

HUMAN FACTORS AND COMAH: A REGULATOR'S PERSPECTIVE

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This paper outlines recent experience of the HSE's Human Factors Team in assessing human factors issues on major hazard installations. It presents the 'Top Ten' human factors issues that have arisen out of inspection and audit of major hazard sites and from assessment of COMAH safety reports. Our involvement on major hazard sites reveals that most duty holders do not adequately address human factors. Primary weaknesses include an imbalance between hardware and human issues, and focussing on the human contribution to personal safety, rather than to the initiation and control of major accident hazards.

However, following targeted inspection and awareness-raising in the industry, the profile of human factors and effective consideration of these issues is steadily increasing. We are beginning to see the results of these efforts reflected in contact with sites. We will continue to work with major accident sites and industry bodies to develop and share emerging best practice.

KEYWORDS: human factors, major accident hazards, safety management, COMAH

INTRODUCTION

Human failures are implicated in the majority of serious accidents in hazardous industries. Some recent examples include Bhopal, Texaco Milford Haven, Chernobyl, Piper Alpha and Flixborough to name a few. As technical safety measures improve, we can expect the significance of human factors in major accidents to increase.

To help address these issues, the UK Health & Safety Executive (HSE) set up a new Human Factors Team in the Hazardous Installations Directorate in 1999. This Team provides site inspectors with specialist advice and support during inspections, investigations and enforcement; as well as preparing industry guidance on human factors issues. The Team is composed of a balanced mix of experienced field inspectors, psychologists and ergonomists.

The focus of the Team's activities is on those sites that fall within the scope of the Control of Major Accident Hazards Regulations 1999 (COMAH), although we are also active in the railway industry. Over the last three years, the team has become involved at numerous chemical sites across the whole of the UK, including most oil refineries.

In addition to our inspection and assessment activities, we develop guidance and standards, train field inspectors, set policies for the field, manage applied research and promote human factors to industry (either directly or through intermediaries such as the Institute of Petroleum, Institution of Chemical Engineers and the Chemical Industries Association). We are also involved in the European Commission PRISM network coordinated by the European Process Safety Centre (EPSC), the aims of which are to develop and disseminate best practice guidance on human factor topics.

WHAT WE MEAN BY 'HUMAN FACTORS'

The HSE document HS(G)48¹ presents a simple introduction to generic industry guidance on human factors. This guidance provides a useful definition:

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

This definition includes three interrelated aspects that must be considered – the job, the individual and the organisation. In other words, human factors is concerned with what people are being asked to do, who is doing it and where they are working. Human factors interventions will not be effective if they consider these aspects in isolation. The scope of our interventions thus includes organisational systems and is considerably broader than traditional views of human factors/ergonomics.

It is deficiencies in either of these three areas, or in the interactions between them, that lead to human performance problems. There are three types of human failures that may lead to major accidents:

- **Errors** are physical actions that were not as intended;
- **Mistakes** are also errors, but errors of judgement or decision-making;
- **Violations** differ from the above in that they are intentional (but usually well-meaning) failures, such as taking a short-cut or non-compliance with procedures.

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

THE ROLE OF THE HUMAN FACTORS SPECIALIST IN COMAH

Our involvement is usually instigated at the request of the local site field inspector where they have a concern or where there has been an accident with a human factors aspect. Furthermore, our contribution to the assessment of COMAH Safety Reports may lead us to visit the site to follow-up issues identified in the assessment.

Our objectives range from obtaining an overview of the site's approach to human factors to undertaking an in-depth investigation of a particular human factors issue. Generally, our involvement on site varies from one to five days, depending on the nature of the intervention, although in certain cases this may be extended. When on site, we undertake several activities, including:

- Interviewing a cross-section of personnel, from Directors/senior management to front-line operators and their representatives;
- Reviewing documentation not obtained prior to the visit;
- Verification inspection (i.e. comparing what we have been told with what we observe);
- Initial feedback to site personnel.

Where necessary, we support formal enforcement action by the site field inspector, i.e. improvement and prohibition notices, or prosecution. Following our visit, we will prepare an inspection/audit report for the field inspector and possibly revisit the site to present our findings/recommendations and agree a way forward. We will monitor progress through contact with the field inspector and may revisit the site for further inspection as necessary.

Human factors is often seen as a rather nebulous concept and so it is convenient to break the subject down into a series of discrete topics. As a result of our site visits and assessment of COMAH safety reports, a small group of topics has emerged and we promote these as our 'top ten':

1. Organisational change and transition management
2. Demanning and staffing levels
3. Training and competence
4. Safety culture
5. Alarm handling
6. Fatigue from shiftwork and overtime
7. Compliance with safety critical procedures
8. Safety critical communications (e.g. shift handover)
9. Ergonomic design of interfaces
10. Maintenance error.

Although general HSE guidance on human factors is available [HS(G)48], the Human Factors Team have a programme of producing guidance specific to the above topics. For example, a free information sheet is available on alarm management. Forthcoming guidance will include organisational change, competency, fatigue and human factors in design. We have also assisted with the production of guidance published on the Institute of Petroleum website².

EXPERIENCE OF REGULATING COMAH SITES - POSITIVE ISSUES

The Human Factors Team has a distinct advantage of having visited a broad sample of Major Accident Hazard (MAH) sites over the past three years, enabling us to construct a picture of best practice in human factors in the process industry. We are therefore able to facilitate the sharing of what works and what doesn't across the industry, through published guidance, seminars and individual site contact.

Clearly, the efforts of the Team in promoting these issues are beginning to reveal themselves in our contact with MAH sites. For example, some sites have addressed issues that we have raised at regional one-day events held in conjunction with industry bodies and associations (including consideration of the top-ten topics listed above). This has been reflected in the structure and content of their COMAH safety report submissions and in information available on site inspections.

As our capabilities are increasingly recognised within HSE, we are now finding that we are becoming involved at an earlier stage of the design lifecycle. For example, we are being consulted prior to site modifications (including proposals for organisational change) and are also involved in specifications for human factors in the design of new process

plants. This opportunity to be involved at such an early stage will increase the impact of our involvement.

Although our approach has been new to many sites, we have received positive feedback following our interventions. For example, some sites apply the lessons learnt from an intervention to other installations in the company. Other sites have commented that we have provided them with a different perspective on their organisation, not obtained from previous 'independent' audits.

Although our interest is in safety improvements, several companies have experienced significant quality and productivity gains following human factors interventions. For example, at one site, the analysis of procedures and task design led to reduced start-up times.

Once their awareness has been raised, some sites have clearly embraced the issues and are developing their in-house capability in human factors. We are seeing an increasing number of companies having a human factors champion on site, who acts as an 'intelligent customer' in dealings with the competent authority and external consultants. This person should be highly visible, have influence, a link to various project teams and access to human factors technical advice and support where necessary.

Over the past couple of years or so, we have recognised that the major hazards industry is readdressing the balance between hardware and human factors. Given that the regulation of these issues has developed rapidly since the formation of a dedicated team of specialists, we expect that 'emerging best practice' will continue to develop across the industry.

EXPERIENCE OF REGULATING COMAH SITES - NEGATIVE ISSUES

Although many MAH sites are managed by multi-national, blue-chip companies, the experience of the Team is that their consideration of human factors issues could be significantly improved. The main failings apparent in relation to human factors are discussed in detail below. These weaknesses have all been observed at numerous installations and are common threads rather than isolated occurrences.

FOCUS ON ENGINEERING ISSUES

Despite the growing awareness of the significance of human factors in safety, particularly major accident safety, many sites do not address these issues in any detail. Their focus is almost exclusively on engineering and hardware aspects, at the expense of 'people' issues. From reading many safety reports it would appear that these sites are unmanned, such is the lack of reference to human performance aspects.

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

Due to the 'ironies of automation'³, it is not possible to engineer-out human performance issues. All automated systems are still designed, built and maintained by

human beings. For example, an increased reliance on automation may reduce day-to-day human involvement, but increases maintenance, where performance problems have been shown to be a significant contributor to major accidents⁴.

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

FOCUS ON OCCUPATIONAL SAFETY

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

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

In his analysis of the explosion at the Esso Longford gas plant, Hopkins (2000)⁵ makes this point very clearly:

'Reliance on lost-time injury data in major hazard industries is itself a major hazard.'

and,

'An airline would not make the mistake of measuring air safety by looking at the number of routine injuries occurring to its staff'.

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

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

- Number of accidental leakages of hazardous substances;
- Environmental releases;
- Time taken to detect and respond to releases;
- Activation of protective devices;

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

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

FOCUS ON THE SHORT-TERM

Where sites do consider human factors aspects in relation to major hazards this is usually in response to a major incident, an inspection by the HSE or both. In these cases, companies tend to view the initiative as having a short-term benefit, such as satisfying the requirements of the regulator, rather than as improving the long-term safety performance of the site. For example, human factors issues may be addressed in the COMAH safety report in order to facilitate acceptance of the report by the competent authority, rather than to make a real difference in major hazard safety. Where sites focus on one area of plant, we encourage the roll-out of a human factors programme to other areas of the site.

LACK OF OWNERSHIP

This issue is related to the short-term outlook discussed above. Sites often consider human factors issues in relation to an immediate need to address a discrete topic. External consultants may be engaged to facilitate the intervention and too frequently, the expertise remains outside of the company reducing ownership of these issues by the site. In these cases, we propose that a senior member of site management adopts the role of a human factors champion.

LACK OF REALISM

We are often informed by a site that operators are well-trained and experienced, partly as justification for relying on human actions. However, it cannot be stressed enough that highly skilled, motivated and experienced people do make errors, whether unintentional or not. It is human nature to take short cuts or break rules, for example when the pressure or inconvenience is high enough. It is also the case that unintentional errors occur, for example when workload is high, a task is complicated, or the situation is abnormal.

MAH installations frequently assume that an operator will perform certain actions in the event of a process upset. However, this assumption often fails to take account of the fact that human behaviour in an emergency situation is different to that in normal operations. Where there is reliance on operator actions in controlling or mitigating a MAH, this should be demonstrated to be realistic. In many cases, manual interaction or intervention could be replaced with reasonably practical physical measures. MAH control should not rely on the heroic actions of operators (Lucas⁶ termed this the 'superman approach' to risk control).

On occasion, quantitative data is quoted by the operator without justification, for example: 'the probability of the operator failing to respond to the alarm is 0.0001' (the 'magic number' approach, Lucas). Such data is to be treated with caution, and we will require the site to make the assumptions explicit and demonstrate that the data is specific to the site.

FAILURE TO IDENTIFY SAFETY CRITICAL ASPECTS

Our experience is that MAH sites fail to produce an inventory of safety-critical tasks, roles, responsibilities and procedures. Without the identification of areas where human intervention is safety-critical, any consideration of human factors will be unfocussed. Human factors analyses, although productive, can be resource-intensive and in order for resources to have maximum impact, they should be targeted where their impact will be the greatest. Again, reference should be made to the MAH risk assessment; and the role of human intervention in the initiation and control of MAH scenarios reviewed.

THE WAY FORWARD

At its inception, the Human Factors Team outlined a strategy which can be summarised as follows:

- Increase awareness of the importance of human factors among UK chemical sites;
- Improve the integration of human factors in design, risk assessment and COMAH safety reports;
- Encourage continuous improvement and sharing of good practice;
- Codify knowledge in a useful way for HSE and transfer to field inspectors.

Over the past three years we have made significant progress towards achieving these objectives, including interventions on a large number of major hazard installations across the UK.

However, there remain considerable weaknesses in the approaches taken to human factors on many of the most hazardous sites in the country, operated by some of the world's largest chemical companies. If further major accidents are to be prevented, duty holders are urged to examine whether any of the failings discussed in this paper apply to their organisation.

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