HUMAN ERRORS AND THE DEVELOPMENT OF ACCIDENTS IN INDUSTRY

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INTRODUCTION

Accidents normally result from a combination of actions, errors or failures either on the part of people or equipment or both. The Health and Safety Executive (HSE, 1991) described the terms "accident" and "incident" as follows:

Accident:- Includes any undesired circumstances which give rise to ill health or injury; damage to property, plant, products or the environment; production losses, or increased liabilities.

Incident:- Includes all undesired circumstances (near accident) and near misses which have the potential to cause accidents.

An accident does not have one cause but involves plenty of root causes. Philley (1992) defined root cause as "an underlying cause which was a direct link in the sequence of events and which has a feasible potential for being corrected." This could be seen and understood when examples of disaster that occurred are studied. Gephart (1984) in explaining environmental disasters gave an example that the sinking of the Ocean Ranger offshore drilling platform and consequent loss of 84 human lives were caused by both bad weather and the crew's lack of knowledge of platform operation. From this disaster it can be seen that the occurrences of disaster are due to more than one type of cause. This reflects the statement made by Kletz (1984) that the deeper the analysis of an accident/incident, the more causes can be found.

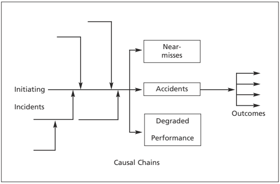

Figure 1: Causal Chains Combine to Produce an Accident (Weaver, 1980)

The occurrence of accidents can be caused by many factors. Kjellen and Larsson (1981) stated that the causes of the accident are due to the defects in individual parts of a system or in the interaction between them. The term "defects" can be associated with the deficiencies or weaknesses in systems either in management systems or physical systems. Therefore accidents/incidents are complex events resulting from combinations of causal chains as described by Weaver (1980). Weaver further stated that causal chains begin with an initiating incident involving human error. The basic structure is pictured in Figure 1.

In this paper, aspects of human errors are discussed. How human errors can be minimized is very important since people do not do something deliberately with the intention of causing an accident.

What Causes Human Errors

It is undeniable to say that everybody errs sometimes. In fact, errors can happen at any moment during the life cycle of a plant. Errors committed by operators can be analysed in a similar way to hardware faults as stated by Wells (1996). Although human error sometimes can be considered as the immediate cause of incidents, this does not easily imply blame. This is partly because blame may lead to defensive behaviour but also

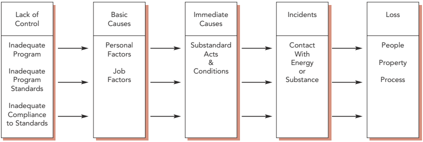

Figure 2: The Loss Causation Model (Bird and Germain, 1985)

because problems cannot be properly solved if human error is seen as the cause and the underlying root causes are not investigated.

There are many factors that cause human error. The obvious examples are those that make up safety technology and safety management within the organisation. Operating procedures can be written taking account of possible human errors.

The loss causation model developed by Bird and Germain (1985) as shown in Figure 2 clearly explained the key points which cause the development of most accidents and loss.

Figure 3: Dynamically interacting components of technology (Phang, 1993)

Model of Sociotechnical System

The sociotechnical system emphasises the individuals, social, organisational and management aspects which affect human behaviour and ultimately influence system performance. This integrates the term 'technology'. Bowonder and Miyake (1988) classify technology as consisting of five basic components, namely:

- *Technoware – which covers hardware aspects of the plant;*
- *Humanware – which deals with human factors aspects;*
- *Inforware – includes information, procedures and communication;*
- *Orgaware – covering aspects of the organisation and management; and*
- *Climoware – which points to climate of regulatory and technology absorption aspects.*

Figure 3 above shows symbolically the interactions between the various technology classes and how they are embedded in the climoware aspect (Phang, 1993). According to Phang, the assessment of a hazardous facility is carried out by identifying the errors arising from the different levels. Technoware errors relating to specific equipment faults and malfunction are embedded in Humanware because they may be compensated by appropriate human interventions at some points. Humanware errors which are seen to be more critical since they interface Technoware and Inforware. Hence deficiencies in the Humanware prevent the correct information and knowledge of the process to be translated into correct operation of equipment, thereby compensating for equipment defects causing the system to fail. Errors at the corporate level (Orgaware) is seen to have maximum effect since it will have repercussions on Technoware, Humanware and Inforware. Climoware is the setting within which the facility operates and according to Bowonder will have a major influence on all the other four aspects.

Modes of Human Error

Wells (1996) discussed some basic external error modes which affect human performance as shown in Table 1. The modes classified seem to be related to plant operators who in practice implement the outlined plans.

Kletz (1991, 1993) in summary, discussed the modes of human errors in which the existence of failures occur because people do not know what to do (lack of training or instruction); some because they know what to do but decide not to do it (lack of motivation); others because the task given is beyond their physical or mental ability (poor selection or training, poor maintenance and poor detailed design), and finally because people have a momentary slip or lapse of attention and fail to carry out an action although they know what to do, intend to do it and are able to do it. Some examples to highlight the occurrences of these errors are shown in Table 2.

How To Minimise Human Errors

Rasmussen (1982) stated that human errors have been considered to be a weakness of operators which can be prevented by improved training, better instructions and improved working situations. However, reviewing accident reports revealed that an error is a result of a complex series of events involving failures associated with the process and plant, the procedures and practices and communication systems (Rosmani, 1999).

In order to avoid those errors the work situation needs to be changed. According to Kletz (1984), changing the work situation depends on the nature of the human errors. The author gave some examples that if the errors are due to poor training or instruction, then better training and instruction would help but perhaps simplifying the job would be more effective. How the job can be simplified is another element that needs a thorough study and review. If an error is due to a lack of motivation, then the instructions need to be checked to see whether they are followed or missed out. Perhaps sometimes a short cut is a valid job simplification, but how safe the short cut is, needs a proper evaluation.

TABLE 1: BASIC EXTERNAL MODES OF HUMAN ERRORS (WELLS, 1996)

Omission of a task step or substep	An error involving: • lack of attention (fatigued, high workload, distracted) • lack of response (absent, incapacitated, time pressure, equipment malfunction) • failure to support or retain • unaware of need for action (no signal, wrong reading, incorrect information processing)
Commission of an extra step or action	An error involving: • a selection mistake (wrong object, wrong action) • wrong action (too much, too little, too long, too late) • wrong direction (insertion, misalignment) • wrong timing (delay or premature action) • wrong duration (mistiming, equipment problems) • performance out of sequence (bad procedure, miscommunication) • replacement of correct action (drop, lift, close, open) • use of excess force (tightening, fitting, closing)
Change in operator's physical or mental condition	An error involving: • operator not in optimal conditions • involuntary action due to fall • operator absent or unable to act

CONCLUSION

Human errors are associated with inadequate safety attitudes. Inadequate attitude is reflected by inadequate motivation in the workplace. In these situations improving safety can be carried out in several ways. Of course, training and motivation are highly recommended. Motivation makes workers wish to work safely and training gives them competence to do so. These elements will then lead people to always carry out their tasks in a first-class manner, to always highlight the safety first in whatever activities carried out, to always question what things might possibly go wrong and to never take shortcuts in their work. Good quality of training and motivation increases safety awareness which then leads to the development of proper safety attitudes. ■

TABLE 2: EXAMPLES OF ERRORS LEADING TO INCIDENTS (WELLS, 1996)	
Errors	**Examples of Incidents**
Mistakes due to lack of knowledge	At Chernobyl the operators were asked to conduct a number of experiments, and seem to have assumed that the outlined instructions overrode the normal safety instructions, which were disregarded. Probably no one actually told the operators that the normal instructions were suspended, but they may have got that impression from several briefings about the experiments without any clarification of the need to follow the normal safety instructions.
Slips	A group was being shown round the emergency service facilities at ICI. The guide left the ambulance garage by pressing the button to open the garage door. Nobody in the garage realised that as the garage door opened, it would knock down a man who was at that time working overhead. Fortunately the man noticed the danger and alerted the guide to the problem. In this case the error occurred due to not isolating either the area or the door opening mechanism.
Examples- Incorrect connections	In 1989, an explosion due to a leak of ethylene at polyethylene plant in Texas killed 23 people. The leak happened because a line was opened for repair while the air-operated valve isolating it from the rest of the plant was open. It was open because identical couplings were used for the two compressed air connections and they were interchanged. The error occurred due to slip and violation. This was a failure to follow company rules and industry practice to fit a blind flange or double isolation valve.
Violations	At Zeebrugge in 1987, it had allegedly become a norm for cross-Channel ferry boats to depart sometimes without closing the doors, in order to maintain the schedule and to clear exhaust fumes from the decks. This has to be considered as a violation since it was carried out as a deliberate practice.

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