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)ENTIFYING MAJOR PROCESS HAZARDS AT THE CONCEPT DESIGN

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.A.F. PYMAN and F.R. MITCHELL*

A systematic procedure currently in use for identifying major hazards on chemical plant at the conceptual design stage is presented. The use of such a procedure, the means by which any potential changes of concept leading to increased safety are fed back into the design, and the establishment of certain safety design criteria for detailed design, are discussed. The emphasis in the paper is on application to process plant on offshore platforms.

INTRODUCTION

ıe identification and evaluation of potential hazards at the conceptual ɜsign stage is particularly important for two main reasons:

.) in order to obtain approval of the development plans by the regulatory body concerned, and

.) to provide a basic safety philosophy for the later stages of detail design.

number of potential problems, (or hazards) are missed at the concept ɜage because of 'complexity' rather than lack of knowledge, the designer's ıin objective being to produce an 'outline flowsheet' of a process which .ll produce the desired output within the limits of a pre-determined ıpital expenditure. The possibility of major failures in items of ;uipment due to control, or mechanical failures, or operation of the ·ocess outside its design parameters, and the second order effect of ıch failures, is seldom considered at this stage. Some of the hazards, ıentified by techniques such as the one described in this paper, can ften be removed by a change of design concept, or in the later stages of ɜtail design, both being inexpensive at this stage. Alternatively, where ıjor areas for concern are raised that have no clear engineering solution, ıudies can be put in hand at an early stage to search for means to reduce ıe probability or the consequences of such areas of concern.

ıis paper outlines a detailed logical procedure which is being successfully ɔplied, at the conceptual stage of design, for offshore platforms. It is ısed upon the structure of a conventional hazard analysis, following

Technica Ltd., 11 John Street, London WC1N 2EB

the procedure shown in Figure 1, but concentrates heavily on the identification of the process hazards and their use in feedback to the design. The area of consequence analysis and frequency analysis, whilst being major subject areas in their own right and essential to the overall structure, are not discussed here.

This paper concentrates primarily on process hazard identification. Other hazards, particularly those directly affecting the substructure such as ship collision or extreme weather, have been considered out of the present scope.

IDENTIFICATION OF THE MAJOR PROCESS HAZARDS

Approach

In order to identify the major hazards on a platform (or on a chemical plant) at the concept stage, the approach adopted must satisfy certain criteria:

i) It must be systematic, to avoid an otherwise arbitrary approach, and to allow confidence that all areas of the platform have been examined.

ii) It must examine hazards to the process from all sources.

iii) It must concentrate on the major areas of concern, and not become side-tracked into specifying detail that is not yet available.

These requirements have been met by formulating a set procedure to be followed, incorporating a check list, a coarse hazard and operability study, and a qualitative engineering safety review.

In the first step of this procedure, the platform is subdivided into a number of broad areas. Typical areas would be subsea lines, any risers/ conductor tubes, and each deck of each module.

Second, a range of potential hazards are defined using the check list and the concept technical design basis. In this listing, each major vessel and its associated piping is defined as a potential hazard.

Third, a coarse scale hazard and operability study is performed on the process and hazardous utilities systems. The flow diagrams for each system or subsystem are studied, and potential malfunctions of the system described in as much detail as the flow diagram will allow.

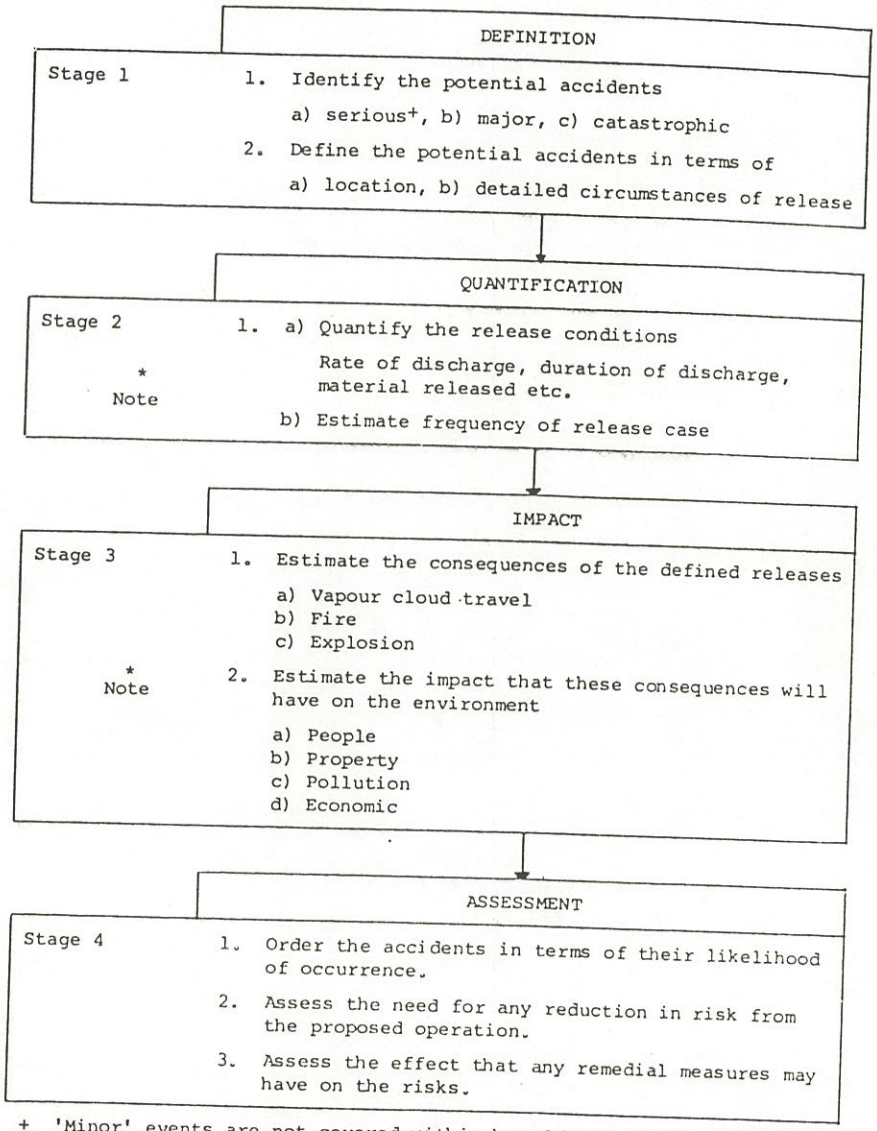
Fourth, a qualitative engineering review of the safety aspects of the platform is undertaken. This review is not systematic, but rather it draws out the specialist knowledge and experience of the engineers carrying out the review, to augment the basic description of the hazard given by the check list. In certain cases, new potential hazards will be defined.

Finally, the three strands of the examination are brought together in a final list that reflects a comprehensive picture of the potential major platform hazards.

This procedure is shown diagrammatically in Figure 2.

The main items in this procedure, the coarse scale hazard and operability study and the qualitative engineering safety review, are now discussed in greater detail.

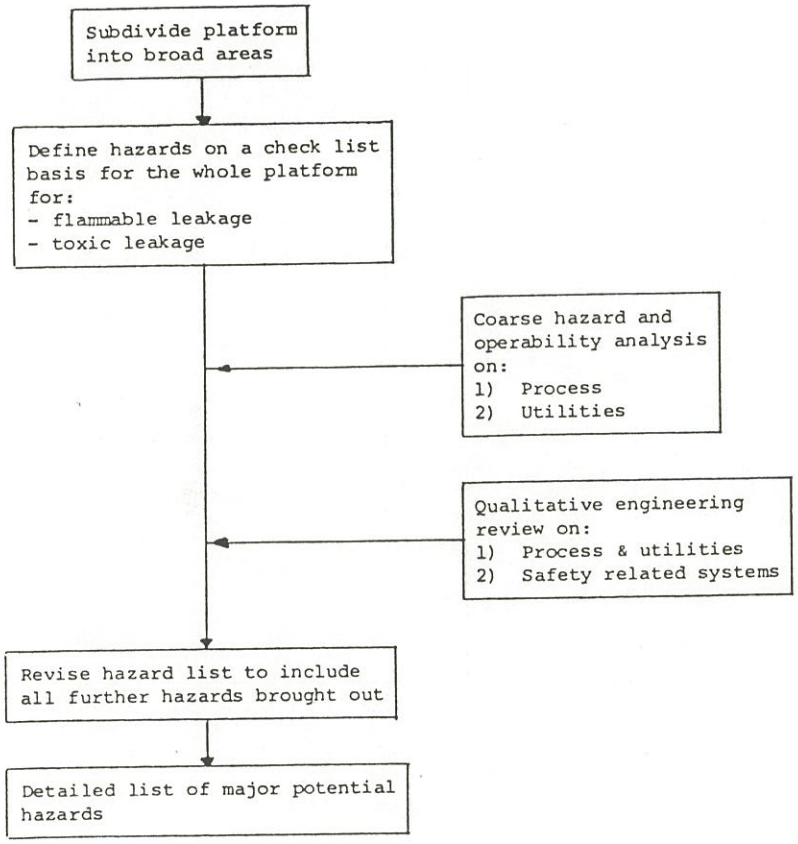
FIGURE 1 - FORMALISED PROCEDURE FOR THE RISK ANALYSIS OF PROPOSED HAZARDOUS OPERATION



\+ 'Minor' events are not covered within broad brush studies of this type

* Not discussed in this paper

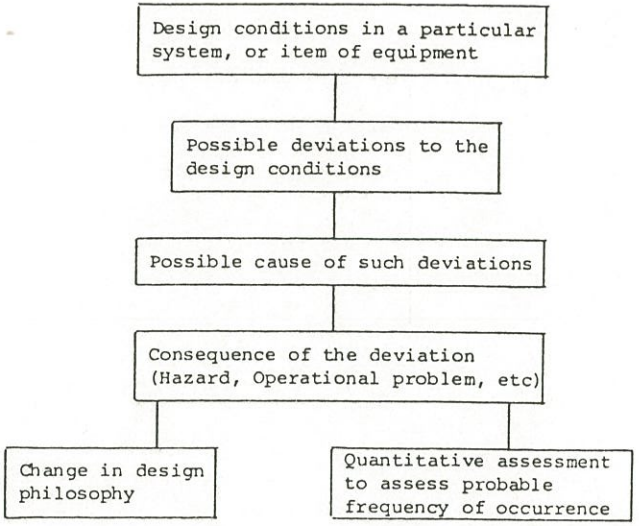
FIGURE 2 - PROCEDURE FOR IDENTIFICATION OF PROCESS HAZARDS



Coarse Scale Hazard and Operability Study

The 'Hazop' technique is a highly disciplined procedure which is based upon the Method Study Critical Examination 'Guide words' - "None", "More Of", "Less Of", "Part Of", etc. In 'Hazop' these guide words are expanded, and used for questioning implications of "No Flow", "More Flow/Pressure/Temperature", "Less Flow/Pressure/Temperature", and the other factors that can cause operational deviations not covered by the design philosophy. This questioning technique is applied to each section of pipework and item of equipment on each line diagram in an attempt to generate possible deviations from the design operating conditions, together with the cause and consequence of such deviations. Where the consequences of deviations indicate an unacceptable situation, (potential hazard or operating problem), the design/control philosophy is changed to minimise such a deviation occurring, or a quantitative assessment carried out to indicate whether the probable frequency of occurrence is within the acceptable limits.

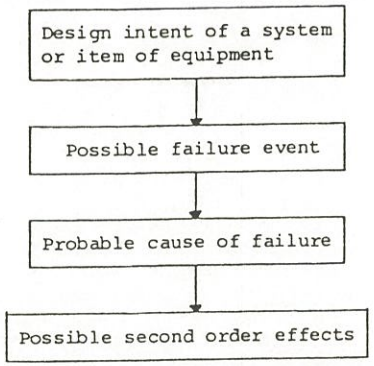
Generally, the basic steps in a full 'Hazop' study can be illustrated as follows:



The full 'Hazop' procedure requires reasonably detailed 'line diagrams', and a team of design/operational personnel who have experience in the study areas concerned, and a team leader with practical experience of other operational situations which can be used to prompt the team.

At the concept design stage only limited information is available, usually in the form of coarse scale flowsheets showing major items of equipment, design operating pressures and temperatures, with instrumentation limited to main E.S.D. valves and major control loops. Also available at this stage will be proposed layouts, engineering design standards, and the requirements of the appropriate regulatory body.

The main objective at the concept design stage is the identification of all hazards, their categorisation, and probable second order effects. Here the emphasis is on major failure rather than operational problems, and these are identified by using the 'Hazop' procedure on the coarse scale flowsheets, the questions being applied to each line and item of equipment shown. The basic steps of this procedure can be illustrated as follows:



This exercise can be carried out relatively quickly using only an experienced team leader and part-time assistance from the project team as required, the full Hazop team not being required due to lack of detail.

The results of this study are recorded on analysis sheets, and essentially show potential failure causes for each of the equipment failures listed in the previous check list, together with additional potential failures and their causes.

The study also produces valuable guidelines for the later detailed design; it will illustrate, for example, where it is essential to fit a low temperature trip to protect a system from potential sub-zero temperatures for which it is not designed, where alarms must be fitted to indicate an operational problem and allow the operator a reasonable chance of taking corrective action, or points which must be included in the operating instructions.

This coarse scale study should be followed by a detailed study when the various line diagrams are nearing completion.

Qualitative Safety Review

The initial Check List, the coarse scale Hazop Study, together with a qualitative Engineering Review, will produce a comprehensive list of potential accidents, i.e. equipment failures resulting in loss of containment and escape of flammable material.

For these events there can be a variety of possible outcomes, ranging from harmless dispersal at one extreme, to a gas explosion at the other, the outcome being determined largely by two factors:

a) The likelihood and type of ignition

b) The active protective system

Process plant handling flammable material is always designed with the intention of minimising the possibility of ignition, but however good the design it is true to say that nothing mechanically made is perfect, and one must assume a potential number of ignition sources, e.g. static electricity, faulty flame proof equipment, furnace fired heaters, etc.

Ignition can occur at various time intervals after an accident resulting in loss of containment of flammable material, but for a coarse study it is usually sufficient to assume three cases:

1) Those that will ignite the flammable vapour immediately upon release.

2) Those that will ignite the gas after a short delay, but before the gas leaves the immediate vicinity.

3) Those that will ignite the vapour after it has left the immediate vicinity of the 'accident', and formed a gas cloud.

Once ignited, a fire or explosion may result, and in the event of a fire various fire fighting systems will be operated either automatically or manually, but particular attention must be paid to the location of fire walls, plant layout, and fire protection of steelwork. A typical problem encountered is that of fire damage that follows the destruction of a firewall by explosion. Incorrect siting of the firewall, or insufficient firewall backup, will then result in real protection against only a proportion of the events it was meant to encounter. Similarly, in the event of an explosion occurring every effort must be made during design to ensure that any loss of inventory will be minimised by the appropriate location of E.S.D. valves.

In the qualitative review, engineers experienced in the various relevant disciplines examine the systems from the point of view of this potential for leakage, and compare the present system to best current practice. In particular, areas in the specialists experience where other operators have experienced severe and/or unexpected problems are highlighted.

The qualitative review is not systematic, in the way that the coarse hazop is. It is, however, a valuable overview of the design and, in many cases, provides a fresh perspective for the designers in reaching the safest solution.

THE SIGNIFICANCE OF THE EVENT

The two areas of consequence analysis and frequency analysis are not considered in the scope of this paper.

The main aim of this part of the analysis is to provide the quantitative backing to the hazard identification, allowing a clear ranking of importance

between the identified events.

FEEDBACK TO THE DESIGN PROCESS

The aim of this type of exercise is, by taking a 'broad brush' approach, to identify those areas of the operation that may have significant hazardous effect, in terms of loss of life, and to rank these risks in terms of impact (quantified as the basis of probability of occurrence and consequential effects) on an order of magnitude basis.

The result of such a systematic identification of potential major hazards are fed back into the design process in four ways:

1) Appearance of major hazards may necessitate a change of concept in order to reduce their probability/consequence.

2) Ranking of the hazards, allowing emphasis to be concentrated on the most important hazards only.

3) During the identification and review of the potential hazards, a number of important measures will be discussed for ensuring that, in the detailed engineering stage, the probability/consequences of major hazardous events are minimised.

4) Where alternative concepts are being considered, a comparison of the major hazard implications of each concept are one important element in the overall comparison.

It is clearly most important that this type of study be done at the conceptual stage, so that the results can be fed into the design and/or operational procedures whilst there is still a large degree of flexibility about options in design that can be swayed by such safety considerations.

These main areas of feedback are discussed below.

Major Points of Concept

The feedback to the design process on major points of concept arises when the significance analysis of the hazardous events points out certain events as being of much greater importance than either the remaining events or similar events in comparable installations. The discussion of such events with the design team is likely to lead to changes of the concept in one of the following areas:

i) Increased safety through layout.

ii) Increased safety through design.

Layout. Depending on the type of event highlighted, the discussion of layout alterations may be at installations level, such as a gross recommendation to alter the location of the whole installation; at function level, to further separate areas such as drilling and process, or at equipment level, to alter the layout within, say, a particular module.

Design. As far as possible, the aim of the study is to point out where greater safety needs to be built into the design. In many cases, a hazard is pointed out as being of greater significance in its present context than

in the situations where it is more commonly encountered. Offshore, one of the most recurring examples of this is the hazard of direct impingement of jet fires on close neighbouring vessels. This hazard stands out more offshore, because the lack of space dictates that reduction of fire hazards be achieved more by fire water deluge systems than by separation. Such deluge systems are unlikely to be very effective against direct jet flame impingement. The detailed identification and quantification reveals that, in order to reach the same level of safety as in the situation for which the item or system was first designed, an increased level of design safety is required. Particularly, reference is likely to be made to the design or operating philosophy, and the design codes.

In the case of the philosophies, such as for E.S.D. operations, gas detection, or process control, a detailed check at this stage, with perhaps some modifications resulting, will have ramifications the whole way through detailed engineering. In the case of design codes, the demonstration of a need to apply perhaps more stringent codes to certain items or systems, whilst still at the concept stage will save much time delay than if the matter is discovered later in the project, and lead to a greater level of design safety. An example of such a case would be where pressure vessel codes may need to be applied to particular sections/units of pipeline, in preference to the sometimes less stringent pipeline codes.

Ranking of Hazards

One of the most fruitful areas of feedback is the ability to give the designer an order of pirority for minimising the hazards. Such a ranking saves considerable effort that may otherwise be expended in say, improving the performance of a safety system that is anyway extremely unlikely to be used.

Design Criteria for Detailed Engineering

In addition to any major points of concept that are sought out by this systematic identification of major hazards, the study will indicate important design criteria to be established for the detailed design. These arise from all three aspects of the procedure detailed earlier:

From the Coarse Hazop: The hazop will point out areas where process abnormalities may have major hazardous effects, and then point to areas where the control system may have to be extended to take account of the system response. The hazop will identify many such areas, that will range from trivial (trivial, that is, from the point of view of conceptual problems), such as the need to provide inerting of certain tanks, to important areas of detail such as the need to provide separate fuel supply to the flare.

From the Qualitative Review: This review, carried out by people with considerable experience in each of the various specialities involved, is valuable in comparing the system and its potential hazards to current practice and experience on other platforms. An indication is thus gained of which areas have been found to be troublesome, and may therefore need a reconsidered approach. In the case of new technology, the review will suggest, by way of comparison with other conceptually similar technological advances, in the field, the kind of problems that may be expected.

From the Probability/Consequence Analysis: The quantitative analysis is likely to point out any need for improved or altered preventive and protective systems. Particularly this would relate to design criteria for the performance of the E.S.D. system, of the fire detection and fire fighting systems, and areas where increased protection against the dominant failure modes will be necessary. Typically, this could be in the form of improved protection against external corrosion for critical vessels, where this is the major failure mode. Alternatively, the need to limit the inventories may lead to a design requirement for isolation.

CONCLUSION

In conclusion, it is our experience that this thorough approach to hazard identification, whether applied solely to process hazards, or extended to include hazards to the structure, or to economic, delay or pollution risks, leads to a valuable and constructive design input, providing the analysis is systematic, and that it is done at a stage when the design is still sufficiently flexible for major changes either to the design or to the concept to be incorporated if required.