Health and Safety Executive

HSE Human Factors Briefing Note No. 1

Introducing Human Factors

Case study

In January 2001, an accident at a lower tier COMAH site led to several tonnes of phenol being released into a bund. The operators setting up the process made an error and later in the operation, a tank outlet inadvertently closed. The phenol then overflowed from the tank.

No one was injured, but the cost in loss of materials, lost production and recovery of the phenol was £39,800.

Investigations found that the system for controlling pumps and valves was badly designed and prone to human error. Phenol is a poison that is absorbed through the skin. It was only luck that no one was injured in the incident because no one was near the leaking tank.

Source: HSE website www.hse.gov.uk/comah/index.htmT

This incident shows that, whenever people use control systems – whether by turning valves, using pushbuttons or a keyboard - if those systems are poorly designed then the operator could make an error. Poor design in this way is one example of a 'Human Factors' problem.

We want to make sure that companies do as much as they can to prevent everyday accidents and injuries - for example slips, trips and falls. But, we are particularly concerned that they prevent major hazard accidents: those that could injure a large number of people, on and off the site.

Since human failures are responsible for up to 80% of all types of accident and figure in almost every major accident it is important to reduce those failures as much as possible. We strongly believe that applying human factors methods helps to reduce accidents.

From recent site inspections and assessment of safety reports at COMAH sites, we believe that a large number of companies need to look more closely at human factors issues.

We know that there is potential for significant human factors problems at most COMAH sites, and we want to encourage all companies to find out more about this important topic area, and to apply that knowledge in a structured and rigorous way to their key safety critical activities.

As part of our strategy, we are providing information and guidance and will want to ensure that managers are applying that information.

This 'Briefing Note' is the introduction to a series of 12 and it:

- Explains what Human Factors are;
- Gives examples of human factors problems in companies like yours; and
- Describes what can be done to help solve those problems.

More information, help and guidance

The other briefing notes (2-12) are on Human Factors subjects that HSE believe need particular attention on major hazard sites:

2. Competence
3. Humans and Risk (integration of human factors into risk assessments and accident investigation)
4. Written procedures
5. Emergency Response
6. Maintenance
7. Safety culture
8. Safety-critical communications
9. Alarm handling and control room design
10. Fatigue
11. Organisational change and transition management
12. Human Factors and the Major Accident Prevention Policy (MAPP)

Human factors checklist

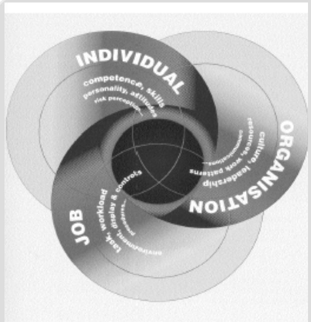
This list doesn't cover every aspect of human factors but will give you an idea of what is involved. It includes safety management factors. If you can tick most of the boxes, then your company is probably dealing with human factors and safety culture issues quite well.…but every company can improve.

For all the jobs done on this site, this company usually:

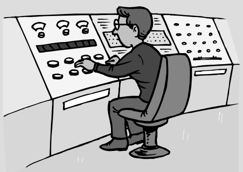
➢ Chooses the most skilled people to do the work, either our own people or contractors *(B'Note 2)*	☐
➢ Gives people interesting and varied work without overloading them	☐
➢ Arranges for work to be done in teams if that's the best approach *(2 and 3)*	☐
➢ Takes care that the working environment is not too hot or cold or uncomfortable *(3 and 10)*	☐
➢ Keeps noise levels down to help communications and concentration *(9)*	☐
➢ Provides good lighting *(9)*	☐
➢ Arranges reasonable working hours, meal and rest breaks *(10)*	☐
➢ Makes sure that there's enough room to work in, that is, not too cramped or confined *(12)*	☐
➢ Issues written instructions and other essential paperwork that work very well *(4)*	☐
➢ Avoids overloading people with information and doesn't give contradictory information *(8)*	☐
➢Provides the proper tools and equipment to do the work *(6)*	☐
➢ Doesn't apply unreasonable time pressure *(3 and 8)*	☐
➢ Minimises interruptions to jobs and doesn't change priorities all the time *(3)*	☐
➢ Makes sure that, if a job is handed over to another shift, key information is handed over with it *(8)*	☐
➢ Provides good supervision of important tasks or of less experienced teams *(2)*	☐
➢ Has practiced and realistic emergency plans in place in case there's a problem *(5)*	☐
➢ Encourages a good working culture and good relationships between people *(7)*	☐
➢ Doesn't keep changing the organisation, individual responsibilities or lines of management *(11)*	☐

Learning more about human factors

HSE's core guidance[1] on human factors defines it as the interaction between the 3 main factors affecting human performance at work - the job, the individual and the organisation. This means that, in a well-managed organisation:



The **Job** is well-designed to match known strengths and limitations of the person or team doing it. This is called fitting the job to the human. This design includes: work areas, the environment, tools, materials, machinery, control and display devices, management and communications systems and all written materials for guidance and job control.



The company will also select **Individuals** matched to the needs of the job. (Fitting the human to the job). They will have: the most suitable physique (size, build and strength), personality and intelligence fitted to the job. They will be fully competent by having the right skills, understanding, experience and training.

Management within the **Organisation** take responsibility for all aspects of work and work design: they devise and maintain a good safety management system, and encourage a good safety culture by showing genuine commitment and consulting the workforce on key decisions. A learning organisation will take into account the latest thinking on best practice in safety and will learn from accidents and near misses.

We need companies to put more emphasis on good job and task design and to assess and organise safety critical tasks so that they are safe.

However, in our inspections and investigations and in reading safety reports, we find that companies spend more time describing the reliability of the ***hardware***. This is important, but so is the reliability of the ***person*** operating the hardware and an equally rigorous and structured approach is needed.

Companies are not always realistic about how people actually behave at work, for example:

Companies state that employees will…	**The reality is….**	**Management should…**
Follow procedures	Procedures are often: missing, out of date or poorly written. People make up their own work methods	Find out why procedures are not being used. See if the way employees actually do the job is more efficient and safer
Be fully competent in everything they do	Everyone has gaps in their knowledge. Some companies have lost highly experienced people	For novices: provide supervision and good procedures For those whose knowledge is 'rusty': reassess them and provide refresher training For those who are leaving: plan for others to take over by learning from the experience of old hands before they leave
Be highly motivated in their work	Even the person in their ideal job has some 'off days'; many routine tasks are simply boring	Design jobs to stimulate interest; even if it means giving someone work that could be done by a machine. 'Rotate' people in and out of the most boring but necessary jobs
Are always where they should be	People wander off or are asked to do favours for others that takes them out of their normal workplace	Accept that people won't always be where they should be. Provide radios and pagers. Arrange for back up cover when someone really does need to go elsewhere

Companies state that employees will…	The reality is….	Management should…
In an emergency, 'save the day'	Real emergencies are often highly complex and stressful. People don't react as in the emergency plan	Practise emergencies so that everyone is familiar with the required routines and maintains skills in these infrequent events. Provide clear information during emergencies. Have a clear structure with fall back plans and ensure everyone knows their role
Work highly reliably: be very unlikely to make an error	All tasks are prone to errors – some more than others. Human errors are a major cause of accidents and can occur in all jobs – including operations, maintenance, modification and management	Consider human error when they assess risks. Make systems as 'forgiving' as possible (resistant to error; allow time for correcting the error). For safety critical tasks, make sure that eg key steps are independently checked, and that procedures and other job aids are clear. Avoid a 'blame culture'

Other key problems we have found from inspection and assessment are:

- Too much emphasis being placed on reducing personal accidents (slips, trips, falls etc) without an equal focus on preventing **major** accidents
- Failing to realise that that safety culture is about everyone in the company, including managers, not just the 'front line'
- Not being clear how the safety management system will prevent or reduce human errors which may lead to major accidents

Reference

1. Reducing error and influencing behaviour (HSG48), HSE Books 1999, ISBN 0 7176 2452 8

HSE Human Factors Briefing Note No. 2

Competence

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

Competence is the ability to undertake responsibilities and to perform activities to a recognised standard on a regular basis. Competence is a combination of practical and thinking skills, experience and knowledge Source: Ref. 1

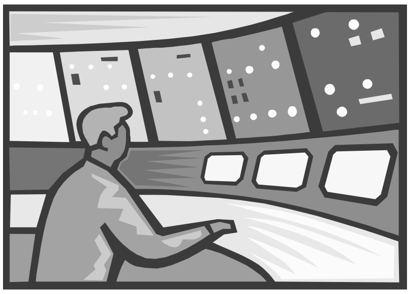
Case study

In July 1999, an operator caused an explosion when drying an unstable compound at too high a temperature. The compound involved is dried on trays; the procedure is to collect water from the process in a reservoir, then transfer it to a drain for treatment. A fault in the system overfilled the reservoir, in addition, the water contained too much of the unstable compound. The operator heated the water in the reservoir using a steam pipe to ease the transfer process. After 20 minutes, the reservoir exploded sending a fireball around the installation. No one was injured as this happened at shift change.

It was recommended following the investigation that the site needed to improve operator training in the risks associated with the compound, in particular the danger of decomposition when heated.

The operator lacked some basic knowledge. This was coupled with a fault in the hardware thus; in common with many accidents, this one had *at least two underlying causes*.

Source: Ref. 2



HSE concerns

- You should have a process to ensure that anyone working with major hazards on your site is competent. (See box below & Ref. 3).
- You should link the 'competence assurance' process to your major accident risk assessment. First, identify hazards on your site. For example, for a particular hazardous material, you should identify related 'critical tasks'. That is, find out what your workforce must do to control the material (keep it contained) and what to do if it is released (abnormal or emergency situation). Then, you must ensure that your workforce has the skill, knowledge and experience of the material and the processes using it to carry out their critical tasks. Remember that managers have critical tasks too.
- The NVQ/SVQ system can provide some general and some site-specific competencies, but is not usually linked to major accident hazards. You should modify your VQ system to make this link.
- You should consider the type of procedures needed based on competence. Generally, the type of procedure needed (detailed vs basic job aid) will depend on whether: the person doing it is competent and whether the task is safety critical, infrequent and complex. (See Briefing Note 4 on Procedures).

We need to know that your company has *competent* employees: people who have the *skills*, *experience* and *knowledge* to do their job properly and safely under all working conditions. The diagram on page 2 shows the three main things you need to do to make sure your staff are competent:

- **Select** the right people
- **Train** them
- **Assess** them (at various stages)

These three stages together form the 'competence assurance' system of the company.
Note: these are continuous not 'one-off' processes.

Learning more about competence

Competence checklist

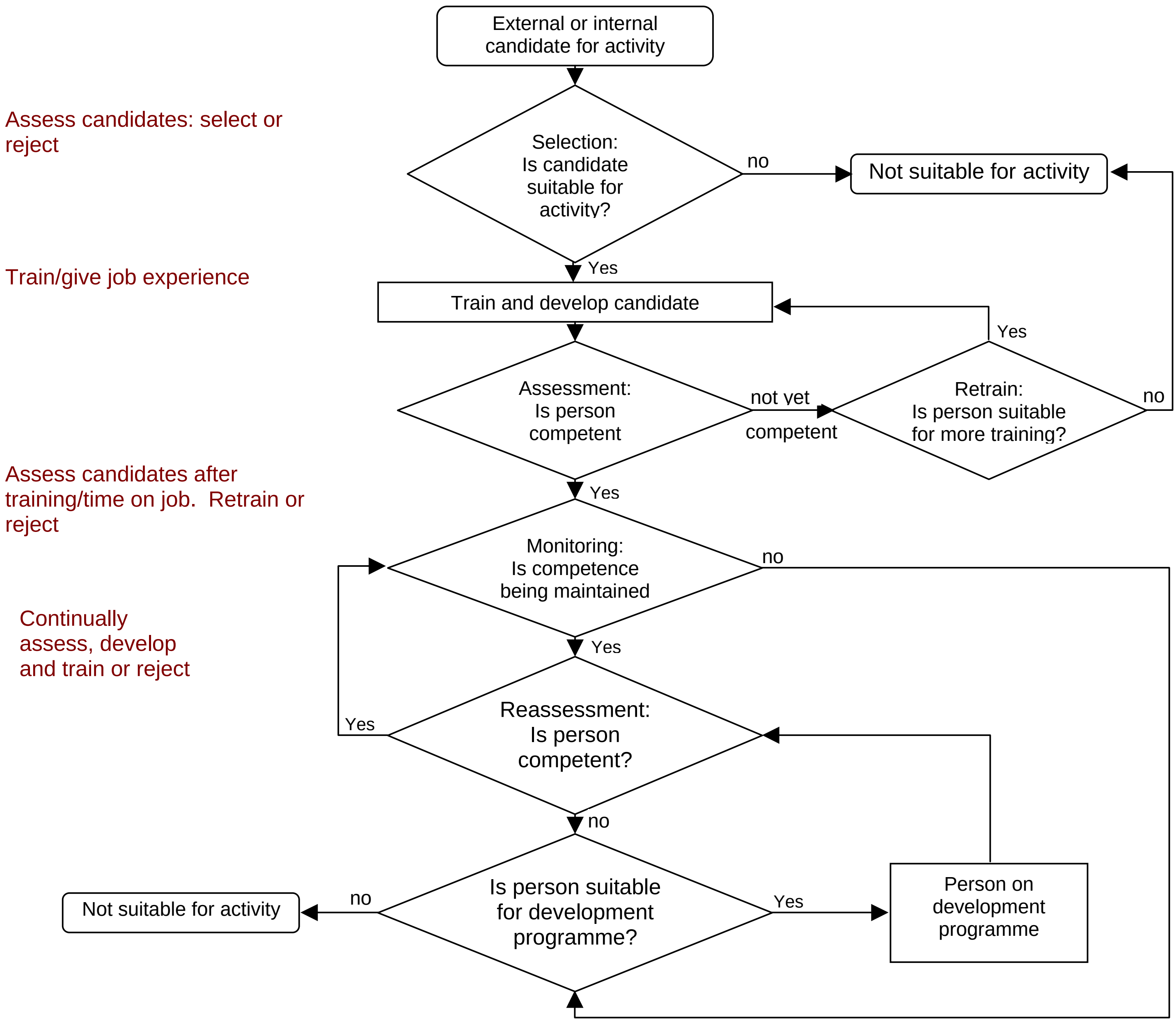
The list below outlines how good companies approach competence.

At this site we:

➢ Know all hazards that could arise in every task (including normal operational, maintenance and emergency tasks)	☐
➢ Have a good selection process to identify suitable employees or contractors for those tasks	☐
➢ Know the exact type of person to assign to each task	☐
➢ Have enough people to always be able to put the right person onto a particular job	☐
➢ Can identify any gaps in a person's skill or knowledge or experience (competence)	☐
➢ Know the best way of providing the skills and knowledge that people need (e.g. training, including on the job)	☐
➢ Have access to the best training resources (training facilities, trainers and equipment)	☐
➢ Make it easy for people to get the training they need	☐
➢ Always use actual work instructions/procedures in our training	☐
➢ Continually improve managers' as well as staff competence	☐
➢ Never make a person do a job they're not competent to do	☐
➢ Assess whether training has worked	☐
➢ Retrain people if they need it	☐
➢ Keep good records so that we know what training/experience each person has had and what they need next	☐
➢ Change the selection, training and assessment system if it isn't working	☐

A tick in every box above would suggest you are a 'world-class' site when it comes to competence. Are you really so sure that you do all of these things? In particular, can you honestly say that your competence assurance scheme takes account of **major accident prevention and recovery?**

Competence Management – selection, training and assessment process

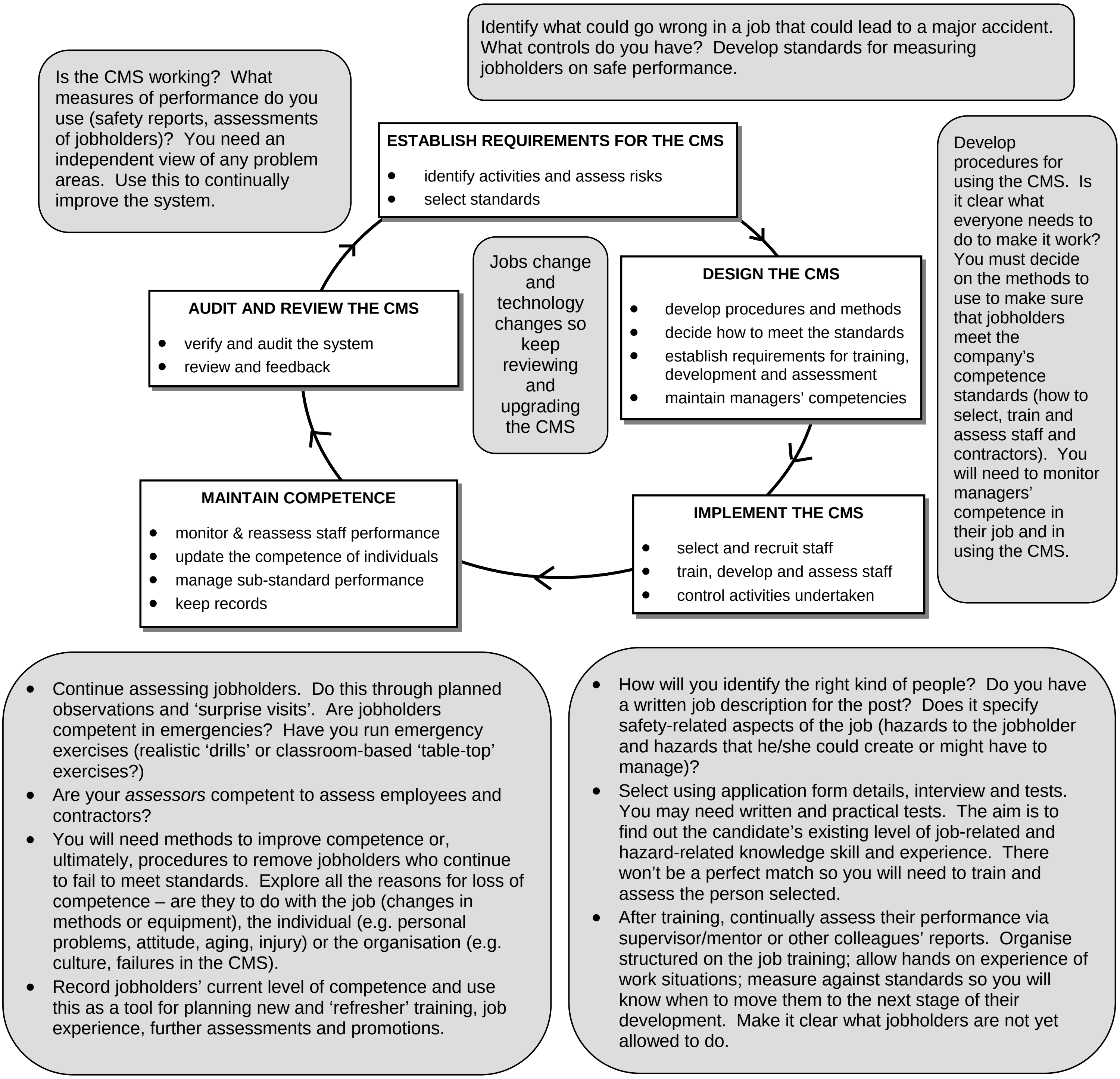


A Competence Management System

Our guide, ‘Developing and Maintaining Staff Competence’ is a useful text on the subject. It was written for the rail industry but applies equally well to many other industries. On this page, we set out the main points of that document and others on the subject of competence management.

The guidance document describes how to design a ‘Competence Management System’ (CMS). This is a 15-step process; the diagram below shows the main elements.

The comments and questions near the boxes below are intended as prompts about things you should consider in developing your own CMS.



References

1. Developing and Maintaining Staff Competence. HSE (2002), ISBN 0 7176 17327
2. Major Accident Reporting System (MARS) http://mahbsrv2.jrc.it/MARS/servlet/ShortReports
3. HSE (1999) Major Accident Prevention Policies for Lower-Tier COMAH Establishments. Chemical Information Sheet No 3. HSE Books, PO Box 1999, Sudbury, Suffolk CO10 6FS

HSE Human Factors Briefing Note No. 3

Humans and Risk

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

A 'hazard' is anything that can cause harm (e.g. chemicals, electricity, working at height); 'risk' is the chance that someone could be harmed by the hazard. Any company will be able to manage risks better if it understands where the hazards are and how to control them.

Case study

"From the perspective of the individual facility manager, catastrophic events are so rare that they may appear to be essentially *impossible*, and the circumstances and causes of an accident at a distant facility in a different industry sector may seem *irrelevant*. However, while chemical accidents are not routine…..they are a monthly or even weekly occurrence, and there is much to learn from the story behind each accident."

"…when we look beyond the obvious to the underlying systemic causes of an accident, we see that *the same root and contributing causes* keep popping up again and again. This indicates that government and industry together are not doing a good enough job at sharing accident information and implementing lessons learned."

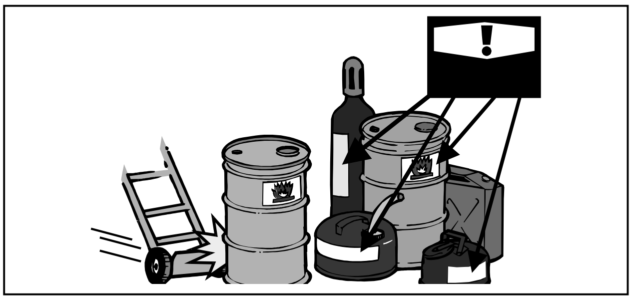
The investigation team quoted above reported these interesting findings:

- before each major accident, there was a series of similar accidents, near-misses and other failures
- new equipment had been installed before some of the accidents.

These two findings suggest that the companies involved did not investigate and learn lessons from earlier events and did not manage the change to the new equipment properly.

- the following root causes were responsible for many different accidents:
  - ➢ hazard review or process hazards analysis were inadequate
  - ➢ operators used inappropriate or poorly-designed equipment
  - ➢ indications of process condition were inadequate
  - ➢ management did not act on early warnings signs of problems.

"One common and useful method of determining root cause is to keep asking "why?" This method must be used with a good dose of engineering judgement. The idea is to ask "why?" enough times to get to the underlying systemic cause of the event, but not so many times that the cause becomes obscured in an overarching general concern which is too vague to address. This sort of over-analysis results in abstractions and doesn't serve any useful purpose."
Source: Ref.1



HSE concerns

Companies focus too much of their current risk management effort (performance measures, audits, behaviour modification) on low consequence high frequency events, such as single minor injuries caused by people tripping over.

More effort needs to be given to the lower frequency high consequence events such as large releases of hazardous chemicals. These are caused by underlying system failures and triggered, typically, by human error.

Most companies still use very basic methods for accident investigation, rarely looking beyond the immediate causes of the accident and with little supporting procedures or checklists for the investigation.

Your MAPP should describe how you identify major accident hazards and assess risks. It should also describe your system for reporting and investigating accidents and near misses (see Briefing Note 12)

The case study on the left shows that risk management and incident/accident investigation have a common aim: to find out what could lead to a loss of control over hazards.

This Briefing Note provides information on the reasons why you can sometimes lose control over hazards and what you can do to control them more effectively.

There is a brief checklist of best practices on page 4.

If you don't do a good risk assessment today, you may have to do an accident investigation tomorrow.

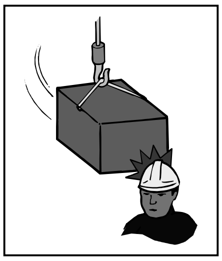
Learning more about humans and risk

'Humans and Risk' is used in this Guidance Note to describe the management system and human failures that can make people lose control over hazards. To prevent or reduce the chance of such failures, you have to know what the failures are and what causes them. These failures form a 'chain' that leads from people in the company who made decisions long before an incident or accident to the person who seems to be immediately responsible. You need to understand this chain and be able to move logically forwards along it – to do risk assessments; and backwards – to do accident investigations.

Slips, lapses, mistakes and violations

By directly observing people at work, specialists in human reliability found that there are four basic types of human failure. It is important to know that there are different types of failures, because there are slightly different ways of preventing each type.

Slip



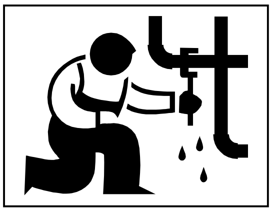
A simple frequently performed physical action goes wrong. You reach for ‘button A’ (which is the ‘raise’ control for a hoist) but push ‘button B’ (the ‘lower’ control) instead. On the control pad, Button B is below Button A. Your error lowers the object being moved onto electrical cables that carry a critical power supply to the plant. Another type of ‘slip’ is reading the wrong instrument. Again, if gauges are too close to each other, there is a risk of reading the wrong one. **Example solutions:** better layout of controls (and displays); design of controls to make it difficult to operate them accidentally; strict control so you never lift loads above vulnerable equipment (or physical barriers above if you can’t avoid this).

Lapse

A lapse of attention or memory. At Step 9 in your 25-step start-up procedure the phone rings and you answer. Afterwards you go back to the task, forgetting where you were in the sequence. You miss out steps 10 and 11 and go straight to step 12. However, steps 10 and 11 are important safety precautions. **Example solutions:** provide written procedures that have ‘place markers’ or spaces to tick off each step. Supervise key tasks; and strictly enforce rules about interrupting staff on critical tasks.

Mistake

Not understanding properly how something works or an error of diagnosis or planning. Your plant starts to behave oddly - you notice fluid flowing in a waste pipe through a valve that you believed was closed. You try to work out why it’s doing this and how to get the plant back to normal. You don’t have exactly the right information or experience. Therefore, your diagnosis, and recovery plan, are wrong. You think the valve has been opened in error so you close it. This diverts fluid via an overflow to a tank. The maintenance crew in the tank had actually opened the valve manually to drain hazardous waste to a treatment vessel while they work. It was their error that they did not tell you, but your ‘solution’ sends the hazardous waste into their work area. **Example solutions:** increase the knowledge and experience applied to such problems (by improving operator competence or by ensuring that operators discuss complex situations in a group and later share knowledge around the plant); use special procedures that guide you to a safe solution.



Violation

A deliberate breach of rules and procedures; you are fitting a new pump and stores have given you the wrong type of seal. It’s almost the same specification as the one you want. It would take too long to get the right one so you fit the one you have and leak test it. It works OK. After a few weeks of operation, the seal fails because it is not designed for that pump. **Example solutions:** learn from violations; improve culture and attitudes towards safety.

Risk management and incident/accident investigation logic

You can use this table in two ways. As a guide for incident and accident investigations, it shows the logic of working from what happened down to different underlying causes. As a guide to risk management, you work logically from hazards up to possible outcomes and see what factors could lead to a hazard happening. In the centre column, the words in brackets are an example case study about moving flammable gas bottles across a worksite.

INCIDENT/ACCIDENT INVESTIGATION (what did happen and how?)	INCIDENT OR ACCIDENT SEQUENCE	RISK MANAGEMENT (what could happen and how?)
Start here and work down the column		*Start at the bottom of the column and work up*
Gather facts about the accident or incident	**HARMFUL OUTCOME** (Personnel injured, plant damage by fire)	What is the worst case in terms of consequences of the events identified below?
What were the immediate causes of the harmful outcome? What happened just before the damage or injury?	**EVENT(S)** (1st operator pushes trolley into door post; 2nd gas bottles fall off and roll down stairwell; 3rd some bottles crack and ignite)	Could the human failures identified earlier still lead to release of the hazard? What are the likely consequences of those failures?
What barriers were reduced or removed that allowed the event to take place?	**BARRIER BETWEEN PEOPLE AND HAZARD** (Restraining straps are main barrier; operator competence is another)	Are there enough barriers in place to keep the hazard under control? Or does the risk of releasing this hazard still seem too high? What other barriers are needed?
What job, person or organisational factors contributed to the event? What particularly reduced the barriers against the hazard?	**PERFORMANCE INFLUENCING FACTORS** (Operator under time pressure – truck ready to go immediately)	What could happen to trigger a human failure on a particular day? Environment, operator fatigue, overload? What could we have lost control over?
What did the person(s) doing the critical task do (or not do) that reduced their control over the hazard?	**HUMAN FAILURES** (Operator does not fasten restraining straps; rushes to good lift)	Could a slip, lapse, mistake or violation lead to a major accident?
Were there any earlier human or system failures that contributed to the accident?	**LATENT FAILURES** (Operator is not fully trained; poor design of workplace (doors narrow); poor design of restraining device)	Are we confident that there are no 'latent failures' in our systems (that is, all job, person and organisational factors are adequate)?
What was the task meant to achieve? What were the critical aspects of the task (those things which the operator had to do to keep the hazard under control)?	**CRITICAL TASK** (To move 12kg propane bottles by trolley to load and dispatch area)	What are the 'critical tasks' involving this hazard? (A critical task being one where human failure could result in a harmful outcome).
What hazard needed to be kept under control? Can you remove the hazard or contain it? If not, did you design suitable systems of work or protective clothing/safety equipment to reduce risk?	**HAZARD** (Flammable gas – propane)	What hazards do we have on this site? Make a list. Take each one in turn and move up this column. ***Start here and work up the column***

Risk management and incident/accident investigation checklist

The list below outlines how good companies approach risk management and incident/accident investigation.

At this site we:

- Have a thorough risk management process and… ☐
- …use experienced risk assessors either from within the company or brought in from outside the company to do the assessment ☐
- …have identified all hazards and risks in every job we do (including normal operational, maintenance and emergency tasks and supervision/management tasks) ☐

And using these resources we…

- Know which parts of every job are 'safety critical' (where an error could reduce our control over hazards) ☐
- Know fairly accurately how likely it is that a task could go wrong and cause an accident ☐
- Are confident that we have put in effective barriers that reduce the risk of a hazard causing harm to a level that is as low as is reasonably practicable ☐

We also:

- Thoroughly and systematically investigate all accidents and near-misses ☐
- Can clearly identify the causes of accidents and incidents we investigate ☐
- Use an accident 'model' that separates causes into system/'latent' and 'immediate' human failures ☐
- Have good system to allow personnel to report incidents and accidents ☐
- Always act on information put into the system…… ☐
- … feed back information to personnel about reports put into the system ☐
- ….provide solutions following an incident or accident that everyone accepts and that are effective in addressing immediate and underlying causes of the incident or accident ☐
- Have highly competent incident/accident investigators with extensive procedures and checklists to help them ☐
- Use information from the system to update our risk assessments ☐

Root causes are the underlying prime reasons for an accident or incident. For example, failures of particular management systems allow faulty design, inadequate training, or deficiencies in maintenance to exist. These, in turn, lead to unsafe acts or conditions which can result in an accident. Contributing causes are factors that, by themselves, do not lead to the conditions that ultimately caused the event. However, these factors facilitate or encourage the occurrence of the event or increase its severity.

People may debate whether particular factors should be classed as root causes, contributing causes, or neither. However, major accidents generally involve more than one root cause. "Virtually none of the accidents investigated involved only a single cause. More commonly, half a dozen root and contributing causes were identified.
Source: Ref. 1

Some principles of error management

- "Human error is both universal and inevitable"
- "Errors are not intrinsically bad"
- "You cannot change the human condition, you can only change the conditions in which people work"
- "The best people make the worst mistakes"
- "People cannot easily avoid those actions they did not intend to commit"
- "Effective error management aims at continuous reform rather than local fixes."

Source: Ref. 4

References

1. James C. Belke, 'Recurring Causes of Recent Chemical Accidents', U.S. Environmental Protection Agency Chemical Emergency Preparedness and Prevention Office. Presented at an International conference and Workshop on Reliability and Risk Management organised by IChE/CCPS in September 1998, San Antonio, Texas
2. HSE (1998) 'Five steps to risk assessment: case studies' HSG183, ISBN 0 7176 1580 4
3. HSE (2000), 'Human Factors Assessment of Critical Tasks'. OTO 1999 092
4. Reason, J. & Hobbs, A. (2003), 'Managing Maintenance Error', Ashgate, London.

HSE Human Factors Briefing Note No. 4

Procedures

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

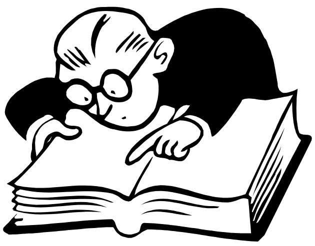
The term 'procedure' refers to the written description of the steps you need to follow to perform a task. Procedures are usually on paper but they could be presented on a computer screen. They may have diagrams, pictures, flowcharts and checklists to make the text easier to understand.

Case study

In May 1995, two process workers at a plant making ferric chloride were killed when they inhaled hydrogen sulphide gas. They had just added sodium sulphide to a 'pickling solution' but the pH of the solution was too low, also, they had added too much sodium sulphide.

The accident report identifies among other faults, 'inadequate management procedures…. work carried out in an improvised manner instead of following working procedures', 'inadequate supervision of how the work was actually carried out' and 'a lack of safety culture'.
Source: Ref 1

A major oil company reviewed its operating procedures and benefited from significant efficiency gains, for example, reduced start-up times. The full involvement of employees was a crucial feature of this process.
Source: HSE Inspector's Comment



Why address procedures?

We are concerned about procedures because research has shown that, where the *general* cause of incidents (near misses) is 'human factors', in most cases the *specific* cause is a problem with procedures.
Source: HSE Training Course slides

Non-Compliance or 'Violations'

Even the best employees can make an error and inadvertently fail to follow a procedure. Sometimes, people deliberately choose to ignore a procedure. This is known as a 'violation'.

Violations are defined as any deliberate deviations from the rules, procedures, instructions and regulations drawn up for the safe or efficient operation and maintenance of plant or equipment. They are important, as they have been found to be linked with between 70% and 90% of incidents and accidents.
Source: Ref. 2

Your Major Accident Prevention Policy (MAPP) should describe how you develop, review/revise and publicise your procedures. This will include your permit to work system and any other systems you have for protecting health, safety and the environment.

HSE concerns

- Operating procedures may not be the best way of controlling major hazards or risks, at least not as the sole defence against human error.
- COMAH sites should have a ‘procedure for managing procedures.’ This should include processes to work out which tasks need procedures, how detailed the procedures need to be, how to keep procedures up-to-date and to make sure personnel comply with procedures.
- Sites should review procedures for safety critical tasks (start-up/shut down, commissioning, abnormal/emergency events, bulk transfers, maintenance and plant/process change). This should include talking to users, identifying ‘informal’ working practices (‘black books’), walking through a sample of procedures at the workplace and analysing incidents/accidents/non-compliances.

Procedures checklist:

If your company has good procedures, you should be able to tick ***most*** of the boxes below:

Our company’s procedures are:

- Always easy to find when you need them – for
  - ➢ Operational tasks (including start up/shutdown) ☐
  - ➢ Commissioning tasks ☐
  - ➢ Maintenance tasks ☐
  - ➢ Abnormal or emergency tasks ☐
- Are completely up to date ☐
- Set out in logical steps ☐
- Very easy to read and clear because: ☐
  - ➢ They use words our people understand ☐
  - ➢ They use diagrams, pictures, flowcharts and checklists to make each task step clear ☐
  - ➢ The size, colour and style of lettering and illustrations is clear ☐
- Are accurate – describe how we actually do the job ☐
- Always highlight the steps in a task where you need to be especially careful ☐
- Helpful in describing all items of special equipment (tools, clothing) you need for each job ☐
- Always in good condition (not dirty, torn or with pieces missing) ☐
- Used to train people how to do the job ☐
- Changed quickly if the way of doing the job changes ☐
- There for a good reason, not just as a ‘knee jerk’ reaction to the latest accident ☐
- Completely consistent with other information (e.g. with verbal instructions from supervisors) ☐
- Supplemented by other job aids (pocket sized checklists; reference material) ☐

Note: no company will be able to tick all of the above; if you have, you should look again very carefully at the questions.

Learning more about procedures

Usually, if something is wrong with a procedure, it means there is something wrong with the system that produced it. The ideas below describe a formal system to develop and maintain procedures.

Procedure for Developing and Maintaining Procedures

First Steps

- Use 'task analysis' to help you fully understand how the job should be done. Task analysis can be used when you devise a new task or to analyse an existing task.
- Base the task analysis on how the job is actually done (or could realistically be done if it's a new task), not on how managers feel it *should* be done
- Identify hazards that could arise in the task: hazards that the person doing the job could cause as well as hazards that they could be exposed to
- Decide if a procedure is the best way of controlling the hazard, if it is, write the procedure

Write Procedures

- Involve the people who will do the job in the first steps and in writing the procedures because:
  - They will have a realistic view of what is possible in the job
  - They can advise on the amount of detail needed in a procedure and on its wording and style
  - They can advise on how and why people might break with procedure (not use it, make a genuine mistake or do the job a different way)

Note. Involving the people who do the work in the early stages of developing procedures will encourage them to use it because it is their product not a management-imposed tool

- Support them with expert guidance in hazard and risk assessment and on how to write procedures.
- Use a good design guide on how best to present procedures e.g. layout, language, wording, typeface styles.
- 'Walk through' the procedure ('act it out') before using it on the job. Correct any problems found.

Use Procedures

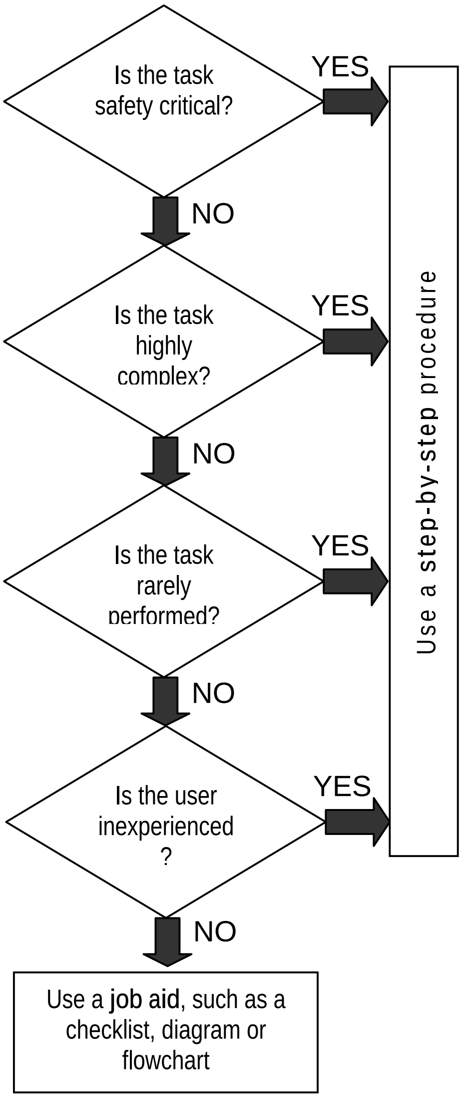
- Train people in procedures: use the training to make them familiar with the content of the procedure but also to test the procedure itself – it may contain errors or may not be practical
- Make sure procedures are suitable for contractors who, for example, may not be familiar with local terminology or work practices and may have come from a different working culture
- Make sure that when someone needs a procedure, they can find it quickly and easily
- Novices may need a different type of procedure compared with 'experts', but, for hazardous and rare tasks, even experts should be required to use a procedure

Manage Procedures

- Keep checking that procedures are being used properly (e.g. if there are steps that need to be 'ticked off', make sure this is done when the step is completed not in bulk when a number of steps are complete).
- Get feedback from operators on any problems – make sure there's a system for reporting problems
- Deal with the problems as quickly as possible
- If people are not using procedures, find out why. They may have discovered a better method of doing the work; on the other hand, their new method may be risky. Make sure there is a system for considering new methods.

- Plan for any changes in the task (changes in equipment or materials used or changes in methods) – start to change the procedures well before they are needed and issues them for training or familiarisation before they are first used.
- You may need temporary arrangements if it is not possible to update a procedure quickly – extra supervision or temporary working instructions
- Control your procedures:
  - Put a date on them
  - Keep a log of who holds a copy and retrieve and dispose of out of date copies
  - Discourage the making and use of unofficial copies
  - Review procedures periodically to see if they need to be updated.

If the system for managing procedures is not working, be prepared to change it.



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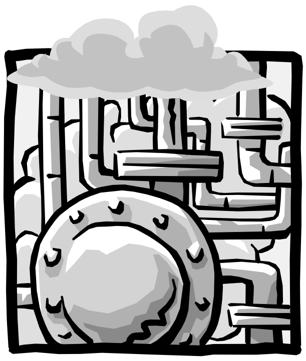
HSE Human Factors Briefing Note No. 5

Emergency Response

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

Plant managers and employees do everything they can to stop emergency situations such as fires or leaks from happening, but emergencies are still possible on any plant. The plant should have the necessary resources in place: designated workspaces, equipment and people organised to manage the emergency so as to reduce damage to facilities and harm to employees and public.

Case study



In June 1988 at a UK plant, the crankcase of a pump used to pressurise ammonia was punctured by fragments of the failed crankshaft. This released 10 tonnes of ammonia in 3 minutes and a further 28 tonnes in the next 40 minutes.

Operators could stop the ammonia supply only by switching off a pump locally. They needed gas-tight suits to do so. Only two were available and were immediately used for search and rescue purposes.

Ammonia entered the plant control room and the operators sounded the alarm and started plant shutdown. They left wearing 10 minute BA sets.

Two operators died immediately, 5 fire crew were injured; 3 000 people on site and 50 000 off site were exposed to ammonia. The on-site emergency plan was activated within minutes of the alarm being sounded. It was found that only 2 men were missing and it was decided to use the 2 gas-tight suits for search and rescue rather than isolate the ammonia ring main supply.

The off-site emergency plan was activated within 5 minutes of the start of the release. Local radio warnings were given but they were too late for some local schools and some mothers and children were affected while making their way home.

The accident illustrates that the site needed additional protective clothing, better communications or alarms (a siren perhaps) to alert local residents and an alternative/gas tight location for activating alarms and plant shutdown.

As a result of the accident, the plant installed automatic remotely operated shut-off valves in the ammonia supply systems to allow the plant to be isolated quickly and without the need for PPE.
Source: Ref. 1

There are three key areas where HSE has taken action on this issue:

- 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 their abilities.

Human factors checklist

The main features of a good emergency response system are set out below as a checklist. See how many you can tick.

For emergencies, our company has:

- Assessed which emergencies are most likely (or are not very likely but could do a lot of damage) ☐
- Set up good warning systems (alarms, PA, flashing lights) to let everyone know that there's a problem ☐
- Installed remote shutdown facilities so that no-one has to go into a danger area to isolate equipment ☐
- Provided back-ups in case equipment is damaged
- Placed alarms and made them loud, bright and clear enough so we will notice them in any conditions ☐
- Provided specific equipment (protective clothes, fire-fighting, radios etc) for the types of emergency we could have ☐
- Made clear plans for each type of emergency ☐
- Put together well-written procedures ☐
- Tested the procedures and our performance in exercises and drills ☐
- Changed equipment or how we do things based on lessons learned from exercises ☐
- Given clear instructions about roles and how to organise for an emergency ☐
- Set out contingency plans in case someone in the emergency team is missing ☐

You can think of emergency response arrangements as what you do:

- Before the emergency (planning)
- During the emergency (doing)
- After the emergency (learning/improving).

The next page sets this out in more detail.

Learning more about emergency response

We have set out below an ideal emergency response system. You must decide which parts of it apply to your site, the work you do and the type of personnel you have. The information below is from a wide range of sources: guidance documents, HSE audits, inspections and case studies.

Stages in Emergency Response: What To Do

Preparing for Emergencies

You should assess your site risks to find out what are the most likely/most damaging emergencies that could arise. You will then know how most emergencies would start and progress and how to detect them.
You should then match your response plans to the scale and probability of those emergencies. Decide what information everyone will need to handle the emergency; how to get that information and pass it on. You should set out what resources you will need. This will include:

- Detectors and alarms
- An emergency control centre
- Access and escape routes
- Fire-fighting and first aid equipment
- Power supplies
- Communication equipment (phones and radios)
- Remote controls to shutdown or isolate plant; clear procedures and checklists.
- Protective clothing and special equipment (e.g. breathing apparatus, cutting or lifting gear)
- A competent, well-organised emergency team with clear responsibilities assigned to all
- Help from off site (e.g. fire brigade)

You should make sure that your plan works under all foreseeable conditions (e.g. day or night, in all weathers, with personnel off sick or on leave, with contractors or visitors on site, if emergency team members are missing or busy).

You must exercise and evaluate emergency plans under realistic conditions as often as needed to maintain competence. Keep records of what happened in exercises; use the information to improve your emergency response. Use different forms of exercise from ‘table top’ exercises to full muster drills.

Actions During an Emergency

Start of Emergency

A sensor, or someone on the site, detects a problem (e.g. a leaking tank). Manual or automatic alarms alert everyone on site. The emergency team assembles; all on site go to their muster station. A roll call establishes who is present and who is missing. The team gathers information to decide:

- What triggered the alarm (a fire, leak, bomb threat)
- Where the problem is
- Possible hazards (smoke, flames, chemicals, unsafe structures)
- What to do next to deal with the problem (stop the leak, put out the fire) and to deal with its effects (rescue and treat casualties; clean up; save property)

Emergency Continues

The emergency team continues to:

- Gather information, which may not be complete
- Keep everyone informed about the situation
- Liaise with outside help
- Take decisions (bring in outside help; evacuate the site)
- Manage the effects of stress (mainly to avoid errors)

Emergency Ends

The team is satisfied that the emergency is over and stands down

Management find out if it is possible to restore operations at the site or sets out to repair damage.

After an Emergency

Site management learns from the emergency about plant safety and emergency response. That is: which decisions and actions were successful and which were not and what changes need to be made to: the overall approach to emergencies, facilities and equipment, procedures, emergency team structure, competence and whether the safety culture supported the execution of the plan.

Management pass on information to other companies and learn from *their* experiences.

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Health and Safety Executive

HSE Human Factors Briefing Note No. 6

Maintenance Error

Briefing Note 1 – ‘Introducing Human Factors’ explains the background to these Briefing Notes.

Human errors and violations in servicing and repair tasks have many of the same root causes as errors in other types of task (see Briefing Notes on competence, humans and risk, procedures, communications and fatigue). However, in maintenance, a fault introduced into the system by human error today might have no effect for several months and then cause a sudden unexpected hazardous breakdown.

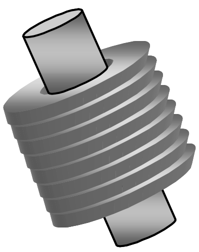
Case studies

A well-known loss prevention expert Professor Trevor Kletz asked for an unusual retirement gift – a filing cabinet. He put his collection of accident records in this and when he sorted them into categories, by far the largest category was ‘preparation for maintenance’.
Source: OTO 01007

An example of poor preparation for maintenance is an accident that occurred during maintenance work on a fire fighting system for a tank in the benzene storage area of a petrochemical plant. Maintenance was carried out even though the tank was full of benzene. Coordination and communication between maintenance and production departments was poor. Production did not supply critical information to maintenance such as: the tank was filled with benzene; a component was missing allowing benzene into the fire fighting foam pipes and, the tank did not have nitrogen blanketing.

One person was killed and 3 injured in the explosion that occurred. Only after the accident, did the company prepare written procedures and a QA procedure for maintenance.
Source: Mars database incident no. 233

‘One way of reducing the number of accidents associated with maintenance operations is to carry out less maintenance’. Kletz in Ref. 3



A maintenance problem

There’s only one way to remove the 8 rings from the peg. Only 1 way in 40,000 puts them back in the same order and the same way up as they started! How would you make sure they went back the right way? Your answers will apply to most maintenance tasks. Example answers – see below.

HSE concerns

Companies focus their attention on accidents during maintenance that could injure the maintenance fitter rather than the major accident potential of the maintenance fitter's error. Human errors in servicing and repair can render unavailable systems needed for safety reasons or could introduce faults that make the equipment unsafe.

Maintenance checklist:

If your company manages maintenance well, you should be able to tick ***most*** of the boxes below.

When it comes to maintenance, we:

..are fully aware of what maintenance work can lead to a major hazard accident	☐
..have good defences in place to make sure these accidents are very unlikely, including:	☐
Physical barriers and guards	☐
'Administrative' controls (permits, procedures, checklists)	☐
Management controls (supervision and checking of tasks)	☐
Highly competent maintenance teams	☐
Well designed maintenance tasks (interesting, no time pressure, comfortable conditions)	☐
..base our maintenance programme on major accident risk assessment	☐
..communicate well during shifts and between shifts	☐
..take special care of temporary or inexperienced maintenance technicians and contractors	☐
..do walk around inspections of maintenance tasks in progress	☐
..have considered the ease of maintaining systems and continually improve it	☐
..look for early signs of problems (e.g. a large backlog of jobs; excessive repair times; adverse feedback from staff)	☐
..investigate near misses and accidents to learn from human failure in maintenance and to improve our systems	☐

The 'ring and pegs' problem:

1. Redesign to make it impossible to reassemble it incorrectly or so that ring order and direction doesn't actually matter

2. Try to make this task more interesting!

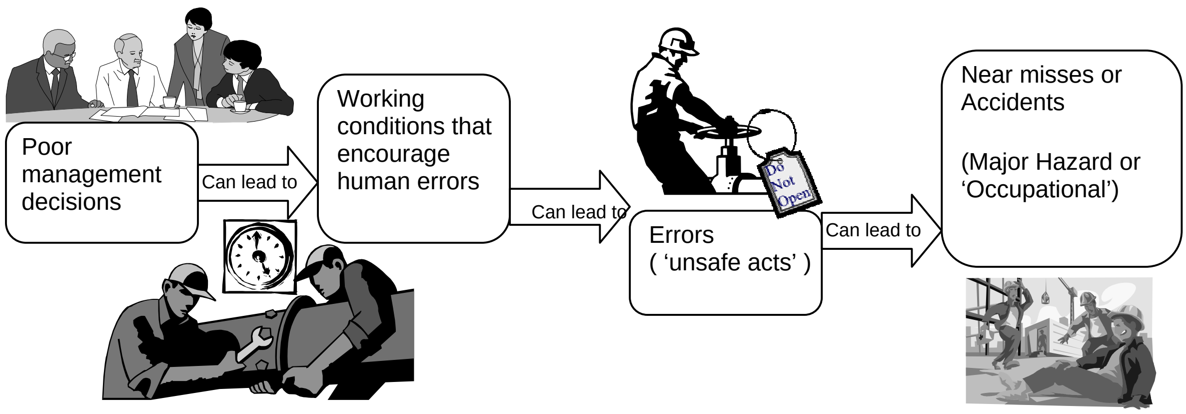
3. Put a colour code, number or other marking to show when the rings are on the right way

4. Design the task to give the person doing it enough time and low stress conditions to do it

5. Make sure a second person checks the order and direction of the rings after they have been assembled.

Learning more about maintenance error

The diagram below shows that, as with most human errors, the root cause of maintenance errors can usually be traced back to management. One way of looking at this is that management are responsible for putting in 'defences' against error. Defences are anything designed to prevent or reduce the chance of human errors or to deal with the consequences of unpreventable or unforeseen accidents. However, accident reports often show that management are responsible for breaking down defences by changes in administration.



The table below illustrates a human error analysis of a general maintenance task and shows the types of defences that should be considered to prevent major accident hazards arising from human errors in them.

Task	**Need to**	**Physical Defences**	**Administrative Defences**
Plan the job	Identify safety critical parts of the job and how to manage them (risk assessment)	Physical barriers around items that could be damaged by maintenance; maintainable systems (designed for easier maintenance); barriers to contain or control hazards if released (e.g. bunds; water curtains; fire detection and fighting systems; protective clothing; refuges)	Safety Management System; good safety culture and morale; permit to work system; procedures for shift handover if task extends over 2 or more shifts; good communications between maintenance and operations personnel; manage possible fatigue or time of day effects on task; team selection; site emergency plan; incident analysis system
Isolate the system	Use best means of containing hazards.	'Blinds' in pipes etc rather than rely on valves; bleed valves; remove circuit breakers rather than rely on switches; take readings to check isolation	Permit system should specify defences to be used; conduct spot checks of permits in use; procedure update system
Gain access to the system	Open up covers/hatches	Housekeeping systems to keep track of tools and components; physical protection of surrounding areas if opening up requires force	Spares, tools and consumables storage and an issuing system
Carry out service or repair task	Test by eye or using instruments; replace damaged or worn out items; replenish fluids	Mostly administrative but, could make systems more 'maintainable' (easier to maintain) and make it impossible to do key tasks incorrectly (e.g. design components that will only fit in one way)	Competent technicians; up to date maintenance procedures/ checklists/ job aids; independent checks by second technician or supervisor; system designed to accept only correct components; good calibration procedures; team training if required; stagger maintenance tasks so that multiples of the same item are not serviced at the same time by the same crew (same fault could be introduced into each item); system of reminders to ensure nothing is left out

Task	Need to	Physical Defences	Administrative Defences
Reassemble	Align the system correctly; do not leave any components out; don't leave foreign object in system	Design of system to resist errors (e.g. by providing only one means of reassembly; components that cannot be damaged by forcing)	Housekeeping system to ensure that all replacements have been fitted and all old ones accounted for. Independent checking, random checking during reassembly
Remove isolation	Make sure it is safe to refill or restart system	Isolations physically locked; barriers against the specific hazard (e.g. screens; protective clothing)	Strict procedure for reinstating equipment; observe for signs of problems; be able to re-isolate the system quickly
Commission and test the system; put back into service	Make sure the system works properly and is in the correct state (running or standby)	Allow only authorised personnel access to the system	Good test procedures; clear measures or criteria for pass/fail; independent checks

References

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HSE Human Factors Briefing Note No. 7

Safety Culture

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

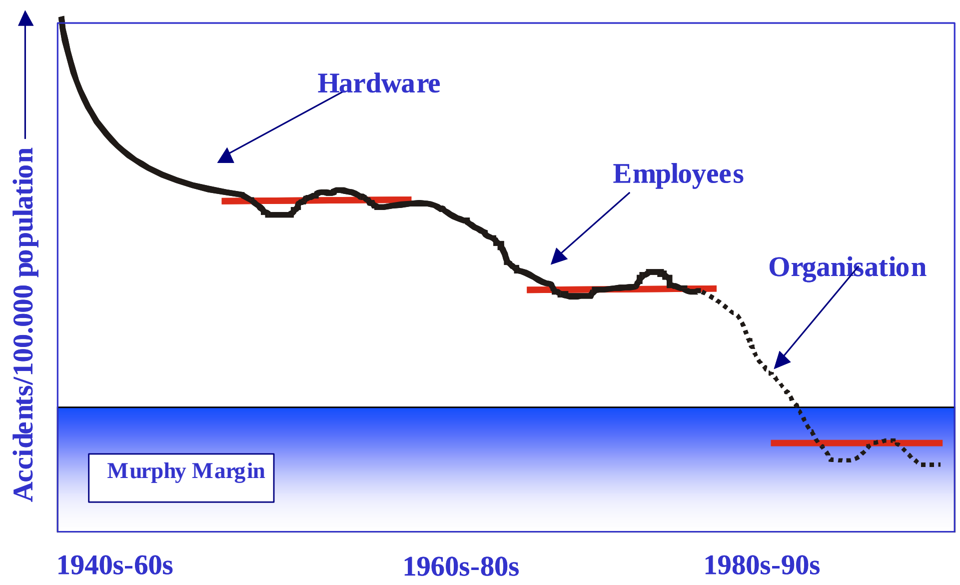
The Confederation of British Industry describes the culture of an organisation as "the mix of shared *values*, *attitudes* and *patterns of behaviour* that give the organisation its particular character. Put simply it is 'the way we do things round here'". They suggest that the "safety culture of an organisation could be described as the **ideas** and **beliefs** that all members of the organisation share about risk, accidents and ill health".

Case study

"The best Safety and Health Programs involve every level of the organization, instilling a safety culture that reduces accidents for workers and improves the bottom line for managers. When Safety and Health are part of the organization's way of life, everyone wins."

The following is an analysis of the safety and health program at a plant

Culture is very poor and does not encourage safe behaviour; rather, it encourages unsafe behaviour and blames employees when something goes wrong. Employees won't participate as a result of fear. There is low trust and credibility, and probably poor communication within the organization.
Source: Ref. 1



Over the last 60 years or so, industry first reduced accident rates by improving: hardware (effective guards, safer equipment); then improved employee performance (selection and training, incentives and reward schemes) and, then changed the way they manage and organise – especially, by introducing safety management systems.

Each improvement reduced accidents down to a ‘plateau’ level where further improvement seemed impossible.

Now, most accidents (and other ‘business disruptions’) stem from employee errors or violations. The next big step change in safety has begun and is based on developing good safety cultures that positively influence human behaviour at work to reduce errors and violations.

Safety culture is not a difficult idea, but it is usually described in terms of concepts such as ‘trust’, ‘values’ and ‘attitudes’. It can be difficult to describe what these mean, but you can judge whether a company has a good safety culture from what its employees actually *do* rather than what they *say*.

The term ‘safety climate’ is also used. This has a very similar meaning to ‘safety culture’: and the difference between them is unimportant here.

HSE concerns

Many companies talk about ‘safety culture’ when referring to the inclination of their employees to comply with rules or act safely. However, we often 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 focus on the short term, or being highly reactive.

Our company has a good safety culture because:

- Managers regularly visit the workplace and discuss safety matters with the workforce ☐
- The company gives regular, clear information on safety matters ☐
- We can raise a safety concern, knowing the company take it seriously and they will tell us what they are doing about it
- Safety is always the company’s top priority, we can stop a job if we don’t feel safe ☐
- The company investigates all accidents and near misses, does something about it and gives feedback ☐
- The company keeps up to date with new ideas on safety ☐
- We can get safety equipment and training if needed – the budget for this seems about right ☐
- Everyone is included in decisions affecting safety and are regularly asked for input ☐
- It’s rare for anyone here to take shortcuts or unnecessary risks ☐
- We can be open and honest about safety: the company doesn’t simply find someone to blame ☐
- Morale is generally high ☐

Learning more about safety culture

A large number of factors contribute to whether you have a good or a bad safety culture. The table below lists the main factors; indicates what would show that you had a good safety culture, and what would support the safety culture. This can be used as a very rough guide to assessing *your* safety culture or as a way of developing ideas for improving it.

A healthy safety culture is one where there is…	this is shown when management…	… and is helped when management…
Visible Commitment to Safety by Management	➢ Make regular *useful* visits to site ➢ Discuss safety matters with frontline personnel ➢ Will stop production for safety reasons regardless of cost ➢ Spend time and money on safety e.g. to provide protective equipment, safety training, and conduct safety culture workshops or audits ➢ Will not tolerate violations of procedures and actively try to improve systems so as to discourage violations e.g. plan work so that short cuts aren't necessary to do the work in time.	➢ Makes time to visit site (not just following an accident or incident) ➢ All show commitment ➢ Has good non-technical skills (e.g. communication skills;) ➢ Are also interested in workforce safety when they are not at work, e.g. provide information on domestic safety ➢ Shows concern for wider issues e.g. workforce stress and general health ➢ Actively sets an example (e.g. always conform to all safety procedures)
Workforce Participation and Ownership of Safety Problems and Solutions	➢ Consults widely about health and safety matters ➢ Does more than the minimum to comply with the law on consultation ➢ Seeks workforce participation in: • setting policies and objectives • accident/near miss investigations	➢ Supports an active safety committee ➢ Have a positive attitude to safety representatives ➢ Provides tools or methods that encourage participation e.g. behavioural observation programmes & incentive schemes that promote safety
Trust Between Shop floor and Management	➢ Encourages all employees and contractors to challenge anyone working on site about safety without fear of reprisals ➢ Keeps their promises ➢ Treats the workforce with respect	➢ Promotes job satisfaction/good industrial relations and high morale ➢ Promotes a 'just' culture (assigning blame only where someone was clearly reckless or took a significant risk) ➢ Encourages trust between all employees
Good Communications	➢ Provides good (clear, concise, relevant) written materials (safety bulletins, posters, guidance) ➢ Provides good briefings on current issues day to day and in formal safety meetings; listening and feedback	➢ Encourages employee participation in suggesting safety topics to be communicated ➢ Provides specific training in communication skills ➢ Has more than one means of communicating
A Competent Workforce	➢ Ensures that everyone working on their sites is competent in their job and in safety matters	Is supportive Has a good competence assurance system

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HSE

Health and Safety Executive

HSE Human Factors Briefing Note No. 8

Safety-Critical Communications

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

Many different types of communication, spoken and written, can be safety critical in the workplace. These include: general communications in the form of safety information, communications between team members or between different teams during operations or maintenance work, and emergency communications.

Case studies

'The lower half of an aqueous ammonia tank was replaced as part of a maintenance task. When the tank was test filled, it began to over pressurise and the feed line to the tank was found to be leaking. Filling was halted. A maintenance crew repaired the feed line and checked the pressure relief line. The attempt to fill the tank was not reported to the shift supervisor. He recorded in his logbook that the tank was empty. It actually contained 50 to 150 litres of aqueous ammonia.

The supervisor of the next shift issued a permit for mechanics to disconnect pipework from the tank as part of the maintenance operation. It is believed that the ammonia-air mixture in the tank was ignited by grinding operations nearby. The tank exploded with the top of the tank being projected 60 metres. Fortunately, no one was injured but there was considerable plant damage.'

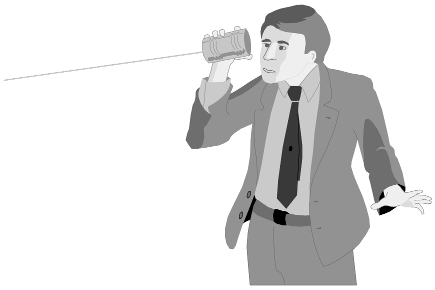
Source: MARS Database Report 497

Originally, 3 field operators working locally operated a chemical manufacturing (batch processing) plant. This was changed to two operators, one in a control room, one on plant – they alternated between these roles. They found that communications between operators increased. Previously, operators would carry out their work without telling anyone else. One problem, though, was the increased use of radios, which were often unreliable. They introduced a text device whereby the control room operator could send messages to the field operator who could then accept or reject the task and send this information back to the control room. This strengthened communications between them.

Source: HSE Report – Ref. 1

Miscommunication between a tanker driver and personnel at a water treatment plant resulted in sodium chlorite and phosphoric acid being mixed in a vessel at the site. The driver and plant manager did not communicate accurately and the sodium chlorite was delivered into the wrong tank. A large gas cloud formed and local residents had to evacuate the area.

Source: US Chemical Safety and Hazard Investigation Board. http://www.csb.gov



HSE concerns

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.

Communications in our company are good because:

- Managers and supervisors regularly discuss safety with us face to face ☐
- Formal safety information: posters, memos, newsletters, talks and presentations are usually:
  - ➢ clear and easy to understand ☐
  - ➢ short and to-the-point ☐
  - ➢ regularly updated ☐
- Jobs are paced so we have time to communicate properly ☐
- Communications equipment – such as radios, intercoms, PA, internal email – are good quality ☐
- Speech communications are generally not swamped by noise in the workplace ☐
- We have a rule of making sure that safety-critical information has been received and understood ☐
- We are good at shift handovers:
  - ➢ there's always enough time for shift handover ☐
  - ➢ oncoming and outgoing shifts discuss plant status face to face ☐
  - ➢ shifts keep and hand over good written records ☐
- The company has good systems of communication during unusual situations or emergencies ☐
- Different groups – operations and maintenance staff, employees and contractors – communicate well with each other ☐

Learning more about communications

Safety critical communications

As a starting point for examining your company's communications, you should consider the different methods that companies use to communicate safety information and how communications could affect safety.

General safety communications – notices, warning signs, posters, memos, 'non-verbal' communications – e.g. gestures, hand signals, the manager visiting the workplace – all communicate a message about the company's safety culture. PA system messages, communication with outside groups e.g. to pass on and to receive information on lessons learned; communication of actions taken after accidents, audits and risk assessments, responsibilities in job descriptions

Safety meetings and the records of those meetings distributed afterwards

Job-specific communications – before the job – 'toolbox talks', written instructions/procedures especially information on job hazards, safety precautions needed. Discussions within teams and between teams (e.g. between team members working on the same job; between operations and maintenance teams, when handing over work from one shift to another)

Informal communications – general discussion and interaction – where these include safety issues

Emergency communications – alarms, PA messages, briefings, communication with emergency services

Communications are basically 'messages'. A message has to be: Created, Sent and then Received. There could be problems at any of these stages which may mean that the intended message receiver fails to take the right action. The box below describes some underlying reasons why there could be problems and the table below describes some specific problems and suggests possible remedies.

General causes of communication problems: making assumptions (e.g. about what the receiver already knows); distractions, time pressure, lack of experience, skill or practice (e.g. when someone has been away from work for a long time), poor culture (e.g. lack of attention to communications issues), unusual conditions (e.g. a long campaign of planned maintenance), poor equipment or means of sending messages.

Communication Stage	Possible Communication Fault	Remedies
Create the Message 	• Message is incorrect: - incomplete or missing information - contains the wrong information - is badly worded or presented (e.g. is ambiguous) • Too much information given	• A second person checks the message • Make sure message sender is competent – give communication training if necessary • Have rules for presentation and content of messages
Send 	• Fail to send message or send too late, message gets lost • Use the wrong means of sending the message (a memo or note where a conversation would be better) • Send to wrong person	• Make sure sender and receiver know when information is needed • Have procedures specifying how information (especially safety-critical information) should be presented • Feedback – sender to check that the person receiving message needs the information
Receive 	• Fail to receive • Receive too late • Receive in a unusable state • Partially received (message obscured e.g. by noise or damaged, or receiver does not retrieve all the information) • Fail to understand	• Feedback – sender to always ensure that information is received and understood; receiver to send an acknowledgement • Receiver to prompt sender for required information • Have system for resending or reformatting messages

References

1. HSE (2002) Human factors aspects of remote operation in process plants. Contract Research Report 432/2002
2. HSE (1996) Effective Shift Handover. OTO 96 003
3. HSE (2000). HSG65, 'Successful Health and Safety Management'. ISBN 0 7176 1276 7

HSE Human Factors Briefing Note No. 9

Alarm Handling

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

Alarm systems alert operators to plant conditions, such as deviation from normal operating limits and to abnormal events, which require timely action or assessment. Alarms are thus key sources of information to the operator in maintaining safety. It is important that alarm systems are well designed and are used correctly.

Case studies

1. An LPG tanker broke away from its moorings in high winds. It drifted and twice lightly grounded before being manoeuvred into a safe anchorage. The vessel was not damaged in the incident and there were no injuries on board. However the incident illustrated a problem with the alarm systems in the marine terminal that is common in other industries. It was found that operators routinely disabled the wind speed alarm - the reason being that, in gusty weather, the alarm would sound at the peak of a gust, and then reset when the wind speed dropped below the alarm activation limit. In addition, terminal staff did not know whether they should have sounded the site alarm during this emergency.

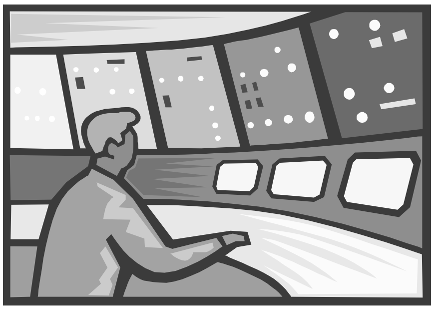
Source: Health and Safety Executive, 'Havkong incident: a joint report of the 'Havkong' incident at Braefoot Bay Terminal by Aberdour Fife on 23 January 1993, 1994.

2. A vapour cloud was released at a Philips chemical complex in Passadena in 1989. The cloud ignited resulting in several explosions and fires. Twenty three people were killed and up to 300 injured. It was found that the alarm siren was too quiet to be heard by all personnel on the site.

Source: Lees, F.P., 'Loss Prevention in the Process Industries – Hazard Identification, Assessment and Control', Volume 3, Appendix 1, Butterworth Heinemann, ISBN 0 7506 1547 8, 1996.

3. On 13th May 2002, pilot lights on the flare system at a chemical plant were extinguished. This occurred because there were fluctuations in the gas supply to the flare. A large gas cloud formed but, fortunately, did not ignite. The flare gas came from an installation which was being restarted. The restart process produced *3,700* alarms so, not surprisingly, the operators failed to detect the alarm for the flare.

Source: MARS database item 520



HSE Concerns

- Alarm handling (or alarm management) is an issue for any site or process where there is claimed reliance on human response to an alarm in order to control major accident hazards. 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.
- There should be a clear link from the site alarm philosophy to major accident hazard risk assessments.
- Alarm systems need continuous management and improvement – in particular, there should be a good link between modification/change processes and alarms.
- Alarm management is primarily a design issue, trying to put matters right later is much more difficult.

If your alarm system is good then:

You will never have a problem noticing alarms because they are:	
➢ well positioned	☐
➢ bright/loud enough to be seen/heard	☐
➢ located in frequently manned areas	☐
You will never be 'swamped' by lots of alarms appearing all at once	☐
If several alarms appear, you will know from training and procedures how to deal with them	☐
The system will not produce an alarm for routine conditions – only where there is a problem	☐
You will not receive many 'false' alarms	☐
You will follow strict procedures if you need to suppress or override an alarm	☐
You will not have any long-term 'standing' alarms (permanently lit up or sounding)	☐
Everyone on site, including contractors and visitors, will know what to do if an alarm appears and will know when and how to raise an alarm	☐
Alarm messages on the alarm panel or on screen are helpful (they describe the alarm cause clearly and what you should do)	☐

Learning more about alarm handling

Problems with alarm handling are of two types: problems with the design of the alarm system, and problems with the procedures for handling alarms. The table below is based on modern alarm guidance. It will help you to identify some of the main alarm handling problems you may have in your workplace and suggest what to do about them.

PROBLEM	POSSIBLE SOLUTIONS
DESIGN	
Masking – alarm sound is not heard above typical noise levels; alarm drowns out communications - lit up alarm cannot be seen above typical lighting levels	Raise alarm volume to 10dB(A) above other workplace noise; allow operators to lower the volume of alarms once they've sounded. Make alarm bright enough for all expected conditions; use colour to highlight the alarm; accompany visual alarm with a sound
Flooding – more alarms than the operators can deal with are presented at once	System should be designed to filter out or suppress unnecessary alarms and to present alarms in priority order; operators may need clear procedures and training on how to prioritise their actions
Difficult to tell one alarm from another – sounds or lights are very similar	Use 'coding' (e.g. different sounds; pulsing of sounds; different colours; flashing) to show importance of alarms and group by the safety function to which they relate
Nuisance alarms - false alarms, 'fleeting' or standing alarms	Change set points, hysteresis or dead bands to make the system less sensitive to short duration unimportant fluctuations. When alarms are expected (e.g. during testing and maintenance) and these cannot be overridden, use tags to indicate they are being tested
ORGANISATION/PROCEDURES	
Operators do not have enough time after the alarm commences to take the right action	Set the alarm levels to show the progress of an alarm situation e.g. a tank overfill alarm sounds at 'high' level then again at 'high high' level
Alarms are missed because the area where they appear is not constantly manned	Install 'repeater' alarms in several places; enforce manning of key operating areas
Operators experience other problems with alarms such as irrelevant and unimportant information being given or poor alarm names being used	Include operators in making suggestions about alarm problems and in suggesting solutions; check solutions against recommended guidance (see references)
Alarms are produced when a warning signal would do (alarm is attached to an event that is safety critical)	Alarms are designed against a risk assessment that identifies what plant conditions should produce an alarm
Alarms are in place because it's too difficult to automate the process – puts the responsibility on the operator to act	Design alarms according to good practice principles (see references) – beware not to overload the operator

Solving alarm problems will require persistence and patience. You will need to collect information on what the problem is – by asking people! – then you will need to persuade management to make improvements. You can change some things easily – others may take a long time.

References

1. 'Better Alarm Handling', Chemical Information Sheet 6 (2000), HSE Books (available free via HSE Books website www.hsebooks.co.uk)
2. 'Alarm systems, a guide to design, management and procurement', Engineering Equipment & Materials Users Association publication No 191. ISBN 0 8593 1076 0.
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HSE Human Factors Briefing Note No. 10

Fatigue

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

Fatigue does not have a clear scientific definition but is generally a feeling of tiredness and being unable to perform work effectively. Specifically, a fatigued person will be less alert, less able to process information, will have slower reaction times and less interest in working compared to a person who is not fatigued.

Case studies

Research into accidents on day, afternoon and night shifts at two paint plants showed that there was a significant increase in accidents, particularly in the last 3 hours of the shift.

The frequency of injuries in an engineering company increased from the morning to the afternoon shift and again from the afternoon to the night shift. Also, there were more accidents during the last two compared to the first two shifts of a weekly rotating shift system. This suggests that operators do not adjust to shifts over successive nights and that more rapidly rotating shifts would be better.

Frequent overtime can increase accident risks and so can long hours at work. For the first 8 or 9 hours in a shift, the accident risk is constant, but after 12 hours, the risk approximately doubles and after 16 hours, it trebles.

Source: Ref. 1

Shift-workers, particularly those on rotating shifts, have a higher incidence of sick leave, a higher rate of visits to clinics at the work site, and poorer scores on a variety of measures of health. In one study, 62% of shift-workers complained of sleep problems, compared with 20% of day-workers. Shift-workers, and particularly night-workers, have a higher incidence of digestive disorders than day-workers, and a number of studies have indicated that they also have a slightly higher incidence of cardiovascular disease. Shift-work may also be a risk factor in such pregnancy outcomes as low birth weight and pre-term births.

Source: Occupational Safety and Health Service New Zealand (1998). ISBN 0-477-03604-X

HSE Concerns

- Fatigue can ultimately lead to operator errors or violations at work. It is often a root cause of major accidents.
- Sites should focus on the system for controlling excessive working hours, especially for staff involved in major hazard work. Fatigue should be managed like any other hazard.
- The legal duty is on employers to manage risks from fatigue, irrespective of any individual's willingness to work extra hours or preference for certain shift patterns for social reasons.
- Changes to working hours need to be risk assessed.

Our company manages fatigue as much as possible by making sure that:

•	Working hours are not too long	☐
•	Employees get enough rest between shifts	☐
•	Employees don’t work too many night shifts in a row	☐
•	Managers negotiate with staff about overtime or double shift working	☐
•	Managers fit in with individuals’ preferences – some people prefer nights	☐
•	Employees avoid critical jobs at the ends of shifts or at ‘low points’ in the day or night e.g. 3a.m.	☐
•	Shifts rotate ‘forwards’ that is, mornings, then afternoons, then nights	☐
•	Employees take quality rest breaks in their work	☐
•	Anyone can report fatigue problems to management and the company will make improvements	☐
•	The environment doesn’t cause drowsiness (it’s light with visual interest, not too hot and there is always variation in the level of sound)	☐
•	There are contingency plans to avoid overloading one person with overtime or double shifts	☐
•	Incidents or accidents where fatigue may be responsible are thoroughly investigated	☐

Learning more about fatigue

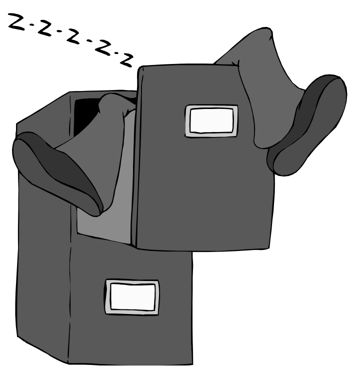
A great deal of research has been done into the causes and management of fatigue and yet it is still poorly understood. For this reason, the suggestions below should be considered as guidelines based on the most useful material available. If fatigue is a problem in your workplace, considering the information below should help you identify this and suggest some possible solutions.

What can cause fatigue?

The main factors are:

- Loss of sleep – ‘acute’, for example, having 5 hours sleep instead of the usual 8; or ‘cumulative’ having 7 hours sleep instead of the usual 8 over each of several days
- Poor quality sleep – lots of interruptions
- Having to work at a ‘low point’ in the day e.g. early hours of the morning; mid to late afternoon and after a meal
- Long working hours, particularly if these are as long as 14 to 16 hours
- Poorly-designed shift work
- Inadequate breaks during the working day

What are the main effects of fatigue?



Compared with their normal state, a fatigued person will:

- Find it hard to: concentrate, make clear decisions or take in and act on information
- Have more frequent lapses of attention or memory
- React more slowly (for example, to hazards arising in the workplace)
- Make more errors
- Occasionally fall asleep at work – momentarily or for several minutes

- Have little motivation or interest in their work
- Be irritable

How can we avoid or reduce fatigue?

- Make sure employees have the opportunity to sleep for at least 8 hours between shifts
- Encourage employees to develop good sleeping habits
- Restrict night shifts to 4 in a row or to 2 in a row if they are 12 hour shifts
- Allow at least 2 days off after nights
- Make sure shifts 'rotate forwards' - mornings, followed by afternoons followed by nights
- Avoid long shifts and too much overtime: aim for less than 50 hours work per week (i.e. comply with the EU Working Hours Directive)
- Arrange for quality breaks during the working day
- Consider personal preferences – some people are 'morning people' some are 'night people' (larks/owls)
- Consider allowing some 'napping' at work to restore performance but beware of a person working immediately after a nap – they will be less effective for between 30 minutes and an hour
- Arrange for more interesting and varied work to be done at night and at other low points but make sure these are not too demanding or too monotonous/repetitive

Additional points to note

- Individuals are not good at assessing how fatigued they are
- They can be skilled at coping with fatigue, but this can increase stress or the risk of gastric disorders or other health problems
- Shorter and more shifts may not solve the problem – errors rise early on, diminish, then peak later

References

1. HSE (1999). 'Validation and Development of a Method for Assessing the Risks Arising from Mental Fatigue'. Contract Research Report 254/1999. ISBN 0 7176 1728 9
2. HSE (2004 pending) 'Managing Shiftwork: Health and Safety Guidance for Employers'

HSE Human Factors Briefing Note No. 11

Organisational Change

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

Organisations usually change for financial rather than safety reasons. Typical changes are: reducing the number of staff, reorganising departments and teams or adopting 'flexible working' (e.g. sharing maintenance and operations tasks). Organisations in the process of change need to manage their risks.

Case studies

A petroleum fire at a US refinery in February 1999 killed four workers and injured 46 others. It was caused by poor maintenance practices at the plant – when working on a pipe containing naphtha, without proper isolation. One of the findings of the investigation into the incident was that:

> "Organizational changes were not reviewed by management to evaluate their potential impact on safety. We were told that following certain changes, organizational changes, employees were asked to take on new safety responsibilities with only limited training. Many employees perceived that organizational changes had a detrimental effect on morale and safety performance".

Source: http://www.baaqmd.gov/enf/incidents/p1680107.doc

From a series of audits across a range of industries, it was found that many organisations have embarked on a process of significant change; changing their structure, staffing levels, methods of operation, maintenance practices, and so on, without carefully considering the implications for risk to their operation, even though the organisations appear fully aware of safety management issues.

The commonest change is to reduce the workforce numbers and this has led, among other things to:

- Loss of skills and knowledge from the organisation
- Overloading remaining personnel
- Removing of hazard barriers
- Increased use of temporary contractors
- Formal systems in use that do not meet changed requirements
- breakdown of morale and culture.

All of which can increase the organisations' safety, environmental and, ultimately, business risk.

Source: Ref. 1

HSE Concerns

- Organisational changes are usually not analysed and controlled as thoroughly as plant or process changes.
- The key issue is that the direct and indirect effects of a proposed change on the control of **major accident hazards** should be identified and assessed.
- Due to the greater potential consequences of an accident, major accident hazard sites should aim for higher reliability in their decision making.

Our company manages change well because management:

…. Tell the workforce when changes are likely to be made to the organisation	☐
…. Explain why these changes are necessary	☐
…. Consult with staff and involve them in planning changes	☐
…. Listen to workforce ideas and concerns	☐
…. Communicate throughout the change process	☐
…. Clearly understand the risks involved in the change	☐
…. Do all they can to reduce the risk	☐
…. Consider the potential for work overload in the new organisation	☐
…. Consider possible losses of skills and experience from the organisation	☐
…. Have sound procedures to manage the transition	☐
…. Arrange the training needed for anyone moving to a new role	☐
…. Continually check to see if the changes have been successful	☐
…. Make contingency plans if the change has not been successful	☐
…. Can cope with sudden unexpected change e.g. the sudden loss of key staff	☐
…. Learn from each change programme so that the next change will be trouble-free	☐

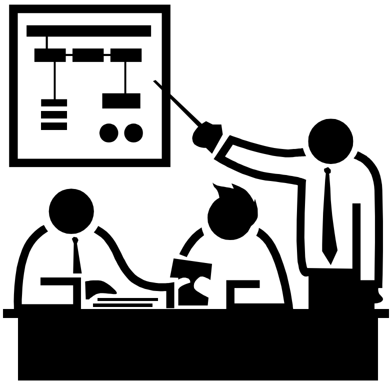
Learning more about organisational change

Why organisations change – what can happen when they do

A typical reason why an organisation may wish to change the way it is manned is to reduce costs. One way of doing this is to reduce the number of staff they employ. This means reorganising the departments/teams and plans may include introducing more automation or making more use of contract staff. The danger is that the 'new' organisation will not be as safe as the 'old' organisation because it doesn't have enough people with the right skills and experience or knowledge to carry out the work safely.

Possible Results of Organisational Change	Potential Problems	Suggested Solutions
In general, the problems likely to arise are increased risk because the 'new' organisation has: …A smaller overall workforce: smaller teams doing the same work …Fewer layers of supervision and management …More automated plant …Increased its reliance on contractors	Overload – personnel are given more or different types of tasks. They may need to be 'multi-skilled' or more flexible in the work they can do - this will require additional training Teams may need to be 'self-managed' – they will need new skills and self discipline Reporting lines are unclear. An individual or team might receive instructions from several 'managers' New teams will need to learn new skills in using any automated plant and to learn new procedures Systems that worked well with a large workforce may not be suitable for a smaller workforce e.g. a simpler permit system may be preferred now Contractors may lack the skills and experience of full time employees; employees may need to develop skills in supervising contractors and this may add to their workload	Consult with the workforce and develop ideas jointly with those subject to the changes proposed. Plan the change by 'mapping' existing tasks onto the new organisation. 'Old' tasks may either: i) disappear (because no longer needed) ii) be automated or iii) be done by contractors. Make it clear who works for whom even if this changes between or even during shifts. Empower individuals to question conflicting instructions or unreasonable demands Make sure all tasks are accounted for, especially safety-related tasks. Consider: • infrequent tasks (e.g. start up and shutdown) and emergencies • staff numbers needed to cover for sickness and holiday absences • new skills that individuals will need Arrange training and other ways of gaining the competence needed including: management and supervisory skills, technical skills and knowledge. More trainers may be needed and allow time for learning. Plan contractor time on plant to make sure they maintain current knowledge and skills

Assess the changes



Monitor the effects of the change: find out people's opinions (what do they think about the change? – beware of initial low morale – people can be negative about change even though the new system is better). Collect 'data' - for example, on 'near misses' that have resulted from the change, delays or backlogs, excess working hours that may indicate overload. Have a fallback plan if the changes do show signs of increasing risks.

Audit/continually improve

Keep records of what worked well and what failed for future reference and to help with inevitable future changes.

References

1. Gall, W (1996). The Management of Change: General Findings. Presented at the Safety and Reliability Society Annual Conference, October 1996
2. HSE (2003) Information Sheet No CHIS7. Available from: www.http://www.hse.gov.uk/pubns/chis7.pdf
3. HSE (1996) Business Re-Engineering and Health and Safety Management: Best Practices Model. CRR 123/1996 ISBN 0 7176 13

HSE Human Factors Briefing Note No. 12

Human Factors in the MAPP

Briefing Note 1 – 'Introducing Human Factors' explains the background to these Briefing Notes.

In the Major Accident Prevention Policy (MAPP) that all COMAH sites are obliged to provide to regulators, you are strongly recommended to refer to the different ways that your company or site controls human factors. This Briefing Note gives an outline of the specific information you could consider providing.

Case studies

Since 1999, HSE has published two reports on Major Accidents (EC Reportable Accidents or 'ECRAs') at COMAH sites. The reports show that the number of accidents per year at COMAH sites is broadly the same as they were before the COMAH regulations came into force. Some examples with human factors root causes are described below:

Three incidents were caused by erosion or corrosion of pipework or other components. In some cases, there was no adequate inspection procedure in place. **Inspection** may thus be regarded as a critical task in that failure to carry it out could lead to a major accident.

Maintenance failures also feature in HSE's reports, for example, a maintenance fitter removed a sensor from a pressurised pipe. Inadequate plant maintenance procedures caused the failure of a compressed air supply and thus, the failure of an isolation valve. In both these cases, ethylene gas was released.

In a near miss incident, 500 kg of vinyl chloride monomer was released because of a series of operational errors during the **commissioning** of a filter unit.

Competency problems and inadequate commissioning **procedures** were cited as causes in the report.

Operators heated up a road tanker filled with molten sodium but failed to vent the pressure that built up inside the tanker as required by **procedures**. The sodium had solidified in the outlet vent valve and operators cleared this with a metal rod causing sodium to escape and subsequently to catch fire.

A large quantity of liquid propane was released when a fitter attempted to drain off a sample but there was no flow. The maintenance crew then failed to close a valve fully before removing an adaptor assembly from the drain point to investigate why.

Following the death of an employee during sampling, HSE issued 4 improvement notices: 2 of these related to a recent reorganisation of the site and required the development of a training strategy for production technicians and a review of risk assessments and staffing levels.

Source: Ref. 1

HSE Concerns

In Ref. 1 HSE state that they are concerned about '..the magnitude and frequency of these accidents and the repeated underlying causes of major accidents'.

The MAPP should state, in general terms, how the human factors issues that may impact on major accident hazards have been managed. This should include reference to other company documents, assessments and standards.

Overall human factors content of the MAPP

Your MAPP might refer to other documents but should contain enough information to assure the reader that you have at least the following matters under control:

Critical tasks – those that, if carried out incorrectly, could lead to a major accident. Ensure that the hazards in those tasks are identified and risk assessments are done with a view to lowering the risk or making sure that the hazard is kept under control.

Emergency tasks – are practised and can be carried out as required.

Procedures – written instructions for carrying out critical operations or maintenance tasks are clear, up to date and actually *used* by operators

Competence – employees involved in major hazard work are properly selected trained and have been assessed as competent and suitably experienced in the work they need to do.

New plant - is properly designed, constructed, installed and commissioned

Accidents and near misses – are reviewed for lessons: i.e. all causes are considered and any human factors deficiencies highlighted are remedied.

Most of the above topics are the subject of Briefing Notes in this series.

Learning more about human factors in the MAPP

Example MAPP statements regarding human factors

Three examples of (edited) statements about human factors from the MAPPs of several leading companies are given below:

1) "…five separate areas have been chosen to demonstrate how systems have been designed to take into account the needs of the user and be reliable:

- Equipment design
- Procedural tasks
- Operational and maintenance training competency
- Work patterns and overtime arrangements
- Manning levels and supervision adequacy"

2) "…operator fatigue is avoided by virtue of the shift rota and having a spare man to cover some of the holidays and sickness. Hazard studies on new and modified plant consider the risk of operator error following a procedure and automation is used where necessary to improve safety. Staff competency in safety is through regular training. Human factors such as layout and access to process equipment (and particularly valves) are designed to standards. Lighting standards are

detailed in *(internal document)*, the noise standards in the Noise at Work Regulations are applied. The Manual Handling Regulations give weight and lifting guidelines."

3) "Human error probably contributes most of the risk from the site, therefore, it is essential that the potential for error in all aspects of the company's business is identified. This can be done by a systematic analysis (task analysis) of all operations involving human activity, and, in particular, where mistakes can have serious consequences. The examples below … illustrate error types:

- Equipment design and construction – design error – e.g. poor specification or dimensions of materials
- Plant maintenance – introduction of failures by damaging equipment or leaving equipment misaligned or open after maintenance; failure to install the correct replacement part
- Control room operations – failure to respond correctly to an alarm situation (failure to control, or make situation worse)
- Testing checking and auditing – failure to detect worn or failed components; failures to carry out tests and falsifying of results

Source: Confidential – extracts from actual Major Accident Prevention Policies

Additional Points

Most of the information about how you keep major accidents under control by attending to human factors will probably be contained in other documents. The MAPP should refer to these. Examples of such information are: risk assessments, the safety management system, site inspection records, management of change procedures, training records and emergency arrangements documents.

It would be useful to consult your employees when developing the human factors aspects of the MAPP, because they will have insights into human factors risks.

You should update the human factors material in the MAPP whenever there are any significant changes to their management that could affect performance, for example, staff reductions/increased workload, new equipment/process as they affect tasks, organisational or procedural changes.

Keep human factors issues under regular review: the Guidance Notes will help to identify the issues that you need to consider.

References

1. COMAH Major Accidents Notified to the European Commission England, Wales & Scotland 1999-2000 and 2001-2002 (two documents)
2. HSE (1999) Major Accident Prevention Policies for Lower-Tier COMAH Establishments. Chemical Information Sheet No 3. HSE Books, PO Box 1999, Sudbury, Suffolk CO10 6FS