HUMAN FACTORS ONSHORE AND OFFSHORE

M A Needham
Health and Safety Executive, Magdalen House, Stanley Precinct, Bootle, L20 3QZ

The potential problems which arise in the operation of major hazard plants have been extensively examined. An array of systems and procedures are available for use to prevent major incidents from occurring. The difficulties which face organisations and enforcing authorities is how to ensure that the theoretical procedures and systems are put into effective practice. To do this it is necessary in each case to consider the complex relationships between individual plants, organisations, the people who run them and the socio-economic climate in which they all exist. Approaches are needed which incorporate effective systems, involve the workforce and encourage flexible and questioning attitudes in both management and employees alike.

Keywords: Effective Systems, Participation, System Monitoring, Total Quality Management, Problem Recognition, Safety Vs Production

Large organisations faced with known hazards now have or are arranging to have systems and procedures to deal with the hazards arising from their operations. The CIMAH Regulations have helped achieve this. Off-shore Safety Case requirements will further this end. Other organisations which do not fall into the major hazard category also are increasingly drawing up procedures to govern their activities. In some instances the COSHH Regulations have provided an influence. Directives from Europe such as the Framework Directive will provide a further impetus. The problem remains however that in spite of all this, incidents, major and minor, with the potential to cause harm still occur. It is now well recognised that the causes can be multiple and some may have lain dormant for some time, only becoming evident when they combine with other factors to provide the conditions for an incident to occur (Rasmussen and Pedersen 1984, Embrey 1989, Reason 1990). Problems may lie in system design, but equally well may arise from organisational structure, the way in which the system is managed, the culture or cultures of the organisation, or production and profitability pressures. It is a tall order for all these issues to be addressed, but it has to be done. It has been said that a hazardous incident occurs when an accumulation of factors occur in an unforgiving environment, that is one where it is not possible to retrieve an error once it has occurred. Only by attempting to address all factors which might give rise to a potential incident is it possible to pre-empt it.

NEED FOR EFFECTIVE WRITTEN SYSTEMS

It is a pre-requisite that appropriate safety systems are drawn up in writing. Knowledge and enthusiasm may reside in one person or a group of people. Unless this is encapsulated in a written system procedural knowledge is lost with staff turn over or retirement. It is particularly important for post incident procedures to be systematised. Memories are short and even following a major incident will fade unless systems are put in place to prevent reoccurrence.

NEED FOR PRACTICE TO MATCH THEORY

The difficulty for a company is to ensure that every day practice matches the theory of the written procedures. Existing organisational theory and research strongly suggest that effective organisations can and must take different forms depending on the demands of the specific organisational context and the history of the specific organisation. Procedures for dealing with safety issues should also differ according to the character of the organisation. But even now procedures are drawn up based on what it is hoped will pass the scrutiny of the inspector examining the system but bearing little resemblance to what happens on the ground in practice. Examples which come to mind are a firm's statement of safety policy which included details of the training manager's function when the firm was too small to have one. The policy had been copied from another company. More serious was the case of a large international chemical company in the United States. In observing their procedures in drawing up written systems to deal with plant hazards, it became clear that what was being drafted was what it was thought the inspecting body wanted with no reference to what happened on a day to day basis. Numerous examples of failure of practice to tally with theory were revealed in the Cullen report on the Piper Alpha disaster. Night shift operators did not know that a pressure relief valve had been removed and replaced by a non-leak proof assembly at one of two condensate injection pumps. They were not told of this during the handover from the day shift and the permit to work system was not implemented correctly. Occidental's written procedures were contained in its safety procedures manual and the work permit procedure was also contained in the Work permit booklet. The inquiry found that many procedures were frequently disregarded. The requirement for the performing authority to take a work permit personally to the approving authority was rarely adhered to. Contrary to written procedures multiple jobs were undertaken on a single permit. Cullen concluded that 'the operating staff had not commitment to working to the written procedure and that the procedure was knowingly and flagrantly disregarded'. He also considered that 'the training required to ensure an effective permit to work system was operated in practice was not provided'. Revised guidance on permit to work systems in the petroleum industry, taking into account some of the lessons learned from Piper Alpha has recently been issued by the Health and Safety Commission's Oil Industry Advisory Committee.

NEED FOR INVOLVEMENT OF OPERATORS IN DRAWING UP PROCEDURES

In order to ensure that written systems tally exactly as possible with working practice it is essential that operators carrying out the practices are closely involved in drawing up procedures. The draft Offshore Safety Case Regulations indicate that the workforce should be involved in preparing Safety Cases. This was not a requirement of the CIMAH Regulations. Those carrying out procedures on a day to day basis very often have information not available to those further removed. In a study I carried out of a large chemical company operators gave examples of occasions where they had been chastised by managers for not carrying out work according to the safety manual. They pointed out to managers that it was not possible to do the work in the way prescribed. The managers, instead of investigating why this was, with a view to drawing up workable safe procedures, simply insisted that the written procedure be followed. The operators concerned indicated that having made several attempts to explain the problem, they simply said yes to the manager, but went on acting as before.

This chemical company would have been well advised to review all of its existing written procedures in discussion with operators. While there could be said to be short-sightedness affecting individual managers, at senior management there was some perception of the value of involving the workforce. When an old, poorly designed resin plant, which had given rise to numerous safety and housekeeping problems over the years as additional parts were bolted on, was to be replaced, management involved representatives from each shift to sit with technical and design staff to discuss what was needed in the replacement plant to prevent re-occurrence of the problems which had characterised the old plant. The company followed a similar procedure when introducing a new highly sophisticated computer console on another unit. The end result was compared favourably by operating staff with yet another unit where two years before similar equipment had been installed without operator involvement. The latter was described as not 'user friendly'. It has been pointed out that where new technology is to be introduced which is highly complex it is more difficult to involve operating staff whose level of understanding may not match the sophistication of the plant. In this situation for participation to be effective some training of staff is required (Blackler and Brown 1986 and 1987). Others have indicated that participative design produces a better and more workable system from a production stand-point (Mumford 1980 and 1983), while some research has suggested companies with a participative culture reap financial benefits (Denison 1984 and 1990). It would appear that benefits must accrue on the safety front if it is possible to have involvement in design and development before new plant is started. De Keyser (1987) described the commissioning of a continuous plant in Belgium where work was carried out for two years before start up by a team of directors, ergonomists, safety engineers, psychologists, design engineers and those who were to operate the plant.

MONITORING OF SYSTEMS

It has been said that 'what gets measured gets done' (Drucker). Organisations having drawn up appropriate systems to try to pre-empt human error have to ensure that they are adhered to. The nature of the systems will vary according to the organisation and systems for monitoring will also vary. As well as traditional hardware fault finding exercises, they should also include observations of individuals carrying out procedures. The large chemical company to which I have referred had procedures involving the workforce for both forms of activity. Safety sampling exercises were carried out involving tours of sections of the plant to detect safety/mostly housekeeping contraventions. The company also had a version of Du Pont's Unsafe Act Visit whereby 2 people discussed with an operator or craftsman their method of work on a particular job. Unfortunately these were less effective than they might have been. A rota of visits was drawn up including members of management, but no checks were made to see whether the visits had taken place and a casual attitude towards the activities developed. The standards being sought were not always made clear. They also had less impact than they might have because the results of observations were not fed back to the workforce in any systematic manner. The systems were well intentioned, but the good intentions of those involved slipped. Any system devised has to be clearly structured with checks incorporated to ensure that there is not reliance on good intention alone.

BS 5750 QUALITY STANDARDS

A number of organisations have been applying the principles of BS 5750 Quality Systems standards to safety (Bond 1989, Whiston and Eddershaw, 1989). Following these principles can lead to a more rigorous approach to the structuring of safety systems. It has been observed however that quality standards devised by companies can also face similar problems to those observed in relationship to safety. The procedures set out in quality manuals do not always marry up with the practice. It appears that much of the value of BS 5750 is that the monitoring procedures carried out by the company are monitored by an outside body which has the power to remove accreditation. In the chemical company I have referred to, the training foreman responsible for drawing up BS 5750 standards for one of the units was concerned to ensure that the lessons learnt following a plant explosion some years before did not fade from memory. Following shut down correct start up procedures had not been followed, certain valves remaining shut which should have been opened. To ensure that this did not happen again he incorporated the start up procedure into BS 5750 standard procedures, although there were no day to day implications for quality. He reasoned that if the procedures were subject to external monitoring, they would be followed.

It is recognised that the implementation of BS 5750 standard procedures is not always welcomed by the workforce. Badly drawn up procedures can prove to be a cumbersome, time consuming, millstone. The same is the case with safety procedures. In both instances there is a necessity for the systems to be as simple as possible while doing justice to the complexity of the environment to be controlled. There is a case to be made for detailed procedures to be fronted by simplified well laid out aide-memoires, provided all essential elements to the procedure are included!

TOTAL QUALITY MANAGEMENT

The reasons why safety procedures may not be followed are a legion ranging from faults inherent in the task design, to organisational pressures: double messages (safety versus productivity) from management, through to complacency (it can't happen here) in both management and workforce. It is hoped to touch on some of these issues later. In considering the application of the quality movement principles to health and safety it is suggested that it is important not simply to stop at quality assurance principles but to consider what lessons can be learnt from the Total Quality Movement, particularly when addressing the problem of complacency and inertia which may be found at times in all human activities.

The International Atomic Energy Authority (IAEA) (1991) in the report by its international nuclear safety advisory group on Safety Culture observes that 'Good practices in themselves, while an essential component of Safety Culture are not sufficient if applied mechanically. There is a requirement to go beyond the strict implementation of good practices so that all duties important to safety are carried out correctly, with alertness, due thought and full knowledge, sound judgement and a proper sense of accountability'. In its report Basic Safety Principles for Nuclear Power Plants drawn up post Chernobyl (1988) the group had identified a need for 'an all pervading safety thinking', which allows 'an inherently questioning attitude, the prevention of complacency, a commitment to excellence, and the fostering of both personal accountability and corporate self regulation in safety matters'.

The British Quality Association in 1989 addressed the relationship between quality assurance and total quality management. Bone (April 1989) commented that perhaps the mechanistic approach had gone too far. The BQA (June 1989) asked what was meant by Total Quality Management. Three people offered definitions (see Appendix) - The first

lays emphasis on a culture of excellence, team-work, management style, training and employee participation. The second emphasises a systematic approach to control activities, with no reference to team-work, or employee participation. This would appear to epitomise the mechanistic approach which Bone felt had gone too far while the first definition is lacking in systems to ensure a satisfactory end product. The third definition has as apex of a triangle 'Develop an obsession with quality' and has as its two bases 'The Scientific Approach', (with identification of problems, isolation of root causes and solutions as its elements) and 'All One Team' (with everyone seeking improvements, team-work and training as its elements). This would appear to be an attempt to combine effective system, with the means to counteract apathy and complacency.

These same principles can be applied to safety. The IAEA is encouraging this. In a paper presented at a meeting jointly organised by IAEA and the International Institute for Applied Systems Analysis on the Influence of Organisation and Management on the Safety of NPPS and Other Complex Industrial Systems Carroll and Perin express the belief that in building an adequate framework to safely manage a complex industrial system there must be recognition of the dynamics and complexities of the production process, analogous to an image of a living organism in a dynamic ecological setting asserting: '(1) self-assessment and adaption are the keys to safety; standardization is a way to make that process easier, but not at the expense of rigidifying the organization or stifling its creativity: (2) creating a technical and social system in which compliance takes place is critical, but compliance must be accompanied by intelligence and vigilance to maintain a continuous adaption process; (3) standards and practices must be developed collectively, acknowledging interdependencies and distributed knowledge'.

NEED FOR A FLEXIBLE AND QUESTIONING ATTITUDE

The need for a flexible and questioning attitude is demonstrated by post disaster analyses which time and again have indicated with hindsight that people could have known about the disastrous potential of their actions. Canter and Donald (1991) note that there are usually cues available that could be taken to indicate that some actions, other than those actually taken, would be less dangerous, but that because of their understanding of what is demanded of them, people do not do what is demanded of them. This is certainly an element in the productivity versus safety pressure which will be deal with later. Canter and Donald in their study of the Kings Cross incident, note that it was normal, conventional behavioural patterns which helped make the loss of life greater than it might otherwise have been (see also Weisaeth, 1992). When authority figures in the form of the Police instructed a number of people waiting for trains to leave the station, they did so and were guided up into the ticket hall at about the time that the fire flashed over into the hall. Even in the last moments as the smoke and flame erupted into the ticket hall people who must have already had some idea of the danger they faced appeared to have continued on their known route. The impact of expected customs and practice in shaping interpretations and expectations of appropriate actions is also illustrated in the study of the fire at Bradford City football ground. A television video film shows clearly that in the early stages people were reluctant to climb out of the stands onto the football pitch until Police Officers started to give direct instructions to people to step onto the turf (Canter and Donald 1991).

FAILURES IN PROBLEM RECOGNITION

Related to difficulties arising from conventional behaviour patterns, are failures in problem recognition. These were present at the Three Mile Island incident where operators were misled by control panel indications and failed to recognise that the PORV relief valve was stuck in the open position. At Bhopal there was a failure to recognise that the pressure rise in the system was abnormal. In the case of the Kegworth air crash the left hand engine vibration indicator on the Electronic Flight Instrument System (EFIS) was overlooked. This was showing a very high reading, but was only the size of a 20p piece. The traditional view of pilots of vibration meters is that they are inaccurate and unreliable. However, on the new 737-400 the vibration meter was highly accurate. The pilots had not been briefed about the new vibration meters. Their training had consisted of a morning's slide show and multiple choice test. No simulation training was required under Civil Aviation Authority regulations and none was given. Thus the first time they saw the EFIS instruments showing anything other than normal readings was when the emergency occurred. Clearly there are human factors design and training implications here also.

THE INFLUENCE OF MANAGEMENT ATTITUDES: SAFETY Vs PRODUCTIVITY

As can be seen in the Canter and Donald studies of behaviour during the Kings Cross fire, a major influence on behaviour is the perception of what is required by authority figures. In industry management is the authority figure. In the field of safety employees "read" managements attitude towards risk taking and usually provide what they perceive management to want. Management can given contradictory messages to the workforce. They may say safety is paramount and comes before production, but the workforce often perceives the opposite. In the chemical company mentioned earlier where operators were involved by management in discussions relating to plant to replace the existing old, poorly designed resin plant, there was concern on the part of management at what was perceived to be a high accident rate. Since the plant was to be replaced by new plant which required fewer operators, the unit was operated with reduced manning levels prior to the introduction of the new plant. At the same time there was an attempt to keep production levels to a high level to build up stocks to cover the change over period from old to new plant. When chastised over the level of injuries, mostly falling into the category of slips and trips the plant manager was asked: 'Do you want production or safety as we have no time to tidy up?' The manager's response was that he wanted production, but did not want people getting hurt. The result despite the manager's good intentions was that the workforce 'read' this as: 'production still takes precedence'.

The imperative to put production before safety is not confined to private industry. The Hanford, Washington State site, run by the US Department of Energy to produce weapons grade plutonium, was two years ago, forced to release information under the Freedom of Information Act relating to the unsafe disposal of waste after cows milk in the area was found to be contaminated. Waste had been disposed of in unprotected holes in the ground. When asked why arrangements had not been made for safe disposal and why charges relating to this had been denied for four years directors one after the other said that they had production schedules to be met.

In the activities of British Rail there is evidence that workers, aware of the need to reduce delays in arrivals of trains, will put themselves at risk when carrying out line work to ensure that delays are kept to a minimum.

In the chemical industry in relationship to continuous process plant there is still a culture among the workforce that the plant must be kept going at all costs, with operators prepared to put themselves at risk where there is a perception that there is a potential for damage and

injury on a large scale should an incident get out of hand. This can lead to a culture of risk taking even where the hazard and potential is not so great.

Not surprisingly there is evidence that the same imperatives operate offshore as well as onshore. This was apparent in evidence given at the Ocean Odyssey fatal accident inquiry relating to drilling operations and a defective well control plan. At a wider level it has been noted that some cynics even suggested desire for safety on the part of the Department of Energy was tempered by the need for revenue from oil in the 1980s to balance Government books (McMahon 1990).

SUMMARY

There is no single simple method which can be applied to achieve safety offshore or onshore. Action has to be taken on a number of fronts simultaneously. The basis must be analysis of potential hazards followed by safety systems drawn up in writing. It is crucial that operators and others required to implement procedures are involved in drawing them up in order to ensure that theory matches reality. Organisations differ and procedures should reflect the specific needs and culture/cultures of an organisation. Effective monitoring of the implementation of systems and procedures is essential to ensure that good intentions do not fall by the wayside. Feedback to the workforce is important.

Quality Assurance, BS5750 Quality Systems approaches have been extended to the safety field. Care has to be taken to ensure that procedures drawn up are not so mechanical and cumbersorce that they are simply regarded as a millstone. A Total Quality Management approach is needed which as well as incorporating effective systems also involves the workforce and encourages a flexible and questioning attitude on the part of management and employees alike. This is the only defence against stereotyped, 'it can't happen here' thinking. Of particular importance for management is the need to recognise and take effective action to counteract the double 'safety Vs productivity' messages it gives out to the workforce.

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Appendix Definitions of T.Q.M., B.Q.A. Newsletter (1989) June pp 12,13

Members are asked to comment on the following three definitions of Total Quality Management. The BQA will endeavour to create a mission statement. Replies to the Editor would be appreciated.

TQM

Total Quality is the brand of Business Management which enables the Company to achieve the stated business priorities by focusing fully on satisfying the needs of the customer chain through:

- Culture of Excellence: giving services equal emphasis to products and applying the same levels of innovation and resources.
- Teamwork: suppliers, functions, operating companies and distributors jointly accepting responsibility for the complete supply chain by working together to make it consistent, reliable and better.
- Management Style: management accepting responsibility for the removal of performance barriers which are identified by their teams.
- Training: provision of essential support to help everybody develop new skills and techniques.
- Employee Participation: everyone accepting responsibility for the continual identification of performance barriers within existing business practices.

This will give a competitive edge which results in:

- rising customer satisfaction
- improving margins
- increasing market shares

Libby Raper

TQM is a systematic approach to the control of all activities in an operation by setting standards, measuring the performance of the operation against those standards, evaluating the results, commending the work done or correcting the programme and resetting the standards of performance expected.

The primary concerns of management are in:

- Quality of the product or service
- Productivity or efficiency of the operation
- Prevention of loss of people or their services, of material or of equipment.

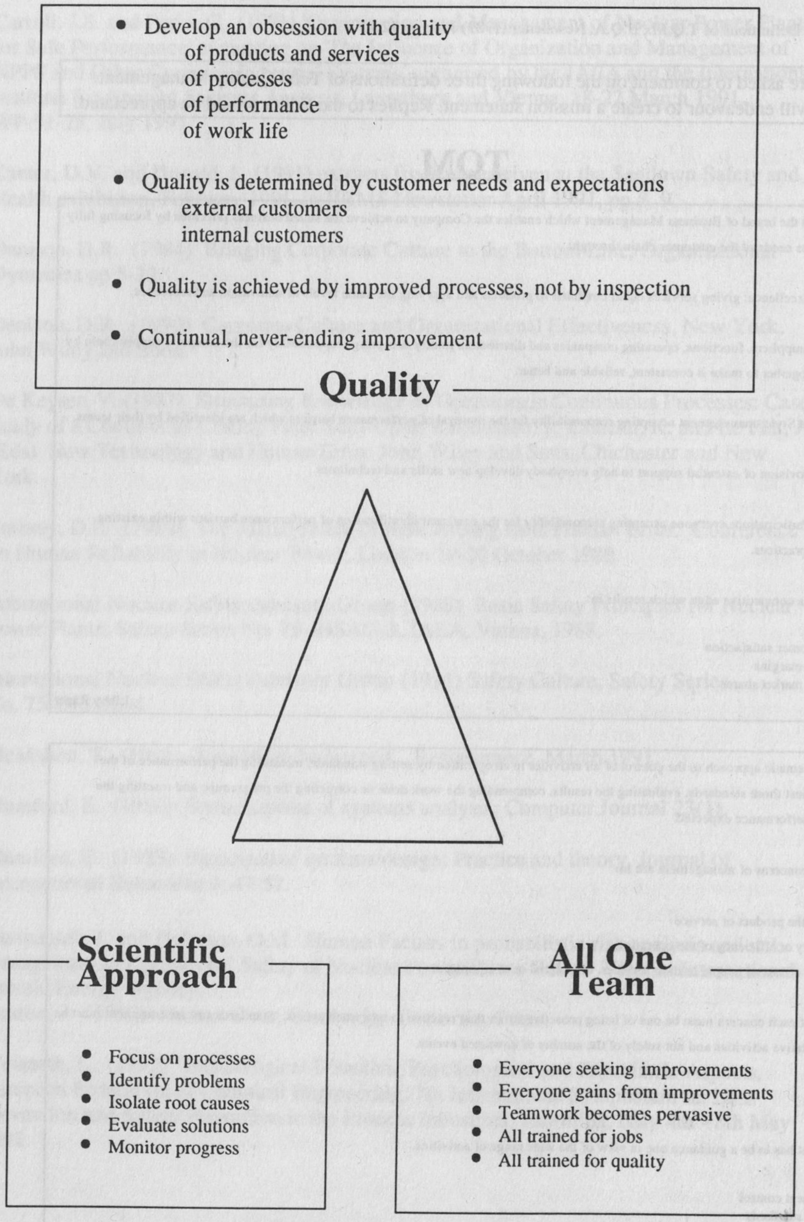
The control of each concern must be one of being proactive rather than reactive to unwanted events. Standards and measurement must be of the preventative activities and not solely of the number of unwanted events.

Structure

The document has to be a guidance one in view of the wide range of activities.

- management control
- setting of standards
- evaluation results

John Bond



Brian Reed

QUANTITATIVE AND QUALITATIVE PREDICTION OF HUMAN ERROR IN SAFETY ASSESSMENTS

D. E. Embrey

Human Reliability Associates Ltd., 1 School House, Higher Lane, Dalton, Wigan, Lancs. WN8 7RP.

This paper describes a comprehensive methodology for addressing human error within the context of Quantified Risk Assessment as performed in the chemical and offshore industries. The role of qualitative and quantitative assessments of human reliability in risk assessment is illustrated by means of examples. A detailed description of the qualitative aspects of the methodology is provided, and is illustrated using a chlorine loading example. The importance of addressing human, hardware and organisational aspects of system reliability within an integrated framework is emphasised.

Keywords: Human reliability, risk and safety analysis, human error reduction.

1. INTRODUCTION

There is an increasing requirement by regulatory authorities for companies to conduct formal safety assessments of both onshore processing plants and offshore oil and gas installations. As part of these assessments, risk and reliability analysts are required to perform evaluations of human reliability in addition to the analyses of hardware systems which are the primary focus of a typical safety assessment. Increasing emphasis is being placed on a comprehensive assessment of the human role in system safety following the occurrence of major disasters in the petrochemical industry (Piper Alpha, Feyzin, Bhopal, Texas City) and other industries (Clapham Junction, Chernobyl, Zeebrugge) where human errors were seen as direct or indirect causes.

Many hardware orientated risk analysts view the prospect of evaluating human reliability with some trepidation. Human error is seen as largely random in nature and therefore essentially impossible to evaluate or reduce. However, this is an unnecessarily pessimistic view. Applied psychologists and ergonomists have been working in this area for many years, and considerable progress has been achieved. In this paper, a systematic framework will be described which can assist risk analysts in performing human reliability assessments.

The usual emphasis in human reliability has been on techniques for the derivation of numerical error probabilities for insertion in fault trees (see Kirwan et. al. (1), for a comprehensive review of these techniques). However, in many ways, this emphasis on absolute quantification is misplaced. Many practitioners emphasise the fact that the major benefits of applying a formal and systematic technique to risk assessment are the qualitative insights that emerge with regard to the sources of risk, and where resources should be expended in minimising these risks. Although the quantitative results of the assessment are important in arriving at decisions in specific areas, for example land use applications for onshore plants, it is widely recognised that there are considerable uncertainties in the data available for inclusion in these analyses.