ASSESSMENT OF CHEMICAL PLANT FOR THE PROPOSED HAZARDOUS INSTALLATIONS (NOTIFICATION AND SURVEY) REGULATIONS

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1. INTRODUCTION

The Advisory Committee on Major Hazards (ACMH) in its First Report (Ref 1) made recommendations for Regulations under the Health and Safety at Work, Etc Act 1974, to deal with the control of major hazard installations. Draft Hazardous Installations (Notification and Survey) Regulations have since been published in a Consultative Document (Ref 2). This paper is concerned with some of the considerations in establishing a system to apply the Regulations should they become law. The paper assumes the Regulations would take the general form suggested in the 1978 Consultative Document and subsequently discussed by the Health and Safety Executive (HSE) with interested parties. Briefly, major hazard installations would be identified by their inventories of specified hazardous substances/ and would be subject to Notification, Hazard Survey or Detailed Assessment.

The paper discusses some of the issues company managements and the HSE may face in meeting the Hazard Survey requirements of the Regulations. It also deals with the selection of plants to be surveyed in a large complex, the extent and quality of information necessary in surveys, and the situation where independent managements have a joint involvement. Some of the conclusions drawn from the survey reports already received by HSE are discussed.

2. SELECTION OF PLANTS FOR HAZARD SURVEY

The terms of reference of the ACMH make it clear that major hazard installations as defined are those which may threaten not only employees but also the public or the environment. The seriousness of the hazard presented by an installation depends on the nature of the threat and the nature of the

/Hazardous substance is defined in the draft Regulations as any substance listed in Schedule 1 of those Regulations

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population or environment at risk. Hazard Surveys will be complicated on many large sites. The need is to distinguish priorities.

The hazardous substances in each location on any given site may vary from time to time as stocks change or manufacturing patterns alter. Hazard Surveys should encompass situations in which the maximum amount of material is found at each location. The hazards at all stages of a process cycle during normal and abnormal operation should be considered and particularly so in those cases where undesirable side reactions are possible. Equally important is the separation distance between various items of plant because vessels and equipment may be physically separate yet able to interact to release significant amounts of hazardous substances. For example, it may not be possible to isolate a reactor and its associated feed vessel from one another sufficiently rapidly to prevent loss of the total contents of the system following a leak in either part. Supposedly unconnected items may have an inter-related accident potential, for example, adjacent storage vessels in the same bund. In order to demonstrate that separate locations on a Hazard Survey site do not present a significant cumulative hazard, it will be necessary to show that the probability of their interacting, in whatever manner, is sufficiently low. The sites which are to be the subject of a Hazard Survey will be identified by means of their inventory of hazardous substances. The ACMH have suggested that the combinations of locations on a site which need to be surveyed should be identified from the probability of their interacting to release a "surveyable" quantity of hazardous substance. Full Hazard Surveys will therefore be necessary for those combinations of location where it cannot be shown that the probability of interaction is sufficiently low.

3. PROBLEMS OF INDEPENDENT MANAGEMENTS JOINTLY INVOLVED AT MAJOR HAZARD INSTALLATIONS

Independent managements may have a joint involvement at installations subject to the proposed Regulations in at least two situations. The first will concern permanent arrangements between companies and might for example include the need for liaison between the operator of a common-user pipeline system and the management of its associated installations. The second will concern the situation during start-up and establishment of turnkey projects when the plant contractors may still be involved and the client company not in exclusive control of all activities at the installation.

Common-user pipeline systems connect plants, frequently storage systems, which are often on independent sites. In certain respects the common-user system and the one site complex are similar. They each have a need to move material between locations by pipeline. When identifying the plant locations in a complex which may be subject to Hazard Survey, the important consideration is the ease and reliability of separation of one location from another. The concept of ease of separation may be extended to systems in which tankage, etc is connected by common-user pipeline. Thus, common-user pipelines and their associated installations should first be considered as total systems, and if the inventory of the total system is sufficiently large the total system should be surveyed. The only locations within the total common-user pipeline and tankage system for which a Survey is not necessary are those which themselves contain less than the Hazard Survey quantity and which can be isolated sufficiently rapidly from the main system should problems start to develop. The materials dealt with by a common-user system will vary from time to time, and some will be more hazardous than others. The need for survey should be decided after consideration of the situation in which the maximum possible amount of each hazardous substance is present at each location. With sufficiently reliable isolation of the various installations from the pipeline, it would be for each management to carry out a Hazard Survey of its own installation. The pipeline management should survey the pipeline, the other managements their different installations. When isolation is not sufficiently reliable, it would be for the pipeline and installation managements jointly to carry out a Survey. In individual instances, as is the case of complex manufacturing sites, HSE would be involved in considering whether proposed means of isolation are sufficiently reliable.

Independent managements may be jointly involved in the control of major hazard plant at the construction phase. The design, construction and bringing on stream of hazardous installations is sometimes too complex or specialised for the eventual operating company to want to cope with the problems. Many organisations use contractors for the design and construction of complicated installations. In some cases the contractors supply everything from the process know-how, through the design and construction of the plant to the start-up and handover of the operating installation - so-called turnkey projects. On other occasions, the process details are proprietary to the future operating company who release to the contractors only sufficient detail to enable them to build the plant. As a third variant, situations occur where a licensor provides the process technology, a contractor designs, specifies and builds the plant and the customer eventually operates the plant. These arrangements are governed by legal contracts, generally with key clauses which guarantee product specification and yield. To this end, the licensor will probably not allow process alterations, nor will the contractor allow plant alterations until satisfactory initial production has been achieved. Plants built under the circumstances described will often be based on established processes and problems are less likely. However, this will not always be the case. There will be situations where the process chemistry is new, or where the process is new to this country and has not been subjected to the safety scrutiny which the Regulations will require. In any construction project, regardless of contractual overtones, the managements involved would have an obligation to ensure that the Regulations are met throughout start-up, establishment and routine operation.

4. EXTENT AND QUALITY OF INFORMATION REQUIRED IN HAZARD SURVEYS

The risk presented by a given hazardous installation is a compound of its inherent hazards and the vulnerability of both the work-people and the surrounding population or environment to injury or harm. The extent and quality of information required in each Hazard Survey will reflect the degree of potential hazard. The need will be to evaluate the potential of a plant in its setting. This will involve consideration of the process, the plant, the means of operation and the management system since these influence the probability of hazardous material escaping to atmosphere; the likely behaviour of the material in the atmosphere, the consequences if for example, it is ignited, the factors which influence dispersion, etc; and the exposed population or environment, in particular perhaps the ease of evacuation. The significance of these factors justifies repetition.

One of the more common reasons for a release to atmosphere through plant failure is an exothermic runaway reaction. Have all causes or combinations of causes of runaway reaction been identified? Is explosion or fire within the plant possible? Would the instrumentation and control system be adequate to detect the onset of fault conditions and be capable of preventing a serious incident? Presumably the plant was designed adequately for all normal excursions in temperature, pressure, chemical environment etc, but were suitable materials of construction in fact used throughout? Is sufficient management expertise being applied to the plant? Are the staff sufficiently qualified, experienced and motivated? How good, committed and well informed are the operators and how much of the plant's safety depends on their efficiency? Are adequate systems available to update operating methods in the light of experience, to predict plant operating parameters with onset of change, to control modifications in process or plant?

Then there is the need to assess the possible consequences if material escapes from the plant. How effective are the scrubbers, dump tanks, flare systems, etc? Will gas or vapour releases be neutrally buoyant or dense? How much material will become airborne from a flashing liquid? Is a fireball, a stabilised flare, deflagration or detonation the most likely result if ignition occurs? Is the TNT equivalent approach and overpressure decay curve appropriate? What level of toxics in the atmosphere should exposed populations be expected to tolerate for a once in a lifetime incident?

Concentrating on the population who may suffer injury from a major hazard installation, rather than on the environment, there is again a range of considerations. Proximity to the installation will be most significant since the effects of fire, blast, toxic gas cloud concentration, etc, all lessen with distance. It is perhaps less desirable to have hospitals and housing which are occupied twenty four hours a day, near to an installation than industry which may only be manned eight hours a day. The likely effectiveness of evacuation in protecting the population is also an important factor. Where the hazard is blast or fireball thermal radiation, evacuation may be of limited value because events might happen too quickly. Where cloud drift of toxic material from the installation is possible, evacuation of people nearby in an emergency may be necessary, and should be planned in advance. In such planning consideration has to be given to alarm systems, to the adequacy of nearby roads for emergency traffic, to informing the population of arrangements, etc.

The possibilities are such that an acceptable Hazard Survey may range from a qualitative form to the fully quantitative. A probabilistic approach will be necessary to predict the outcome of statistically defined events, but there may be important issues in areas not yet defined scientifically.

5. HAZARD SURVEYS ALREADY CONSIDERED BY HSE

HSE has carried out a few hazard surveys along the lines proposed in the Regulations, and has received others done by industrial companies. Certain observations can be made. The first is that the basic approaches used by companies in safety evaluation vary from the simple to the sophisticated and are not always in fact appropriate for the particular plant in question. The approaches used include:

(i) informal discussion between members of management

(ii) the use of check lists

(iii) the use of guide words

(iv) fault tree analysis

Each has advantages and disadvantages, and may be more or less appropriate in any individual case. Informal discussion generally involves ad hoc circulation independently to staff, who may or may not respond, and has no provision for the interactive benefits of team discussion. Generally, the approach has a considerable probability of overlooking significant aspects and seems only justified for simple plants. In its favour, the approach can be operated by organisations with fewer management resources. The check list method is necessarily derivative from some prior system, and seems rigid and at risk of failing because of familiarity on the part of the users. What is more, a given check list may be inappropriate to the problem in hand. The guide words approach, in which, for example, in examining a plant line diagram, the consequences of the formalised possibilities too much (flow), too little (flow), other than (flow of possible unexpected materials) etc is in turn assessed certainly is useful. It particularly lends itself to iterative discussion within a multi-disciplinary team. The technique is in general deterministic rather than probabilistic, and in this contrasts with the fully probabilistic free-ranging fault tree approach. Qualitative guide word investigation often precedes quantitative fault tree investigation. The latter is well established and is generally reliable, yet has drawbacks in that it is time consuming, involves the use of considerable numbers of staff and is therefore expensive. There can, however, be no doubt that certain installations around the country potentially are sufficiently hazardous and complicated to warrant its use. In all of this, HSE can only repeat that compliance with the Regulations will entail an adequate survey on each occasion.

The second observation which can be made on surveys already seen by HSE is more important. This concerns the need to make assumptions. There have been a significant number of surveys where the key assumptions have not been supported by data or references. HSE has been able to evaluate these assumptions only by employing disproportionate resources. The need is for a balance, with sufficient information being supplied for HSE to be able to assess the acceptability of each assumption.

Illustrations can be given of cases where insufficient information has been supplied to HSE. Lists of factors such as plant corrosion, runaway reaction, operator error, which could precipitate a serious incident, have been provided without any supporting narrative. In other cases only certain items from the lists have been pursued in detail, leaving the impression management believes the other items to be insignificant but giving no reasons why. Confirmation and justification as appropriate of management's view would be valuable. There will always be situations where significant factors may be overlooked, but often seemingly obvious items such as valve fail safe arrangements have not been mentioned. HSE will need details of the process plant and its means of operation. An adequate plant line diagram rather than a schematic outline will often be necessary. Assumed leakage orifice sizes will need to be defined when appropriate, and the reasons for their selection set out. Management may need to consider, for example, the consequences to the major hazard installation itself of the ignition of a drifting flammable vapour cloud.

After identifying potential failure cases requiring more thorough evaluation, it will be necessary to decide on suitable bases of calculation etc. HSE's experience of surveys to date suggests this area will be among the most significant for Hazard Surveys, because here assumptions will often be needed in areas of limited scientific knowledge. For example, indications will be necessary of the leak rate calculations employed for situations where complicated phenomena such as jets of flashing liquids escaping to atmosphere are to be assessed. Reasons for any assumed limitation on the duration and therefore volume of escape should be stated. The methods used for predicting atmospheric dispersion of released material should certainly be indicated. The source of any statistics, whether on pipe failure, valve failure, operator error, etc, will need to be clearly given.

In conclusion, therefore, it is clear that many assumptions in these areas will be relevant to whole series of Hazard Surveys. The most sensible way forward to avoid duplication of effort by individual companies will probably involve agreement at an early date between HSE and industry on acceptable assumptions. Accordingly, HSE proposes to extend into other areas the type of involvement with industry which it already has on methods of predicting dense gas dispersion. Research topics will certainly be identified and it is hoped that collaborative work on solutions may be possible.

REFERENCES

1. "Advisory Committee on Major Hazards - First Report" HMSO £1.00 plus postage

2. Health and Safety Commission, Consultative Document "Hazardous Installations (Notification and Survey), Regulations 1978" HMSO 50p plus postage.

ACKNOWLEDGMENTS

The author wishes to express his thanks to the Health and Safety Executive for permission to publish this paper.