

HUMAN FACTORS AND COMAH – THE CHALLENGE OF EXISTING PLANT

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The Health and Safety Executive is seeking a higher level of attention to human factors (HF) in the hazardous industries sector. They have issued guidance on the inclusion of HF in COMAH safety reports, focusing on the need to evaluate the potential impact of human error on process safety, and to ensure that appropriate measures are in place to minimise the contribution of human error. One challenge for industry is to identify and implement practical and integrated approaches to the evaluation of existing plant and systems, and plant modifications, and the identification of cost-effective responses to identified HF shortcomings.

This paper describes a systematic HF assessment completed at Hickson & Welch (H&W). The assessment was commissioned by H&W as part of their overall programme for improving process safety management, and was designed to satisfy HSE expectations both in terms of the assessment, and also in terms of enhancement of H&W's existing HF knowledge and competence. The work comprised training sessions, and an assessment involving task analysis, error identification, consequence assessment and recommendations for HF improvements. A designated process (Stage F) was analysed in detail, to provide generic recommendations and a framework for a more simplified future analysis process that could become integral to H&W's approach. The work was accepted by HSE.

The paper highlights practical lessons for undertaking HF analyses of existing plant and for making best use of HF consultants.

Human Factors, COMAH, Assessments, Safety Case

INTRODUCTION

The Health and Safety Executive (HSE) is seeking a higher level of attention to human factors (HF) in the hazardous industries sector. They have issued guidance on the inclusion of HF in COMAH safety reports, focusing on the need to evaluate the potential impact of human error on process safety, and to ensure that appropriate measures are in place to minimise the contribution of human error. One challenge for industry is to identify and implement practical approaches to the evaluation of existing plant and systems, and planned plant modifications, and to identify cost-effective and appropriate responses to identified HF shortcomings.

Following an incident on one of their batch processes, which led to a release, Hickson & Welch (H&W) received an Improvement Notice from HSE that required, *inter alia*, that they take full account of HF. The objective for H&W was both to incorporate HF into their process safety management (PSM) system in an appropriate manner, and to demonstrate that they had done so to HSE's satisfaction.

This paper provides an overview of the issues facing H&W, and how they were addressed. It describes how H&W used HF consultants to enhance their own HF capability,

and ultimately to satisfy HSE that they had sufficient in-house HF capability to assure future assessments. Additionally, the paper presents some lessons learned and guidance, both for HF assessments and for the use of HF consultants.

THE BACKGROUND

H&W is a specialty chemicals company operating semi-batch processes. By its nature, their plant tends to operate for comparatively short periods before being reconfigured for the production of a new product. This continuous process of operation, plant redesign, plant reconfiguration means that there is a constant need to assess and assure the safety and operability of the new configuration, and to be able to assure HSE that the assessment undertaken has been done rigorously and effectively and that the error opportunities have been properly identified and controlled. Equally importantly, it is necessary constantly to manage the change process, and to assess error opportunities in the context of previous plant configurations, as well as the current or proposed one.

H&W suffered a runaway exothermic reaction. The immediate cause of the event was difficult to determine, but one root cause was inadequate attention to the types of human error that could arise, and hence to appropriate defences against them that should be put in place.

This incident occurred at a time when HSE was showing increasing interest in HF – a new specific HF unit had been created within the Hazardous Industries Directorate.

HSE served an Improvement Notice that comprised a number of elements. One of these was to carry out an HF assessment of the batch process, to identify clearly the HF shortcomings. A second was to improve H&W's understanding of the HF issues that arose from their batch process operations. A third was to develop an appropriate method for incorporating HF into their PSM system that addresses COMAH safety case requirements, such that H&W could be confident in future assessments. HSE strongly recommended in the Improvement Notice that H&W make use of HF consultants to support the work required to discharge the Improvement Notice.

The Improvement Notice provided a focus for H&W to consider plant, and plant modifications. It also provided a focus on demonstrating proactively that all practical error reduction measures have been implemented.

HSE EXPECTATIONS

The Control of Major Accident Hazard Regulations 1999 (COMAH) came into force on 1 April 1999. HSE COMAH guidance requires that "For hazardous events that could lead to a major accident, the safety report should show that risk-reduction measures have been put in place to reduce the risks to as low a level as is reasonably practicable."

The HSE has set out expectations and principles regarding the HF elements of major accident prevention. These expectations are contained within both the HSE's general Safety Report Assessment Manual, available at www.hse.hid./comah2/index.htm, and in their specific "Human Factors for COMAH safety report assessors" internal guide. In short, the HSE expect that the same systematic, demonstrable and "empirically" based approach that is applied to technical safety be applied to HF. Figure 1 illustrates this approach.

This means that Duty Holders need systematically to identify potential errors, choose and implement safety measures, and manage such measures within their management system. The following quotes from HSE guidance illustrate their expectations:

“The report needs to show that the measures taken and SMS are built upon a real understanding of the potential part that human reliability, or human failure, can play in ... major accidents”

“It should be clear how human factors have been taken into account in the risk assessment.”

“The safety report should show what measures are in place to ensure adequate performance by human operators, ...”

“The safety report should also show how human factors have been taken into account in the design of equipment and systems (e.g. usability, tolerance of errors, detectability and recovery).”

“The safety report should show how systems which require **human interaction** have been designed to take into account the needs of the user and be reliable.”

All of this emphasises the importance that HSE places on effective management of HF, and how the safety report must provide adequate assurance that HF issues have been properly considered.

When HSE served the Improvement Notice, they emphasised to H&W that they wished to see clearly how H&W was both addressing HF issues to prevent recurrence of the specific incident, and also how their PSM system took proper account of HF.

Generally, HSE has identified a set of ‘priority’ HF issues of concern to them:

- Organisational change
- Demanning and staffing levels
- Training and competence
- Fatigue from shiftwork and overtime
- Alarm Handling
- Compliance with safety critical procedures
- Safety culture/blame culture
- Communications e.g. shift hand-over
- Ergonomic design of interfaces
- Maintenance error

These span a range of issues far broader than interface design and the working environment – the issues that frequently are considered to be the full range of HF. Instead, this list demonstrates that HSE view HF as being far broader and all-embracing, and that HF issues cover all aspects of human performance at work. The challenge for a COMAH site in preparing its safety case is to ensure that it provides sufficient information to demonstrate that all of these areas have been considered, and appropriate measures implemented.

THE COMMISSION

GSB was approached by H&W to help discharge the Improvement Notice. The assessment was to be carried out on a batch process the company intended to re-introduce to plant – to

enable the company to explore how the HF assessment process could be fitted into H&W's existing Process Safety Management (PSM) system.

The commission emphasised that the key objective for H&W - although it was not required by the notice - was to ensure that they learned from the process of discharging the Notice. The company was clear that it was not sufficient for them simply to discharge the Improvement Notice, important though that was. Their primary goal was to ensure that they acquired the competence and processes to incorporate HF into their PSM system for use on both future and existing products. This in turn meant ensuring that there was proper 'buy-in' to HF across the company. The HSE had highlighted the need for H&W to understand where there were gaps in their existing HF knowledge - to "know what they don't know" - and then to fill those gaps.

INITIAL APPROACH

In responding to the commission, GSB identified a number of stages to the planned work. Whereas it would be possible for GSB to go to site, carry out an assessment of the relevant batch process, and report on human error opportunities, human engineering discrepancies, and to make recommendations for improving the design of the batch process - this would fail completely to meet the needs of H&W (though it would have discharged the notice).

Instead, it was apparent that perhaps the most important aspect of the support that GSB could offer would be to enhance H&W's understanding of HF, human error, and methods for controlling human error through design and operations. Consequently, the approach adopted was partly to provide formal training at the outset, and partly to use the assessment of the batch process as a form of further on-the-job coaching for selected site staff. The detailed assessment would be used to provide a set of specific recommendations relating to that batch process, but also to draw out generic issues that would be common to the majority of batch processes operated at the H&W site. From this, a more streamlined HF assessment process would be derived, taking account of the detailed recommendations already made. This streamlined process would be planned to be implemented by H&W, and would fit with their existing PSM system.

H&W accepted the proposed approach, and assigned a project manager to act as liaison throughout the work.

TRAINING

The first activity was to provide formal HF training for H&W. Two complementary training activities were planned. The first was a half-day senior management awareness session. The purpose of this session was to enable senior management to understand both the importance of HF, and the manner in which it could be addressed. It was essential that senior management was properly engaged in the subsequent HF assessment processes, and would properly support them. To achieve this, the session was planned to highlight the importance of HF, to highlight the tractability of the issues - human error can be managed, and to highlight the methods and approaches that would be adopted, together with their objectives.

Successful delivery of this session, although only a small part of the commission, was considered extremely important by H&W if they were to be able properly to take ownership of future assessments, and to take proper account of recommendations derived from them.

The second training activity, delivered the following day, comprised a full-day training and awareness course for a cross-section of site staff, including union representatives, to equip them with an understanding of HF issues and solutions, and an understanding of the methods that could be applied. Delegates at this second session included those staff who would receive the more intensive on-the-job training by being involved in the detailed assessment itself – the training session included elements of the processes and tools that would be applied during the detailed assessment. An important element of this training was the focus on practicality of recommendations, and that any HF assessment would be carried out on existing plant, which therefore imposed significant constraints in terms of what could be changed or adapted, and how human error could be controlled.

These two training sessions were delivered back-to-back, ahead of the start of the detailed assessments. Both sessions were well-received, and participants were very conscious of how the value of the session content went beyond the immediate concerns surrounding the Improvement Notice, and extended to all aspects of their normal work.

DETAILED ASSESSMENT OF BATCH PROCESS

Once the training was completed, and the member of H&W staff who would participate in the detailed assessment was comfortable with the planned process, a GSB consultant went to site to work with him.

The batch process selected for analysis was scheduled for implementation shortly after completion of the assessment, and hence it was anticipated that there would be both generic recommendations concerning the overall H&W approach, and batch-specific recommendations that could be implemented immediately to improve the planned process.

The analysis would focus not only on the operation of the planned batch process, but also on the differences between the preceding and following processes, to understand the implications of the change process. Additionally, there was a need to consider maintenance activities, both planned and unplanned, and how they could influence process safety. Whereas H&W considered carefully the opportunities for incorrect assembly of plant when configuring a new batch process, they were less careful about considering the similar opportunities for incorrect assembly following maintenance during a batch campaign. (However, although the opportunities for error might be similar, maintenance during campaigns is either on a “like for like” basis or is controlled by a separate control of change process. The consequences of error here should always be considerably less.)

Because the batch being assessed was still at the planning stage, much of the assessment was based, on the ‘batch sheets’ – the detailed step-by-step operational instructions.

This assessment required active participation by H&W. GSB worked alongside H&W to complete the task analysis and initial error and consequence analysis. H&W then took this and completed the detailed error and consequence analysis.

The assessment process can be summarised as follows (see also Figure 2):

Task Analysis

Developing and verifying with operational staff, a task analysis of operator actions of the operation, maintenance and emergency/abnormal states of the batch reaction operations.

This entailed:

- Identifying key documentation and personnel;
- Reviewing procedures and drawings to develop an initial view of tasks;
- Completing “walkthroughs” of each part of the operation, and interviews with relevant staff;
- Producing a draft Task Analysis – detailed for production, high level for configuration, maintenance and emergency procedures;
- Talking through draft with key staff for confirmation and clarifications.

The purpose of the Task Analysis is to provide the equivalent of a verified “P&ID” for the operator tasks – clarifying the precise tasks, how they are undertaken, and their inputs and outputs. This provides the basis for the subsequent error analyses.

Identifying Safety Related and Safety Critical Tasks

This was a screening of tasks identifying those critical to preventing major accidents. Consequences were allocated to 4 categories according to severity, the top two categories were taken as being Major Accidents as defined in COMAH. Those categorised C & D were not taken forward, but H&W could subsequently decide whether to examine these further for other risks to health or safety (or quality).

The purpose of the screening process was to enable H&W to focus effort only on the critical tasks, and hence to ensure that the HF assessment remained practical in the time available.

Error Analysis

Examining in detail the tasks identified as having potential consequences in the top two categories entailed identifying the sub-tasks (from the task analysis) where human errors have the potential to cause major accidents, reviewing the opportunities for detecting significant errors and the consequences of not doing so.

H&W held several “**what-if**” sessions guided by an error mode checklist. The aim was to identify which errors could lead to a major accident regardless of the probability of error.

Production was analysed to a detailed level of tasks. Plant configuration, maintenance and abnormal states were analysed at a high level due to the very high range of circumstances and potential interactions with processes.

This process provided the basis on which to determine whether error reduction measures were required, and what form they should take.

Identifying Opportunities to Reduce Reliance on Human Intervention

Where significant error modes were identified, engineering and management control measures were reviewed both for prevention and mitigation, as well as for opportunities for detection of error. A view was then taken as to whether these ensure that the human error could not reasonably lead to a major accident hazard.

For those errors for which engineering control measures for prevention or mitigation were not adequate, a view could then be taken as to whether current engineering (and management) control measures could reasonably practicably be improved to prevent (and/or mitigate) errors and their consequences.

HF best practice judgement was applied at this stage in the process.

Identify Opportunities for Human Factors Improvements

Where reliance on human intervention was unavoidable, reviews were made of relevant controls (interface design, procedures, competencies, etc) to identify options for improvement and to show clearly the links between the likely consequences of error and the control measures in place.

Prioritisation and Justification

Review of current risk assessments in light of the above to assist in identifying priorities for action and ensure reliance is justified and can be demonstrated.

IDENTIFICATION OF IMPROVEMENT OPTIONS

Following completion of the detailed error and consequence analyses, GSB worked with H&W to develop recommendations for error reduction and mitigation.

These recommendations fell into two categories. One set was batch-specific. They would allow H&W to improve the design and operability of the planned batch process. The second set of recommendations was generic, and was the reason for undertaking the very detailed assessment. The intention was that subsequent assessments would build upon the detailed generic understanding gained during this work, and hence could be more streamlined.

The level of detail of the assessment did lead to a significant number of issues being raised, and it quickly emphasised the importance of having a process for prioritising recommendations. A further issue that arose during the assessment was the distinction between safety and quality issues. The focus of the study was safety. However, whereas errors that would lead to quality problems without impacting on safety could in theory be discounted, in practice H&W understandably were very keen also to address those. This led to a potentially huge burden of plant modifications, and this burden needed to be managed. GSB's approach was to prioritise with respect to risk, but the site needed also to consider quality and performance issues.

INTEGRATION INTO THE H&W PSM SYSTEM

GSB provided a report that summarised the process undertaken, and the conclusions and recommendations, both batch-specific and generic. GSB also facilitated a meeting with H&W managers to review both the assessment process and the assessment outcomes, in order to help identify how to ensure the integration into the H&W PSM system.

The approach taken, including both the training and the assessment process, supported this integration process. The elements of the training process that were oriented towards achieving management buy-in were considered essential, as was the in-depth coaching of key staff to create an internal 'champion' for the process.

As anticipated, this stage of the overall process required some modification at the time. The complexity of the selected batch process was greater than expected, which increased the time spent on the analysis. H&W needed to make rapid progress on the integration process, and therefore chose to carry out some of the integration work in parallel with the preparation of the GSB report. However, this had the effect of increasing their ownership of the process. Another issue that arose concerned the accuracy of the batch sheets. This was less than originally expected – which both increased the time spent in the analysis, and also influenced the manner in which H&W could expect to carry out subsequent assessments. The batch sheets are aimed at supporting the operators, and do not provide all of the information necessary for assessing potential maintenance errors. However, identifying the inaccuracies was itself beneficial.

SUCCESSSES AND ISSUES

A number of particular successes were achieved during the course of the work – some planned, and some that were more unexpected. Similarly, a number of issues arose, either that needed to be resolved as the work progressed, or that adversely affected the progress of the work or its outcome. This section describes some of those successes and issues.

TRAINING AND ASSESSMENT PROCESS

- The training provided at the start of the project was an essential precursor – it enabled H&W to understand the elements of the HF assessment process and their purpose, and also supported buy-in across the company. Furthermore, it provided reassurance that the process that was about to be applied would provide benefit, and hence warranted the H&W effort and resources that would be required.
- The training involved site staff at all levels, from senior managers through to plant operators, and included union representatives. This ensured that the process was seen to be transparent, and was not intended to apportion blame, or to bias the conclusions in favour of ‘preferred’ solutions.
- The GSB consultant who undertook the detailed task analyses and ‘what-if’ assessments was not familiar with batch processes. This was both a strength and a limitation. The strength was that it allowed the consultant to ask fundamental questions, and thereby highlighted a number of issues that might otherwise have remained undetected. It also demonstrated that the strength of the analytical process lay, in part, in the manner in which it was applied – that it should address all aspects of the batch process that had the potential for safety-related consequences if there were a failure. The limitation was that, initially, it slowed the process, until an effective relationship was established between the consultant and the H&W assessor. A conclusion is that the ‘application’ of a naïve view was beneficial, but probably not required throughout the assessment process.
- The assessment was based on the batch sheets for the planned batch process. The development of the detailed task analysis was time-consuming, in part because of batch sheet errors. The process may have been more efficient if the assessment had been

integrated into the PSM earlier, such that a high-level assessment of the proposed batch process could have been undertaken as a screening process.

- The proposed assessment process involved a detailed ‘what-if’ analysis following on from the task analysis. The task analysis process revealed many issues, and hence was valuable but lengthy. The intention was to use a high-level screening process to determine the safety significance of ‘top-level’ failures and only to analyse further those that appeared to have such safety significance. In the event, the initial analysis proved extremely time-consuming. It also transpired that the potential blurring by H&W of the distinction between quality and safety issues – because of the wish to address both – made it difficult for the H&W analysts to avoid continually being sucked into a very detailed analysis. Once they had gained familiarity with the screening process, H&W were then able to complete the analysis much more quickly, relying also on their process knowledge.
- The balance of GSB and H&W staff appeared to be essential to the successful assessment, but there is a need to give careful thought to how best to achieve that balance.
- The selected batch process was extremely complex. It was selected for analysis because it was the next batch process planned for a campaign. However, the complexity of the process made it more difficult to stand back and determine how effective the proposed assessment process had been, and how easily it could be incorporated into H&W’s PSM system in due course.
- The complexity of the process highlighted the value of having at least two people involved in the assessment – one to carry out the detailed assessment, and one to ‘stand-back’ and take a view about the implications of the assessment findings.
- Involvement of operators (and the union) was essential to ensure “buy-in” by everyone on site. This also ensured that H&W undertook the bulk of the assessment – both for speed and efficiency of the assessment, and in order that they could determine how best to implement a system that would be effective in the long-term.
- The prioritisation process needed to be pragmatic. When considering existing plant it was apparent that many potential errors were being controlled by administrative defences – and were being controlled effectively. Consequently it would not be appropriate always to recommend plant modifications and hardware defences. However, there was a need carefully to consider whether the administrative defences were robust – this was where the HF consultant added value.
- By providing the one-to-one coaching of H&W staff, and following on from the HF training, it was possible to equip H&W with the skills to develop further their ability easily to assess the adequacy of their administrative controls.

OUTCOMES FROM ASSESSMENT

- The number of quality issues that were raised during the assessment was both a strength and also a challenge. On the one hand it confirmed the value of the detailed analysis process – it highlighted opportunities for enhancing the batch process. On the other hand it created significant concern in respect of the amount of work that would be needed to implement remedial measures.

- The Improvement Notice was successfully discharged, and hence the assessment process could be considered effective. The level of detail in the assessment was greater than was necessary merely to discharge the notice, but it enabled H&W to carry forward some generic messages that could be incorporated into future batch processes. Future assessments would be more streamlined.
- The shortcomings in the batch sheets was a significant finding. In practice, the skill and experience of site staff allowed them to overcome these errors, but it made the process potentially vulnerable. The assessment has allowed H&W to refocus on the validity of the batch sheets.
- The assessment highlighted the importance of the change process – moving from one material to be produced to the next. A number of issues were identified where the error potential was aggravated because of the manner in which the previous batch process was operated.
- The assessment highlighted the importance of providing effective controls over breakdown maintenance activities.
- Integration into PSM.
- The entire assessment was planned as a linear process – the task analysis and error assessments, followed by recommendations, and the development of a process that could be incorporated into the PSM system. In practice it became apparent that, due to time pressures imposed by the Improvement Notice deadline, it was necessary to carry out some steps in parallel – particularly when considering the manner in which PSM was enhanced. It is unclear whether this is a presentation issue, or whether it is important to ensure that the various activities happen in parallel. GSB considered that a strength of their approach was the allocation of an experienced safety management consultant to stand back from the detailed analysis, and work in parallel with H&W to identify how to incorporate the assessment activities into the PSM system.
- H&W need to be able to ‘challenge’ themselves quickly when developing a new batch process. The assessment undertaken for Stage F was extremely detailed and H&W faced the difficulty of developing a simplified process that would support such a rapid challenge. The generic issues raised in the detailed assessment provide a surrogate checklist to support a more rapid and hence acceptable process.
- H&W had not planned to include HF in their HAZOP process during batch process development. The outcome of the assessment and subsequent discussions led to an acknowledgement that it could beneficially be incorporated at the design stage – to improve their ability to engineer out the opportunities for human error.

LESSONS LEARNED

H&W and GSB have both learned a number of lessons from this work. These lessons cover three areas:

- the assessment process, and the batch design and operating issues that it highlighted;
- how such assessments can and should be incorporated into the company PSM system;
- how the value of the HF consultant can be maximised.

THE ASSESSMENT PROCESS

- The earlier that HF assessments can be incorporated into the design of plant modifications and new batch processes, the more effective will be the error controls that can be implemented. However, there is a need to ensure that they are applied at a point in the design process when the potential human errors can be identified – too early on in the process these may not be readily apparent. In the end a two pass approach may be required.
- A balance must be struck between familiarity with the processes, and hence the efficiency with which the assessment can be undertaken, and ‘naivety’, and hence the ability to ‘challenge’ the system. In practice, a significant element of the requirement for challenge was satisfied through the initial assessment undertaken for this project. Those challenges provide a generic framework with which to question future modifications. H&W already had a good pragmatic understanding of potential errors, and the formal assessment provided a more robust framework to support understanding of the underlying error causes.
- An extensive set of recommendations arose from the assessment. The precise recommendations were based, in part, on the application of HF judgement. They also took account of the need to implement pragmatic and practical changes. Consequently, many recommendations focused on enhancing existing checking processes, rather than proposing impractical or costly plant modifications or procedural changes. HF expertise was applied to assure that the proposed changes were likely to be effective in controlling human error, and failures.
- A number of recommendations arose concerning the physical environment. None of them alone was considered fundamental, but together they provide the opportunity to enhance the working environment for operators, and thereby reduce further the likelihood of error.
- Recommendations arose concerning ‘hidden knowledge’, typically acquired through informal on-the-job training. It was suggested that such knowledge could usefully be formalised – examples included the rules of thumb used by operators for controlling batch temperatures, which if inappropriate could give rise to significant problems.
- Some recommendations concerned plant labelling – the importance for safe operation of the plant was recognised by H&W, and suggestions were made as to where further improvement could be made.
- Recommendations concerned the conceptual design process that preceded modifications to the batch process in order to manufacture a new product. The opportunities for human error in the design process were noted, and H&W has examined the level of independent checking that it applies, in order to be confident that it remains appropriate.
- Correct plant and software configuration was recognised as being critical. Recommendations concerned a review of the strength and independence of the checking processes associated with re-configuring. In particular, the danger of inadvertent failure to change an aspect of the configuration from the previous process

was noted. This recommendation also applied to the testing activities that were intended to detect errors introduced in the design and configuration processes.

- Some recommendations concerned batch sheets. These included measures intended to ensure the accuracy of batch sheets, encouragement to operators to question aspects of the process that caused them concern, and also opportunities for making more use of the batch sheets for other purposes such as training, highlighting safety issues, etc.
- A number of recommendations concerned specific ergonomic improvements that could enhance batch processing at H&W (e.g. improve the accuracy with which defined quantities of water or other products were introduced; disable/remove duplicate or redundant interfaces to reduce ambiguity; improve monitoring accuracy; ensuring that ergonomic conventions were followed and that historical maintenance had not inadvertently contravened such conventions – e.g. incorrect alarm colour coding). The generic elements of these recommendations were highlighted.
- Some recommendations concerned opportunities to reduce error likelihood through improved procedural control of product availability. However, the importance of keeping such controls simple, and minimising unnecessary bureaucracy was emphasised in order to have confidence that the procedural controls would be complied with, and hence remain robust.
- A set of recommendations specifically addressed maintenance issues. One recommendation concerned the need to consider how to engineer out the opportunity for maintenance error (e.g. making it not possible incorrectly to assemble a plant item). Another concerned the need clearly to indicate plant item safety significance for that particular batch process. This is important where the safety significance of a particular plant item may change from one batch to the next, and hence maintenance staff cannot know, from the plant item alone, what is its safety significance. Recommendations also concerned maintenance management and planning.
- The assessment also enabled H&W to review its arrangements for responding to abnormal events. It clarified the extent to which operators were sometimes the only line of defence against interlock failure. Furthermore, routine reliance on interlocks during normal operations may reduce the operator's awareness of the criticality of certain operations, and hence of their role in assuring safety.

INCORPORATION INTO PSM

Four complimentary activities exist within PSM where HF has a particular bearing. Each of these was addressed when considering how best to incorporate HF into PSM:

- Process hazard assessment (e.g. HAZOP)
- Engineering (standards) management
- Safety and reliability demonstration
- Other SHE management activities

In the light of this work the following specific recommendations were proposed for H&W to consider.

Process Hazard Assessment

HF should be incorporated at a number of stages, including:

- Stage 2 Activity Risk Assessment (HF HAZOP)
- Stage 3 Detailed Event Assessment (human error analysis, task analysis, human error guidewords/checklists, appropriate human reliability assessment)
- Process hazard analysis to include explicit HF consideration

Engineering Standards

Revisions to current site standards to incorporate HF guidance. Extending the current standards to make them bespoke to H&W processes.

Safety and Reliability Demonstration

Giving greater weight to HF issues in the company's COMAH report, e.g.:

- HF reliability principles (e.g. no single human error shall have a major incident potential)
 - Expand principles covering interface design, supervision, competence assurance
 - Develop links between human error analysis and HF safety and reliability decisions
- Hickson & Welch hope to be able to describe how they have modified their Process Safety Management System to incorporate the lessons learned in this exercise at a future "Hazards" conference.

General SHE Management Systems

Many aspects of management influence the likelihood of human error, e.g. hiring, placement, training, permitry, change management, organisational structure, supervision. It is important to be able to compare company current practice with best practice/HSE guidance.

USE OF HF CONSULTANTS

H&W commissioned HF consultants for two reasons. One was to support their assessment and to help them understand better the HF issues that affect their operations. The other was because the HSE had clearly indicated that they expected to see external HF consultants involved in the assessment. A number of learning points arose from this:

- "Technology transfer" was an essential element of the work – the ability of the consultants to help H&W acquire new skills, and robust HF assessment processes. This was also important if effective prioritisation of potential error reduction recommendations was to take place.
- H&W and GSB had to work closely together – each brought knowledge and experience that together would enable the development of an effective process. During the work it became apparent that communication between H&W and GSB needed to be strengthened and made more explicit, to allay H&W concerns about the perceived complexity of the process. For example, as planned, H&W continued the analysis using their own resources. It became apparent that they were going further with the consequence analyses than originally intended, and were becoming understandably

concerned about the time and resources required. It was important that lines of communication remained open between H&W and GSB to highlight this concern and correct the process accordingly.

- GSB underestimated the complexity of the Stage F process, because it was not possible to have access to the batch sheets in advance of tendering. This caused GSB initially to propose and commence a process that proved to be too detailed. The more information that can be provided to the consultant at the outset, the more appropriate will be the proposed approach.
- It is essential that both the client and the consultant have a common understanding of the intended deliverables, and their proposed use. In this instance, there would have been benefit from a more detailed discussion of how GSB's report could be used to satisfy HSE. In the event the report structure was more suited to H&W's needs than to HSE's. For future assessments, a report section suited to HSE's concerns (with a focus on the Headings in the Improvement Notice) would be helpful.
- The value of external consultants appears, in part, to lie in the early stage of the assessment process, where they can question and challenge existing arrangements, and propose and co-develop an assessment process. Building on the knowledge transferred during the assessment, the client can carry out subsequent assessments without making such extensive use of consultants.
- There remains a role for the consultants in providing ad-hoc HF advice and guidance in respect of specific issues – assisting prioritisation, assessment of remedial measures, and recommending particular solutions.
- Even with external consultants, H&W needed to put in significant resources. Whilst this was expected – the discharge of the improvement notice was the responsibility of H&W, and could not be transferred to an external consultant – nevertheless, the level of effort to gain sufficiently detailed understanding of the basic processes and HF should not be underestimated. Subsequent assessments should be more manageable.
- There may be merit in setting up an industry peer group to support future assessments and to exchange information on best practice and common issues.
- The involvement of the operators and the union was considered essential. It provided an avenue to ensure that best use was made of operator experience.
- The 'naïve' perspective that can be offered by a consultant is important for ensuring systematic 'challenge' to the 'normal' way of doing things. Additionally, a consultant can stand-back from the process and look for gaps, barriers and other shortcomings.
- The development of an in-house 'champion' for HF also was considered essential. That person could provide robust upward and downward links. It was important that they were a reasonably senior process manager.
- An identified potential vulnerability concerned the expertise that lay within the design team. There was reliance on two people to undertake HAZOPs. Succession management may need to be considered.

GUIDANCE

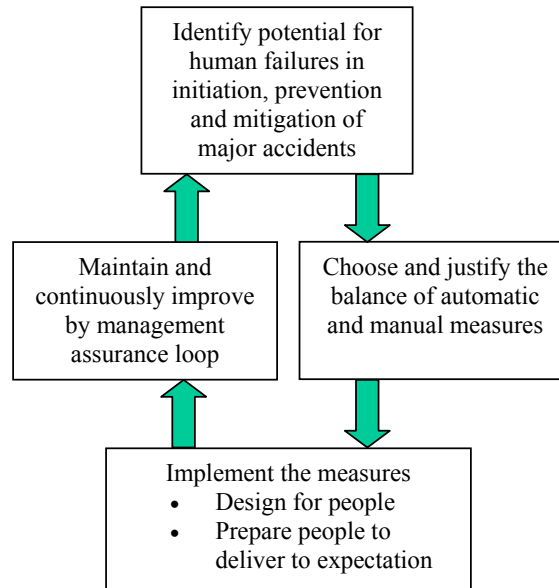
The following 10 points are recommended as guidance when considering how to incorporate HF assessment into the PSM system for existing plant:

1. HSE has made clear that they consider HF to be of prime importance when considering the adequacy of a COMAH safety case – the need to provide assurance that HF is being adequately addressed is ignored at your peril.
2. Adequate incorporation of HF must start as early as possible in the design process – at the conceptual stage.
3. The Duty Holder requires a good grounding in HF to be able properly to identify HF issues, to prioritise areas for attention, and to identify effective solutions.
4. Independent advice, both to challenge existing practices and to provide guidance on the effectiveness of potential solutions, should be available.
5. The first assessment will be very resource intensive – it is important to ensure that generic messages are taken from this assessment and incorporated.
6. An in-house ‘champion’ for HF is invaluable.
7. The assessment focus must remain broad, taking account not only of operations, but also of design, commissioning, maintenance, abnormal operations, etc.
8. HF expertise can help to discriminate between alternative solutions, and to advise on the strengths and weaknesses of different error defences, thereby helping to make the chosen defences robust and cost-effective.
9. Existing plant will present a range of HF discrepancies. It is important to be able to distinguish between those that demand attention for safety reasons, and those that may have only economic disadvantages. A screening process will help this.
10. HF consultants are a valuable source of advice, guidance and support, which HSE expects Duty Holders to make use of. However, HF consultants are an adjunct to, and not a substitute for, the application of in-house expertise.

CONCLUSIONS

H&W wished to enhance the manner in which they demonstrated adequate control of HF within their PSM system. They commissioned GSB to assist in analysing a selected batch process, both to reduce the likelihood of human error and hence poor safety on the next planned batch process, and to help them determine how best to improve their treatment of HF.

The assessment and support, carried out over a relatively short period of time, proved invaluable for H&W in helping them better understand HF and how it affects their operations. The process was detailed, and raised many issues. A key requirement was to derive a more streamlined assessment process that could be incorporated reliably into their PSM system. The information derived from the detailed assessment allowed H&W to do this.



From: Human Factors for
COMAH safety report assessors,
HSE 2001

Figure 1. Human factors and COMAH

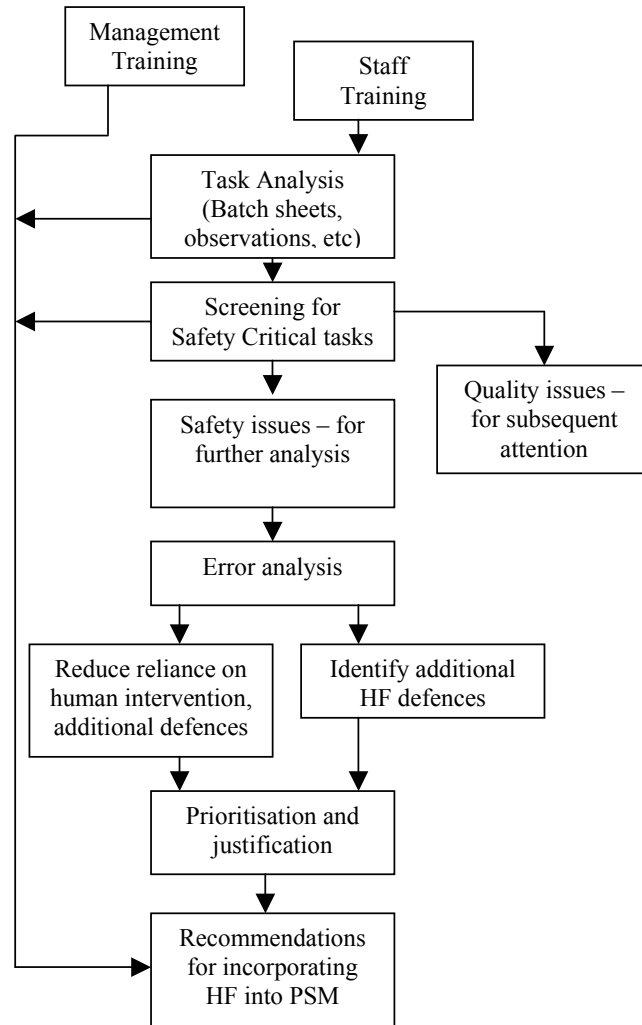


Figure 2. Assessment process