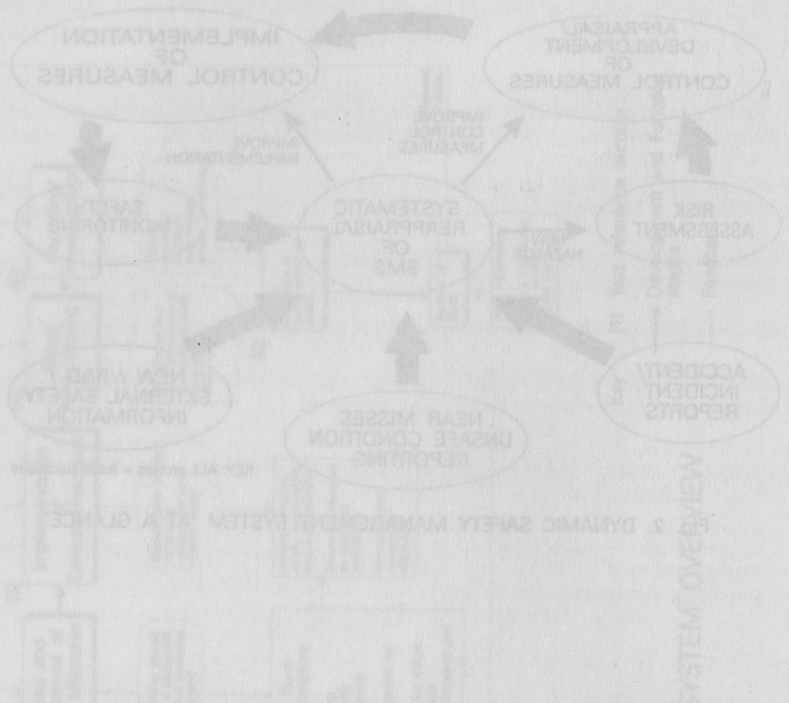

MANAGEMENT OF SAFETY - PERMIT-TO-WORK SYSTEMS

S J SCOTT

CHEMICAL MANUFACTURING NATIONAL INTEREST GROUP
HEALTH AND SAFETY EXECUTIVE, THE TRIAD, STANLEY ROAD, BOOTLE

In his report, Lord Cullen emphasised the importance of safety management systems (SMS). For major hazard installations, an important part of any SMS will be permit-to-work (PTW) procedures, particularly for maintenance related activities. Thirty per cent of the reported incidents in the chemical industry are maintenance related, and PTW system defects account for over 20% of these. This paper describes the purpose and essential functions of permit-to-work systems and the legal framework within which they are required. It also describes the auditing of permit-to-work systems and provides information on research currently being undertaken by the Health and Safety Executive.

KEYWORDS: PERMIT, MANAGEMENT SYSTEMS, MAINTENANCE, AUDIT, MONITORING

MANAGEMENT OF SAFETY - PERMIT-TO-WORK SYSTEMS

1. Introduction

1.1 The HSE Report prepared by the Chemical Manufacturing NIG and the Accident Prevention Advisory Unit "Dangerous Maintenance" (1) concluded that 30 per cent of all reported accidents within the chemical industry were maintenance related and that failures to implement and operate an adequate permit-to-work system accounted for over 20 per cent of the cases investigated. Permits-to-work are a vital component of a safe system of work for many chemical and maintenance operations and they are used extensively in the industry. It was a source of concern that such a long established and widespread system failed to prevent so many accidents. The failure of a permit-to-work system was highlighted by Lord Cullen as one of the major causes of the Piper Alpha disaster.

1.2 The conclusions in "Dangerous Maintenance" were supported by the experience of the Health and Safety Executive throughout the country. Despite the guidance available on permit-to-work systems including an Oil Industry Advisory Committee booklet entitled "Guidance on permit-to-work systems in the petroleum industry" (2) which was published in a significantly revised version last year, the experiences of inspectors continue to highlight basic failures on the part of

companies to properly implement and audit effective permit-to-work systems. The OIAC booklet though aimed at the petroleum industry gives guidance relevant to all industries.

1.3 The emphasis when inspectors visit chemical works is now clearly focused on ensuring that companies have and properly monitor safety management systems. Effective management systems are essential if the risks associated with all phases of a plant's life are to be adequately controlled. These phases include design, commissioning, operation, inspection, maintenance, modification and finally decommissioning. Because of the importance of permit-to-work systems to safety management inspectors will be looking in detail at how a company's system operates and probing for weaknesses in it.

1.4 This paper discusses the purpose and essential functions of permit-to-work systems and briefly describes the legal framework within which they are required. It also discusses the auditing of permit-to-work systems and provides information on current research.

2. The Problem

2.1 Where a hazard cannot be substituted, the first line of defence against injury during normal operation is containment, whether it be a guard to prevent contact with moving moving machinery, or pipework and vessels of suitable integrity to prevent release of toxic, corrosive, or flammable substances. Maintenance jobs, of necessity, breach this first line of defence. The guard has to be removed to gain access to a worn part, a vessel may need to be entered to clean it, the pipework needs to be broken to disconnect equipment. Maintenance therefore carries an inherently higher risk than many other operations. The maintenance work itself may also introduce hazards not normally present, a classic example being "hot work".

2.2 Maintenance operations often involve more than one class of person in the preparation or carrying out of the work. Production personnel might be responsible for making plant safe, whilst maintenance personnel undertake the job. In addition there might be a number of maintenance trades having an input to a single job. A safe system of work depends on each person being aware of their responsibilities and ensuring adequate lines of communication between the different participants.

2.3 The complexities of chemical plant mean that the state of the plant is not always obvious. There is a danger of people proceeding on the basis of assumptions rather than first hand knowledge. Plant complexities also

make it essential that the impact of operations remote from the site of the maintenance work are taken into account. The effects of the maintenance work on other parts of the plant also need careful consideration.

3. Purpose and Functions of Permit-to-Work Systems

3.1 There are three main objectives of permit-to-work systems:

3.1.1 Firstly to ensure that adequate consideration has been given to all of the hazards. This implies knowledge of the process and its hazards, the properties of the chemicals involved, and also knowledge of the potential problems which may be caused by the work being done. (For example, if welding is to be done the person assessing the work should know about the hazards of not placing the welding return lead as close as possible to the welding being done). This last requirement is sometimes overlooked when considering selection and training of those who issue permits.

3.1.2 Secondly to confirm that adequate precautions have been specified and where possible taken before work is allowed to start. Work should only start after safe procedures have been defined, and where appropriate, implemented.

3.1.3 Thirdly to formalise and improve communications between all of the parties involved in the work. Permits should never be used as a substitute for full discussion between permit issuers and those in charge of the work.

3.2 The main requirements of a good permit-to-work system can be summarised as follows:

3.2.1 To provide a clear description of the work to be done, specifying unambiguously the plant, job and location. Identification of the work area must be precise enough to avoid any possibility of confusion. Sketches or diagrams should be used where necessary. Identification of the plant must, likewise, be precise. There have been numerous examples where the wrong pumps or valves have been disconnected and even one case where a motorised valve was removed when the permit specified a pump. Some form of plant identification numbering or tagging system must be provided.

The specification of the work should include all its limitations. Descriptions such as "clear blockage" and "carry out general maintenance" must not be used in permits as they may be seen by fitters as authorising work never envisaged by those issuing the permits. Any definitions used must be clear. It should be borne in mind that contractors are likely not to understand

"local" terminology. For example, they may not realise that a company's interpretation of "hot work" includes use of spark generating tools, such as electric screw drivers.

3.2.2 To identify all of the hazards, both apparent and hidden. This requires careful selection and training of the permit issuer. In addition to good knowledge of the plant and processes the issuer also requires a degree of imagination to think broadly in considering foreseeable hazards. Residual hazard introduced by the work, such as welding fume and the use of cleaning solvents, must also be included.

The hazards should be removed or adequately controlled where removal is not reasonably practicable. The requirements of COSHH must be carefully considered and included in training programmes.

3.2.3 To specify the precautions which are necessary to control or eliminate the hazards. The paperwork should clearly identify who is responsible and for what tasks.

3.2.4 To highlight the hazards and precautions to all the persons required to do the work and others who might be affected. This requires a system for ensuring that persons new to the job are made aware of the hazards and is one of the advantages of displaying permits at the job. It also requires control over contractors by the occupier.

3.2.5 As a check to ensure that the precautions are taken. Some are taken before work starts for example isolations, while some can only be taken during the work, for example wearing of protective clothing. The permit should document the precautions, and who has or is required to take them. It is especially important that protective clothing is clearly specified. Meaningless phrases like "standard" are not helpful. Issuers often over-specify protective clothing to "cover themselves". This is a dangerous practice because it devalues those times when full protective clothing is really necessary.

3.2.6 To provide essential communication during shift changeover. The procedures must ensure that necessary precautions remain in place, that new operational staff are fully aware of work being undertaken and that new maintenance personnel are briefed on the hazards and precautions required.

3.2.7 As a check that the work has been done as specified for example correct gaskets inserted. (This is often done by maintenance supervision, and should be part of the hand back procedure) Suspension procedures may need to be devised if the work cannot immediately

be done, the plant always being left in a safe condition.

3.2.8 To check that the work equipment is safe to bring on line, for example leak tight. As this will involve removal of isolation it will be necessary to check that it will not lead to danger, for example if isolation is in common for two or more jobs. This is an essential part of hand back procedures, and must be properly documented to avoid confusion about plant status. This "test for real" may not be practicable as soon as the job is completed and may have to be done at a later date. The permit-to-work procedure should cater for this.

3.2.9 To highlight the work to be carried out to others who may be affected, for example operators. This is a further benefit of displaying the permit.

3.2.10 To ensure co-ordination between jobs so that unforeseen hazards are not introduced, for example line breaking being done near hot work.

4. Form Design

It is important that these requirements are built into the permit-to-work form in a logical sequence. An example of a form laid out in a logical sequence is shown in figure 1.

5. Use of Permits

5.1 Permits should be used when the safeguards provided in normal production are no longer available or when new hazards are introduced by the work. Examples include entry into vessels, hot work and pipeline breaking. Permits are not a substitute for good well trained fitters and maintenance staff who should know and follow safe systems of work for routine jobs and should be aware of general hazards at the site and the precautions required.

5.2 Companies should not use permits for every maintenance operation as a kind of job authorisation. If permits are used for every job, irrespective of its potential risk, the permit system is unlikely to be achieving its objectives. This is because jobs where the risks are significant will not be sufficiently highlighted and the permit issuer is unlikely to be able to give them the detailed attention which they require. For each job which requires a permit, it is essential that sufficient time is given to allow the issuer to ask enough 'what if' questions to identify all of the potential hazards. It is equally important that permit users do not regard permits as indicating that the job is 'safe' irrespective of their own actions. They must

be continually aware of the potential risks and act accordingly.

6. Auditing of Permit-to-Work Systems

6.1 An indepth and thorough audit of the permit-to-work system incorporates 2 elements:

(i) Examination of the permit paperwork.

(ii) Inspection of jobs in progress, and interview of those involved.

Dealing with each in turn:

6.2 Examination of the permit paperwork

6.2.1 The paperwork should include a full description of how the system is implemented, maintained and audited. It should include in particular:

- Specification of when permits should be used.
- Details of the operation of the system including individual responsibilities.
- The selection process for key personnel, including issuers and receivers of permits.
- The training provided for issuers, receivers and contractors and others who need to be aware of the system. Refresher training should be specified, the frequency of which should be based on the results of auditing the system. Training must be carefully evaluated.
- The auditing of the system. The paperwork should detail who carries out the auditing and at what frequency.

6.2.2 Once it has been established that the written description of the permit system is sufficiently comprehensive the permit form itself should be examined together with examples of a large number of permits completed by a range of personnel. The following points should receive particular emphasis:

- is the permit design adequate? Is the form clear and logical, allowing adequate space for comments, and is it unambiguous and easy to fill in?
- are precautions relevant? Permits adapted from other companies often contain irrelevant and out of date precautions. The precautions specified must be realistic. Inappropriate precautions

are often specified by issuers in the belief that if every eventuality has been mentioned, however unlikely, they cannot be blamed if anything goes wrong.

- is the permit sufficiently comprehensive?. Does the permit contain all of the essential features previously described?
- are sections being filled in accurately, with sufficient detail and are they unambiguous?

6.3 Inspection of the Job

6.3.1 The following should be checked when looking at work being done under a permit:

- that the paperwork has been correctly filled in, including recognition of all the relevant hazards. This implies knowledge of the plant condition at the time of the job, on the part of the person inspecting the job.
- that the job specified is being done.
- that all the necessary isolations have been properly made. It is important that the hierarchy of isolations as given in the OIAC booklet (2) is followed.
- that precautions (and in particular the wearing of protective clothing) are being followed.
- that all those involved with the work are aware of the hazards and precautions.
- that laid down permit procedures are being followed.
- that the work done has been checked. The person inspecting the job should identify what checks have been made and who made them. Many jobs at different stages of completion should be assessed if the audit is to be considered complete.

6.4 Interviewing

Interviews with permit issuers and fitters should be aimed at finding areas of weakness in the permit system or their understanding of it, areas where the theory and practice do not match, and examples of any permits or incidents which have given rise to confusion or problems.

6.5 After the Audit

Any deficiencies found should be recorded and remedial action implemented. It is a good idea to record when and how the deficiencies were remedied. If the system is not working as intended, for example individuals not undertaking their duties as specified, then the system itself, and such aspects as training, practicality of doing the job as specified etcetera, should be questioned. Blame should not be placed upon individuals unless it is clear that the system itself is not at fault. Many companies are poor at actioning work shown to be necessary at audits.

7. Research and Guidance on Permit-to-Work Systems

7.1 A survey of permit-to-work systems in small to medium sized chemical plant by the CM NIG between April and September 1989 found that:

- Two thirds of companies were not monitoring their system in practice.
- Two thirds of companies did not identify hazards adequately.
- Nearly half dealt poorly with isolation.
- A third of permits were unclear on what protective equipment was needed.
- A quarter of permits did not deal adequately with hand back once the work had finished.
- Little thought had been given to the design of the permit form itself.

7.2 A further survey and enforcement initiative took place between 1 April 1991 and 31 March 1992. The survey took the form of a questionnaire completed after each company's permit-to-work system had been inspected. A part of the results of the survey are shown at figures 2 and 3. A total of 137 factories were visited and it is disturbing to find that significant numbers of companies still have inadequate systems in many important respects. It is especially of concern to find that over 60 per cent of the companies surveyed are still not effectively auditing their systems.

7.3 A research survey has also been conducted by the Chemical Manufacturing National Interest Group and the HSE's Research and Laboratory Services Division. The survey took the form of structured interviews of all of those involved with permit-to-work systems. In addition to being questioned on the permit-to-work system in operation at their premises

interviewees were also asked to comment on a range of options concerning permit-to-work form design.

7.4 The results of these surveys will be used to produce a guidance booklet on the use of permit-to-work systems in the chemical manufacturing industry, with particular emphasis on form design. Preliminary research results indicate that there was generally no systematic approach to permits, little or no expertise was available within companies concerning form design and little thought had been given to it. Approximately half the companies surveyed copied their permits from elsewhere and only the larger companies tended to develop permits specific to their sites and hazards. Very few companies had systematic monitoring and auditing of their system, hand back procedures were not always effective, and training was generally inadequate.

7.5 In addition to the guidance booklet referred to above the Chemical Manufacturing National Interest Group have recently redesigned and substantially expanded the leaflet "permit-to-work systems" (3). The leaflet gives concise advice on many of the aspects covered in this paper.

8. Legal Framework

8.1 Unlike the off-shore situation permit-to-work systems are not a specific legal requirement on-shore, but they are, in the circumstances I have described, an essential element of a safe system of work. The provision of safe systems of work is required under Sections 2 and 3 of the Health and Safety at Work etc Act 1974, which places duties on employers relating to employees and third parties such as contractors, respectively. Sections 30 and 31 of the Factories Act 1961, dealing with entry into confined spaces and precautions with regard to hot work are also applicable. Permits are often required to ensure that the "effective steps" and "practicable measures" required by these sections are taken.

8.2 The Control of Substances Hazardous to Health Regulations 1988 must also be carefully considered in the context of permit-to-work systems. Removal of hazards must always be the first consideration. Protective clothing and similar precautions should only be specified if the prevention of exposure is not reasonably practicable.

9. Conclusions

9.1 In conclusion, although it is fair to say that the operation of permit-to-work systems in the chemical industry has improved in recent years, there is still a considerable way to go before wholly satisfactory

standards are achieved in the majority of companies. It is hoped that this paper provides some guidance on those areas of permit-to-work systems where further attention needs to be paid.

References

1. Dangerous Maintenance: A study of maintenance accidents and how to prevent them. HMSO (rev) ISBN 0 11 886347 9.

2. Guidance on permit-to-work systems in the petroleum industry. HMSO 1985 ISBN 0 11 883518 1.

3. Permit-to-Work Systems, Chemical Manufacturing NIG. IND(G)98(L).

ESSENTIAL ELEMENTS OF A PERMIT-TO-WORK FORM

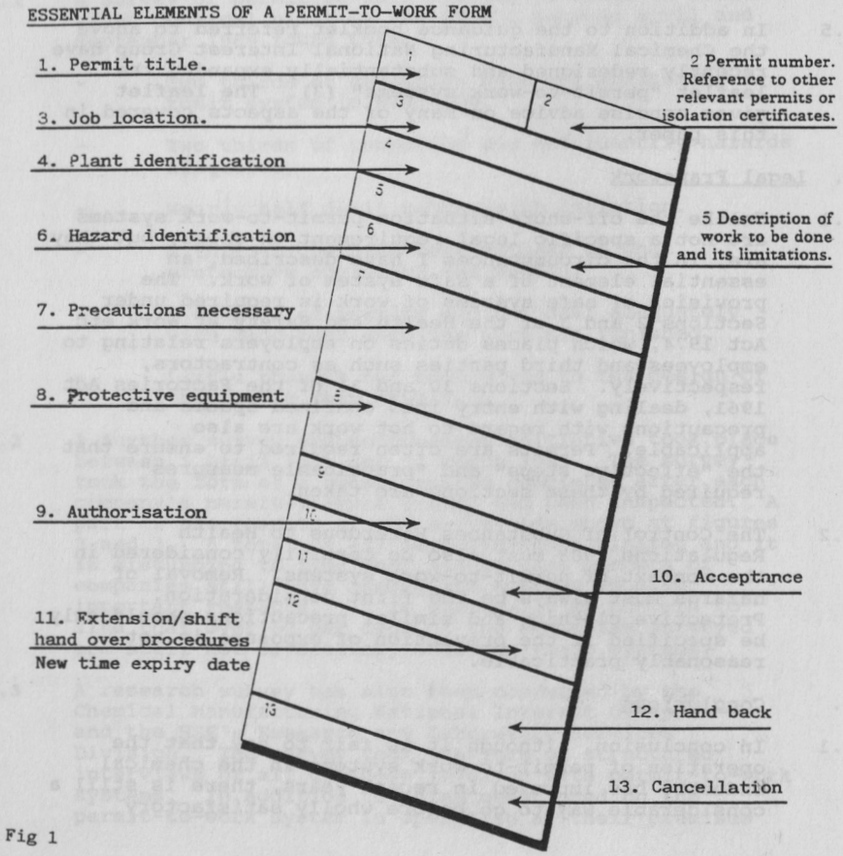

Fig 1

SURVEY OF DEFICIENCIES IN PTW SYSTEMS

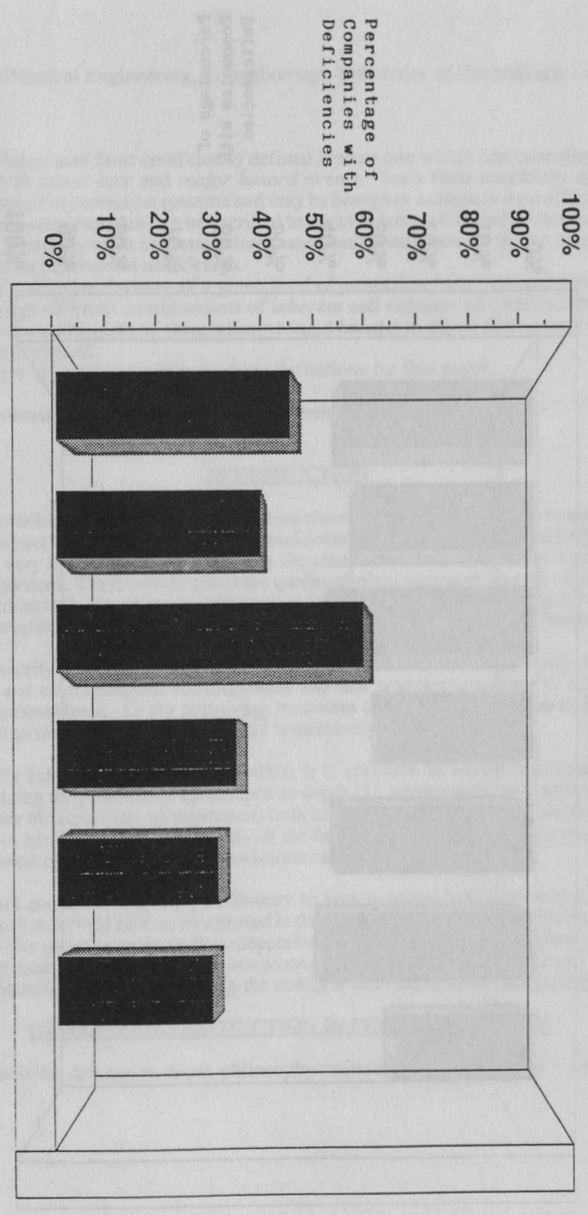

Fig.2

SURVEY OF DEFICIENCIES IN PTW SYSTEMS

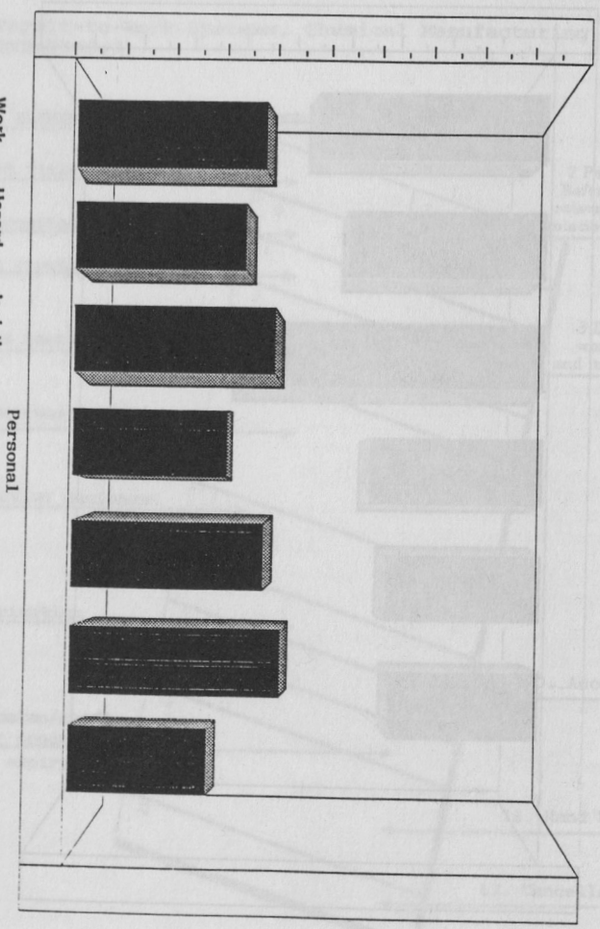

Fig.3

A.G. Rushton
Department of Chemical Engineering, Loughborough University of Technology, Loughborough, LE11 3TU.

An *integrated* fault condition is defined here as one which can contribute to both *minor loss* and *major hazard* events. Such fault conditions are common in protective systems and may be *benign* or *malign* in their effects on the assurance that can be ascribed to the avoidance of the *major hazard*. An attempt is made to classify *integrated* fault conditions for the purposes of plant description and design.
The qualitative features of a given level of protection (*integrity*) achieved through different combinations of *inherent* and *engineered* contributions and the redirection of threats from *major hazard* to *minor loss* events is also discussed.
Terms in italics are given working definitions for this paper.

Keywords : Fault, protective device, fault tree, hazard.

INTRODUCTION

In general it is possible to distinguish between two classes of undesirable acute events. On the one hand there are events with safety or environmental consequences. The expected frequency of such events must be very low to be acceptable. On the other hand there are events with economic or nuisance consequences. These would affect the quality of plant output or the ease of plant operation. This class would include, for example, the production of off-specification output, reduced output capacity and operability problems requiring greater effort on the part of plant personnel.

The range of severity of these consequences is very wide, but here only the sub-classes of high severity safety and environmental consequences and low severity economic or nuisance consequences is to be considered. In the following treatment the terms ***major hazard*** and ***minor loss*** are used to refer to events in these sub-classes respectively.

Where inherently safer operation is not feasible, it is common to obtain protection from *major hazards* by pursuing the philosophy of defence in depth (1), whereby the realisation of the hazard requires a number of (nominally independent) fault conditions to be satisfied. Such protection can be undermined in two distinct ways: directly, if the fault conditions are not truly independent, and insidiously, if some of the various fault conditions can accumulate over time.

A particular fault condition may be contributary to both a *minor loss* event and a *major hazard* event. Such a fault is defined here as ***integrated*** in the sense that it is common to both consequences. The purpose of this paper is to show that, dependent on the configuration of plant components, a classification of fault conditions as *non-integrated*, *neutrally integrated*, *benignly integrated* or *malignly integrated* is useful in describing the configuration and setting design objectives.

DEMAND AND PROTECTION IN DEFENCE IN DEPTH

Figure 1 illustrates the defence in depth philosophy represented in the form of a generalised fault tree.