (reference 8)
- *Competence assessment for the hazardous industries* Research report 086, includes a usable format for sites to use for self assessment of their training and competency arrangements (reference 9).

Question set: Competence assurance

	Question	Site response	Inspectors view	Improvements needed
1	Is competence in relation to management of the major hazards approached in a structured manner?			
2	Are the training requirements linked to major accident hazards (MAHs) clearly identified? • Is the approach to training and competency clearly set out in relation to MAHs?			
3	Are safety-critical roles, responsibilities and tasks clearly identified? • Are the competence standards required to ensure their safe conduct defined? • What are the links to safety critical procedures and tasks? • Is training clearly linked to these? • Are all levels of staff included (including managers)?			
4	Is the competence of those managing the competence management system maintained?			
5	Are trainers - including training managers – trained (e.g. ‘train the trainer courses)? • Are there assessors appointed and trained?			

	• Are trainers and assessors credible? • Is the system documented and controlled? • Is there verification of the system (internal and external)?			
6	Are staff recruited and selected against defined criteria for the job?			
7	Are all relevant staff trained and assessed against the defined criteria by appropriate means? • Is there evidence that training is designed appropriately? • Is this training supplemented as required when roles or plant / processes are changed? • Is on-the-job training structured, e.g. training plans and objectives, testing knowledge etc? • If SVQ/NVQs are used, do management understand the scope and limitations of these? ➢ Are they generic or tailored? ➢ If tailored, are they tailored to the site or more widely? ➢ Is on-the-job training structured along similar lines to the VQs? ➢ What confidence do staff have in VQs and on-the-job arrangements?			
8	Are staff and contractors only asked to undertake			

	work for which they are competent or, when learning, under adequate supervision?			
9	Is the competence of staff monitored and reassessed at suitable intervals to ensure performance is consistently maintained? • Are infrequently performed and critical tasks, roles and responsibilities targeted?			
10	Is there a suitable record system that can demonstrate competency? • Records for each person? • Evidence of appropriate validation? • Evidence of training AND assessment?			
11	Is the system for managing competence periodically audited and reviewed?			

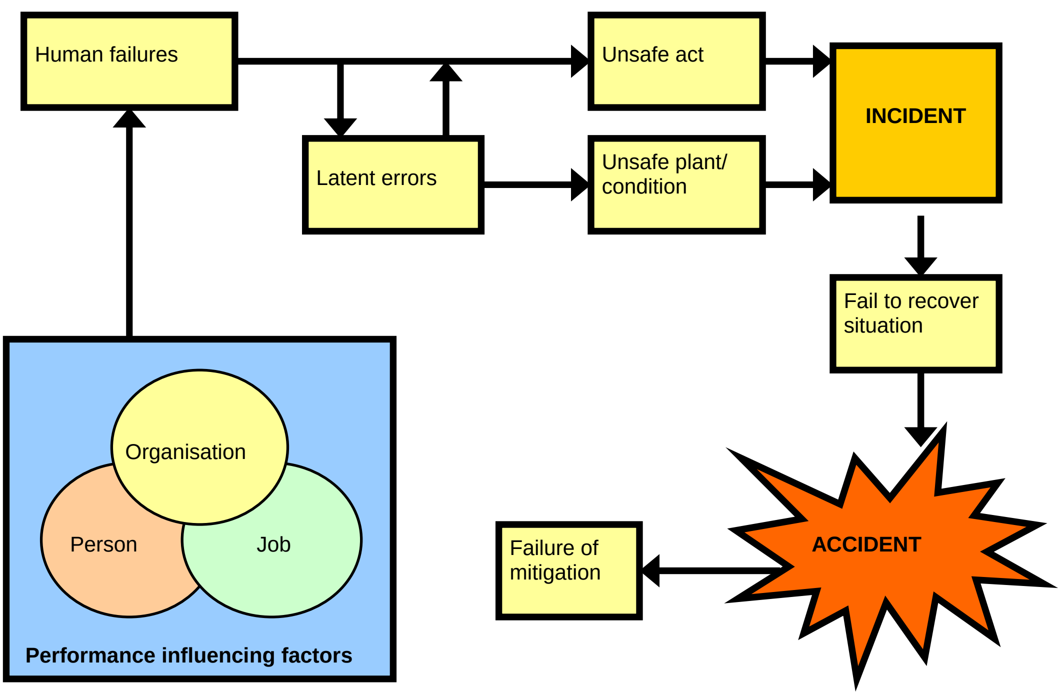
Core topic 2: HF in accident investigations

Human Factors view of accident causation

Accidents are caused by active failures or latent conditions which can lead to human error or violations. Active failures are the acts or conditions precipitating the incident situation. They usually involve the front-line staff, the consequences are immediate and can often be prevented by design, training or operating systems.

Latent conditions are the managerial influences and social pressures that make up the culture ('the way we do things around here'), influence the design of equipment or systems, and define supervisory inadequacies. They tend to be hidden until triggered by an event. Latent conditions can lead to latent failures: human error or violations. Latent failures may occur when several latent conditions combine in an unforeseen way. We all make errors irrespective of how much training and experience we possess or how motivated we are to do it right.

Fig 7: Accident model



The human contribution to accidents

People can cause or contribute to accidents (or mitigate the consequences) in a number of ways:

- Through a failure a person can directly cause an accident. However, people tend not to make errors deliberately. We are often 'set up to fail' by the way our brain processes information, by our training, through the design of equipment and procedures and even through the culture of the organisation we work for.

- People can make disastrous decisions even when they are aware of the risks. We can also misinterpret a situation and act inappropriately as a result. Both of these can lead to the escalation of an incident.
- On the other hand we can intervene to stop potential accidents. Many companies have their own anecdotes about recovery from a potential incident through the timely actions of individuals. Mitigation of the possible effects of an incident can result from human resourcefulness and ingenuity.
- The degree of loss of life can be reduced by the emergency response of operators and crew. Emergency planning and response including appropriate training can significantly improve rescue situations.

The consequences of human failures can be immediate or delayed.

Active failures have an immediate consequence and are usually made by front-line people such as drivers, control room staff or machine operators. In a situation where there is no room for error these active failures have an immediate impact on health and safety.

Latent failures are made by people whose tasks are removed in time and space from operational activities, e.g. designers, decision makers and managers. Latent failures are typically failures in health and safety management systems (design, implementation or monitoring). Examples of latent failures are:

- Poor design of plant and equipment;
- Ineffective training;
- Inadequate supervision;
- Ineffective communications;
- Inadequate resources (e.g. people and equipment) and
- Uncertainties in roles and responsibilities.

Latent failures provide as great, if not a greater, potential danger to health and safety as active failures. Latent failures are usually hidden within an organisation until they are triggered by an event likely to have serious consequences.

Investigating the causes of accidents

After an accident involving human failure the investigation into the causes and contributing factors often makes little attempt to understand *why* the human failures occurred. Finding out both the immediate and the underlying causes of an accident is the key to preventing similar accidents through the design of effective control measures. Typical examples of immediate causes and contributing factors for human failures are given below:

- Job factors
    - Illogical design of equipment and instruments
    - Constant disturbances and interruptions
    - Missing or unclear instructions
    - Poorly maintained equipment
    - High workload
    - Noisy and unpleasant working conditions
- Individual factors
    - Low skill and competence levels
    - Tired staff
    - Bored or disheartened staff
    - Individual medical problems
- Organisation and management factors
    - Poor work planning, leading to high work pressure
    - Lack of safety systems and barriers
    - Inadequate responses to previous incidents
    - Management based on one-way communications
    - Deficient co-ordination and responsibilities
    - Poor management of health and safety
    - Poor health and safety culture

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
    - Copy of company accident report into recent near miss, MAH, or accident with MAH potential.

Guidance

- *Reducing error and influencing behaviour*, HSG48 (reference 1)
- Successful health and safety management HSG65

Question set: HF in accident investigation

	Question	Site response	Inspectors view	Improvements needed
1	Are investigations carried out by multi-functional teams, including operators where appropriate?			
2	Do investigations recognise that accidents normally have more than one cause?			
3	Do investigations identify underlying causes and system failures, not only immediate causes?			
4	Do investigations recognise that there are different types of human failure, and take appropriate remedial action (i.e. avoiding pat answers to ‘human error’)?			
5	Do investigations of human failures look for root causes (performance influencing factors)?			
6	Are employees blamed only where fair?			
7	Is the quality of investigations controlled, i.e. through management arrangements such as training, guidance and quality assurance?			
8	Is there an effective mechanism for action tracking?			

Core topic 3: Identifying human failures

Introduction

Human failures are often recognised as being a contributor to incidents and accidents, and therefore this section has strong links to the section on accident investigation. Although the contributions to incidents is widely accepted, very few sites will **proactively** seek out potential human performance problems. Human failure is described fully in section 3, where different types of human failures are outlined. In summary, there are two kinds of unintentional failures - physical errors ('not doing what you meant to do') and mental errors, where what you do the wrong thing believing it to be right (i.e. making the wrong decision). In addition, there are intentional failures or violations – knowingly taking short cuts or not following known procedures.

This will be a relatively new area for many duty-holders and so evidence may not be available to demonstrate that a human factors risk assessment has been completed. Therefore, the inspection will be more likely providing guidance on what is expected in such an assessment on COMAH sites. To assist in this process, a description of a method for identifying and managing human failures is attached below. However, some duty holders will have partially addressed these issues in an unsystematic manner and the question set will tease out the aspects that they have addressed in part.

Most companies, even if aware of 'human failure', will still focus on engineering reliability. It is useful to make this point to duty holders by asking how they ensure the reliability of an alarm in the control room – usually a detailed and robust demonstration will be made, referring to redundancy, testing etc. However, asking them how they ensure the reliability of the operator who is tasked with responding to the alarm will usually reveal some gaps. You may wish to probe <u>how</u> they know that the operator will always respond in the correct manner, and then discuss what factors may effect an inappropriate response (such as tiredness, distractions, overload, prominence of the alarm indication etc). If any factors are identified, you can ask the site how they could be improved (e.g. providing auditory as well as visual indication, providing a running log of alarms). This process is essentially a human reliability assessment and it is useful to talk through this process so that the company is clear what we mean by addressing human failures.

In assessing human performance, it is all too easy to focus (sometimes exclusively) on the behaviour of front line staff such as production operators or maintenance technicians. The site should be made aware that such focus is undesirable and unproductive. There may be management/organisational failures that have the potential to influence several front line human failures (for example, inadequacies in competency assurance). The technique outlined below can be applied to the identification of failures at the management level.

Human failures in Major Accident Hazards

It should be stressed to the site that we are concerned with how human failures can impact on major accident hazards, rather than personal safety issues.

There are two important aspects to managing human failures in the safety critical industries. First, individual human failures that may contribute to major accidents can be identified and controlled. Second, consideration needs to be given to wider issues than individual human error risk assessments; and this includes addressing the culture of an organisation. Positive characteristics that will support interventions on human failures include open communications, participative involvement of all staff, visible management commitment to safety (backed up by allocated financial, personnel and other resources), an acceptance of underlying management/organisational failures and an appropriate balance between production and safety. These characteristics will be manifested through a strong safety management system that ensures control of major accident hazards.

Human reliability assessment

The information below is intended to assist in the first of these aspects – an assessment of the human contribution to risk, commonly known as Human Reliability Assessment (HRA). There are two distinct types of HRA:

(i) **qualitative** assessments that aim to identify potential human failures and optimise the factors that may influence human performance, and

(ii) **quantitative** assessments which, in addition, aim to estimate the likelihood of such failures occurring. The results of quantitative HRAs can feed into traditional engineering risk assessment tools and methodologies, such as event and fault tree analysis.

There are difficulties in quantifying human failures (e.g. relating to a lack of data regarding the factors that influence performance); however, there are significant benefits to the qualitative approach and it is this type of HRA that is described below. The company should be informed that our expectation is that they conduct *qualitative* analyses of human performance – identifying what can go wrong and then putting remedial measures in place.

At the end of the visit, it is expected that the company will be left with a human failure risk assessment proforma, together with guidance on its completion. Agreement from the company should be obtained to undertake such analyses on safety critical operations.

Example of a method to manage human failures

The following structure is well-established and has been applied in numerous industries, including chemical, nuclear and rail. Other methods are available, but these tend to follow a similar structure to that described below. This approach is often referred to as a 'human-HAZOP', and this is a useful term to help duty-holders understand our expectations. A proforma for recording the assessment of human failures is provided at Table 1.

Overview of key steps

- Step 1: consider main site hazards
- Step 2: identify manual activities that affect these hazards
- Step 3: outline the key steps in these activities
- Step 4: identify potential human failures in these steps
- Step 5: identify factors that make these failures more likely
- Step 6: manage the failures using hierarchy of control
- Step 7: manage error recovery.

Step 1: consider main site hazards

Consider the main hazards and risks on the site, with reference to the safety report and/or risk assessments.

Step 2: identify manual activities that affect these hazards

Identify activities in these risk areas with a human component. The aim of this step is to identify human interactions with the system which constitute significant sources of risk if human errors occur. For example, there is more opportunity for human performance failures in chlorine bulk transfer than there is in a chlorine storage due to the number of manual operations. Human interactions which will require further analysis are:

- those that have the potential to initiate an event sequence (e.g. inappropriate valve operation causing a loss of containment);
- those required to stop an incident sequence (such as activation of ESD systems) and;
- actions that may escalate an incident (e.g. inadequate maintenance of a fire control system).

Consider tasks such as maintenance, response to upsets/emergencies, as well as normal operations. It is important to note that a task may be a physical action, a check, a decision-making activity, a communications activity or an information-gathering activity. In other words, tasks may be physical or mental activities.

Step 3: outline the key steps in these activities

In order to identify failures, it is helpful to look at the activity in detail. An understanding of the key steps in an activity can be obtained through talking to operators (preferably walking through the operation) and review of procedures, job aids and training materials as well as review of the relevant risk assessment. This analysis of the task steps establishes what the person needs to do to carry out a task correctly. It will include a description of what is done, what information is needed (and where this comes from) and interactions with other people.

Step 4: identify potential human failures in these steps

Identify potential human failures that may occur during these tasks – remembering that human failures may be unintentional or deliberate. Consider the guidewords below for the key steps of the activity. Key steps to consider would be those that could have adverse consequences should they be performed incorrectly.

A task may:

- Not be completed at all (e.g. non-communication);
- Be partially completed (e.g. too little or too short);
- Be completed at the wrong time (e.g. too early or too late);
- Be inappropriately completed (e.g. too much, too long, on the wrong object, in the wrong direction, too fast/slow);

Or,

- Task steps may be completed in the wrong order;
- The wrong task or procedure may be selected and completed;

Additionally, there may be:

- A deliberate deviation from a rule or procedure (a ‘procedural violation’).

A more detailed list of ‘error types’, similar to HAZOP guidewords, is provided at the end of this section. Note that an operator may make the same failure on several occasions, known as dependency. For example, an operator may miscalibrate more than one instrument because they have made a miscalculation.

Step 5: identify factors that make these failures more likely

Where human failures are identified above, the next step is to identify the factors that make the failure more or less likely.

Performance Influencing Factors (PIFs) are the characteristics of people, tasks and organisations that influence human performance and therefore the likelihood of human failure. PIFs include time pressure, fatigue, design of controls/displays and the quality of procedures. **Evaluating and improving PIFs is the primary approach for maximising human reliability and minimising failures.** PIFs will vary on a continuum from the best practicable to worst possible. When all the PIFs relevant to a particular situation are optimal, then error likelihood will be minimized.

Some PIFs that should be considered when assessing an activity/task are outlined in the previous section on accident investigation. HSG48 also lists often-cited causes of human failures in accidents under the three headings of Job, Individual and Organisation. These ‘root causes’ of accidents are in effect the factors that can influence human performance and which should be reviewed in a human factors risk assessment. It is important to consider those factors under the control of management (such as resources, work planning and training) as they can often influence a wide range of activities across the site.

Step 6: manage the failures using hierarchy of control

In order to prevent the risks from human failure in a hazardous system, several aspects need to be considered.

- Can the hazard be removed?
- Can the human contribution be removed, e.g. by a more reliable automated system (bearing in mind the implications of introducing new human failures through maintenance etc)?
- Can the consequences of the human failure be prevented, 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)?

Step 7: manage error recovery

Should it still be possible for failures to occur, improving error recovery and mitigation are the final risk reduction strategies. The objective is to ensure that, should an error occur, it can be identified and recovered from (either by the person who made the error or someone else such as a supervisor) – i.e. making the system more ‘error tolerant’. A recovery process generally follows three phases: *detection* of the error, *diagnosis* of what went wrong and how, and *correction* of the problem.

Detection of the error may include the use of alarms, displays, direct feedback from the system and true supervisor monitoring/checking. There may be time constraints in recovering from certain errors in high-hazard industries, and it should be born in mind that a limited time for response (particularly in an upset/emergency) is in itself a factor that increases the likelihood of error.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
    - Risk assessment documents outlining the main hazards on site,
    - Any analyses or documentation (e.g. procedures) referring to safety critical tasks, roles or responsibilities.

A Classification of Human Failures

This list of failures, akin to HAZOP guidewords, can be used in place of the simplified version in Step 4 of the method above.

Action Errors

A1	Operation too long / short
A2	Operation mistimed
A3	Operation in wrong direction
A4	Operation too little / too much
A5	Operation too fast / too slow
A6	Misalign
A7	Right operation on wrong object
A8	Wrong operation on right object
A9	Operation omitted
A10	Operation incomplete
A11	Operation too early / late

Checking Errors

C1	Check omitted
C2	Check incomplete
C3	Right check on wrong object
C4	Wrong check on right object
C5	Check too early / late

Information Retrieval Errors

R1	Information not obtained
R2	Wrong information obtained
R3	Information retrieval incomplete
R4	Information incorrectly interpreted

Information Communication Errors

I1	Information not communicated
I2	Wrong information communicated
I3	Information communication incomplete
I4	Information communication unclear

Selection Errors

S1	Selection omitted
S2	Wrong selection made

Planning Errors

P1	Plan omitted
P2	Plan incorrect

Violations

V1	Deliberate actions

Table 1: Proforma for recording identification of human failures

Practical suggestions as to how to prevent the error from occurring are detailed in this column, which may include changes to rules and procedures, training, plant identification or engineering modifications.

Not all human errors or failures will lead to undesirable consequences: There may be opportunities for recovery before reaching the consequences detailed in the following column. It is important to take recovery from errors into account in the assessment, otherwise the human contribution to risk will be overestimated. A recovery process generally follows three phases: *detection* of the error, *diagnosis* of what went wrong and how, and *correction* of the problem.

Human Factors Analysis of Current Situation				**Human factors additional measures to deal with human factor issues**		**NOTES**
Task *or task step description*	***Likely human failures***	***Potential to recover*** *from the failure before consequences occur*	***Potential consequences*** *if the failure is not recovered*	*Measures to* ***prevent the failure*** *from occurring*	*Measures to* ***reduce the consequences*** *or* ***improve recovery potential***	***Comments****, references, questions*
Task step 1.2 – CRO initiates emergency response (within 20 minutes of detection)	**Action Too Late:** *Task step performed too late, emergency response not initiated in time*	*CR supervisor initiates emergency response*	*Emergency shutdown not initiated, plant in highly unstable state, potential for scenario to escalate*	*Optimise CR interface so that operator is alerted rapidly and provided with info required to make decision; training; practice emergency response*	*Recovery potential would be improved by ensuring that the CCR is manned at all times and by clear definition of responsibilities*	
Task step 1.3 – CRO checks that emergency response successfully shut down the plant	**Check Omitted:** *Verification not performed*	*Supervisor may detect that shutdown not completed*	*Emergency shutdown not initiated, or only partially complete, as above*	*Improve feedback from CR interface*	*Ensure that training covers the possibility that shutdown may only be partially completed.* *Ensure that the supervisor performs check*	
Task step 1.4.1 - CRO informs outside operator of actions to take if partial shutdown occurs	**Wrong information communicated**: *CRO sends operator to wrong location*	*Outside operator provides feedback to CRO before taking action*	*Delay in performing required actions to complete the shutdown*	*Provide standard communication procedures to ensure comprehension* *Provide shutdown checklist for CRO*	*Correct labelling of plant and equipment would assist outside operator in recovering CRO's error*	

Task steps taken from procedures, walk through of operation and from discussion with operators.

This column records the types of human error that are considered possible for this task. It also includes a brief description of the specific error. Note that more than one type of error may arise from each identified difference or issue.

This column records the consequences that may occur as a result of the human failure described in the previous columns.

This column details suggestions as to how the consequences of an incident may be reduced or the recovery potential increased should a failure occur.

This column provides the facility to insert additional notes or comments not included in the previous columns and may include general remarks, or references to other tasks, task steps, scenarios or detailed documentation. Areas where clarification is necessary may also be documented here.

Question set: Identifying human failures

	Question	Site response	Inspectors view	Improvements needed
1	What does the site understand by the term ‘human failure’? Do they recognise the difference between intentional and unintentional errors?			
2	Do they consider that human error is inevitable, or can failures be managed, and how?			
3	What are the typical ways to prevent human failure?			
4	What are the main hazards on the site? How has the site addressed human failures that may contribute to major accidents? (E.g.1 if a significant risk is reactions in batch processes, how has the site addressed human failure in charging incorrect amount or type of product? E.g.2 if a significant risk is transfer between storage and road/rail tankers, how has the site addressed temporary pipework/hose connection failures?)			
5	Is there a formal procedure for conducting human failure analyses? – Is there any science/method to how they assess human failures, or is it seen as ‘common sense’?			
6	Does the site identify those manual operations that			

	impact on major accident hazards? (for example, maintenance, start-up, shut down, valve movements, temporary connections).			
7	Does the site identify the key steps in these operations? – How (e.g. by talking through the task with operators, walking through the operation, reviewing documentation)? – How do they record this analysis/what formal techniques used (if any)?			
8	Does the site identify potential failures that may occur in these key steps (e.g. failure to complete the task, completing tasks in the wrong order)?			
9	What types of failures did the site identify? - Do they include unintentional failures as well as intentional violations? – Do they address mental (decision making) failures or communication failures, as well as physical failures?			
10	If they claim to perform human failure analyses 'as part of HAZOP', what list of potential failures do they refer to (i.e. what is the error taxonomy – does it include action too early, too late, on wrong object, action in wrong direction etc.). - If such a structure is not used then how do they ensure that all potential errors are identified?			
11	Does the site identify factors that make these failures			

	more or less likely (such as workload, working time arrangements, training & competence, clarity of interfaces/labelling)?			
12	Has the site considered the hierarchy of control measures in addressing the human failure (e.g. by eliminating the hazard, rather than simply providing training)?			
13	Do control measures focus solely on training and procedures? – Is there any recognition that people do not always follow procedures? – How do they ensure that people always follow procedures? - What factors do they consider might lead to non-compliance with procedures? – Is there awareness that training can only help to prevent mistakes (mental errors) and that training has no effect in preventing unintentional failures (slips) or intentional violations?			
14	Do analyses lead to new control measures, or are failures considered to be addressed by existing controls? - Obtain an example of a measure that was implemented as a result of human failure analysis.			
15	Have attempts been made to optimise the performance influencing factors to make failures less likely (e.g. addressing shift patterns, increasing supervision, updating P&IDs/procedures, clarifying			

	roles)?			
16	Are operators involved in assessments of activities for which they are responsible? (e.g. task analysis or identifying potential failures).			
17	How has the site recorded such assessments?			
18	What training/experience do the assessors have to demonstrate that they are able to identify potential human failures and means of managing them? – How do they know that they have identified all of the failures and influencing factors?			
19	Have estimates of human failure probabilities been produced? - By what technique? - What were these probabilities used for? – How precise are these estimates and what are the confidence intervals?			
20	Has the site employed external help/advice in conducting these assessments?			
21	Has the site considered human failures in process upsets or emergency situations? Have they considered how the influences on behaviour may be different under these circumstances? (e.g. people may experience higher levels of stress in dangerous or unusual situations, or their workload might be greatly increased in an upset).			

22	Does the analysis focus on operator failure, or do they address management failures? – what about failures in planning, allocation of resources, selection of staff, provision of suitable tools, communications, allocation of roles/responsibilities, provision of training, organisational memory etc.)?			

Core topic 4: Reliability and usability of procedures

Introduction

- Good written procedures are vital in maintaining consistency and in ensuring that everyone has the same basic level of information. They also play a key role in ensuring that good quality training is delivered. Poor procedures, however, can be a reason for people not following the required actions.
- Reliable and usable procedures are the key to avoiding 'mistake' type errors (rule based and knowledge based ones – see Section 2).
- Assuring MAH safety through procedures requires such procedures to be useable and used. Suitable task or job aids (flow diagrams, checklists, diagnostic tools etc) are needed to help assure critical steps or sequences within tasks. These should have appropriate warnings and critical information relating to control of MAHs, and should keep to one simple subtask or action per step.
- The key issue when preparing procedures is to consider who the documents are intended for and what they are expecting them to be used for i.e. the procedures need to be proportional for their intended purpose. Procedures can fulfil various functions, such as reference manuals, training documents, on-the-job aids, etc, and this function will determine the type of procedure that is needed e.g. for use on-the-job flow sheets and checklists will be more appropriate.
- Developing these requires operator participation from the start (or in a review) if ownership is to be built in and violations/non-compliance to be avoided. Typical critical procedures include start-up and shutdown, tanker deliveries and tank filling, emergency response, maintenance of safety critical plant and equipment. Poor safety culture is also a major cause of procedural violations.
- The more rarely a procedure is used, e.g. those for plant upsets, emergency response, etc, the more detailed the procedure will need to be.
- As well as being technically accurate, procedures need to be consistent (within the organisation) well-written, usable and up to date.
- The style (format/layout) of procedures can be critical in the clear and accurate assimilation of the information. HSG48 contains good guidance on this, with a typical procedure having the following elements:
    - Purpose of the procedure;
    - Precautions which must be observed to avoid potential hazards;
    - Special tools or equipment needed;
    - Initial conditions which must be satisfied before starting;
    - References to other relevant documents, e.g. data sheets or manuals; and
    - Procedural steps to perform the task safely and efficiently.
- HSG48 also includes guidance on the format/layout of procedures with the following all being elements to consider:

- Divide longer procedures into shorter chunks (helps users to go back to a particular step if they are interrupted or if the task takes some time to carry out).
- AVOID USING ALL CAPITAL LETTERS FOR THE TEXT (this is slower and more difficult to read). Decide how features such as capitals, bold, italics, and underlining will be used. Overuse of these features is very distracting for users.
- Avoid using very small fonts (e.g. 8 point or smaller, as they are very difficult to read).
- Make good use of open space in the printed text (if the page appears too cluttered, users will be discouraged from reading it).
- Use a consistent **format** for all procedures (helps users find their way around the text).

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
  - The site standard or 'procedure for writing/designing procedures'
  - Copies of example operating procedures (preferably ones actually used to carry out the task) for selected safety critical tasks e.g. tanker unloading, start-up etc

Enforcement and advice

- Enforcement for a review should be considered where key procedures are demonstrably poor or not followed, particularly after an incident or near miss.
- Developing suitable procedures has been part of several enforcement interventions e.g. as part of human factors' risk assessment for batch reaction processes.
- The HF Team have produced additional guidance on the subject which has been published as a Chemical Information Sheet. A copy of this is included as Appendix 7.

Guidance

- *Reducing error and influencing behaviour*, HSG48 (reference 1)
- *Improving compliance with safety procedures: reducing industrial violations* HSE Books 1995 (reference 5)
- *Evaluation report on OTO 1999/092 Human factors assessment of safety critical tasks* Research Report 033 (reference 10)

Question set: Reliability and usability of procedures

	Question	Site response	Inspectors view	Improvements needed
1	Is there a formal process in place to determine which safety critical operations/tasks need procedures (e.g. HAZOPs/risk assessment)? • Do these arrangements consider the potential for human error?			
2	Do the procedures in existence cover the range of areas/operations expected, such as: • Maintenance operations? • Plant start-up and shutdown? • Plant operation? • Training and competency arrangements?			
3	Is there a process in place to consider how the work activities of non-company personnel are managed?			
4	Is there an approvals process for operating procedures? • Who is responsible for managing this?			
5	Is the format, type of procedure and the user considered when writing procedures?			
6	Are the types (checklists, instructions, flow sheets etc) of procedure appropriate for:			

	• Routine operations? • Safety critical operations? • Emergency and upset conditions?			
7	Is there a consistency in the procedures used across site/plant where the task or operation is identical?			
8	Are Operators involved in the identification and writing of procedures?			
9	Do Operators have ready access to procedures in the normal working environment? • How often do they refer to them? • Why do they refer to them?			
10	Is there a process in place to ensure that procedures remain valid and are up-to-date? • Does this consider both hardcopies and electronically held documents?			
11	Is there a formal mechanism in place for removal of all out-of-date procedures? • Does this occur in practise (or are older versions still found in control rooms, maintenance offices, etc)?			
12	Is there a formal mechanism in place to ensure that staff are trained in new/updated procedures?			
13	Is there an ongoing monitoring system to ensure			

	compliance to procedures? • Do the results of this monitoring feed back into the review/revision/validation process?			
14	Is there a process to ensure that relevant procedural controls are reviewed following an incident or audit non-compliance?			

Section 5: Common topics

Common topic 1: Emergency response

Introduction

- Key areas to examine are:
  - An effective organisational structure for implementing the emergency plan (which will require a good safety culture to avoid any hesitation in implementing the plan) and a good command and control structure for managing the incident.
  - Suitable training (and competency assessment) for all those allocated roles in the emergency.
  - Good selection criteria and assessment for allocating staff to roles within the emergency plan (seniority and job titles are not necessarily the best criteria for selection for key roles, needs to be done on suitability).
  - Clear and well rehearsed procedures which include a consideration of human reliability and error issues such as preparing people to deliver to realistic expectations and the usability of equipment. Procedures need to include good 'job aids' e.g. summaries of responsibilities, check sheets, etc.
  - Have the staffing levels required to implement any emergency response been formally assessed (e.g. using the system in reference 23)? Are the staffing levels in place appropriate, both during normal working hours and, most especially, during the night and at weekends?
  - Planned and rehearsed interfaces between the various responders with all aspects of the emergency response have been practiced, at all levels (plant, site and off-site), covering all expected scenarios, using both table-top exercises and drills.
  - Efficient means of information handling during the emergency and good critical communication arrangements.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
  - On-site emergency plan
  - Any details of a post exercise review
  - Site arrangements for training staff in emergency response.

Enforcement

- Little formal enforcement action on this subject has been taken by the Human Factors Team. Much advice to the field has, however, been provided, including support for specific audits into the topic, carried out at major top tier sites.
- The key areas where enforcement action would be expected to be appropriate are:
  - Lack of adequate training and competency arrangements
  - Poorly thought out and designed procedures.
  - Lack of an understanding of the role of people in emergency response, leading to unrealistic expectations of them.

Guidance

- *A guide to the Control Of Major Accident Hazard Regulations 1999*, L111
- *Emergency planning for major accidents: Control Of Major Accident Hazard Regulations 1999*, HSG191
- *Recent major accidents: lessons on emergency planning* - HSE Information Chemicals Sheet No.1
- *Dealing with disaster* – Home Office guidance (up-dated June 2003) available free from http://www.ukresilience.info/contingencies/dwd/index.htm.
- *Protocol for auditing on-site emergency response arrangements* – HSE, LD6, 2002 (as amended)
- *Lessons from Longford: the Esso Gas Plant Explosion* (reference 2)
- *Performance indicators for the assessment of emergency preparedness in major accident hazards*, Contract Research Report 345/2001 (reference 14)
- 'Emergency Response Competencies & Human Factors in Emergency Response', Paper for SIESO & COMAH Competent Authority Workshop, John Wilkinson (contact Human Factors Team for copy).

Question set: Emergency response

	Question	Site response	Inspectors view	Improvements needed
1	Is there a designated and recognised chain of command to deal with emergency situations? • Is there a designated person with overall responsibility for dealing with an emergency situation on all shifts? • Are contingency plans in place to cover the absences of the designated people? • Are provisions made for the safe handling of an emergency situation that may arise out of normal working hours? • Do staff on each shift know what the designated chain of command is? • Does the chain of command defined in the safety Plan adequately cover all likely eventualities? • Is there recognition that emergency support roles are equally important as frontline/immediate response roles? • Are appropriate measures in place to ensure 24-hour cover, 7 days a week (including sickness and holiday cover)?			
2	Is there good collective awareness of potential emergency situations?			

	• Are risk assessments considered as part of the emergency planning process? • Are previous incidents / accidents reflected in exercises? • Does the plan consider both worst-case scenarios and more realistic, though less serious, events?			
3	Is there a written on-site emergency plan which covers the following key areas: • Clear, concise and unambiguous definitions of all roles? • Clearly defined decision-making boundaries? • Deputising arrangements? • Who should assume responsibility in an emergency? • Identify of who responds to whom in the event of an emergency (including off-site)? • A defined command and control structure? • Overview charts showing the emergency command and control structure available? • Un-ambiguous criteria for calling the emergency services? Does the presentation of the plan include: • Well structured formatting in order to enhance the information for communication & training?			

	• Aide memoirs such as charts, maps, and flow charts to remind staff of key information? • Do team members consider the procedures usable?			
4	Is there provision for controlling of the plant once an emergency arises? • Is there an appropriately located Emergency Control Centre and is it maintained? • Is there an emergency plan and are staff aware of it? • Is the plan credible and understood and were the workforce involved in drawing it up? • Are there procedures in place for the safe management of plant, processes, and equipment during an emergency? • Are these procedures realistic? • Is the Control Centre adequately supplied with adequate emergency equipment (e.g. communications equipment)? • Do staff know how to contact the ECC? • Is there an adequate emergency alarm system?			
5	Is there an on-going training programme? • Is there a process for defining the skills and knowledge required of core personnel in the			

	event of an emergency? • Are emergency support staff (as well as frontline/immediate response staff) trained in their roles? • Are the emergency plan and procedures used appropriately in the training programme? • Do operational staff / contractors receive regular training to prepare them for potential emergencies? • Is training realistic e.g. have operators practised in full BA and in likely plant areas? Has BA training reflected likely real conditions (low visibility, smoke etc)? • Is there evidence in training records or via discussions with staff that training has been received? • Do the training arrangements include competency assessment and is this seen as credible by staff?			
6	Is there an on-going programme of drills/exercises to prepare on-site personnel for an emergency? • Is there a process to ensure that emergency planning arrangements are reviewed in light of any changes to plant/processes/operation? • Do exercises reflect current operations and			

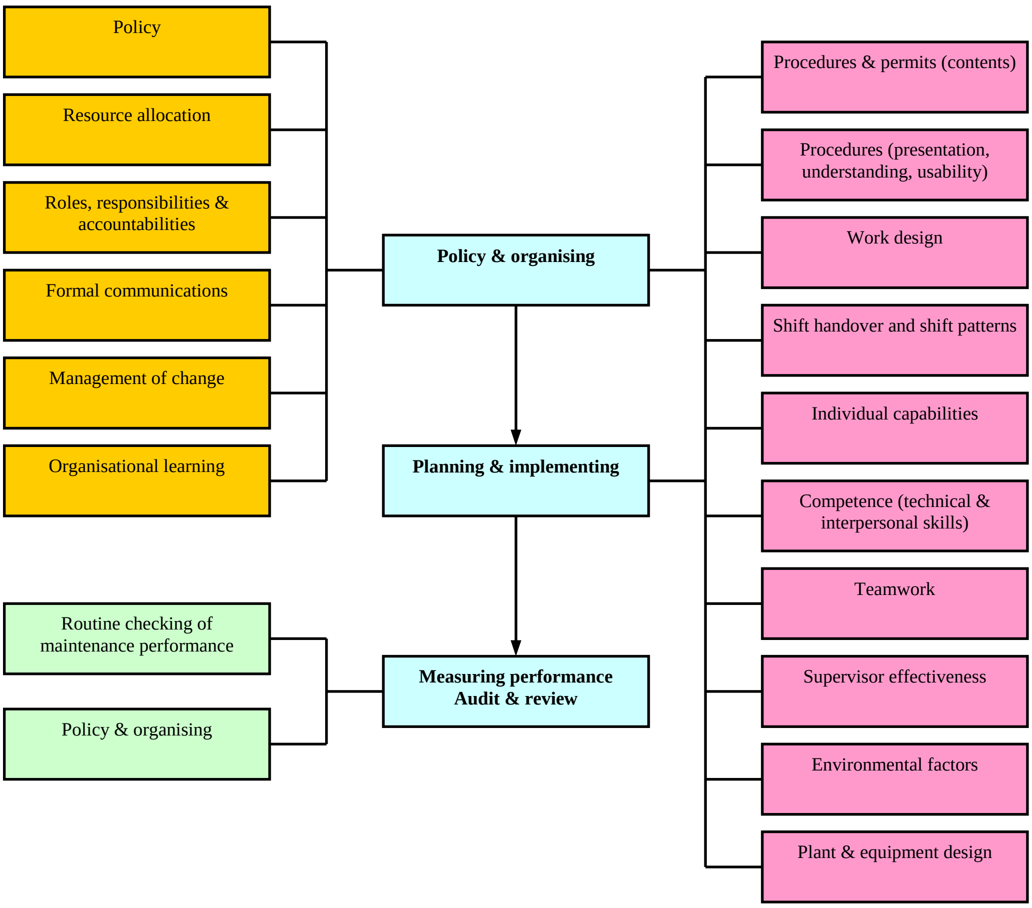
	cover all expected scenarios? • Are the exercises realistic and credible? • Are emergency training programmes reviewed and updated in the light of changes to plant, processes or operations? • Is there an effective mechanism to ensure that the lessons from exercises and accidents are used to improve the effectiveness of emergency planning arrangements?			
7	Has liaison with the Emergency Services established and maintained? • Is it clear who is responsible for activating the plan and liasing with outside bodies (e.g. local authorities/ fire/emergency services) especially outside normal hours? • Are the Emergency Services informed and kept updated on current practices/ procedures which form part of the emergency plan?			

Common topic 2: Maintenance error

Introduction

- The key is assuring the adequate performance of routine or breakdown maintenance activity either on, or potentially affecting, control of MAHs i.e. work on safety critical plant and equipment or processes.
- It is important to be clear what is being examined here, that is, the risk of maintenance error leading to a major accident, and not the personal risk to the maintenance staff (although good control of the former will often greatly improve the latter).
- Although many maintenance systems and databases do distinguish critical equipment this is often not linked to the MAH analysis and main scenarios, and criticality may not be defined adequately for this.
- Sites should have reliably identified such activities, plant, instrumentation and equipment and have arrangements in place to assure their maintenance e.g. via task analysis, supporting job aids (including procedures, checklists, diagnostic tools, up-to-date diagrams/P&IDs etc), competency of personnel involved, and communication of key major accident hazard information.

Figure 8: Maintenance management issues



- Figure 8 illustrates 18 specific issues which affect maintenance performance linked to elements of health and safety management. These issues need to be controlled in order to ensure optimal maintenance performance. An understanding of these issues will help to identify the likelihood of human failure.

Common failures found at major hazard sites:

- Major accidents and near misses resulting from maintenance errors are often not separately identified and addressed,
- Risk assessments, training and procedures do not usually assure adequately against error,
- Many sites don't do even simple assurance against error,
- Safety critical maintenance tasks and procedures are often not identified,
- Sites don't make the link between maintenance error and their risk assessments,
- Statistics and investigations show this is a continuing serious issue.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
  - Any evidence of reviews of human performance in maintenance activities
  - Lists of safety critical equipment, plant and processes.

Enforcement and advice

- Enforcement should be considered following an incident or near miss where a maintenance error or failure was a significant cause. HF and mechanical engineering support is likely to be needed for this initially. A review or assessment of maintenance activity re MAHs would be appropriate, following the questionnaire approach in the guidance and considering the consequences of human failure and error.
- No enforcement yet but advice given as part of several field interventions and guidance increasingly being used by individual inspectors to support routine COMAH inspection and audit, and to get operators to start looking at this issue in a structured way.
- A more detailed question set than the one below is available if needed. Please contact the Human Factors Team for a copy.

Guidance

- *Improving maintenance - a guide to reducing human error* (reference 15)
- *Managing Maintenance Error – Reason & Hobbs,* Ashgate, 2003, ISBN 0-7546-1591-X

Question set: Maintenance error

	Question	Site response	Inspectors view	Improvements needed
1	Is there evidence that maintenance is firmly based on a robust understanding of, and linked to, an analysis of the site's major accident hazards? • Are safety-related & safety-critical maintenance items and activities reliably identified? • Are associated job aids and procedures developed for these priority items? • Is human failure, including violations and error, understood and addressed/managed?			
2	**Policy:** Is there a clear strategy on maintenance? • Does it consider the role of human error? • Does it recognise that some maintenance is of higher priority than others? • Are safety critical equipment/tasks/activities identified? • Is there a link between preventing loss of containment and general plant/equipment reliability?			
3	**Resource allocation:** Is there an adequate system for maintenance resourcing, planning and prioritisation?			

4	**Roles, responsibilities and accountabilities:** Are responsibilities defined and made clear to staff?			
5	**Formal communication:** Are major accident hazard safety requirements and priorities communicated regularly and reliably to key staff?			
6	**Management of change:** Are maintenance requirements adequately assessed for new projects or modifications? • Does this include *organisational* change (e.g. moving to team working)? • Are procedures and training reviewed and revised?			
7	**Organisational learning:** Is there evidence of visible commitment to continuous improvement and is this resourced?			
8	**Procedures and permits:** Are procedures clear? Is the permit system designed to an accepted standard (e.g. OIAC guidance) Are adequate job aids provided, based on e.g. task analysis or risk assessments, for critical tasks (job aids include procedures, checklists, diagnostic tools)? • Do staff find procedures useful and accurate? • Do they *use* them? o Is compliance checked and			

	monitored? o Are they reviewed regularly?			
9	**Work design:** Is attention paid to design of maintenance tasks? • How is critical work scheduled (e.g. shouldn't be planned for the end of long shifts/cross-shift)? • Is fatigue managed e.g. is overtime monitored individually; are clear limits set on hours?			
10	**Communication issues:** Are critical communications assured? • Is there a shift handover procedure and log? • Is there adequate co-ordination and tracking of maintenance work?			
11	**Competence:** Is there a competence assurance system linked to the analysis of major accident hazards on site, and the safety-related/critical tasks?			
12	**Teamwork:** Are there formal or informal teams and are these recognised and managed? • How are temporary teams managed e.g. for shutdown, major breakdowns?			
13	**Supervisor effectiveness:** Do supervisors or team leaders monitor key work practices?			
14	**Environmental factors:** Are the conditions in which			

	tasks are carried out (e.g. lighting, access) likely to lead to poor work, errors and mistakes, and incomplete work?			
15	**Plant and equipment design:** Is there evidence that design or modification for maintainability is considered?			
16	**Monitoring and review:** Are key performance indicators for safety and reliability set and monitored with maintenance, inspection and test performance included? Is performance reviewed via the results of an adequate inspection and audit programme? • Are maintenance accidents/incidents/near-misses (or those with maintenance root causes) adequately investigated and the results and actions communicated appropriately? • Are the MA aspects reliably captured and prioritised?			

Common topic 3: Safety critical communications

Key areas to examine

- Safety critical communication situations which could be examined include:
  - Shift handover (see below)
  - Communications during emergencies,
  - Any form of remote communication between control room and outside operators e.g. during shutdowns,
  - Permit-to-work procedures, particularly if the work continues over a shift change,
  - Communication of hazards and risks to contractors,
  - Use of radios,
  - Plant labelling and identification,
  - Communication of changes to procedures.
- Problems with communication leading to major accidents/incidents are well known, for example Piper Alpha.
- Effective communication is important in all organisations when a task and its associated responsibilities are handed over to another person or work team. Critical times when good communication must be assured include: at shift changeover, between shift and day workers, between different functions of an organisation within a shift (e.g. operations and maintenance) and during process upsets and emergencies. Although the importance of reliable communication may be recognised, guidance for personnel on how to communicate effectively may be lacking.

What can go wrong?

- Unreliable communications can result from a variety of problems including:
  - Missing information,
  - Unnecessary information,
  - Inaccurate information,
  - Poor or variable quality of information,
  - Misunderstandings,
  - Failing to carry forward information over successive shifts.
- Miscommunications and misunderstandings are most likely to occur when the parties communicating have a different understanding of the current state of the process. More time will be needed to communicate when such differing ‘mental pictures’ exist.

Improving communications

- A number of simple steps can improve communications in the workplace:
  - ➢ Carefully specify what key information needs to be communicated;
  - ➢ Aim to cut out the transmission of unnecessary information;
  - ➢ Use aids (such as logs, computer displays) based on the key information needs to help accurate communication;
  - ➢ Aim to repeat the key information using different mediums, e.g. use both written and verbal communication;
  - ➢ Allow sufficient time for communication, particularly at shift handover;
  - ➢ Encourage two-way communication with both the giver and recipient of the information taking responsibility for accurate communication;
  - ➢ Encourage the asking of confirmation, clarification and repetition;
  - ➢ Encourage face-to-face communication wherever feasible;
  - ➢ Try to develop the communication skills of all employees; and
  - ➢ Aim to set standards for effective and safe communication.

Shift handover

- Risk areas:
  - ➢ During plant maintenance, particularly when this work continues over a shift change.
  - ➢ When safety systems have been over-ridden;
  - ➢ During deviations from normal working;
  - ➢ Following a lengthy absence from work;
  - ➢ When handovers are between experienced and inexperienced staff.

- In order to manage the risks, sites should:
  - ➢ Give effective shift handover communication a high priority;
  - ➢ Include communication skills in the selection criteria for shift-workers and develop the communication skills of existing staff;
  - ➢ Provide procedures which specify how to conduct an effective shift handover;
  - ➢ Place greater reliance on written communication when 12-hour shifts are in operation;
  - ➢ Where possible, plan maintenance work to be completed within one shift, thereby eliminating the risk of miscommunication of maintenance issues at shift handover.

- For shift handovers to be effective they should be:
  - Conducted face-to-face;
  - Two-way - with both participants taking joint responsibility for ensuring accurate communication via verbal and written means, based on a pre-determined analysis of the information needs of incoming staff;
  - Given as much time as necessary to ensure accurate communication.

- Areas for improvement may include:
  - Specification of key information needed by incoming operators to update their 'mental model' of plant status;
  - Design of operator supports (logs, displays etc.), based on the operator's information needs;
  - Involvement of end-users when implementing changes to established methods of communication at shift handover, thereby facilitating their acceptance and use.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
  - Details of training for safety critical communications, such as in emergencies;
  - Procedures for conducting shift handovers;
  - Details of Permit-to-work system and procedures.

Enforcement and advice

- Enforcement should be considered where there is evidence of a lack of formal or effective procedures and training in safety critical communications.

Guidance

- *Reducing error and influencing behaviour*, HSG48 (reference 1)
- *Effective design of workplace risk communications*, Research Report 093 (reference 11)
- *Guidance on permit-to-work systems in the petroleum industry*, OIAC 1997 (reference 12)
- *Effective Shift Handover - A Literature Review* OTO 96 003 (reference 13)

Question set: Safety critical communications

	Question	Site response	Inspectors view	Improvements needed
1. Is there is a process to identify and define the communications requirements for the safe operation of plant e.g. for PTW, shift handover, control room to field/maintenance communications?				
1a	Management questions: • Has the company considered effective ways to communicate major hazard information to contractors/temporary staff/visitors? • Is there a process to select the key information to be communicated (from internal and external sources)? • Is there a system to communicate changes in practice and lessons following an incident? • Does a process exist to monitor the effectiveness of the communication of major hazard information? • Are the workforce actively involved in communications (i.e. not just passive receivers of information)? • Is there a process to ensure that modifications, changes to processes, procedures, systems and organisation are communicated to all relevant staff?			
1b	Operator questions:			

	• Is there evidence that the key major hazard information has been understood by the target audience (i.e. staff, contractors, visitors)? • Is there is evidence that changes to practices, as a result of an incident, are understood by staff? • Is there is an audit trail documenting the monitoring process?			
2. Have the communication routes been clearly defined?				
2a	Management questions: • Have communications been considered in defining the plant's safety command and control structure? • Are there routes by which operators can raise safety concerns with management and is the loop then closed adequately? • Is there is a process to review the communications routes in light of plant / organisational change? • Are the key communication aspects of critical procedures assured? • Is there a defined structure for shift handover arrangements?			

2b	Operator questions: • Is there evidence that key communication channels are documented? • Do operators know when to report safety concerns? • Do operators understand where they can obtain key safety information? • Can staff describe the safety implications of any recent changes to the plant?			

Common topic 4: Safety culture

Introduction

> **What is safety culture?**
> "The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management. Organisations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures."
> ACSNI *Human Factors Study Group: Third report - Organising for safety* HSE Books 1993

Note: Safety culture is an important topic, but time consuming to inspect (because of the sample required) and difficult to tackle. It is recommended that it is only be taken on where there is good reason to believe that there is a significant issue to address, such as a poor safety record over a period, and where the company is likely to be receptive to advice.

- An organisation's culture can have as big an influence on safety outcomes as the safety management system. 'Safety culture' is a subset of the overall company culture (and is defined in the box on the right).
- Many companies talk about 'safety culture' when referring to the inclination of their employees to comply with rules or act safety or unsafely. However we find that the culture and style of management is even more significant, for example a natural, unconscious bias for production over safety, or a tendency to focussing on the short-term and being highly reactive.
- Symptoms of a poor cultural factors can include:
    - Widespread, routine procedural violations;
    - Failure to comply with the company's own SMS (although either of these can also be due to poor procedure design);
    - Management decisions that appear consistently to put production or cost before safety.
- In inspection, it is possible to gather evidence about a company's culture, although this requires interviewing a suitably representative sample of people from all levels.

Key aspects of an effective culture:

- **Management commitment:** this commitment produces higher levels of motivation and concern for health and safety throughout the organisation. It is indicated by the proportion of resources (time, money, people) and support allocated to health and safety management and by the status given to health and safety versus production, cost etc. The active involvement of senior management in the health and safety system is very important.
- **Visible management:** Managers need to be seen to lead by example when it comes to health and safety. Good managers appear regularly on the 'shop floor', talk about health and safety and visibly demonstrate their commitment by their actions – such as stopping production to resolve issues. It is important that management is *perceived* as sincerely committed to safety. If not,

employees will generally assume that they are expected to put commercial interests first, and safety initiatives or programmes will be undermined by cynicism.

- **Good communications between all levels of employee:** in a positive culture questions about health and safety should be part of everyday work conversations. Management should listen actively to what they are being told by employees, and take what they hear seriously.
- Active **employee participation** in safety is important, to build ownership of safety at all levels and exploit the unique knowledge that employees have of their own work. This can include active involvement in workshops, risk assessments, plant design etc. In companies with a good culture, you will find the story from employees and management being consistent, and safety is seen as a joint exercise.

Inspection

- Inspection needs to involve interviewing a suitable cross-section of the company, particularly a reasonable number employees, who need to be interviewed in a non-threatening manner. The number needs to be sufficient to take account of differing views and experience. Given this condition the open questions given in the question set will provide a helpful picture of the overall style of the company.
- NB unless the inspector has significant personal experience of trying to tackle safety culture, it would be best to simply reflect back what has been found, and give general rather than specific advice on how to improve it.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
    - ➢ Results of climate/attitude/opinion surveys;
    - ➢ Results of procedure surveys;

Enforcement and advice

- Clearly, safety culture itself is not enforceable, and interventions are generally reserved for receptive companies, or as part of an overall incident investigation. However there can be enforcement to address outcomes of a poor culture. For example if a company is unsuccessfully relying on procedural controls to avoid major accidents, there could be enforcement of management arrangements to either ensure compliance or provide alternative safeguards through the hierarchy of control.
- An Improvement Notice has been issued on implementing an SMS including identification and control of human reliability risks - the company subsequently managed to reduce accidents by over 50%. The recently published investigation report for BP Grangemouth was partly the result of an investigation into cultural factors underlying a series of major incidents. There

have now been several other field interventions, generally seen as valuable by the company and site inspector.

Guidance

- *Successful health and safety management*, HSG 65
- *Reducing error and influencing behaviour*, HSG48 (reference 1)
- *ACSNI Study Group on Human Factors. Third report: Organising for safety.* Advisory Committee on the Safety of Nuclear Installations *(1993) reprinted 1998, ISBN 0717608654*
- *Health & Safety Climate Survey Tool,* HSE Books, ISBN 071761462X HSE Books.

Question set: Safety culture

	Question	Site response	Inspectors view	Improvements needed
1	**Management commitment** • Where is safety perceived to be in management's priorities (Senior/middle/1st line)? • How do they show this? • How often are they seen in the workplace? • Do they talk about safety when in the workplace and is this visible to the workforce? • Do they 'walk the talk'? • Do they deal quickly and effectively with safety issues raised? • What balance do their actions show between safety and production? • Are management trusted over safety?			
2	**Communication** • Is there effective two-way communication about safety? • How often are safety issues discussed; • With line manager/subordinate? • With colleagues? • What is communicated about the safety programme of the company?			

	• How open are people about safety?			
3	**Employee involvement** • How are people (all levels, especially operators) involved in safety? • How often are individual employees asked for their input safety issues? • How often do operators report unsafe conditions or near misses etc? • Is there active, structured operator involvement e.g. workshops, projects, safety circles? • Is there a continuous improvement / total quality approach? • Whose responsibility is safety regarded to be? • Is there genuine cooperation over safety – a joint effort between all in the company?			
4	**Training/information** • Do employees feel confident that they have all the training that they need • How accurate are employees' perceptions of hazards and risks? • How effective is safety training in meeting needs (including managers!)? • How are needs identified?			

	• How easily available is safety information?			
5	**Motivation** • Do managers give feedback on safety performance (& how)? • Are they likely to notice unsafe acts? • Do managers (all levels - S/M/1st) always confront unsafe acts? • How do they deal with them? • Do employees feel they can report unsafe acts? • How is discipline applied to safety? • What do people believe are the expectations of managers? • Do people feel that this is a good place to work (why/why not)? • Are they proud of their company?			
6	**Compliance with procedures** • What are written procedures used for? • What decides whether a particular task will be captured in a written procedure? • Are they read? • Are they helpful? • What other rules are there? • Are there too many procedures and rules? • How well are people trained in them?			

	• Are they audited effectively? • Are they written by users? • Are they linked to risks?			
7	**Learning Organisation** • Does the company really learn from accident history, incident reporting etc? • Do employees feel confident in reporting incidents or unsafe conditions? • Do they report them? • Do reports get acted upon? • Do they get feedback?			

Section 6: Specific topics

Specific topic 1: Alarm handling

Introduction

- Alarm handling (or alarm management) is an issue for any site or process where there is claimed reliance on human response to an alarm to control major accident hazards. This can range from sites with a small number of alarms (e.g. small storage sites) up to sites with a central control room and a full distributed control system (DCS). The principle is the same though – assuring the human response to alarms through e.g. good interface and system design, monitoring and review; competency arrangements; procedures.
- The Engineering Equipment and Materials Users Association (EEMUA) has produced guidance on the design and optimisation of alarm systems for industrial processes such as chemical plant. The aim of this guidance is to help engineers develop alarm systems that are more useable and which result in safer and more cost effective operation.
- Alarm management is primarily a design issue, for example, it is one key issue for control room design. Wider control room design issues (from *ISO11064 'Ergonomic design of control centres')* are based on seven principles for human-centred design & consist of: ergonomic design framework; control suite arrangements; control room layout; workstations layout; displays, controls & interactions (includes alarms); and environmental ergonomics.
- Trying to put matters right later is much more difficult and so the EEMUA review process is time and resource-intensive; therefore companies need to manage such reviews as a major project. Alarm systems need continuous management and improvement
- The overall control philosophy is crucial – can the balance of manual versus automatic control be justified (what is automated and why? Beware – what is hardest to automate is often what gets left for operators to do!)
- Do companies recognise that even fully-automated trip/ESD systems can fail or part-fail? Check how they assure operator decision making in or after a major upset & on restart and if competence assurance arrangements cover all foreseeable operating conditions (NB role of simulators/simulation for upset or abnormal conditions).

Key principles

- *Usability* – does the system meet user needs & operate within their capabilities;
- *Safety* – identify the safety contribution of the system; human performance/reliability claims should be soundly based;
- *Performance monitoring* – initial design, commissioning then audit – commitment to review/continuous improvement;
- *Engineering investment* – structured design method – justify & engineer all alarms – there should be a justification for each alarm documented (in effect this is what a later alarm review does but at a later and more difficult stage).

General:

- Very often, older systems will be likely to have been designed better for normal state operation than for upset/emergency.
- Management of change (including organisational change impacting directly or indirectly on the control room operation/operators): is there a good link between modification/change processes and modifications to – or introduction of new – alarms?
- Balance of control/allocation of function: is this right for the hazards/risks and system as whole? For example if there are too many safety critical alarms (i.e. +20) then the balance is likely to be too far towards reliance on the operators.
- Is there a clear link from the site alarm philosophy to MAH risk assessments? Is any review or prioritisation programme based on the priorities – and the claimed reliability of operator/ESD arrangements – in the assessment?
- The Human Factors Team have developed and published an information sheet on alarm handling. A copy of this is attached.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
  - Details of alarm handling philosophy;
  - Documents relating to any alarm review – e.g. list of alarms, their purpose and the required operator response.

Enforcement and advice

- Alarm handling has been the subject of two major interventions at refinery sites and raised as an issue at many other visits. It's vital that significant (i.e. more than 300 alarms) new DCS systems going in are designed to EEMUA principles and we should enforce on this. For existing systems enforcement to carry out a review is appropriate where there is evidence of problems (e.g. large numbers of standing alarms on the system). HF and process safety support is likely to be needed for both.
- A more detailed question set than the one below is available if needed. Please contact the Human Factors Team for a copy.
- Major intervention at BP Grangemouth including examination of alarm handling (see report on HSE website: www.hse.gov.uk/comah/bpgrange/index.htm).

Guidance

- *The explosion and fires at the Texaco Refinery, Milford Haven, 24 July 1994* (reference 16)
- *Alarm systems, a guide to design, management and procurement*, EEMUA Publication No 191, detailed guidance for designers and essential for alarm system managers/engineers (reference 17)

- *Better alarm handling*, Chemicals Sheet No. 6 (reference 18)
- *Training on alarms management*, EEMUA & 4-sight Consulting (reference 19)
- *The management of alarm systems*, Contract Research Report 166/1998, detailed guidance for designers (reference 20)

Question set: Alarm handling

	Question	Site response	Inspectors view	Improvements needed
1	What size of alarm system is involved? How many installed alarms per operator?			
2	Is there a site strategy or philosophy (and a site version of any corporate one)?			
3	Is there a commitment to continuous improvement?			
4	How are alarm modifications handled?			
5	What is the process for new projects?			
6	Have the current alarm systems been reviewed? • What was the outcome of the review? • Is it being implemented?			
7	Is the system 'context sensitive'? • Does it recognise different operational states and the different operator needs e.g. normal/upset/emergency & what has and hasn't occurred?			
8	How is the competence of all those involved assured (e.g. designers and users)?			
9	Are safety-critical alarms clearly distinguished and separately displayed (and hard-wired)?			

	• In design the target number for critical alarms is 20.			
10	How are the alarms prioritised? • Do operators find the categorisation appropriate? • Targets: high priority 5%, medium 15% and low 80% • Target alarm occurrence rates: safety-critical - very infrequently; high priority – less than 5 per shift; medium priority – less than 2 per hour; low priority – less than 10 per hour			
11	Does the system work currently (discuss with the Operators)? Are key performance measures for the system (e.g. alarm rates) recorded and tracked?			
12	Are there repeating (nuisance) alarms in normal or upset conditions? • Targets: *normal/steady state*: <1 per 10 minutes (1 per 5 minutes is manageable); *upset*: max of 10 in the ten minutes (20-100 hard to cope with, 100+ excessive) • Is the supporting information adequate (i.e. what to do for each safety-critical or safety-related alarm)? • Are any procedures compliance audited?			

13	Is there an adequate alarm log/history? • What information is recorded? • How is the information used?			
14	Is the alarm list clear and easy to navigate? • Are different alarm priorities distinguished on screen e.g. by colour/sound? • Is there a clear process overview (plant detail mimic) with adequate information including alarm details? • Is the alarm list clear? (Best is a page design - like a book, with a font and size that can be read standing back from normal VDU sitting position e.g. to allow conferring with supervisor). • Can the alarm list be filtered e.g. by priority or plant area? • Can alarms be silenced before being studied/accepted? (Essential feature) • Resetting of alarms should only be possible if *cleared* (i.e. have returned to normal) *and accepted* by operator			
15	Are emergency arrangements adequate? • Are there enough people available at all times (especially out of hours) to cover for emergencies?			

Specific topic 2: Managing fatigue risks

Suggested approach for sites

- The suggested approach for sites on this issue is to focus more on the system for controlling excessive or fatiguing working hours, rather than individual, one-off instances. Sites should be reminded that the legal duty is on employers to manage risks from fatigue, irrespective of any individual's willingness to work the extra hours. Sites will be aware of the topic but are unlikely to have in-house competence and, in many cases, management control of overtime is delegated inappropriately to work teams.

Introduction

- Fatigue, as it affects control of MAHs, is an issue which has been little-addressed traditionally in inspection and investigation. It is clear however from previous major accidents, and from recent railway accidents especially, that it is often a root cause.
- Fatigue refers to the issues that arise from excessive working time or poorly designed shift patterns. Fatigue is a perceived state of 'weariness' caused by prolonged or intensive exertion. Fatigue results in slower reactions, memory lapses, absentminded slips, 'losing the picture', lack of attention etc.
- As a minimum, employers, rather than operators, should have a good base shift pattern and monitor changes to the shift patterns and overtime worked on a individual basis for those involved in MAH work, and have agreed (and reasonable) limits in place to control fatigue risks. Essentially fatigue needs to be managed, like any other hazard. During investigations evidence on possible fatigue should be sought.
- Changes to working hours need to be risk assessed. One way of doing this is to use HSE's Fatigue and Risk Index. This Excel spreadsheet has been developed as a simple tool to enable comparison of differing shift patterns and to identify when fatigue risks are excessive. It allows shift patterns to be quickly evaluated prior to any significant changes in structure or hours. It can be applied to assess the shifts and hours worked by key safety critical players (e.g. control room operators, emergency response personnel, maintenance technicians) during normal operation and following incidents.
- Employers may need to set limits for working hours and shift patterns and these need to be monitored and enforced.
- The Management of Health and Safety at Work Regulations 1999 are the main instrument for risk assessment and management systems to control fatigue. The Working Time Regulations 1998 are of some relevance to managing fatigue (see OC1/6) with assessments for night workers, 48 hour weeks (with opt out), 1 days rest in 7 etc.
- It should be remembered that operators may prefer badly designed shift patterns for social reasons e.g. ones which give long breaks between shifts despite having to work 14 hour shifts.

Some good practice guidance on shift roster design

Night shifts

- Restrict number of night shifts (to 4 maximum if possible).
- Allow at least 2 days off following night shift.
- Avoid keeping workers on permanent night shifts.

Early starts

- Move early shift starts before 6am forward (e.g. 7am not 6am start).
- Limit the number of successive early starts ie before 7am (to 4 maximum if possible)
- Shifts involving an early start should be shorter in length to counter the impact of fatigue later in the shift.

Shift length

- If 12-hour shifts worked then no overtime worked in addition.
- Avoid long working hours (more than 50 hours per week).
- If 8/10 hour shifts then no more than 4/2 hours additional overtime to be worked.
- Restrict 'back to backs' with 8 hour shifts and avoid entirely with 12 hour shifts.

Rest periods

- Allow minimum of 12 hours between shifts and avoid 'quick return' of 8 hours if possible. (Rest period between shifts should permit sufficient time for commuting, meals and sleep.)
- Plan some weekends off, advisably at least every 3 weeks.

Rotation

- Rotate shifts quickly (e.g. every 2-3 days). Avoid rotating shifts every 1-2 weeks.
- Use forward rotation (morning/afternoon/night) for preference.

Social considerations

- Arrange start/finish times of the shift to be convenient for public transport, social and domestic activities.
- Consider travelling time of workforce.
- Allow some individual choice where possible to accommodate larks/owls and family commitments.
- Keep the timing of shifts regular and predicable but also allow employees to have some flexibility to choose their own work schedule.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:

    - Any policy on working hours;
    - Copy of the base shift roster/pattern;
    - Copy of computerised sample of working hours over 30 days;
    - Site arrangements for overtime.

- When the documents are obtained they should be compared with good practice and use the 'Fatigue and Risk Index' (by the HF Inspector) to determine if any shift has high fatigue and risk scores and review a sample of an individuals hours over the last month and examine if this fits with the base roster.

Enforcement and advice

- Support for enforcement can be provided where there is evidence of excessive overtime being worked by staff involved in safety critical (MAH) work and operators are not monitoring overtime; or following an incident where fatigue was a significant factor.
- HSWA Section 3 responsibilities towards contractors and other non-employee staff on site are especially pertinent.
- MHSW Regs 1999 regulations 3 and 5 are the key areas for enforcement.

Guidance

- **Reducing error and influencing behaviour**, HSG48. Available from www.hse.gov.uk/pubns/books/hsg48.htm. This guidance contains a good summary of key fatigue issues on pages 35-37.
- **Managing Shift Work: Health and Safety Guidance**, HSG 256. Available from www.hse.gov.uk/pubns/books/hsg256.htm. Particularly useful for employers, safety representatives, trade union officials, employees, regulators and other stakeholders. By drawing together advice and best practice from a range of sources, the guide explains employer's legal duties, the key risk factors and describes the impact shift work can have on health and safety. It also offers sensible advice on controlling, managing and monitoring the risks of shift work.
- **Good practice guidelines**, www.hse.gov.uk/humanfactors/topics/fatigue.htm
- **Hints and Tips for Shift Workers**, www.hse.gov.uk/humanfactors/topics/fatigue.htm
- **The development of a fatigue / risk index for shiftworkers**, HSE Research Report RR446, www.hse.gov.uk/research/rrhtm/rr446.htm. This guidance includes a spreadsheet calculator.
- **Shift work booklet** from ASLEF, www.aslef.org.uk/hs/rs_fatigue.pdf

Question set: Managing fatigue risks

	Question	Site response	Inspectors view	Improvements needed
1	**Policy** Is there a policy that specifically addresses working hours, overtime and guards against fatigue? • Does the policy demonstrate commitment to the management of this issue? • Have front-line staff been involved in the development and review of the policy? • Does the policy state how risks arising from fatigue related to hours of work and shift work be assessed and controlled? • Does the policy identify who it affects, and outline the responsibilities of management, supervisors and staff? • Is there a periodic review and update of the policy?			
2	**Recognition** Has there been any consideration of hours of work/shift system and their effect on staff? • Did this specifically assess the risk of fatigue in safety critical staff and tasks? • Is the review/risk assessment process repeated at specific intervals? • Have the key pinch points and the underlying			

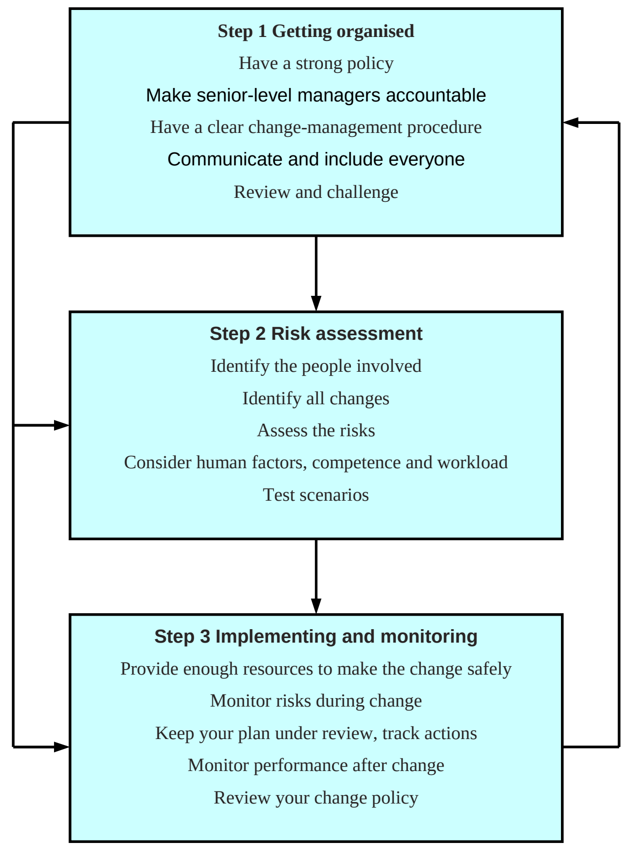
	causes of fatigue been examined? • Is there an effective classification and recording system for working hours and the causes for exceeding the working policy? • Have they identified what measures are effective for managing fatigue and which are not? • Have employees been consulted in the means for avoiding and managing fatigue?			
3	**Control** Have the site set limits for the number of hours and the type of shift pattern? • What are the consequences if these limits are exceeded? • Are there arrangements for the maximum amount of agreed overtime? • Is any overtime spread equally over all staff and shifts (and how do they know this)? • Is shift swapping allowed and if so how is it monitored and controlled? • Are the consequences of staff taking 2^{nd} jobs when off-shift considered and monitored? • Get the opinion of the staff on the shift pattern.			
4	**Monitoring**			

	• Is there a system of recording working hours, overtime, on-call working? • Is there a robust, effective system for ensuring that the monitoring system triggers changes in staffing levels and workload should the need arise? • Is the monitoring on an individual level?			
5	**Assessment** • Does the shift system conform to HSE's good practice guidelines (sfarp)? • Does the Fatigue and Risk Index indicate any shifts with high fatigue and/or risk scores?			

Specific topic 3: Organisational change and transition management

Introduction

Fig 9: Managing organisational change



- This can range from simple limited change (e.g. apparently minor change in supervision arrangements for shifts) through delayering, takeover/merger changes, multiskilling etc to a full business process re-engineering (BPR) exercise.
- The key issue is the identification and assessment of effects (direct and indirect) on the control of MAHs on site from a proposed change, and during the transition to the new structure. In the case of the apparently minor supervisory change at a TT site, there was a real – but unassessed – impact on this control, and the team provided substantial support for the inspector concerned in dealing with this.
- The Human Factors Team have developed and published an information sheet on the management of organisation change. A copy of this is attached as Appendix 5.
- Guidance is available (Contract Research Report 348/2001, commonly referred to as the 'Entec report') on determining staffing levels. This does not, however, provide all the answers. It can be used to confirm (or not) that the levels of staffing in place/proposed are adequate, but if the level is not adequate the guidance will not tell you by how much it needs to be increased (i.e. needs to be used iteratively to determine an adequate level). This Entec guidance does not work well for highly automated plant.

Specific documents

- In addition to the general documents that should be requested prior to the visit (see section 1) it is recommended that the following documents, which are specific to this topic, should also be requested:
    - ➢ Management of (organisational) change policy and/or procedure;
    - ➢ Risk assessments from previous or current change process.

Enforcement and advice

- Improvement and Prohibition Notices have been issued on transition risk assessment and training for major BPR exercise at a large TT chemical site. Extensive advice and support for major organisational change at an oil terminal following new ownership. The Human Factors Team also recently provided support for an extensive investigation of organisational change offshore.
- This is an area for which the Human Factors Team have developed much expertise.

Guidance

- *Business re-engineering and health and safety management: best practice model* Contract Research Report 123/1996 (reference 22)
- *Organisational change and major hazards* Chemical Information Sheet No CHIS7 (reference 24)
- *Assessing the safety of staffing arrangements for process operations in the chemical and allied industries* HSE Contract Research Report 348/2001 (reference 23)
- *Development of a multiskilling life cycle model* HSE Contract Research Report 328/2001 (reference 25)

Question set: Organisational change and transition management

	Question	Site response	Inspectors view	Improvements needed
1	Is there a robust procedure for management of organisational change with: • Clear objectives? • Clear leadership from senior management? • Structured, to a prescribed, consistent process, thorough, well documented?			
2	Is there an assessment process that: • Identifies and maps all changes to both tasks and personnel that could have an impact on MH prevention, no matter how small the change? • Is facilitated by well-trained persons independent of the facility being assessed?			
3	Does the risk assessment methodology guide assessors to take full, realistic account of the range of human reliability? This may include: • Workload (including non-productive work); • Competence; • Work priorities; • Team work and communication.			

4	Where applicable, are there realistic assessments of the organisation's handling of a range of crisis scenarios post-change, including upsets, escalating incidents and emergencies?			
5	Are all assessments fully participative, ensuring that the knowledge (including informally held knowledge) and views of people involved is gathered and given dispassionate consideration?			
6	If outsourcing is considered: • Is major accident prevention accepted as core business? • Are there arrangements to continue, and resource, effective control of outsourced major accident risks? • Have appropriate performance indicators been selected for signs of degradation of performance?			
7	Where required, is there a competence assurance process to ensure adequate transition arrangements? • Does it include identification of training needs for changed or additional roles in relation to major hazards/process safety – bearing in mind that some key knowledge may well not be documented? • Is there adequate planning for competent			

	cover during the training period?			
8	Is there an overall view of site or business-wide requirements for the core technical competencies required to keep risks 'ALARP', including capacity for engineering and adequate, intelligent supervision of contractors?			
9	Is there a mechanism for reviewing decisions, and to ensure that all necessary measures are in place before 'go-live'?			
10	Are there plans to monitor performance indicators well beyond the end of the transition?			

Section 7: Sources of guidance

Introductory and general		
1	**Topic**	**General guidance**
	Title	*Reducing error and influencing behaviour*
	Reference	HSG48, HSE Books 1999, ISBN 0 7176 2452 8
	Comment	Essential HSE generic industry guidance on human factors – a simple introduction
2	**Topic**	**Incident report**
	Title	*Lessons from Longford: the Esso Gas Plant Explosion* Andrew Hopkins
	Reference	CCH Australia Ltd, 2000, ISBN 1 86468 422 4 (email dmckail@cch.co.uk or Tel 0161 6436133
	Comment	Excellent and clear summary of main issues arising from the incident including the widespread over-focus on personal safety matters and indicators on major hazard sites.
3	**Topic**	**General guidance**
	Title	Managing Human Error Postnote
	Reference	Parliamentary Office of Science and Technology, June 2001 Number 156: www.parliament.uk/post/home.htm
	Comment	A clear and useful summary of the main issues on managing human error.
4	**Topic**	**General guidance**
	Title	*Improving compliance with safety procedures: reducing industrial violations*
	Reference	HSE Books 1995, ISBN 0 7176 0970 7
	Comment	Useful guide to assessing compliance with, and design of, procedures (see also HSG48 for a summary)
5	**Topic**	**General guidance**
	Title	*Human factors integration: Implementation in the onshore and offshore industries*
	Reference	RR001
	Comment	
6	**Topic**	**General guidance**
	Title	*Managing Human Error*
	Reference	The Vision Consultancy, 15 Greek Street, London W1D 4DP; tel. 0207 734 6840
	Comment	Multi-media (video/CD-Rom) training package. HSE contributed towards this video training package. A clear introduction to the main issues with supporting training materials etc.
7	**Topic**	**General guidance**
	Title	*Development of human factors methods and associated standards for major hazard industries*
	Reference	RR081
	Comment	
Core topics		
8	**Topic**	**Competency**

	Title	*Developing and maintaining staff competence: railway safety principles and guidance (part 3 section A)*
	Reference	HSE, HSG197, 2002, ISBN 0-7176-1732-7
	Comment	Although written for the rail industry it contains much good information and guidance which can be equally applied to the chemicals sector.
9	**Topic**	**Competency**
	Title	*Competence assessment for the hazardous industries*
	Reference	RR086
	Comment	Includes a usable format for sites to use for self assessment of their training and competency arrangements
10	**Topic**	**Procedures**
	Title	*Evaluation report on OTO 1999/092 Human factors assessment of safety critical tasks*
	Reference	RR033
	Comment	
Common topics		
11	**Topic**	**Communication**
	Title	*Effective design of workplace risk communications*
	Reference	RR093
	Comment	
12	**Topic**	**Communication**
	Title	*Guidance on permit-to-work systems in the petroleum industry*
	Reference	HSE, Oil Industry Advisory Committee, 3rd ed, 1997
	Comment	
13	**Topic**	**Communication**
	Title	*Effective Shift Handover – A Literature Review*
	Reference	OTO 96 003
	Comment	
14	**Topic**	**Emergency Response**
	Title	*Performance indicators for the assessment of emergency preparedness in major accident hazards*
	Reference	CRR 345/2001, ISBN 0 7176 2038 7
	Comment	Includes useful guidance on current good practice.
15	**Topic**	**Maintenance error**
	Title	*Improving maintenance – a guide to reducing human error*
	Reference	HSE Books 2000, ISBN 0 7176 1818 8
	Comment	Useful guide to assessing major accident hazards and risks from maintenance.
Specific topics		
16	**Topic**	**Alarm handling**
	Title	*The explosion and fires at the Texaco Refinery, Milford Haven, 24 July 1994*
	Reference	HSE Books 1997, ISBN 0 7176 1413 1

	Comment	Background Reading & key incident report
17	**Topic**	**Alarm handling**
	Title	*Alarm systems, a guide to design, management and procurement*
	Reference	EEMUA Publication No 191 (Tel. 020 7628 7878/Fax 020 7628 7862)
	Comment	Essential for alarm system managers/engineers; includes useful tools
18	**Topic**	**Alarm handling**
	Title	*Better alarm handling*
	Reference	Chemicals Sheet No. 6, www.hse.gov.uk/pubns/chis6.pdf
	Comment	Basic guidance and introduction to the issue
19	**Topic**	**Alarm handling**
	Title	*Training on alarms management*
	Reference	EEMUA (tel. 01582 462324)
	Comment	Contact EEMUA for a list of training providers
20	**Topic**	**Alarm handling**
	Title	*The management of alarm systems*
	Reference	CRR 166/1998, HSE Books 1998 ISBN 0 7176 1515 4
	Comment	Detailed guidance for alarm system designers/installers/manufacturers/user specification
21	**Topic**	**Fatigue/Shiftwork**
	Title	*Validation and development of a method for assessing the risks arising from mental fatigue*
	Reference	CRR 254/1999, HSE Books 1999 ISBN 0 7176 1728 9
	Comment	Contains a useful summary of the main do's and don'ts of shift rotas, hours etc and a method (the 'fatigue index') for assessing planned shift pattern/hours changes. See also HSG48 for a good summary.
22	**Topic**	**Management Of Organisational Change**
	Title	*Business re-engineering and health and safety management: best practice model*
	Reference	CRR 123/1996 ISBN 0 7176 13
	Comment	Useful guidance for significant or major organisational change
23	**Topic**	**Management Of Organisational Change**
	Title	*Assessing the safety of staffing arrangements for process operations in the chemical and allied industries*
	Reference	CRR 348/2001, ISBN 0 7176 2044 1
	Comment	Essential guidance for assessing manning levels pre- and post-change
24	**Topic**	**Management Of Organisational Change**
	Title	*Organisational change and major hazards*
	Reference	Chemical Information Sheet No CHIS7, HSE 2003. www.hse.gov.uk/pubns/chis7.pdf
	Comment	
25	**Topic**	**Multiskilling**
	Title	*Development of a multiskilling life cycle model*
	Reference	CRR 328/2001, ISBN 0 7176 2001 8

	Comment	Useful on varieties of multiskilling and their implications.
26	**Topic**	**Remote Operation**
	Title	*Human factors aspects of remote operation in process plants*
	Reference	CRR 432/2002, ISBN 0 7176 2355 6
	Comment	

Section 8: Glossary

Hazard:

Something that has the potential to cause harm.

Human factors:

'Human factors refers to environmental, organisational and job factors, and human and individual characteristics which influence behaviour at work in a way which can affect health and safety.' (Definition in HSG48)

Human failure and human error:

'A human error is an action or decision which was not intended, which involved a deviation from an accepted standard and which led to an undesirable outcome'. Human failure refers to errors AND violations (i.e. non-compliance with rules or procedures) (Definition in HSG48)

Major accident:

'Means an occurrence (including in particular, a major emission, fire or explosion) resulting from uncontrolled developments in the course of the operation of any establishment and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances.' (COMAH Reg 2(1))

Mistakes:

Errors arising from a correct intention that leads to an incorrect action sequence. This may arise, for example, from lack of knowledge or inappropriate diagnosis.

Performance Influencing (or Shaping) Factors:

Factors which influence the effectiveness of human performance and hence the likelihood of failures.

Recovery failure:

Failure to correct a human error before its consequences occur.

Risk:

The chance (big or small) of harm actually being done.

Root causes:

The combinations of conditions or factors that underlie accidents or incidents.

Slips:

Errors in which the intention is correct, but a failure occurs when carrying out the activity required. Slips occur at the skill based level of information processing.

Violations:

An error that occurs when an action is taken which contravenes known operational rules, restrictions and/or procedures. The definition of violations excludes actions taken to intentionally harm the system, i.e., sabotage.

Appendix 1: Human factors and major accidents

Some illustrative major accidents and the associated human factors elements.

Accident, industry and date	Consequences	Human contribution and other causes
Three Mile island, USA *Nuclear industry* 1979	Serious damage to core of nuclear reactor.	Operators failed to diagnose a stuck open valve due to poor design of control panel, distraction of 100 alarms activating, inadequate operator training. Maintenance failures had occurred before but no steps had been taken to prevent them recurring.
King's Cross Fire, London *Transport sector* 1987	A fire at underground station in London killed 31 people.	A discarded cigarette probably set fire to grease and rubbish underneath one of the escalators. Organisational changes had resulted in poor escalator cleaning. The fire took hold because of the wooden escalator, the failure of water fog equipment and inadequate fire and emergency training of staff. There was a culture which viewed fires as inevitable.
Clapham Junction, London *Transport sector* 1988	35 people died and 500 were injured in a triple train crash.	Immediate cause was a signal failure caused by a technician failing to isolate and remove a wire. Contributory causes included degradation of working practices, problems with training, testing quality and communications standards, poor supervision. Lessons not learnt from past incidents. No effective system for monitoring or limiting excessive working hours.
Herald of Free Enterprise, Zeebrugge *Transport sector* 1987	This roll-on roll-off ferry sank in shallow water killing 189 passengers and crew.	Immediate cause was the failure to close the bow doors before leaving port. No effective reporting system to check the bow doors. Formal inquiry reported that the company was 'infected with the disease of sloppiness'. Commercial pressures and friction between ship and shore management had led to safety lessons not being learnt.
Union Carbide Bhopal, India *Chemical processing* 1984	The plant released a cloud of toxic methyl isocynate. Death toll was 2500 and over one quarter of the city's population was affected by the gas.	The leak was caused by a discharge of water into a storage tank. This was the result of a combination of operator error, poor maintenance, failed safety systems and poor safety management.

Space Shuttle Challenger, USA *Aerospace* 1986	An explosion shortly after lift-off killed all seven astronauts on board.	An O-ring seal on one of the solid rocket boosters split after take-off releasing a jet of ignited fuel. Inadequate response to internal warnings about the faulty seal design. Decision taken to go for launch in very cold temperature despite faulty seal. Decision-making result of conflicting scheduling/safety goals, mindset, and effects of fatigue.
Piper Alpha, North Sea *Offshore* 1988	167 workers died after a major explosion and fire on an offshore platform.	Formal inquiry found a number of technical and organisational failures. Maintenance error that eventually led to the leak was the result of inexperience, poor maintenance procedures and poor learning by the organisation. There was a breakdown in communications and the permit-to-work system at shift changeover and safety procedures were not practised sufficiently.
Chernobyl, USSA *Nuclear industry* 1986	1000 MW Reactor exploded releasing radioactivity over much of Europe. Environmental and human cost.	Causes are much debated but Soviet investigative team admitted 'deliberate, systematic and numerous violations' of safety procedures by operators.
Texaco Refinery, Milford Haven *Chemical processing* 1994	An explosion on the site was followed by a major hydrocarbon fire and a number of secondary fires. There was severe damage to process plant, buildings and storage tanks. 26 people sustained injuries, none serious.	The incident was caused by flammable hydrocarbon liquid being continuously pumped into a process vessel that had its outlet closed. This was the result of a combination of: an erroneous control system reading of a valve state, modifications which had not been fully assessed, failure to provide operators with the necessary process overviews and attempts to keep the unit running when it should have been shut down.
BP, Grangemouth *Petroleum refining* 2000	Three incidents occurred within a two-week period: power distribution failure, steam main rupture and fire on catalytic cracker unit. Serious process interruption but no serious injuries. All incidents had the potential to cause major accidents.	The key findings of the Human Factors team explained why, notwithstanding the high standards set by BP, those standards were not always implemented and met consistently over each part of the Complex. The consequences of a non-unified management structure and differences resulting from the three historical business streams operating at the Complex, in large part provided a compelling explanation of the incidents which occurred. There was also a lack of monitoring of major hazard performance at the Complex.