Chapter 2

How To Use This Manual
2. HOW TO USE THIS MANUAL

2.1 Background

This manual aims to describe methods which may be used by engineer and safety analysts to estimate the major accident hazards associated with industrial plants. The basic procedure requires that potential failures should be identified, the quantities of hazardous material released should be calculated and the impact of each release on plant equipment and personnel or the surrounding population and environment should be estimated. The methods have been simplified so that they may be used by an engineer with a hand-held programmable calculator or preferably on a mini computer.

Large industrial sites may contain several process units each of which will be made up of vessels, pipes and instruments. A large part of this manual consists of advice on how to organise the safety analysis including the subdivision of the plant into manageable units, the avoidance of unnecessary calculations and the collation of large numbers of results. The calculational models for estimating the discharge rates and consequences of plant failure may also be applied outside of the context of a complete plant analysis. The analyst may conveniently use these models to answer more specific and less complex questions. For example, he may estimate whether a fire at a particular hydrogen storage tank would be likely to cause failures on adjacent equipment and whether such a fire would render escapeways unusable.

In order to guide the analyst through the hazard assessment of a complete plant, the method has been divided into 14 main steps. Figure 2.1 shows the order in which the relevant sections of this manual where each modelling procedure is described. A rigorous hazard assessment of a plant is a complex and subtle problem which has been greatly simplified for this manual. The analyst responsible for a hazard assessment should be aware of the advantages and limitations of the methods described here and the complete manual should be read and digested before embarking upon any computational work. Although the sections indicated in Figure 2.1 provide the primary source of information on the technicalities of the calculational procedures which may be adopted in the assessment of potentially hazardous installations, a brief description of the purpose of each step in the analysis is given below.
FIGURE 2.1 GUIDE TO USE OF THIS MANUAL

ANALYSIS OF ONE VESSEL

WHERE SITE ANALYSIS

STEP 1 DIVISION OF SITE INTO UNITS
STEP 2 DIVISION OF UNITS INTO VESSELS AND PIPES
STEP 3 FIND INVENTORIES OF VESSELS AND PIPES
STEP 4 RANK VESSELS BY INVENTORY
STEP 5 FIND REPRESENTATIVE RELEASE CASES FOR VESSELS AND PIPES
STEP 6 CLUSTER RELEASE CASES
STEP 7 CALCULATE RELEASE RATES
STEP 8 CLUSTER RELEASE RATES
STEP 9 CALCULATE CONSEQUENCES
STEP 10 COLLATE RESULTS
STEP 11 PLOT EFFECT DISTANCES
STEP 12 ESTIMATE EVENT FREQUENCES
STEP 13 APPLY RESULTS
STEP 14 REMEDIAL MEASURES
2.2 Description of Steps

Step 0 - Read the whole manual

Step 1 - Divide the Site into Functional Units

The choice of units is often rather arbitrary. It is customary to begin the sub-division of the plant into units according to the process functions which are involved e.g. import, export, storage, distribution and fabrication. Usually, the releases from any given unit are described as coming from one particular point which defines the given co-ordinates of the unit. For very large plants, there may be a need to split a single process unit into subunits for the purposes of this analysis if the components of the main unit are installed over a large area and large separation distances are involved.

Step 2 - Divide the Units into Vessels and Pipes

Each unit must be split into "building blocks". These are pieces of equipment such as those shown in the Figures 3.1 to 3.10. If the analyst is confronted with a novel component not included in this list, he should consider which of the listed items most nearly correspond with his plant so that the analysis may proceed.

Step 3 - Find the Inventories of the Vessels and the Pipes

The inventories of all hazardous materials should be found by consulting relevant process flow and instrumentation diagrams. The description of each inventory should include material type, phase, pressure, temperature and volume or mass.

Step 4 - Rank the Vessels by Inventory

In order to confine the amount of calculation needed to manageable proportions, it is important to limit the analysis to only those components containing significant inventories. The minimum significant inventory should be judged with consideration of the lower flammability limit and/or the toxicity of the material. For a hazard assessment concerned with the potential on-site consequences
of accidents, it is very difficult to quote minimum inventories. However, for hazards bearing the potential to cause serious off-site impacts, reference may be made to the extract from the World Bank Guidelines reproduced in Appendix 2. It should be noted that potentially hazardous quantities may range from hundreds of grams to hundreds of tonnes depending upon the detailed flammability and toxicity of the materials in questions. As a general rule, however, vapour releases can usually be ignored in the assessment of acute off-site risks, if the vapour pressure within the vessel is less than 1 bar gauge.

Step 5 - Find Representative Failure Cases for the Vessels and the Pipes

A small number of major hazard failure cases may be postulated for each vessel, component and pipe. A guide to the scale and size of the most commonly used failure cases is shown as part of the "building-blocks" given in Figures 3.1 to 3.10. These failure cases were chosen to represent the sizes of failure which may be encountered using conservative assumptions.

Step 6 - Cluster the Release Cases

Some of the releases which may be postulated in an hazard assessment may involve the same material under similar conditions albeit at different locations in the plant. To reduce the amount of calculation needed, these similar releases may be grouped together and only one calculation for each specified release rate or quantity is then required.

Step 7 - Calculate the Release Rates

The postulated failures may be followed by an instantaneous or a continuous release of hazardous material. Figs 3.11 to 3.14 provide guidance on the selection of the correct model to be used, dependent upon the nature of the material and the assumed discharge condition. The quantity or rate of this release is calculated using the models described in Section 4.1. These modules are designed to account for whether the material discharge is in the form of a liquid, or gas or a mixture of both.
Step 8 - Cluster the Release Rates

In order to reduce further the amount of calculation required, those releases which involve similar amounts of any given material at similar temperatures may also be "clustered" together. Dispersion and consequence calculations may then be carried out just once for each cluster.

Step 9 - Calculate the Consequences

Guidance on the selection of the correct model to apply for the estimation of off-site consequences, under the various conditions which may be encountered in practice, is given in Figures 3.11 to 3.14. The calculational methods for the estimation of spreading/expansion, dispersion, fires, explosions and toxic impacts are given in Section 4.2 to 4.6 inclusive.

Step 10 - Collate the Results

A pro forma tabulation has been included in Section 5 of this manual in order to assist the analyst in recording ordering and collating the results of an hazard assessment for a complex modern plant, where a diverse range of storage, distribution and continuous or batch processes may be involved. By examination of the effect ranges summarised as a result of the analysis, it is possible to order or rank potential hazards for further consideration.

Step 11 - Plot Effect Distances

Ultimately, the results of the hazard assessment calculations should be considered in the context of local demographic, geographic and land use patterns. Since the results are available for each release case as an "effect distance", to a first approximation, hazard impacts may be estimated by superimposing "effect radii" or circles on maps of the areas under investigation.
Step 12 - Estimate Event Frequencies

By examination of reliability and other data, each failure case may be associated with a frequency of occurrence. Estimates of the frequencies of failures of various sizes can be made on the basis of previous experience. If the analyst has data which relates to the particular plant under examination, used in preference to failure statistics available generic information. Nonetheless, it should be noted that, at this stage, the analyst will only be able to use the available frequency data in a semi-quantitative manner; a full risk analysis is beyond the scope of this manual and would require additional resources and data in the form of reliability and availability analyses.

Step 13 - Interpret the Results

Advice is given in Section 6 of this manual on the application of the results of the hazard assessment methodology to any given plant having a major hazard potential.

Step 14 - Examine the Need for Remedial Measures

There are established and diverse means in engineering and management techniques which may be deployed to mitigate, and in some few cases, eliminate hazards in complex process plant. Many remedial measures will be plant specific and it is not the intention in the preparation of this manual to provide a comprehensive description of all of the options which may be available. Nonetheless, by way of examples, some suggestions are made in Section 6. Where improvements to plant design and operation may be identified, the degree of reduction in hazard potential may be examined by the analyst by the selective repetition of the consequence calculations for those failure cases which would be altered by the design changes. In this way, the benefits of design changes in terms of possible reductions in hazards may be quantified and compared.