6. APPLICATION OF METHODOLOGY

By following the procedures in Section 3 and 4 the analyst will have identified which off-site areas are at risk from on-site failures. He also will have identified failures, which could potentially lead to knock-on effects in the plant. The items of plant equipment responsible for the most severe of these consequences will have also been identified.

In this chapter some corrective measures which the analyst might consider to reduce the consequences, frequencies and impacts of the failures are proposed. These suggestions are necessarily of a general nature and the analyst must decide which are suitable for the process and site under study. It is not possible to be comprehensive and the emphasis is placed on basic design modifications rather than secondary "add-on" remedial measures.

6.1 Knock-on Effects

The results from the consequence calculations are in the form of effect distances which are particularly suitable for the investigation of knock-on possibilities. The analyst should examine plans of the site looking for the vulnerable plant within the effect radii of failures leading to structural damage, as well as possible effects on the operability of the plant, safe shut-down, etc. Of particular importance are:

- large inventories in vulnerable vessels

The analyst should check to see if inventories that appear to be at risk are in fact protected by blast walls, firewalls or some other system. He will normally find that large storage vessels are protected from radiation damage by water drenching. He may consider whether the specification and reliability of this system is sufficient for the calculated hazard.

- load-bearing structures

It is of course necessary to examine qualitatively the consequences of the failures of the load-bearing structure due to fires and explosions. The analyst will be interested in vessels and employees on the structure or positioned under the structure.
- control or shutdown devices

These devices may be automatic or manual. In the latter case the analyst will be able to check if the consequences of a release prevent an approach to the control position for emergency shutdown.

- projectile effects

Projectiles from an explosion may damage vessels or piping nearby and cause secondary releases of flammable and toxic materials. In addition the analyst must determine if operators or the public are at risk. Blast walls may be indicated in certain cases.

- design and siting of control rooms

Fires, explosions and toxic gas releases are important considerations in the design and siting of control rooms, as this is the critical area because of the concentration of operators and the need to ensure safe shut-down of critical plant areas.

- modify plant layout and/or siting.
6.2 Reduction of Consequences

The evaluation method outlined in Sections 2 to 5 identifies pieces of plant that have potential of causing severe damage both on and off-site. A list of measures leading to reduced effect distances are proposed here. The analyst should repeat the effect calculations to estimate the benefits of the proposed measures.

A hazard analysis is best carried out at the design stage of the plant, where design, layout and siting modifications can be made to reduce or eliminate potential hazards. Even at the operational stage a hazard analysis will reveal critical items of equipment, piping, etc., where modifications, improved containment and/or operation and control will effectively reduce the hazard. Some hazard reduction possibilities include: reduction of inventories, modification of process or storage conditions, elimination of hazardous material, improvement in plant operability.

6.2.1 Reduce Inventories

The primary object should be to reduce the inventory of hazardous material, so that the potential hazard outside the plant boundary is greatly reduced or even eliminated. For example:

- reduce the inventory of hazardous materials in storage and in the process. Many instances can be sited where it has been possible to operate plants with considerably lower quantities of raw materials and intermediate products than originally designed;

- change the process to produce the hazardous material as a small quantity of intermediate rather than store large quantities of this material;

- change from batch to continuous reaction system with lower inventories better mixing etc.;

- use a low inventory high efficiency process, eg. in distillation and evaporation systems.
6.2.2 Modify Process or Storage Conditions

If it is not possible to reduce the inventory of hazardous material, it may be possible to change the process or storage conditions to reduce the hazard potential of an accidental release.

- Store and process toxic gases in a suitable solvent rather than in large volumes;
- Store and handle all materials in small discrete quantities rather than in large volumes;
- Process hazardous reactive materials in a large volume of recycle carrier material containing the catalyst in a continuous reactor and thus prevent runaway reactions;
- Process hazardous material as a gas rather than as a liquid in a flammable solvent;
- Store hazardous gas as a refrigerated liquid rather than under pressure;
- Reduce process temperatures and pressures through process modifications.

6.2.3 Elimination of Hazardous Material

Should the first two alternatives prove ineffective, it may be possible to use material or alternative process routes to eliminate the hazardous material.

6.2.4 Improve Plant Operability and Reliability

A hazard analysis may identify critical plant items where it is not possible to reduce significantly the hazard by means of the above measures. Other methods such as HASOP (Section 7) or reliability studies etc. may be used to determine corrective design, operation and control measures which will reduce the risk of accidents and provide adequate protection for plant operators as well as the surrounding population.
6.2.5 Other Protective Measures

Other protective measures may include:

- automatic shutdown to reduce release duration;
- the provision of bunkering or blast walls;
- it is occasionally considered necessary to protect employees or nearby plant from shrapnel from exploding vessels or rotating machinery;
- firewalls/fire proofing of structures;
- increased bunding (diking);

Using the release calculations, the analyst can check that the bunds have sufficient volume for the predicted release scenarios. Bunds are more efficient if they have vertical walls. Since this may prevent liquid surging out after a major leak, bunds with sloping floors may reduce the surface area of pool and thus the rate of evaporation. The analyst should also check that jet releases are contained, if these are considered to be likely. Evaporation rates are reduced if bund areas are decreased and bund heights are increased. In the cases where the calculations indicate that knock-on effects are possible, the analyst may wish to check that those bunds which are common to adjacent vessels provide for an adequate containment capacity.

- Water curtains which may restrict gas release.

6.3 Reduction of Impacts

A range of measures are available to reduce the impacts of major hazard accidents. The analyst should at least consider the following:

- provision of escape routes;
  The format of the output as effect distances makes the examination of the effect of failure on escape routes very convenient;
- evacuation planning;
- public alert systems;
The response of the public to an alert is every difficult to predict. Nevertheless the installation of such systems must be considered where significant inventories of toxic materials are held.

- emergency procedures on and off-site;
- maintenance and inspection of plant;

These are normally determined by statutory codes.

- safety and emergency training;
- provision of safety buffer zones around the plant boundary;
- modify siting of proposed plant.