# Chapter 7
# Additional Studies
# (Risk Assessment &Disaster Management Plan)

## 7.0 Risk Assessment & Disaster Management Plan

The principal objective of the risk assessment study is to identify and quantify the major hazards and the risk associated with various operations of the proposed project, which may lead to emergency consequences (disasters) affecting the public safety and health. Based on this information, an emergency preparedness plan is to be prepared to mitigate the consequences. The approach involves hazards identification, hazards assessment and evaluation, developing Disaster Management Plan (DMP).

## 7.1 Hazard Identification

Identification of hazards is of primary significance in the analysis, quantification and cost effective control of accidents involving chemical handling and process. A classical definition of hazards states that hazard is in fact the characteristics of system/plant/process that presents potential for the accident. Hence, all the components of a system/plant/process need to be thoroughly examined to assess their potential for initiating or propagating an unplanned events /sequence of events, which can be termed as an accident.

Estimation of probability of a unexpected event and its consequences form the basis of quantification of risk in terms of damage to property, environment and personnel. Therefore, the type, quantity, location and condition of release of toxic or flammable substances have to be identified in order to estimate its damaging effects, the area involved, and the possible precautionary measures required to be taken. The following two methods for hazards identification have been employed in the study:

Identification of major hazardous units based on Manufacture, Storage and Imports of Hazardous chemicals Rules, 1989 of Government of India and amended rules 1994 & 2000. Identification of Fire-Explosion and Toxicity Index (FE&TI).

### 7.1.1 Identification of Major Hazard Chemical

Identification of Major Hazard Installations Based on GoI Rules, 1989 as amended in 1994 & 2000.By Studying accidents occurred in industries in India over a few decades, a specific legislation covering major hazard activities has been enforced by Government of

India in 1989 in conjunction with Environment Protection Act, 1986. This is referred here as GOI rules 1989. For the purpose of identifying major hazard installations the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals.

### 7.1.2 Indicative Criteria for Identification of Toxic, Flammable Explosive Chemicals (GOI Rules, 1989) & Amended rules 1994 & 2000

a) **Toxic Chemicals:**

Chemicals having the following values of acute toxicity and which owing to their physical and chemical properties are capable of producing major accidents:

| S. No | Toxicity | Oral toxicity LD50(mg/kg) | Dermal toxicity LD50(mg/kg) | Inhalation toxicity LC50(mg/l) |
|---|---|---|---|---|
| 1. | Extremely toxic | 1-50 | 1-200 | 0.1-0.5 |
| 2. | Highly toxic | 51 – 500 | 201-2000 | 0.5 - 2.0 |

**(b) Flammable Chemicals:**

Flammable gases: Gases which at $20^0$C and at standard pressure of 101.3 KPa are:-

1. Ignitable when in a mixture of 13 per cent or less by volume with air, or
2. Have a flammable range with air of at least 12 percentage points regardless of the lower flammable limits.

Note: - The flammability shall be determined by tests or by calculation in accordance with methods adopted by International Standards Organization ISO Number10156 of 1990 or by Bureau of Indian Standards ISI Number 1446 of 1985 in Draft EIA report preparation and review of report.

i. Extremely flammable liquids: chemicals which have flash point lower than or equal to $23^0$C and boiling point less than $35^0$C
ii. Very highly flammable liquids: chemicals which have a flash point lower than or equal to $23^0$C and initial boiling point higher than $35^0$C.
iii. Highly flammable liquids: chemicals which have a flash point lower than or equal to $60^0$C but higher than $23^0$C.
iv. Flammable liquids: chemicals which have a flash point higher than $60^0$C but lower than $90^0$ C.

**(c)Explosives:**

Explosives means a solid or liquid or pyrotechnic substance (or a mixture of substances) or an article.

Which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings; Which is designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as a result of non-detonative self-sustaining exothermic chemical reaction?

### 7.1.3 Analysis of Units of Different Processes

A systematic analysis of the chemicals and their quantities of storage of chemicals has been carried out to determine threshold quantities as notified by GOI **Manufacture, Storage and import of hazardous chemical** Rules, 1989 and the applicable rules are identified. The results are summarized in **Table 7.1.**

**Table 7.1**

**Description of applicable provisions of GOI rules Manufacture, Storage and import of hazardous chemical rules '1989 as amended in 1994 & 2000**

| Applicable rules | *Description* |
|---|---|
| 4 | **Identify Major accident**<br>Take adequate steps to prevent major accidents<br>Provide information to persons working onsite<br>Impart training, provide equipment and antidotes |
| 5 | Notification of major accidents to concerned authority<br>If any major accident occurs, occupier to inform Concerned authority as listed in SC-5 and submit report as per the format in SC-6<br>(applies after commencing of the activity) |
| 7 | Notification of site to competent authority |
| 8 | Updating of site notification following changes in threshold quantity |
| 9 | Transitional provision for the existing activity |
| 10 | Preparation of safety reports for commencement of activity |
| 11 | Updating of safety reports based on modification |
| 12 | Provision of further information on safety reports to the authority |
| 13 | Preparation of onsite emergency plan by the occupier |
| 14 | Preparation of offsite emergency plan by the occupier |
| 15 | Information to be given to persons liable to be effected by a major accident |
| 17 | Collection, development and dissemination of information on hazardous chemicals employed by the occupier |
| Occupier shall develop information in the form of safety data sheet as specified in SC-9. Every container of the hazardous chemical should be labelled with name of the manufacturer or importer of the hazardous chemical. | |

From the above table it can be inferred that there would be major Hazardous chemical stored at the proposed plant, which would attract the GOI rules 4 5,7-9 and 13-15, as the quantity likely to be stored at site lies above the stipulated threshold quantities.

### *7.2* Storage facilities of hazardous chemicals

The storage capacities / details of the major hazardous chemicals proposed to be used for manufacturing various products are given in **Table 7.2**

**Table 7.2**

**Details of Chemicals proposed, sizes, type of tanks proposed and Applicability of GOI rules**

| S. No | Solvent | CAS No | LEL | UEL | TLV/TWA | Storage type | Storage Capacity | | No. of tanks with capacity | Threshold Quantity (MT) for Application of Rules | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Kgs | KL | | 5,7,9,13-15 | 10 12 |
| 1 | 1,2-Dimethoxy ethane | 110-71-4 | - | - | | Vertical Tank | 5885 | 6 | 10KLD - 1 | 1500 | 10000 |
| 2 | 1,2-Epoxy butane | 106-88-7 | 1.7 | 19 | | Vertical drums | 324 | 1 | 220 L - 2 | 1500 | 10000 |
| 3 | 1,4-Dioxane | 123-91-1 | - | - | 25.0 | Vertical Tank | 2643 | 3 | 5KLD - 1 | 1500 | 10000 |
| 4 | 1-Methoxy-2-Propanol | 107-98-2 | 1.80 | 0.16 | 50.0 | Vertical Tank | 2500 | 3 | 5KLD - 1 | 1500 | 10000 |
| 5 | 1-methyl 2-pyrrodinone | 872-50-4 | 1.30 | 0.10 | 25.0 | Vertical drums | 600 | 1 | 220 L - 5 | 1500 | 10000 |
| 6 | 2-Butanol | 78-92-2 | 1.70 | 0.10 | 20.0 | Vertical Tank | 5656 | 6 | 10KLD - 1 | 1500 | 10000 |
| 7 | 2-Methoxy ethanol | 109-86-4 | 1.8 | 14 | 5.0 | Vertical drums | 804 | 1 | 220 L - 5 | 1500 | 10000 |
| 8 | 2-Methyl THF | 96-47-9 | 1.2 | 5.7 | 100.0 | Vertical drums | 1180 | 2 | 220 L - 10 | 1500 | 10000 |
| 9 | 2-Propnaol | 67-63-0 | 2 | 12.7 | 200.0 | Vertical drums | 156 | 1 | 220 L - 5 | 1500 | 10000 |
| 10 | 3 – BromoButanol | 33036-62-3 | - | - | | Vertical Tank | | | | 1500 | 10000 |
| 11 | Acetic acid | 64-19-7 | 4 | 16 | 10.0 | Vertical Tank | 7474 | 10 | 10KLD - 1 | 1500 | 10000 |
| 12 | Acetone | 67-64-1 | 2.6 | 12.8 | 250.0 | Vertical Tank | 24224 | 25 | 10KLD - 2<br>5KLD - 1 | 1500 | 10000 |
| 13 | Acetonitrile | 75-05-8 | 4.4 | 16 | 20.0 | Vertical Tank | 11278 | 15 | 10KLD - 1<br>5KLD - 1 | 1500 | 10000 |
| 14 | Benzyl alcohol | 100-51-6 | 1.3 | 13 | 200.0 | Vertical Tank | | | | 1500 | 10000 |
| 15 | Butanol | 71-36-3 | - | - | 20.0 | Vertical Tank | | | | 1500 | 10000 |
| 16 | chlorobenzene | 108-90-7 | 1.3 | 9.6 | 10.0 | Vertical Tank | 5369 | 6 | 10KLD - 1 | 1500 | 10000 |
| 17 | Chloroform | 67-66-3 | - | - | 10.0 | Vertical Tank | 21569 | 25 | 10KLD - 2<br>5KLD - 1 | 1500 | 10000 |
| 18 | Cyclohexane | 110-82-7 | 1.3 | 8 | 100.0 | Vertical Tank | 17351 | 20 | 10KLD - 2 | 1500 | 10000 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | Di isopropyl ether | 108-20-3 | 1.4 | 7.9 | 250.0 | Vertical Tank | 9650 | 10 | 10 KLD - 1 | 1500 | 10000 |
| 20 | Di ethyl ether | 60-29-7 | 1.9 | 48 | 400.0 | Vertical Tank | | | | 1500 | 10000 |
| 21 | Dimethyl acetamide | 127-19-5 | 1.8 | 11.5 | 10.0 | Vertical Tank | 2245 | 5 | 5KLD - 1 | 1500 | 10000 |
| 22 | Dimethyl sulfoxide | 67-68-5 | - | - | | Vertical drums | 1682 | 2 | 220 L - 10 | 1500 | 10000 |
| 23 | Dimethyl formamide | 68-12-2 | 2.2 | 15.2 | 10.0 | Vertical Tank | 8922 | 10 | 10KLD - 1 | 1500 | 10000 |
| 24 | Ethanol | 64-17-5 | - | - | 1000.0 | Vertical Tank | 15033 | 15 | 10KLD - 1<br>5KLD - 1 | 1500 | 10000 |
| 25 | Ethylacetate | 141-78-6 | 2 | 11.5 | 400.0 | Vertical Tank | 105219 | 110 | 20KLD - 5<br>10KLD - 1 | 1500 | 10000 |
| 26 | Ethylene dichloride | 107-06-2 | 6.2 | 16 | 10.0 | Vertical Tank | 21103 | 22 | 20KLD - 2<br>5KLD - 1 | 1500 | 10000 |
| 27 | Ethylene glycol | 107-21-1 | 3.2 | 15.2 | | Vertical Tank | 3330 | 5 | 5KLD - 1 | 1500 | 10000 |
| 28 | Heptanes | 142-82-5 | 1.05 | 6.7 | 400.0 | Vertical Tank | 9499 | 10 | 10KLD - 1 | 1500 | 10000 |
| 29 | Hexanes | 110-54-3 | 1.2 | 7.7 | 50.0 | Vertical Tank | 10176 | 15 | 10KLD - 1<br>5KLD - 1 | 1500 | 10000 |
| 30 | Isopropyl acetate | 108-21-4 | 1.8 | 7.8 | 250.0 | Vertical Tank | 2292 | 5 | 5KLD - 1 | 1500 | 10000 |
| 31 | Isopropyl alcohol | | - | - | 200.0 | Vertical Tank | 33664 | 35 | 20KLD - 3<br>5KLD - 1 | 1500 | 10000 |
| 32 | Methanol | 67-56-1 | 6 | 36 | 200.0 | Vertical Tank | 85669 | 90 | 20KLD - 4<br>10KLD - 1 | 1500 | 10000 |
| 33 | Methyl cyclohexane | 108-87-2 | 1.2 | 6.7 | 400.0 | Vertical drums | 1028 | 2 | 220 L - 10 | 1500 | 10000 |
| 34 | Methyl ethyl Ketone | 1338-23-4 | - | - | | Vertical drums | 483 | 1 | 220 L - 5 | 1500 | 10000 |
| 35 | Methylene chloride | 75-09-2 | 13 | 23 | 50.0 | Vertical Tank | 159993 | 160 | 20KLD - 8 | 1500 | 10000 |
| 36 | Methyl-tert-butyl ether | 1634-04-4 | - | - | | Vertical Tank | 43306 | 44 | 20KLD - 2<br>5KLD - 1 | 1500 | 10000 |
| 37 | N,N-Dimethylaniline | 121-69-7 | - | - | | Vertical Tank | 510 | 1 | 220 L - 5 | 1500 | 10000 |
| 38 | n-Heptane | | - | - | | Vertical Tank | 3635 | 5 | 5KLD - 1 | 1500 | 10000 |
| 39 | n-Hexane | | - | - | | Vertical Tank | 1449 | 2 | 220 L - 10 | 1500 | 10000 |
| 40 | n-propanol | 71-23-8 | 2.2 | 13.7 | 200.0 | Vertical drums | 1247 | 2 | 220 L - 10 | 1500 | 10000 |
| 41 | O-Xylene | 95-47-6 | - | - | 100.0 | Vertical Tank | 11698 | 15 | 10KLD - 1<br>5KLD - 1 | 1500 | 10000 |
| 42 | Petrolium ether | 8032-32-4 | 1.4 | 5.9 | 100.0 | Vertical Tank | 8898 | 10 | 10KLD - 1 | 1500 | 10000 |
| 43 | t-Butanol | 75-65-0 | 2.4 | 8 | 100.0 | Vertical Tank | 503 | 1 | 220 L - 5 | 1500 | 10000 |
| 44 | Tetrahydrofuran | 109-99-9 | 2 | 11.8 | 200.0 | Vertical Tank | 12799 | 15 | 10KLD - 1<br>5KLD - 1 | 1500 | 10000 |
| 45 | Toluene | 108-88-3 | 1.1 | 7.1 | 50.0 | Vertical Tank | 168377 | 170 | 20KLD - 8<br>10KLD - 1 | 1500 | 10000 |
| 46 | Trimethylamine | 121-44-8 | 1.2 | 8 | 5.0 | Vertical drums | 14 | 1 | 220 L - 5 | 1500 | 10000 |
| Dia of tanks 20KL - 2m, 15KL-2m, 10KL- 2m, 5KL- 1.5m | | | | | | | | | | | |
| Length of tanks 20KL - 7m, 15KL- 5m, 10KL- 4m, 5KL- 3.5m | | | | | | | | | | | |
| Dia of drums 0.5m | | | | | | | | | | | |

* All Solvents are in schedule 3(part II) of The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989

### 7.2.1 Potential Hazards

Hazard is an event/incident that can lead to damage of equipment or injury to personnel. The following are the potential areas in a proposed project that can lead to major accidents.

- Solvents storage areas
- Coal storage and handling
- Electrical Hazards

### 7.2.2 Nature of Possible Hazards

There can be three kinds of major hazards

- Leakage of Solvents tanks leading to pool Fire – Explosion and Fire hazard
- Spontaneous ignition of coal – Explosion and Fire hazard
- Electrical Hazards like flashover and short circuits

### 7.2.3 Fire Explosion and Toxicity Index (FETI) Approach

The most widely used relative ranking hazard index is Dow's Fire Explosion Index (F&EI) and Mond's Toxicity Index (TI) together is called as Fire Explosion and Toxicity Index (FETI). It involves objective evaluation of the realistic fire, explosion, toxicity and reactivity potential of process or storage units. The quantitative methodology relies on the analysis based on historic loss data, the energy potential of the chemical under study and the extent to which loss prevention measures are already applied.

F&EI is a product of Material Factor (MF) and Hazard Factor (F3). While MF represents the flammability and reactivity of the substances, hazard factor (F3) is itself a product of General Process Hazard (GPH) and Special Process Hazard (SPH). An accurate plot plan of the plant, a process flow sheet and Fire and Explosion Index and Hazard classification Guide published by Dow Chemical Company are required to estimate F&EI of any plant or storage units.

The toxicity index is primarily based on the index figures for health hazards established by NFPA in codes NFPA 704, NFPA 49 and NFPA 325m.

The F&EI is calculated from,

$$F\&EI = MF \times F3$$

Where $F3 = GPH \times SPH$

The degree of hazard potential is identified based on numerical value of F&EI as per the criteria given in **Table 7.3.** The TI is calculated as follows,

$$TI = \left(\frac{Th + Ts}{100}\right)(1 + GPH + SPH)$$

Where, $T_h$ is the health factor.

By comparing the indices of F&EI and TI, the unit under analysis is classified into one of the following categories established for this purpose.

**Table 7.3**

**Categories of substances based on F&EI and TI**

| Category | Fire and Explosion Index (F&EI) | Toxicity Index (TI) |
|---|---|---|
| Low | < 65 | < 6 |
| Moderate | 65 ≤ F&EI < 95 | 6 ≤ TI < 10 |
| Severe | ≥ 95 | ≥ 10 |

Certain basic minimum preventive and protective measures are required for the three hazard categories.

Detailed computations of FETI for various storage tanks at proposed TPP are given in the **Table 7.4.** The flammability, reactivity, health, MF for all the materials under consideration was derived from NFPA codes. The GPH and SPH were calculated accordingly.

**Table 7.4**

**F&EI and TI of chemical**

| S. No. | Raw Material Name | NFPA Classification | | | | GPH | SPH | F&EI | F&E category | TI | Toxicity category |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $N_h$ | $N_f$ | $N_r$ | MF | | | | | | |
| 1 | 1,2-Dimethoxy ethane | 2 | 3 | 0 | 16 | 2.2 | 2.4 | 81.7 | Moderate | 6.9 | Moderate |
| 2 | 1,2-Epoxy butane | 3 | 3 | 2 | 24 | 2.2 | 2.2 | 113.6 | Severe | 11.4 | Severe |
| 3 | 1,4-Dioxane | 2 | 3 | 1 | 16 | 1.8 | 2.1 | 60.4 | Low | 6.1 | Moderate |
| 4 | 1-Methoxy-2-Propanol | 1 | 2 | 0 | 10 | 2.2 | 1.8 | 38.7 | Low | 2.5 | Low |
| 5 | 1-methyl 2-pyrrodinone | 2 | 2 | 0 | 10 | 2.2 | 1.9 | 41.7 | Low | 6.4 | Moderate |
| 6 | 2-Butanol | 1 | 3 | 0 | 16 | 2.2 | 1.9 | 65.1 | Moderate | 2.5 | Low |
| 7 | 2-Methoxy ethanol | 2 | 2 | 0 | 10 | 2.2 | 2.0 | 43.9 | Low | 6.5 | Moderate |
| 8 | 2-Methyl THF | 2 | 3 | 1 | 16 | 2.2 | 2.2 | 74.9 | Moderate | 6.7 | Moderate |
| 9 | 2-Propnaol | 2 | 3 | 0 | 16 | 2.2 | 2.0 | 68.8 | Moderate | 6.4 | Moderate |
| 10 | 3-Bromo butanol | 2 | 3 | 0 | 16 | 2.2 | 1.9 | 65.4 | Moderate | 2.5 | Low |
| 11 | Acetic acid | 3 | 2 | 0 | 10 | 2.2 | 2.5 | 54.6 | Low | 11.2 | Severe |
| 12 | Acetone | 1 | 3 | 0 | 16 | 2.2 | 2.1 | 73.6 | Moderate | 2.6 | Low |
| 13 | Acetonitrile | 2 | 3 | 0 | 16 | 1.8 | 2.3 | 66.0 | Moderate | 6.4 | Moderate |
| 14 | Benzyl alcohol | 2 | 2 | 0 | 10 | 2.2 | 1.9 | 40.9 | Low | 6.3 | Moderate |
| 15 | Butanol | 1 | 3 | 0 | 16 | 2.2 | 1.7 | 58.5 | Low | 6.1 | Moderate |
| 16 | chlorobenzene | 2 | 3 | 0 | 16 | 2.2 | 2.1 | 71.0 | Moderate | 6.1 | Moderate |
| 17 | Chloroform | 2 | 0 | 0 | 0 | 2.2 | 2.1 | 4.6 | Low | 6.6 | Moderate |
| 18 | Cyclohexane | 1 | 3 | 0 | 16 | 2.2 | 2.3 | 77.5 | Moderate | 2.7 | Low |
| 19 | Di isopropyl ether | 2 | 3 | 1 | 16 | 2.2 | 2.3 | 77.6 | Moderate | 6.8 | Moderate |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | Diethyl ether | 2 | 4 | 0 | 21 | 2.2 | 2.1 | 94.4 | Moderate | 6.6 | Moderate |
| 21 | Dimethyl acetamide | 2 | 2 | 0 | 10 | 2.2 | 2.2 | 47.8 | Low | 6.7 | Moderate |
| 22 | Dimethyl sulfoxide | 1 | 2 | 0 | 10 | 2.2 | 1.8 | 39.1 | Low | 2.5 | Low |
| 23 | Dimethyl formamide | 2 | 2 | 0 | 10 | 1.8 | 2.0 | 36.7 | Low | 6.0 | Moderate |
| 24 | Ethanol | 2 | 3 | 0 | 16 | 2.2 | 2.2 | 74.6 | Moderate | 6.6 | Moderate |
| 25 | Ethylacetate | 1 | 3 | 0 | 16 | 2.2 | 2.2 | 77.3 | Moderate | 2.7 | Low |
| 26 | Ethylene dichloride | 2 | 3 | 0 | 16 | 2.2 | 2.1 | 72.7 | Moderate | 6.7 | Moderate |
| 27 | Ethylene glycol | 1 | 1 | 0 | 4 | 2.2 | 1.9 | 16.4 | Low | 2.5 | Low |
| 28 | Heptanes | 1 | 3 | 0 | 16 | 2.2 | 2.2 | 74.8 | Moderate | 2.7 | Low |
| 29 | Hexanes | 2 | 3 | 0 | 16 | 2.2 | 2.3 | 78.9 | Moderate | 6.8 | Moderate |
| 30 | Isopropyl acetate | 1 | 3 | 0 | 16 | 2.2 | 1.8 | 62.3 | Low | 2.5 | Low |
| 31 | Isopropyl alcohol | 2 | 3 | 0 | 16 | 2.2 | 2.6 | 89.2 | Moderate | 7.2 | Moderate |
| 32 | Methanol | 2 | 3 | 0 | 16 | 2.2 | 2.3 | 80.3 | Moderate | 6.9 | Moderate |
| 33 | Methyl cyclohexane | 2 | 3 | 0 | 16 | 1.8 | 2.1 | 60.1 | Low | 6.1 | Moderate |
| 34 | Methyl ethyl Ketone | 2 | 3 | 0 | 16 | 2.2 | 1.9 | 66.9 | Moderate | 6.4 | Moderate |
| 35 | Methylene chloride | 2 | 1 | 0 | 4 | 2.2 | 2.4 | 20.7 | Low | 6.9 | Moderate |
| 36 | Methyl-tert-butyl ether | 2 | 3 | 0 | 16 | 2.2 | 2.0 | 70.2 | Moderate | 6.9 | Moderate |
| 37 | N,N-Dimethylaniline | 3 | 2 | 0 | 10 | 2.2 | 2.2 | 47.4 | Low | 2.7 | Low |
| 38 | n-Heptane | 1 | 3 | 0 | 16 | 2.2 | 2.1 | 71.8 | Moderate | 2.6 | Low |
| 39 | n-Hexane | 2 | 3 | 0 | 16 | 2.2 | 2.1 | 72.7 | Moderate | 6.6 | Moderate |
| 40 | n-propanol | 1 | 3 | 0 | 16 | 2.2 | 1.8 | 61.5 | Low | 6.2 | Moderate |
| 41 | O-Xylene | 2 | 3 | 0 | 16 | 2.2 | 2.3 | 78.0 | Moderate | 6.8 | Moderate |
| 42 | Petrolium ether | 2 | 3 | 0 | 16 | 2.2 | 2.1 | 70.7 | Moderate | 6.5 | Moderate |
| 43 | t-Butanol | 2 | 3 | 0 | 16 | 1.8 | 2.0 | 57.6 | Low | 6.0 | Moderate |
| 44 | Tetrahydrofuran | 2 | 3 | 0 | 16 | 2.2 | 2.0 | 67.9 | Moderate | 6.4 | Moderate |
| 45 | Toluene | 2 | 3 | 0 | 16 | 2.2 | 2.7 | 91.6 | Moderate | 7.3 | Moderate |
| 46 | Triethylamine | 3 | 3 | 0 | 16 | 2.2 | 2.1 | 72.3 | Moderate | 11.5 | Severe |

## 7.3 Short listing of Maximum Credible Accident Scenarios (MCA analysis)

Maximum Credible Accident Analysis (MCA) defines the accident with maximum damage distance, which is believed to be probable. Based on the storage quantities and properties of the chemicals, hazard identification has been done.

- ✓ Pool Fire due to rupture / leakage
- ✓ Toxic dispersion due to leak or pool evaporation
- ✓ Vapour cloud due to vessel rupture

### 7.3.1 Consequence analysis

Aloha 5.4.1 developed by Office of Emergency Management, EPA and Emergency Response Division, NOAA is used for prediction of risk for various gas cylinders. The following table indicates likely damage level for different level of heat radiations:

**Table 7.5**

**Damage Criteria for Heat Radiation**

| Incident Radiation Intensity ($KW/m^2$) | Type Of Damage |
|---|---|
| 37.5 | Sufficient to cause damage to process equipment |
| 25 | Minimum energy required to ignite nearby wood at infinitely long exposure (non piloted) |
| 12.5 | Minimum energy required for piloted ignition of wood, melting plastic tubing etc. |
| 4.5 | Sufficient to cause pain to personnel if unable to reach cover within 20 seconds; however blistering of skin ($1^{st}$ degree burns) is likely. |
| 1.6 | Will cause no discomfort to long exposure |

The consequence analysis of the solvents is given in **Table 7.6.** Analysis has been done considering three scenarios, based on the type of and the quantity stored.

### 7.3.2 Solvent Storage Yard:

Safe storage of laboratory chemicals is dependent on 2 variables: 1) location and 2) the compatibility of the types of chemicals needing to be stored. To make sure that chemical containers are stored in places where they aren't likely to fall or break, but if they do all results will be relatively manageable.

Storing chemicals with compatible chemicals decreases the chance of violent reactions occurring if the containers leak and the chemicals mix accidentally.

Compatible chemicals have similar hazards. Chemicals with similar hazards, if mixed together, produce mild or no reaction. To avoid violent reactions, incompatible chemicals with dissimilar hazards should be stored separately. Determining which chemicals can be safely stored together can be a multiple step process.

To determine which of the chemicals can store together safely, *Chemical Compatibility Chart* has been referred. It is observed that all the chemicals are compatible. Solvent storage yard showing location for the solvents is given as **Figure 7.1**

**Figure 7.1**

**Tank form area for chemical storage**

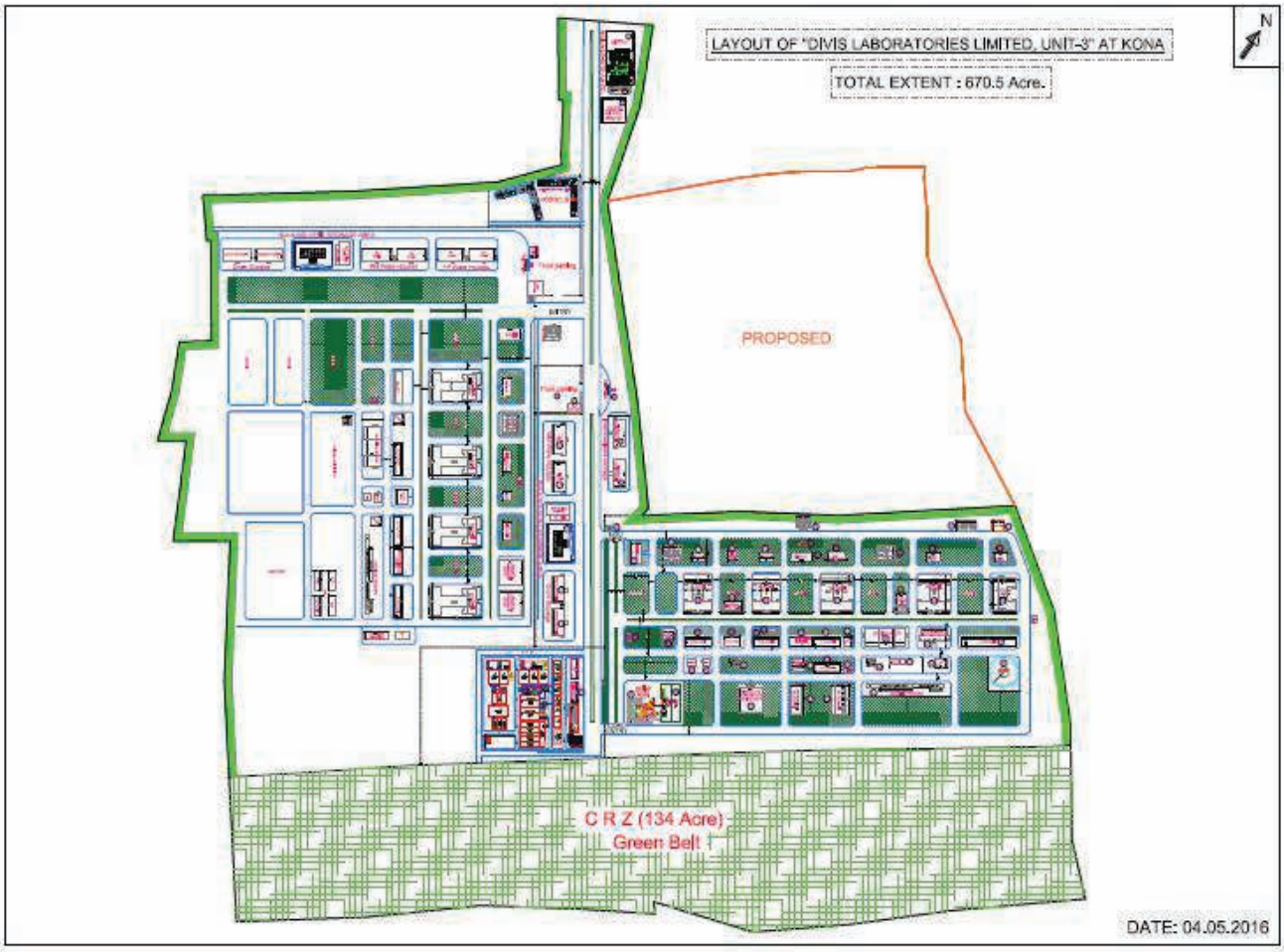


**Table 7.6**

**Damage distances for the three scenarios depending upon the type of the solvent and the quantity**

| | 1,2-Dimethoxy ethane* | 1,2-Epoxy butane* | 1-Methoxy-2-Propanol | 1-methyl-2-pyrrodinone | 2-Butanol | 2-Methoxy ethanol | 2-Methyl THF | 2-Propnaol | 3-Bromo butanol* | Acetic acid | Acetone | Acetonitrile | Benzyl alcohol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pool fire (Heat Radiation), Damage Distance(m) | | | | | | | | | | | | | |
| 100% Lethality(37.5 KW/$m^2$) | <10 | <10 | <10 | - | <10 | - | <10 | <10 | <10 | - | <10 | <10 | - |
| 50% lethality(25 KW/$m^2$) | <10 | <10 | <10 | - | <10 | - | <10 | <10 | <10 | - | <10 | <10 | - |
| 1% lethality(12.5 KW/$m^2$) | 11 | <10 | <10 | - | 12 | - | 14 | 10 | <10 | - | 11 | 10 | - |
| 1st degree Burns(4.5 KW/$m^2$) | 21 | 11 | 18 | - | 22 | - | 26 | 19 | 12 | - | 21 | 18 | - |
| No discomfort(1.6 KW/$m^2$) | 37 | 19 | 31 | - | 37 | - | 45 | 33 | 19 | - | 37 | 31 | - |
| Toxic Area of vapour cloud (Toxicity), Damage Distance(m) | | | | | | | | | | | | | |
| IDLH/PAC-1 | 207 | 56 | - | <10 | - | <10 | 47 | 23 | - | 109 | - | 65 | 12 |
| STEL/PAC-2 | 938 | 95 | - | 12 | - | 124 | 105 | 69 | - | 212 | - | 85 | 128 |
| TLV/TWA/PAC-3 | 1.3 km | 145 | - | 27 | - | 226 | 265 | 109 | - | 265 | - | 393 | 145 |

| | Chlorobenzene | Chloroform | Cyclohexane | Di isopropyl ether | Diethyl ether | Dimethyl acetamide | Dimethyl formamide | Ethanol | Ethyl acetate | Ethylene dichloride | Heptanes | Hexanes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pool fire (Heat Radiation), Damage Distance(m) | | | | | | | | | | | | |
| 100% Lethality(37.5 KW/m2 ) | <10 | - | <10 | <10 | <10 | - | - | <10 | <10 | <10 | <10 | <10 |
| 50% lethality(25 KW/m2 ) | <10 | - | 11 | <10 | <10 | - | - | <10 | <10 | <10 | 12 | 12 |
| 1% lethality(12.5 KW/m2 ) | 11 | - | 19 | 17 | 16 | - | - | <10 | <10 | <10 | 19 | 20 |
| 1st degree Burns(4.5 KW/m2 ) | 22 | - | 36 | 33 | 31 | - | - | 17 | 19 | 11 | 36 | 38 |
| No discomfort(1.6 KW/$m^2$) | 38 | - | 62 | 57 | 53 | - | - | 28 | 33 | 19 | 62 | 65 |
| | | | | | | | | | | | | |
| Toxic Area of vapour cloud (Toxicity), Damage Distance(m) | | | | | | | | | | | | |
| IDLH/PAC-1 | <10 | 105 | - | 53 | 107 | <10 | <10 | 11 | - | 276 | - | 62 |
| STEL/PAC-2 | 41 | 381 | - | 121 | 215 | 59 | 27 | 16 | - | 496 | - | 130 |
| TLV/TWA/PAC-3 | 208 | 1.1 km | - | 137 | 241 | 90 | 132 | 28 | - | 726 | - | 380 |

| | Isopropyl alcohol | Methanol | Methyl cydohexane | Methylene chloride | n-propanol | O-Xylene | t-Butanol | Tetrahydro furan | Toluene | Triethylamine |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pool fire (Heat Radiation), Damage Distance(m)** | | | | | | | | | | |
| **100% Lethality(37.5 KW/m2 )** | <10 | <10 | - | - | - | <10 | - | <10 | <10 | <10 |
| **50% lethality(25 KW/m2 )** | <10 | <10 | - | - | - | <10 | - | <10 | 10 | 10 |
| **1% lethality(12.5 KW/m2 )** | 10 | <10 | - | - | - | 17 | - | 14 | 17 | 18 |
| **1st degree Burns(4.5 KW/m2 )** | 19 | 13 | - | - | - | 31 | - | 26 | 32 | 33 |
| **No discomfort(1.6 KW/$m^2$)** | 33 | 20 | - | - | - | 53 | - | 45 | 55 | 58 |
| | | | | | | | | | | |
| **Toxic Area of vapour cloud (Toxicity), Damage Distance (m)** | | | | | | | | | | |
| **IDLH/PAC-1** | 23 | 12 | 32 | 80 | - | <10 | 27 | 47 | 45 | 110 |
| **STEL/PAC-2** | 69 | 128 | 41 | 144 | - | 26 | 120 | 157 | 63 | 547 |
| **TLV/TWA/PAC-3** | 109 | 145 | 62 | 601 | - | 38 | 157 | 179 | 199 | 679 |

Note: Model used for solvent having Fire & Explosion Index> 65 is Pool fire (Heat Radiation)&
Model used for solvent having Toxicity index >6 is Toxic Area of vapour cloud (Toxicity)
Note: * Considered PAC values for representing Toxicity, Damage Distance.
PAC – Protective action criteria
IDLH - Immediately dangerous to life or health
STEL - Short Term Exposure Limit
TWA - Time Weighted Average
TLV - Threshold Limit Value

## 7.4 On-Site Emergency Plan

An on-site emergency is caused by an accident that takes place in plant itself and the effects are confined to the factory premises involving only the people working in the factory. On-site emergency plan to deal with such eventualities is the responsibility of the occupier and is mandatory.

The preparation of an on-site emergency plan and furnishing relevant information to the District Emergency Authority for the preparation of the off-site emergency plan are statutory responsibilities of the occupier of every industry and other units handling hazardous substances. An on-site emergency plan should contain the following key elements:

- basis of the plan: Hazard analysis
- accident prevention procedure/measures;
- accident/emergency response procedure/measures and
- recovery procedure.

### 7.4.1 Elements of Planning

#### 7.4.1.1 Charts & Maps Indicating Hazardous Substances and Zones

It describes the management of the industry information on areas where accidents can take place, likely severity, spread and measures that could be taken to mitigate/contain the effects; the date which need to be collected include hazardous materials used, total storage/maximum unit storage and storage conditions. The charts and maps should highlight the accident-prone areas of the industry so that in case of an emergency. It provides a basis for taking any action.

#### 7.4.1.2 Emergency Personnel's Responsibility During Normal Office Hours

- **Site Controller**

The General Manager (however called) or his nominated deputy will assume overall responsibility for the plant / storage site and its personnel. His duties will be to:

i. assess the magnitude of the situation and decide if staff needs to be evacuated from their assembly points to identify safer places;
ii. Exercise direct operational control over areas other than those affected;
iii. Undertake a continuous review of possible developments and assess in consultation with key personnel as to whether shutting down of the plant or any section of the plant and evacuation of personnel are required;

iv. Liaise with senior officials of Police, Fire Bridge, Medical and Factories Inspectorate and provide advice on possible effects on areas outside the factory premises:
v. Look after rehabilitation of affected persons on discontinuation of emergency;
vi. Issues authorized statements to news media, and ensure that evidence is preserved for enquiries to be conducted by the statutory authorities.

- **Incident Controller**

A Production Manager or an Officer of similar rank of the unit may be nominated to act as the Incident Controller. Immediately on knowing about an emergency, he will rush to the incident site and take overall charge and report to the Site Controller. On arrival, he will assess the extent of emergency and decide if major emergency exists and inform the Communication Officer accordingly. His duties will be to:

i. Direct all operations to stop within the affected area taking into consideration priorities for safety of personnel, minimize damage to the plant, property and environment and minimize loss of materials.
ii. Provide advice and information to the Fire and Security Officers and the local fire service;
iii. Ensure that all non-essential workers/staff of the areas affected are evacuated to the appropriate assembly points and the areas are searched for casualties;
iv. Set up communication points and establish contact with Emergency Control Centre in the event of failure of electric supply and thereby Public Address System (PAS) and internal telephones;
v. Report on all significant developments to the communication officer: and
vi. Have regard to the need to preserve the evidence so as to facilitate any enquiry into the cause and circumstances, which caused or escalated the emergency.

- **Personnel/Administrative Manager**

He will also work as Liaison Officer and will be stationed at the main entrance (Gate House) during the emergency. He will, under the direction of the site controller, handle Police, Press and other enquiries, receive reports from roll-call leaders from assembly points and pass on the absentee information to the Incident Controller. His responsibilities shall be:

i. To ensure that causalities received adequate attention/ to arrange additional help if required and inform relatives;

ii. To control traffic movements into the factory and ensure that alternative transport is available when need arises; and
iii. When emergency is prolonged, arrange for the relief of personnel and organise refreshments / catering facility.

- **Communication Officer**

He will, on hearing the alarm, proceed to Control Room and maintain communication with the Incident Controller. He will:

i. Advise the Site Controller of the situation, recommending (if necessary) evacuation of staff from assembly points.
ii. Recruit suitable to act as runners between the accident Controller and himself if the telephone and other system of communication fall. Also maintain contact with congregation points like Canteen etc.,
iii. Maintain prior agreed inventory in the control Room:
iv. Maintain a log of the incident on tape; and
v. In case of a prolonged emergency involving risk to outside areas by wind-blown materials- contact local meteorological office to receive early notification of changes in weather conditions.

- **Fire & Security Officer**

The Chief Fire and Security Officer will be responsible for fire fighting. On hearing the fire alarm he shall reach the fire station immediately and advise fire and security staff in the factory of the incident zone and cancel the alarm. He will also announce on PAS or convey through telephones or messengers or canteens to the Communication Officer, Incident Controller and Site Controller about the incident zone. He will open the gates nearest to the incident and stand by to direct the emergency services.

- **Telephone Operator**

On hearing the emergency alarm, he will immediately contact Site Controller and on his advice call the local fire-bridge or mutual-aid scheme members. In case the internal/external telephone system becomes inoperative, he shall inform the Communication Officer through a messenger. In case fire has been detected and the alarm is not in operation, he shall receive information about location from the person who detected the fire and thereafter immediately consult the Incident Controller and make announcement on public address system or telephone telling the staff about location of the incident and to evacuate to their assembly points. He will

continue to operate the switch board advising the callers that the staffs are not available and pass all calls connected with the incident to the Communication.

- **Departmental Heads**

The Departmental Heads will report to Incident Controller and provide assistance as required. They will decide the staff they require at the incident site.

- **FirePump Attendant**

Two persons identified in each shift will work as fire pump attendants. On hearing the fire alarm, they will immediately proceed to pump house to ensure that pumps are operating and stand by to maintain them. At the end of emergency, they will be relieved of their duty by the Fire and Security Officers.

#### 7.4.1.3 Responsibilities of Emergency Personnel outside normal working hours:

- **Site Controller**

As soon as he becomes aware of the emergency and its location, he will proceed to the scene. On arrival, he shall assess the scale of the incident and direct operations within the affected areas with the following priorities:

a. Secure the safety of persons, which may require evacuation to the assembly points in the event of escape of materials if the wind is from an adverse direction.
b. Minimize damage to plant, property and the environment.
c. Prevent spreading and damage to outside the premises.
d. Minimize loss of materials : and
e. Have regard to the need for preserving evidence that may facilitate subsequent enquiry.
f. Inform shift engineer –in-charge as to what services are/are not required.
g. Hand over charge of operations to the Incident Controller when he arrives at the site.

- **Fire & Security Officer**

On hearing the call, he shall advise the Fire & Security staff at the incident point of the factory zones. He shall cancel the fire alarm and on advise of Shift Incharge, inform the local fire brigade (or active mutual aid system where exists). He shall:

a. Announce over the PAS in which zone the incident has occurred and on the advice of the Shift Incharge informs the staff to evacuate the assembly service.
b. Inform the Shift Incharge, if there is any large escape of gas.

c. Call out in the following order:

i. Incident Controller or his nominated deputy.

ii. Engineering Manager and Service Manager.

iii. Personnel and Administrative Manager.

iv. Departmental Head in whose plant the incident occurred.

- **First Aid Teams**

The Personnel Manager shall keep the roll call lists for the Fire and First-Aid team on duty. Roll call leaders and first – aid team are appointed by each Departmental Head for his shift team. Roll call leaders shall check their rolls as members of the services and report for emergency duty. Names of unaccounted persons or absentees will be informed to the Fire and Security Officer. Members of the First-Aid teams will report to the Shift Executive Incharge/ Incident Controller on hearing the alarm and follow his directions.

- **Factory Fire Bridge Personnel**

The duty Fire Brigade personnel under the command of the Fire and Security Officer shall be responsible for fire fighting and rescue. On hearing the alarm, they shall proceed to the place of incident, if known, otherwise they will report at the fire station. The men at fire station shall find out the location of the emergency the equipment and proceed to the site of occurrence. At the site, all the squad members will respond to the directions given by the Incident Controller.

### 7.4.2 Infrastructure

**Emergency Control Room**- Emergency Control Room is to be set up and marked on the site plan. The Control Room will be the focal point case of an emergency from where the operations to handle the emergency are directed and coordinated. It will control site activities and should be furnished with external and internal telephone connections, list of essential telephone numbers, list of key persons and their addresses.

**Assembly Points**- Assembly points are to be set up farthest from the location of likely hazardous events where pre-designated persons from the works, contractors and visitors would assemble in case of emergency. Up-to-date list of pre-designated employees of various departments (shift-wise) must be available at these points so that roll call could be taken. Pre-designated persons would take charge of these points and mark presence as the people come into it.

### 7.4.3 Operational Systems During Emergency

#### *7.4.3.1 Communication System*

There are different types of alarms to differentiate one type of an emergency from other as described below:

| | |
|---|---|
| Fire or Gas | Normal Fire Siren |
| Emergency/Evacuation | High-pitched wailing Siren |

Alarms should be followed by an announcement over Public Address System (PAS). In case of failure of alarm system, communication should be by telephone operator who will make announcement in industrial complex through Public Address System which should be installed. Walkie-Talkie and paging system are very useful for communication during emergency with predetermined codes of communication. If everything fails, a messenger could be used for sending the information.

#### *7.4.3.2 Warning System & Control*

The Control Centres should be located at an area of the minimum risk or vulnerability in the premises concerned, taking into account the wind direction, areas which might be affected by fire/explosion, toxic releases, etc.

For promptness and efficiency, the factory premises/storage sites may be divided into 'X' number of zones, which should be clearly marked on the site plan.

**Emergency Services:**

1. Under this, each factory should describe the facilities of fire-fighting, first-aid and rescue. Alternate sources of power supply for operating fire pumps, communication with local bodies, fire brigade, etc. Shall be clearly indicated.
2. An adequate number of external and internal telephone connections should be installed.

A plan or plans of the works to illustrate-

a. Areas with large inventories of hazardous material.
b. Location of radio-active sources, if any.
c. Sources of safety equipment.
d. Fire-hydrant system and alternate supply sources.
e. Stock of other fire-fighting materials.
f. Assembly points, first-aid centres.
g. Surrounding habitation within 1/ 2 km distance.

h. Availability of first-aid equipment.

#### *7.4.3.3 Mutual Aid*

It is essential to have mutual aid arrangements as it is useful in cases of major fire and other emergencies. Mutual aid arrangements are to be worked out in the plan to facilitate additional help in say, fire-fighting or medical attention which might be beyond the capacity of an individual factory/unit. To make the mutual aid plan a success, the following are considered essential:

i. Written procedure which spells out how call for help will be made and how it will be responded.
ii. The type of equipment which would be used and procedure for making replacement.
iii. A quick hot-line method of communication.
iv. A brief mention of the type of hazard in each plant and fire-fighting measures.
v. Orientation and joint training program for staff.
vi. Joint inspections and drills.

### 7.4.4 Declaration of Off-Site Emergency

The person responsible for declaring the emergency (Site Controller) will assess the situation and in case its effects are likely to be felt outside the factory premises, he would get in touch with the District authorities who will at once take over the management of emergency situation and declare off-site emergency. The situation should also be immediately declared by coded Siren, which will help to inform the people in the vicinity of the industry / unit about the emergency situation. They should help to move to the safer area as prescribed in the off-site plan. The management of emergency henceforth has to be conducted by the District Crises Management Group from a Control Room under the supervision of the District Collector.

## 7.5 Hazard Control During Plant Operation

Safe operating procedures will be laid down and the personnel will be informed of the safety protocol required. Safety audit will be undertaken at least once every year. Employees will be given periodic training on various safety precautions to be followed during the operation of the plant. This training will make the workers safety conscious and make them confident to handle any type of emergency situation.

### 7.5.1 Personnel

Adequate number of personnel for various services such as security, fire, safety, medical, and communications shall be recruited. Security staff of the company will be trained to liaison with fire, safety and medical services personnel during emergencies. They will register incidents/episodes as per the existing police rules.

Fire services personnel will be able to use appropriate fire-fighting methods (water, foam etc.) Depending upon type of construction materials and chemicals involved. They will have through knowledge of location of utilities such as electrical and water supply services in the area. Fire services personnel will be responsible for the overall execution of fire fighting operations, and evacuation of public from the affected areas.

Personnel in the safety services will be responsible for the declaration of disaster. They will be responsible for the overall implementation of disaster management at site. Fully equipped ambulance will be provided for use during emergencies. Personnel in medical services will be able to immediately move the affected personnel to hospitals with adequate facilities. They will be equipped to provide medical care during transportation in ambulance.

### 7.5.2 Personnel Training

Personnel working in the plant will be aware of various safety steps needed to be followed in the event of hazards/emergencies. Periodic personnel training programs will be conducted over information of material safety, occupational health, first aid, spill containment, co-ordination with various service agencies, and accident notification protocol. Mock emergency combat exercises will be performed periodically to ensure effective personnel participation during real emergency situations.

### 7.5.3 Disaster/Emergency Management Plan

In spite of various hazard control procedures practiced at the plant, there still is possibility for certain hazards to blow up into disasters. Plant management will be equipped to handle such disasters or emergencies. A comprehensive disaster or emergency management plan with an objective to minimize exposure of people and maximize the speed of corrective action is required for any industry. Potential for hazards due to fire, explosion is significant in the proposed project.

**Objectives:**

* Assessing the dangers, which could arise on and off site as a result of foreseen emergencies & the effects that could be on the environment.
* Training of individual personnel, with duties under the plans will familiarize the onsite personnel with their roles, their equipment and details of the plans.
* Emergency plans should be based on the specific needs of each particular site for dealing with those emergencies, which may arise. These plans should be tested when first devised and thereafter to be rehearsed at suitable intervals.
* Assessing the causes, which lead to disaster. E.g., fires, spillages, release of toxic and corrosive materials etc. consequences of which should be assessed.
* Safeguarding employees, & minimizing damage to property & environment.
* Mitigation of the risks involved by preplanned remedial & rescue measures using when necessary, the combined resources of the organization concerned and the public emergency services.

Risk assessment of the unit has to be carried out for the preparation of the emergency planning.

Following are the precautions to avoid the risk involved and the emergency control measures to be taken for handling any incident, which can take place in spite of taking all precautions.

1. Adequate ventilation systems for fumes, smokes and dust will be provided.
2. Exit signs will be clearly displayed to facilitate easy and quick evacuation of personnel during emergencies.
3. Danger signs will be prominently displayed near electrical installations and other potential hazards.
4. Plant layout showing entry and exit points, fire hydrants, fire extinguisher, electrical and other hazardous installation etc. will be displayed prominently at several locations within the plant to enable personnel to effectively combat emergencies.

### 7.5.4 Fire And Explosion Hazards:

Adequate fire fighting equipment will be located throughout the plant. Description of the operation of the fire extinguisher will be clearly provided by the side of the extinguisher. Test runs will be made periodically to ensure satisfactory functioning of the equipment.

The major fire hazards can be encountered in storage houses, in plant premises, stores and during transportation.

Besides hampering productivity accidental fires cause considerable damage to lives and property. The emergency planning should identify fire hazards in buildings, plant process, machines and operating procedures before outlining measures to minimize outbreak of fires. Basic precautionary measure governing fire safety attempts is to ensure that fires do not start in the first place and if at all they start they should be restrained by quick detection and extinguishments. In spite of taking all the precautionary measures there are possibilities of catching fire which can assume enormous proportions and lead to heavy loss.

Following are the different measures adopted by the industry to avoid disasters:

1. Flame proof electrical parts to be fitted throughout the plant.
2. Automatic detection systems shall be installed which will provide visible or audible alarms at designated manned locations at the slightest risk of fire.
3. Various firefighting systems which include hydrant systems such as water sprinkler system, foam system, emulsifier system, and portable fire extinguishers for preventing and controlling fire instantly.
4. The site personnel should be trained and practiced for firefighting in order to combat the fire in actual situation.

### 7.5.5 Fire Hazards

Following are the steps necessary to regulate the ignition sources which includes –

- Storage of flammable substances in well ventilated areas.
- Process control instrumentation to prevent overheating.
- Enforcement of no smoking regulations.
- Selection and use of appropriate flame proof electrical equipment's.
- Building should be of built of non-combustible construction and subdivided into Compartments of limited size through fire resistant walls and floors.
- Prevention of accumulation of static charges.
- Regular lubrication of machinery to avoid spark generation due to friction.
- Provision of lightening arrestors.

Suitable fire fighting equipment's are provided if fire breaks out in addition to other precautionary measures.

### 7.5.6 Fire Control Plan

A detailed plan of action will be prepared. Clear lines of communication will be established between the nearest fire department and the site, and on-site staff will undergo rigorous training in fire control.

### 7.5.7 Machinery Failure

It's quite common to confront machine failures in any set up of a factory. Due to different types of machines operating during the process its quite obvious that there are failures of these machines due to power cut down, water scarcity or even due to incorrect handling or operation. In either case the safety of the personnel is the first and foremost criteria. Following are the preventive measures for the safety of the factory personnel.

1. Provision of alarm systems where by the machine can be indicated and if necessary suspend the operation process.
2. Provision of automatic lock up facilities.
3. Proper maintenance of the machines.
4. Automatic protection for the persons and plant machinery.

Due to use of some raw materials proposed to be used there are always chances of accidents, such as fire, explosion, release of toxic substances, accidental spillages etc. that can result in disaster if not controlled or managed properly. Apart from the hazards mentioned the direct consequences like inhalation of toxic substances, their contact with skin, or exposure to eyes, can also lead to severe implications to the personnel safety of the staff.

During the emergency planning many factors have to be considered such as nature and type of the hazard, their explosive potential, toxic inflammable corrosion nature and details of their handling, storage and transportation. Following measures will be taken during the emergency planning:

1) List of materials used recorded with respect to the hazardous properties of the substances.
2) A list of all the major hazards associated with the substance along with the method for their control is prepared.
3) Nature of the hazard should be identified.

### 7.5.8 Hazards Due To Explosion

Damage due to explosion hazards is far higher than that caused by fire. The violent nature of the explosion will depend on the combustion conditions. The following measures will be taken up by the plant to avoid explosion.

# Good ventilation will be ensured to prevent possible formation of explosive mixtures.
# Equipment's used are explosion proof.
# Temperature and pressure will be controlled to prevent explosions.
# Fire hazards area will be illuminated with flood lights and lighting towers if required.

### 7.5.9 Waste Spillage Control Plan

Wastes handled at the site are stabilized solid material and spent solvents which may cause problems. These will be handled under controlled conditions within the site. The most likely emergency foreseen is a major vehicle accident and spillage of solid waste from the trucks. This would require the vehicle to be unloaded into the temporary storage area so that treatment can be carried out and the vehicle cleaned and repaired before leaving the facility. Other emergencies are likely to be industrial accidents associated with the improper use of on site plant and equipment. These will be avoided to the greatest extent possible by workforce training and management supervision.

In addition to these most probable events, other emergencies like fire, explosion and similar emergencies are also possible but unlikely on-site during operations.

### 7.5.10 Safety While Handling Electricity Gadgets

All the activities related to use of electricity oriented should be handled carefully & necessary preventive measures be taken in case any accidents pertaining to electricity takes place. The necessary preventive measures include wearing of rubber soled shoes, rubber gloves to attend to the electrical repair, Switching of the line before attending the repair work, checking of the point if any electricity flow is there or not, proper earthing should be done. It should be checked by the personnel involved that no negligence should be on the part of the electricians in the repair work & the works are done in a proper fashion. The equipment & the cable must be properly isolated with suitable isolating device and identified by proper marking. Suitable isolators are installed, properly marked, locked and out point circuit should be suitably earthed. It should be ensured that suitable preventive measures are taken in case overloading takes place.

Power cables should be secured properly & must be protected from all the physical hazards and damages. Junction boxes must be protected and well supported. Proper earthing is given at places where necessary.While using transformer it should be ensured that it is placed in a well enclosed room. Regular checking of the transformer is necessary.

At the substation entry of reptiles, snakes etc should be prevented and the rubbles should be evenly spread. The checking of the quantity of the oil, leakage from the transformer, gasket or radiator tube of the transformer, installation of the extinguisher near the transformer, checking of control switches, starters, operating handles and reset handles should be free of operation, Periodic checking of terminal cables, contacts etc.

### 7.5.11 Safety Measures During Power Failure

In case supply fails due to internal problem or due to fault in supply line then:

1. At first the MOCB is tripped and the fault is detected.
2. The electrician is provided with hand gloves, goggles, safety apron etc.
3. The General Manager (Works) is informed about the rectification & the line is switched on.
4. Following are the safety equipment's provided in the control room for any emergency:
    - First Aid Box.
    - Artificial respiration chart
    - Discharge rod.
    - Hand gloves
    - Asbestos apron
    - Goggles
    - Fire extinguishers and sand buckets

### 7.5.12 Precautions While Using Electrical Appliances:

In spite of taking precautionary measures a number of accidents take place from time to time all over the world due to electrocution. The main cause behind these accidents lies in being carelessness and ignorance about the appliances using. To avoid such accidents following are the safety measures suggested:

1. Use of damaged plugs, wires, switches etc., should be avoided.
2. Do not touch the electrical appliances with screwdrivers etc., until & unless the supply is cut off.

3. Do not touch the electrical appliances with wet hands when supply is there.
4. Connecting a number of appliances is strictly objected as there is a more risk of catching fire.
5. Do not keep wires hanging or loose but fittings should be proper & safe.
6. Use of three pin plug is advised as only one point has earthing facility.
7. In ceiling fans, nuts and safety pins fitted must be checked properly.
8. Connect the supply to appliances through plugs only do not insert naked wires, matchsticks or wooden stick.
9. Defective appliances should be immediately rectified through a competent person.
10. Power supply should be cut off before attending a repair on equipment.
11. Keep heaters or room heaters away from the material which are sensitive to fire.
12. Use the appliances as long as you actually require. After the job is done switch off the supply to save the energy.
13. Fuse wire of proper size should be used.
14. Clean the dust etc., of appliances before using.
15. Do not rush to save electrocuted person without taking proper care.
16. Before touching the electrocuted person switch off the main.
17. Use rubber insulated tools and rubber hand gloves for working during supply or in its line.
18. Where there is danger caution board or HI line, please keep yourself away from the site.
19. Always prefer equipment of ISI marked.

Above mentioned precautions saves from the accidents in industry as well as at homes.

### 7.5.13 Risk & Disaster Handling Procedures

The range of services to be provided and their envisaged duties are indicated below:

1. Plant start-ups and emergency shut downs – Every operating person will be properly trained and proper instructions written down on strategic locations to ensure that plant start-up/ shut down is as per procedures.
2. As a policy, the management will entrust definite assignment of responsibility on specific functions to various departmental heads and co-ordination by one individual as chain of command who will be available round the clock either in the industry on duty or available on phone, with proper communication facility to reach the site in minimum time.
3. Medical services – details of names of Doctors and hospitals with first aid services & other medical facilities with telephone numbers will be provided.

4. Fire protection facility – full-fledged fire fighting facilities in the factory and the crew will be readily available handy at all times.
5. In order to keep employees abreast with fire fighting in the event of actual fire, the employees will be trained by mock fire exercises periodically.
6. All control instruments will be maintained in up to date conditions. Safety values and rupture discs, alarms and level indicators will be checked by dummy trails. Remote operation facility for critical valves and machines will be provided.
7. Arrangement for emergency power and plentiful water supply will be kept ready at all times.
8. Before supervisors and workers are designed to work with chemicals, they will be trained in operations and provided with literature about correct handling, possible hazards and protective equipment.
9. They shall be trained in safety procedures and be examined that they have absorbed this knowledge. Persons with a habit of adopting shortcuts or who are complacent must be disqualified.
10. Emergency procedures shall be written down and made known to each person concerned. Escape routes shall be properly marked. Information will be provided through alarms, siren with proper coding, and public address systems.
11. Monitoring of accidents, their causes and other relevant data will be recorded as per MoEF guidelines. Hazardous chemicals Rules, 1989 and discussed in floor committees/ safety committees. The management will take necessary steps, which include details of the accidents reporting to State Pollution Control Board and Inspector of Factories.
12. Information on Off site emergency plan will be furnished to the Chief Inspector of Factories for possible emergency. Facilities of telephone transport and Do's and Don'ts to be adopted must be furnished to the neighbours and District Emergency Authority.

### 7.5.14 First Aid

In case of contact with skin, remove the contaminated clothes; wash with plenty of water and report for medical treatment.

1. In case of exposure to eyes flush thoroughly with large quantities of water from the tap, spray or by inserting the head in a water container and repeatedly opening and closing of the eyes for at least 10 minutes.
2. In case of inhalation, move the affected person immediately to uncontaminated place, loosen his clothing and make him to lie down in face down position and observe breathing.

If breathing stops, apply artificial respiration and do not attempt to give anything orally to patient if he is unconscious.

**Measures**

Following are the first aid measures, which would be taken before the personnel taken to the hospital.

An Emergency control centre will be established and equipped with adequate means of communication to areas inside and outside the works. This centre will have the relevant data and equipment which will assist those manning at the centre to be well aware of the developing situation and plan accordingly.

The Emergency Control Centre will be equipped with the following data / information:

1. Safety data pertaining to the hazardous materials likely to cause emergency.
2. Procedure of major and special fire fighting, rescue operations, first aid, artificial respiration system, etc.
3. Emergency call out list of persons drafted for emergency control i.e. key personnel and notified team members, security, police and state authorities.

Following are the some of the facilities proposed at the Emergency Control Centre:

1. Intercoms
2. P & T Telephone
3. Telex & Fax facilities
4. Plant area map – big size
5. District telephone directory
6. Emergency lights
7. Wind direction and speed indicator
8. On site emergency plan manuals
9. Safety & chemical goggles
10. Helmets, Blankets, First aid box, etc

The above items shall be inspected and ensured serviceable by the concerned shift Incharge of the location on regular intervals.

Replacement of the above equipment if any damage is found shall be ensured by the shift Incharge and simultaneously put into records.

### 7.5.15 Assembly Point

In emergency it is almost certain to evacuate affected persons for inside the factory to a safer place. It is also essential to evacuate non-essential workers to streamline emergency action plan activities and ensuring safety. The evacuation will be effected after getting information from the works incident controller soon after emergency arises. On evacuation, all works staff and employees than notified members shall be assembled at the assembly point for receiving further information, etc.

A suitable location will be identified as the assembly point at the plant gate. A second alternate Assembly point will be identified in case the first identified location is not accessible due any reason.

A non-essential work staff and employees shall not leave the assembly point unless and until asked for by the competent authority.

### 7.5.16 Fire Prevention Facilities

The unit will be provided with appropriate firefighting equipment including pumps for emergency requirement. Any one or combination of the following system will protect all yards and plant.

* Hydrant system
* High velocity and Medium velocity sprinkler system.
* Water spray (Mulsifier System)
* Foam system.
* Chemical extinguishers.

**a) Hydrant System**

A ring header, hydrants and hose stations will provide general plant protection.

**b) Transformer Protection**

High velocity water spray system is proposed for the generator transformers and station transformers. Water supply for this system will be tapped off from dedicated high velocity sprinkler system with separate pumps.

**c) Fuel Protection System**

The fuel unloading area, DM plant area, cooling tower area, boiler area will be protected from fire hazard through fire hydrant system. Two Nos. of firewater pumps are envisaged, which will be installed in the pump house. One Centrifugal pump driven by electrical motor is provided for high velocity sprinkler system. One jockey pump along with hydropneumatic tank will also be installed to maintain pressure in the fire hydrant lines. In addition to above, adequate number of portable fire extinguishers will be installed at strategic locations throughout the plant.

**d) Fire Alarm System**

A fire alarm system would provide visual and audible alarms in power plant for fire detection at the incipient stage. The system would comprise manual call points located at strategic locations in areas which are normally manned, and automatic smoke & heat detectors located at important points such as cable vaults, control rooms, switchgear rooms etc. to detect fire at an early stage and provide visual and audible alarm.

**7.6 Occupational Health Centre**

Some of the following Medical Facilities would be made available at plant and some will be utilized from nearby hospital on regular long term agreement.

1. First Aid Centre
2. Qualified Medical officer (nearby hospital)
3. Compounder cum dresser
4. Ambulance van
5. First aid related medicines.
6. Sterilisers
7. Emergency oxygen systems
8. First aid injuries treatment facilities
9. Stretcher – 01 No. (Excluding available with ambulance from nearby hospital)

First aid boxes are kept in all important locations of the plant to cater the needs of the employees at the spot. All cases other than of First Aid nature should be referred to a designated hospital close from the plant. It should be a full-fledged hospital equipped with all necessary treatment facilities.

## 7.7 Off-Site Emergency Plan

### 7.7.1 Introduction

If an accident takes place in a plant and its effects are felt outside its premises, the situation thus created is called an "off-site" emergency. It no longer remains the concern of the factory management alone but also becomes a concern for the general public living outside or passing by the premises of the factory or storage site involved. To meet such situations, off-site emergency plans are to be prepared as stipulated and put into operation.

It is mandatory under Rule 16 of the Hazardous Chemical Rules for District authorities to prepare an off-site emergency plan in respect of clusters of hazardous chemical industries or at locations where accidents are likely to have an off-site adverse effect.

The off-site emergency plan should detail how emergency related to major accidents on the site will be dealt with. For preparing the plan, the concerned district authorities should consult the industries and other persons who would be concerned with its execution should such an emergency arise. The following points should be noted by all concerned in respect of an off-site emergency plan:

- The Industrial or storage units to be covered under the plan should provide all the necessary information related to industrial activities under their respective control to the concerned authorities.
- In case of any new industrial activity proposed or being set up in the area, an on-site emergency plan should be prepared before the activity is commenced
- All districts having major hazard installation should have an off-site emergency plan.
- The off-site emergency plan should be updated from time to time, especially when a new process is started or new units are established.
- The off-site emergency plan should be tested for its efficacy through mock exercises / drills.
- The persons outside the site, who may be affected by a major accident, should be informed about:
    - the nature of the major accident hazard and
    - *Safety measures to be adopted*

### 7.7.2 Responsibility for Planning an Off-Site Emergency

The planning for emergency response requires cooperation among the responders to know the persons responsible for various activities. This understanding is facilitated through personal interaction and close working in devising and updating a plan. Therefore, the pre-requisite for preparing a plan is the formation of a planning team. The possible composition of the planning team is given below:

### 7.7.3 Planning Team- Members

- Collector/Deputy Collector
- District authorities Incharge of Fire Services, Police
- Medical Services
- Factory Inspectorate
- Pollution Control Board
- Industries and
- Transport

### 7.7.4 Co-Opted Members On Need Basis

District authorities concerned

- Civil Defence
- Publicity Department
- Municipal Corporation, and
- Non- Officials such as elected representatives. MPs / MLAs and Voluntary Organization.

The District Collector or his nominated representative would be the team leader who shall conduct the planning task in a systematic manner.

### 7.7.5 Compilation of Demographic, Meteorological & Seismic Information

Details of public transport network including information of local conditions around the industry, is required for preparation of off-site plan. The information required includes public transportation network, details of road network including conditions of road, width, traffic load and connecting road with industries and the rail network are to be collected and shown on map.

- **Pipeline network**

Details of pipeline network carrying flammable and toxic materials are to be shown in the map to indicate possible impact.

- **Land use (actual and future use)**

Land use plan in the vicinity of the hazardous industries would require in depth analysis to determine the likely effect of any spill in the area.

- **Water supply**

Details of the water supply lines, water sources, water tanks, in the near by area to be marked

**a) Demographic Information**

The population of the industry as well as neighbouring areas is a key factor for this type of planning. The information to be collected in this regard is :

- neighbouring population
- housing colonies of industries
- Sensitive institutions i.e. schools, hospitals
- Type of housing
- Cattle/livestock
-

**b) Meteorological Information**

Meteorological data for a period of 10 years related to wind speed/direction, humidity and temperature inversion is essential of preparation of dispersion models for toxic gas release.

**c) Seismic Data**

Information regarding seismic zone and record of earthquake is considered to be an important input in off-site planning

### 7.7.6 Elements of Off-Site Planning

*A typical off-site emergency plan should have the following important components.*

*Plan Pre-requisite*

- Plan requirement
- Planning Team
- Hazard Analysis and Quantification
- Scenario development
- Assessment of Capabilities
-

7.7.6.1.1 Plan Development

- Incident information
- Authority for responding
- Basic Assumption
- Operation of the Plan
- Coordination with other plans
-

7.7.6.1.2 Emergency Assistance

- Names and address of the key personnel
- Telephone numbers
-

7.7.6.1.3 Response Functions

Initial Notification

- Control Room
- Access
- Direction and Control
- Communication amongst responders
- Warning System/Emergency Notification
- Public information
- Resources Mobilisation and Management
- Health and Medical Response
- Public protection including evacuation
- Fire and Rescue
- Law and Order
- On-going Incident Assessment

Besides the above, other elements of off-site planning are containment, clean up and Disposal; Documentation and Investigation: Plan Testing and Updating and Community Awareness, preparedness and Training.

For developing an off-site plan of a particular locality, the elements of relevance to the plan should be carefully selected. The elements would be based on location situations, hazards present, existence of vulnerable area in the vicinity and resource availability, etc.

The main pre-requisite of an off-site emergency plan is to define and lay down the clear cut objectives and requirements. As stated earlier, a planning team representing local industries, response agencies and other bodies should be formed. The plan should be based on a systematic hazard analysis of the units in the area and scenarios based thereon. This should be done by the units and made available for updating the plan. Resource planning has to be based on the assessment of capabilities in the area.

Plan development should clearly indicate the format to be used for reporting information related to accidents, basic assumptions in preparing the plans, plan operation and dove tailing with other plans. The plan should include the names and contact telephone numbers of persons responsible for emergency assistance. Complete detailing of the response functions is the most important part of the plan. The plan should cover details about Central Control Room, access to and from the incident area, direction and control of emergency public information, resource management, communication during emergencies, response personnel safety, on-going incident assessment, etc

Specific roles of the police, fire fighting and medical personnel should be worked out in the plan. The aspect of containment clean-up and disposal should also be covered in the plan. If it is not done properly, there could be secondary effect from the accident. Testing and updating of the plan needs lot of preparatory work in the form of training of teams, developing assessment mechanisms using observers and mobilisation of resources. The role of adjacent communities during emergencies and building community awareness dare also important aspects of the plan.

### 7.7.7 List of Hazardous Installations

*It is important to identify the hazardous units located in the area up-to-date information regarding the on-site plans prepared by each individual unit if required to be compiled for formulating the off-site plan for the area.*

### 7.7.8 Off-Site Control Room

The control of crisis during major accidents is to be exercised through a Control Room established at an easily accessible central location in the area. This Control Room should be capable of functioning on being required to be activated at any time. The Control Room for off-site plan is thus over and above the Control Room set up by each unit for its on-site plan. The Control Room shall:

i) Act as a focal point of emergency management.
ii) Keep records of all messages.
iii) Inform Operation Officer on receipt of first information relating to accident.
iv) Monitor implementation of mutual aid.
v) Serve as the focal point for meeting of the Crisis Management Group (CMG).

In order to operate the Control Room round the clock, manpower and transport are required on a shift basis. The Control room should be equipped with proper communication system, data processing network and should be a storehouse of information to combat emergencies.

### 7.7.9 Key Personnel and Their Duties

The ultimate responsibility for the management of the major emergencies rests on the District Magistrate/ Collector.

He will be assisted by representatives from all concerned organisations, departments and services at the district level. This group of officials forms the **District Crisis Management Group (CMG).** The members of the group may vary according to the District and local conditions. The CMG will:

a) Control all emergency operations
b) Guide on matters related to policy issues
c) Provide official information and instructions to the general public.

An **operation response Group (ORG)** will have to be put up to implement the directions of the CMG. The duties of the ORG are as under:

a) To develop an integrated response strategy based on the available information.
b) To plan deployment of field units to ensure the availability of appropriate force to deal with the situation.
c) To coordinate the functioning of the various agencies.
d) To deal with crisis and implement decisions of CMG.
e) To monitor the progress till the crisis ends and keep the CMG posted with the development.

### 7.7.10 Communication Systems Network

An efficient and reliable Communication System is required for the success of the off-site emergency plan. The efficient communication system is required to alert:

a) Off-site Emergency Authorities and Services.
b) Neighbouring factories in the area and public in the vulnerable zone.

A communication network of the following type maybe helpful:

i) Radio communication between Control Room to Unit Control Rooms of the Industrial Unit and respondents outside the area.
ii) Hotlines between Control Room to industrial units, Emergency Services, Meteorological Station and the Media.
iii) P&T Telephone Lines.
iv) Data Processing Network hooked to all Computers/ PCs.

A communication flow chart is to be prepared and kept in the Control Room. An up-to-date Telephone Directory of key personnel concerned with the emergency should be available at all times.

In coordinating the communication system efficiently, there should be a Communication Officer in Control Room to ensure that all the modes of communication are functional round the-clock. All communication operators should maintain a Log-book for the messages received in/out and actions taken. These activities should be incorporated in the data processing.

### 7.7.11 Warning System

In an Off-site Management Plan, one of the most important pre-requisites is a good 'Warning System'. Efficient Warning System will save lives, prevent injuries and reduce losses. Emergency Commander will decide the appropriate Warning System and implement it. The Commissioner of Police will be responsible for implementation of the Warning System.

The Warning Systems are of the following types:

a) **Disaster Warning :**

(Maximum Credible Loss Scenario) High Pitched Continuous Wailing Siren.

b) **Fire/Toxic Release :**

Long Siren followed by short Siren

c) **All Clear**

Long Continuous

Depending upon the nature of hazards and the area affected, other methods of warning may be used as follows:

a) Out-Door Warning Sirens
b) Public Address System with Police.
c) ARP Sirens.
d) Mass Media.
e) Door to door visit by civil Defense Personnel
f) Telephonic contact with schools and other organizations/ public Institutions.
g) Information to be provided at common gathering places such as Canteens, Shops, etc

### 7.7.12 Public Information System

During a crisis following an accident, the people of the area and large number of media representatives would like to know about the situation from time to time and the response of the district authority to the crisis. It is important to give timely information to the public in order to prevent panic and rumour mongering. The emergency public information could be carried out in three phases.

a) **Before the Crisis**

This will include the safety procedure to be followed during an emergency through posters, talks and mass media in different languages including local languages. Leaflets containing do's/ don'ts should be circulated to educate the people in the vicinity.

b) **During the Crisis**

Dissemination of information about the nature of the incidents, actions taken and instructions to the public about protective measures to be taken, evacuation etc, are the important steps during this phase.

c) **After the Crisis**

Attention should be focused on information concerning restoration of essential services, travel restrictions etc.,

Various tasks of the public information system could include:

a) Quick dissemination of emergency instructions to the public.
b) To receive all calls from media/public regarding emergency situations and respond meticulously.
c) Obtain current information from the Central control Room.
d) Prepare news release.
e) Brief visitors/media.
f) Maintain contact with hospital and get information about the causalities.

### 7.7.13 Fire Fighting System

The industrial areas having major accident-prone hazardous installations should have special fire fighting arrangements. In order to tackle great risk of fire explosion, spillage of hazardous liquid or release of toxic gases, there is need for constant preparedness to mobilise all available fire fighting and toxicity control resources in minimum time. There should be an inside control of all fire-fighting resources in the affected areas under the overall charge of Chief Fire Officer. The operational response will be coordinated from the Central Control Room. The planning for fire fighting should be as follows:

**a) Before the Crisis**

- Proper road and means of escape should be identified.
- Considering the possible hazards, there must be adequate water supply.
- Training of the personnel in fire fighting duties in the industry.
- Provision of adequate and proper arrangement of the fighting vehicles is important.

**b) During the Crisis**

Immediate response to an emergency should be coordinated by the Control Room by matching all the resources, in a major emergency having wide off-site implications more than one industry would be affected necessitating concurrent fire fighting operations at a number of places. In this case, the whole area may be divided in different fire zones. The task of the fire zone commanders should be as under:

- Command and control of all fire fighting resources in the respective fire zones.

- Deployment of additional fire resources allocated by Control Room.
- Coordination of fire fighting institutes.

### 7.7.14 Mutual Aid

All the industrial units in the affected areas should have mutual aid arrangement for getting/extending help in fire fighting facilities, special fire fighting agents, trained manpower, etc. The Control Room will allocate additional resources to fire zone including protective equipments kept centrally as a pool

## 7.8 Services Support System

### 7.8.1 Health & Medical

A major off-site emergency in an area may affect a number of units and the surrounding colonies resulting in more casualties. The medical response plan had to cater for immediate pooling of all available medical resources and provide emergency medical treatment to the victims of the incident. A coordinated utilisation of all available local medical resources in the incident areas as well as the additional resources should be mobilised under the overall charge of the District Health Department. The operational response should be coordinated by the Chief Medical Officer from the Control Room. Before the crisis, the following actions should be carried out:

- Specialised training of doctors relating to chemicals hazards.
- Blood grouping of all employees working in the industrial unit.
- Maintenance of list of blood donors group wise.
- Arrangement of adequate buffer stock of essential medicines.
- Stocking of anti-dotes and special medicines for hazardous substances.
- Planning of additional capacity in the base hospital for large-scale casualties.

During the crisis, medical plan in terms of manpower, transport and equipment as per organisational response be implemented. The organisational response structure should be set up as under:

- First-aid Post
- Casualty Response Centre
- Base Hospital

It is essential to guide medical relief and establish public health measures like sanitation, immunisation, etc. In the absence of proper information about the chemical exposure, their symptoms, first-aid and treatment, the physicians attending such emergencies are generally faced with great problems.

### 7.8.2 Transportation

A large number of ambulances would be necessary to transport casualties to the casualty response centre and base hospital. For this purpose, jeeps/ matadors/ special wagons which can be converted as ambulance at short notice should be kept at the unit and the Control Room.

### 7.8.3 Security and Police

Security, protection of life & property and traffic control & maintenance of law and order are the traditional and statutory functions of the police. During an emergency duties and responsibilities of the police may be:

a) Cordoning of the incident area
b) Warning public about the hazards
c) Traffic Control
d) Assist fire fighting services
e) Assist first-aid medical teams
f) Assist evacuation and ensure protection of property in evacuated areas.

Control of security operations in the area should be exercised by the Deputy Commissioner of Police. Different phases of emergency management practices would be as under:

a) **Before the Crisis**

Contingency plan of manpower, transport and communication network to coordinate possible incident areas and to regulate traffic should be made for each industry in the area.

b) **During the Crisis**

The Security Commander of the area will set in motion the relevant contingency plan to control the operation.

c) **After the Crisis**

Protect property in the evacuated area.

d) **Media**

The Control Room should release an up-to-date information to the media.

### 7.8.4 Evacuation Including Safe Evacuation Areas

In a disaster situation evacuation is the movement of people from the place of danger to places of relative safety. It is most effective action to protect people. A comprehensive and coordinated planning is necessary to implement orderly evacuation of population.

The process of evacuation should be based on the nature of threat, possibility of spreading of toxic gases and weather conditions. In this case, the hazard analysis in maximum credible loss scenario would help in planning of evacuation. The people of the area should be advised to leave the threatened area and to take shelter in the nearest reception centres. The whole process requires to be completed within quickest possible time. The command and control of the evacuation should be under the supervision of the District Development Officer. The evacuation process should be carried out in three phases.

**a) Before the Crisis**

Contingency plan of manpower, transport and communication network to coordinate possible incident areas and to regulate traffic should be made for each industry in the area.

**b) During the Crisis**

The Security Commander of the area will set in motion the relevant contingency plan to control the operation.

**c) After the Crisis**

Protect property in the evacuated area.

**d) Media**

The Control Room should release an up-to-date information to the media.

### 7.8.5 Relief to the Victims

Post emergency activities include the relief to the victims. The Public Liability Insurance Act (PLI Act), 1991 provides for the owner who has control over handling hazardous substances to pay specified amount of money to the victims as interim relief by taking insurance policy for this purpose. The District Collector has definite role in implementation of the PLI act, 1991. After proper assessment of the incident, he may invite applications for relief, conduct an enquiry into the claims and arrange payment of the relief amount to the victims.

### 7.8.6 Checklist for Capability Assessment

The checklist will help in assessing the preparedness, prevention and response resources capabilities. The points included in the checklist are only indicative and the planner should closely examine the local requirements while preparing the checklist.

## 7.9 Testing & Updating Of the On-Site/Off-Site Emergency Plan

### 7.9.1 Introduction

An emergency response plan both on-site/off-site is required to be tested for its validity, refinement and updating. The plan should also be evaluated to ensure its efficiency during emergency.

### 7.9.2 Testing Of the Plan

Objectives for testing the plan are given below:

- To familiarise emergency response personnel with their roles and duties to be performed.
- To ensure efficacy of the emergency response mechanism.
- To check coordination of reactions and response of emergency services.
- To gain experience and confidence.

### 7.9.3 Types of Exercises to Be Performed

- A full scale mock-drill exercise should be conducted both by the individual industry as well as the District authorities to handle the situation efficiently.
- A functional exercise is required to assess the capability of individual or multiple activities.

- Frequent meetings/discussions are required among the representatives of the industries, various departments and district authorities to discuss the plan and remove confusion, if any.

### 7.9.4 Responsibility, Frequency, Procedure for Evaluation

The Site Controller/Incident Controller is responsible for evaluating the effectiveness of the on-site emergency plan in an industry. Collector/ District Magistrate is responsible to evaluate the effectiveness of the off-site plan both for industrial and transportation accidents, Each industry should conduct the on-site emergency mock-drill at an interval of six months. The District authority may carry out the off-site drill yearly. Experts from the relevant fields and the representatives from the public should be invited to observe the mock drill in order to know their response and opinion. The recommendations following the discussions will help to identify the loopholes in the plan and response capability of the organisation. Such periodic recommendations of the mock drill should be kept in order to update the plan.

The Site Controller/Incident Controller in an industry should be responsible to update their on-site emergency plan regularly. The District authority should designate an officer to ensure that the plan is updated regularly to disseminate the information of changes to all plan holders. A regular review of plan, at least once in a year, should be carried out to replace outdated information or to incorporate the results of mock-drills. The data processing unit of the Control Room should be updated regularly as above and data be readjusted/modified as necessary.

### 7.9.5 Accident Reporting

According to Hazardous Chemicals (Management & Handling) Rules of 1989 promulgated by the Government of India, it is mandatory for the management to:

- Identify major accidents and hazards and outline steps to be taken to prevent such accidents.
- Notify state pollution control board and the inspectorate of factories in the event of any accident.
- Submit a safety report to state pollution control board and inspectorate of factories at least three months before the commencement of commercial production.

Protocol for accident reporting will be adopted to ensure compliance with the above said rules. Each and every accident, however small it may be, will be reported and investigated. Accident report will contain a detailed description of the incident and identify immediate cause. Accident

report will also incorporate information on steps take to prevent the said accident, impact of the accident on the environment, and cost estimate of loss incurred.

## 7.10 Occupational Health & Safety

The occupational health and safety issues that may occur during the construction and operation of proposed project are discussed in this section.

### 7.10.1 Construction Phase

Construction work is dynamic, diverse, and constantly changing. This poses a great challenge in protecting the health and safety of construction workers.

Construction workers are at risk of exposure to various health hazards that can result in injury, illness, disability, or even death. Factors increasing the health risk of construction workers include:

i. Constantly changing job site environments and conditions
ii. Multiple contractors and subcontractors
iii. High turnover; unskilled laborers
iv. Constantly changing relationships with other work groups
v. Diversity of work activities occurring simultaneously
vi. Exposures to health hazards resulting from own work as well as from nearby activities ("bystanders exposure")

Health hazards are generally grouped as 1) Chemical 2) Physical 3) Biological 4) Ergonomic 5) Multiple Hazards.

Ergonomic hazards are the most frequently occurring health hazards in construction and the cause of most injuries. Major construction health hazards are given in **Table 7.7**

**Table 7.7**

**Major Construction Health Hazards**

| Occupations | Potential health hazards |
|---|---|
| Brick masons | Cement dermatitis, awkward postures, heavy loads |
| Drywall installers | Plaster dust, heavy loads, awkward postures |
| Electricians | Heavy metals in solder fumes, awkward posture, heavy loads, asbestos |
| Painters | Solvent vapours, toxic metals in pigments, paints additives |
| Pipe fitters | Lead fumes and particles, welding fumes, asbestos dust |
| Carpet layers | Knee trauma, awkward postures, glue and glue vapour |
| Insulation workers | Asbestos, Synthetic fibers, awkward postures |
| Roofers | Roofing tar, heat |
| Carpenters | Noise, awkward postures, repetitive motion |
| Drillers, earth, rock | Silica dust, whole-body vibration, noise |
| Excavating and loading machine operators | Silica dust, histoplasmosis, whole-body vibration, heat stress, noise |
| Hazardous waste workers | Heat Stress, toxic chemicals |

#### *7.10.1.1 Chemical hazards:*

Chemicals can exist in the form of Dusts, Fumes, Fibers (Solids), Liquids, mists, Gases, Vapours Chemicals are found in variety of products used at construction sites. Workers may also be exposed to chemicals generated during construction activities. Some of the chemical hazards found in construction work are a) Asbestos b) Lead c) Silica d) Cadmium e) Carbon monoxide f) Welding fumes g) Spray paints h) Cutting oil mists i) Solvents j) Hexavalent chromium. Chemicals can enter the body through the inhalation, ingestion, absorption.

- **Inhalation**: Breathed in Inhalation is typically the most common way chemicals can enter the body in a work situation
- **Ingestion**: Accidental swallowing through eating, drinking, or smoking
- **Absorption**: Absorbed through contact with skin or eyes.

Injection, in which a chemical enters the body when the skin is punctured, occurs rarely (e.g., paint from a high-pressure spray gun).Two types (acute and chronic) of health effects from chemical exposure as given in **Table 7.8**

**Table 7.8**

**Types of health effects due to chemical exposure**

| Type | Health Effects | Exposure | Example |
|---|---|---|---|
| Acute | Appears immediately or within short time following exposure, (minutes or hours); death possible from some hazardous substances | Typically sudden, short-term, high concentration | Headache, Collapse or death from high levels of carbon monoxide |
| Chronic | Usually develops slowly, as long as 15-20 years or more | Continued or repeated for a prolonged period, usually years | Lung cancer from exposure to asbestos |

Note: Some chemicals can have both acute and chronic effects, eg: Carbon Monoxide

#### *7.10.1.2 Physical Hazards*

Physical hazards are different types of energy which may be hazardous to workers. They include:

a. Noise
b. Vibration
c. Temperature extremes
d. Radiation

#### *7.10.1.3 Biological Hazards*

Diseases or illnesses can occur from biological sources:

a. Microorganisms
   - (e.g., bacteria, Viruses, Fungi, Molds)West Nile Virus
   - Lyme Disease
   - Histoplasmosis (fungus in bird droppings)
   - Hantavirus

b. Plant Toxins -
   - Poison oak & Sumac
   - Stinging nettles

Some of these diseases are minor infections and others can be serious or deadly.

#### *7.10.1.4 Ergonomic Hazards*

Ergonomic hazards can cause painful and disabling injuries to joints and muscles. They can occur from:

a. Heavy, Frequent, or awkward lifting
b. Repetitive tasks
c. Awkward grips, postures
d. Using excessive force, over execution
e. Using wrong tools for the job or using tools improperly
f. Using improperly maintained tools
g. Hand-intensive work

Ergonomic hazards are the most frequently occurring health hazards in construction and the cause of most injuries. Also can lead to musculoskeletal disorders (MSDs) and injuries like: Strains and sprains (One of the most common injuries among construction workers), Tendonitis Carpal tunnel syndrome Low back pain, Fatigue

#### *7.10.1.5 Multiple Hazards*

In some cases, workers can be exposed to several health hazards at the same time or on the same worksite over time.

#### *7.10.1.6 Safety Measures*

Construction sites are having many types of hazards due to complexity of the work environment. Even after the implementation of the safety requirements through engineering means during design, there would be always residual risk to worker. Thus, as a good safety culture, all workers will be ensured to use the required PPE. At times some workers may feel some inconvenience in using the PPE, but we will scrupulously enforce the use of PPE right from day one and each worker should be made to consider these as last defence in depth to save his life. Broadly these are Safety helmets, Safety Belts, Safety Shoes, Hand Gloves, goggles, fall arrester etc. Personal Protective Equipment (PPE) will be made available near the work spot for ease of use by safety workers.

In order to ensure proper coordination and communication on safety aspects on a periodical basis, it is necessary to have regular exchange of views and experience as given below:

- Daily interaction between Contractors safety Officer and departmental Safety in charge.

- Monthly Safety meetings by each Works Manager of the contractor along with his Safety Officer with departmental Safety Group.
- Sectional Safety meetings for the departmental and Contractor employees.
- Quarterly Project level Apex Safety Committee meeting
- Regular experience feedback among various agencies.

### 7.10.2 During Operational Phase

The most significant occupational health and safety hazards occur during the operational phase of a proposed project primarily include:

- Process Safety
- Chemical Hazard
- Fire and explosion hazards
- Gaseous cylinders handling

#### *7.10.2.1 Process Safety*

Process Safety programs will be implemented, due to industry specific characteristics, including complex chemistry reactions, use of hazardous materials (e.g. toxic, reactive flammable or explosive compounds) and multi-step organic synthesis reactions are conducted.

**Process safety management includes the following action.**

- Physical hazard testing of materials and reactions
- Hazard analysis studies to review the process chemistry and engineering practices, Including thermodynamics and kinetics
- Examination of preventive maintenance and mechanical integrity of the process equipment and utilities
- Worker training
- Development of operating instructions and emergency response procedures.

#### *7.10.2.2 Chemical Hazards*

Toxic chemicals in the proposed project include solvents, acids, alkalies, etc. Threshold values associated with specific health effects can be found internationally published exposure guidelines / material safety data sheets (MSDS). The MSDS sheets of the respective chemicals

used at various locations will be kept at respective locations for immediate reference purposes in addition at the stores and EHS department.

Recommendations to prevent and control the exposures include the following:

- Installation of gas detectors in hazard areas, where ever possible
- Regular cleaning of spills on the floors.

#### *7.10.2.3 Fire and Explosions*

Common causes of fire and explosions in the proposed project include:

- Fires and explosions due to accidental release of gases / solvents in the premises.
- Fires of products or dust contaminated with oil or other combustible materials in the presence of a heat source.

**Recommendations to prevent and control of fire and explosion hazards:**

- Install leak detection units and other devices (alarm detection systems, such as automatic pH monitoring) to detect release early;
- Segregate process areas, storage areas, utility areas, and safe areas and adopting of safety distances or by safety walls / dykes
- Limit the inventory which may be released through isolation of large inventories from facility operations, and isolation and blow down pressurized flammable gases inventories.
- Remove potential ignition sources;
- Remove or dilute the release and limiting the area affected by the loss of containment.
- Using flame proof material and lighting equipment

#### *7.10.2.4 Gaseous Cylinders Storage*

The potential for toxic releases in handling and storage of gaseous cylinders should be minimized by adopting the following measures.

- Implement and maintain a specific Emergency Management Plan providing guidance on emergency measures to protect both operators and local communities in the event of Gas release.

**Recommendations to prevent hazards**

- Good ventilation will be provided in storage area.
- Safe practices of handling of chemicals will be practiced in the complex
- Training will be provided in handling emergency situations (fire control, accidents, etc), by conducting mock drills
- Medical checkup of all employees will be carried on regular intervals as per the government guidelines.
- Helmets, hand gloves, goggles and gum boots will be provided in all working areas.
- Air masks with carbon filters, Ear muffs in high noise areas. Self-contained breathing apparatus for all confined space entries.
- Air suits for handling of corrosive chemicals etc.
- A sufficient green belt will be developed surrounding the production blocks and around the industrial estate.
- Open fire & smoking will be prohibited
- Flame proof electrical systems and with isolated distribution system will be provided
- Firefighting equipments will be arranged at strategic locations.
- Drinking water and canteen facilities are extended to all employees

### 7.10.3 *Community Health and Safety*

The most significant community health and safety hazards during the operation of proposed project relate to:

- Management, storage and transportation of hazardous products with potential for accidental leaks/releases of toxic and flammable gases:
- Disposal of wastes (off-spec products, sludge)
- Plant design and operations should include safe guards to minimize and control hazards to the community, including the following measures:
- Identify reasonable design leak cases:
- Assess the effects of potential leaks on surrounding areas, including ground water and soil pollution:
- Assess potential risks arising from hazardous material transportation and select the most appropriate transport routes to minimize risks to communities and third parties;
- Select plant location with respect to the inhabited areas, meteorological conditions (e.g., prevailing wind directions), and water resources (e.g., groundwater vulnerability)

identify sage distances between the plant area, especially the storage tank farms and the community areas;

- identify prevention and mitigation measures required to avoid or minimize community hazards;
- Develop an Emergency Management Plan with the participation of local authorities and potentially affected communities.

### 7.10.4 Prevention Of Occupational Diseases

The various measures for the prevention of occupational diseases are grouped under three heads viz. medical, engineering and statutory or legislative.

#### *7.10.4.1 Medical Measures*

7.10.4.1.1 Pre-Placement Examination

Pre-placement examination is the foundation of an efficient occupational health service. It is done at the time of employment and includes the worker's medical, family. occupational and social history; a thorough physical examination and a battery of biological and radiological examinations, e.g., chest x-ray, electro-cardiogram, vision testing, urine and blood examination, special tests for endemic disease. A fresh recruit may either be totally rejected or given a job suited to his physical and mental abilities.

The purpose of Pre-placement examination is to place the right man in the right job. So that the worker can /perform his duties efficiently without detriment to his / health. This is ergonomics. The following is a list of some/occupations in which it is risky to employ men suffering from certain-diseases.

**Table 7.9**

**Occupations which it is risky to employ men suffering from certain diseases**

| HAZARD | UNDESIRABLE CONDITIONS |
|---|---|
| Lead | Anaemia, hypertension, nephritis, peptie ulcer. |
| Solvents | Liver function tests and kidney disease, dermatitis, alcoholism |
| Radium and X-Rays | Signs of ill-health, especially any blood diseases |

Pre-placement examination will also serve as a useful bench-mark for future comparison. It may be mentioned that in most countries, many workers start employment without the benefit of a pre- employment medical examination. This is particularly true of workers in small-scale

industries and mines and those engaged In construction and agricultural work in the developing countries.

7.10.4.1.2 Periodical Examination

Many diseases of occupational origin require months or even years for their development. Their slow development, very often, leads to their non-recognition in the early stages and this is harmful to the worker. This is the reason why a periodical medical check-up of workers is very necessary when they handle toxic or poisonous substances.

The frequency and content of periodical medical examinations will depend upon the type of occupational exposure. Ordinarily workers are examined once a year. But In certain occupational exposures (e,g., solvents, hazardous chemicals, etc) monthly examinations are Indicated. Sometimes, even dally examinations may be needed such as when Irritant chemicals like dichromates are handled. The periodical examinations may be supplemented, where necessary by biological and radiological examinations. Particular care should be given to workers returning from medical leave, to assess the nature and degree of any disability and to assess suitability or otherwise of returning to the same job.

7.10.4.1.3 Medical and Health Care Services

The medical care of occupational diseases is a basic function of an occupational health service. In India, the Employees State Insurance Scheme provides medical care not only for the worker but also his family. Within the factory, first aid services will be made available. Properly applied first aid will reduce suffering and disability and hasten recovery. Immunization is another accepted function of an occupational health service.

7.10.4.1.4 Notification

National Laws and Regulations (Factories Act, 1976; Mines Act, 1952; Dock Laborers Act, 1948; etc.) require the notification of cases and suspected cases of occupational disease. In the Factories Act, a list of 22 diseases is included while in the Mines Act 3 diseases and in the Dock Regulations 8 diseases are listed. These diseases are recognized internationally for the purpose of workmen's compensation. The main purpose of notification in Industry is to initiate measures for prevention and protection and ensuring their effective application; and to investigate the working conditions and other circumstances which have caused or suspected ' to have caused occupational diseases.

7.10.4.1.5 *Supervision of Working Environment*

Periodic inspection of working environment provides Information of primary importance in the prevention of occupational disabilities. The physician should pay frequent visits to the factory in order to acquaint himself with the various aspects of the working environment such as temperature, lighting, ventilation, humidity, noise, cubic space, air pollution and sanitation which have an important bearing on the health and welfare of the workers. He should be acquainted with the raw materials, processes and products manufactured. He should also study the various aspects of occupational physiology such as occurrence of fatigue, night-work, shift-work, weight carried by the workers and render advice to the factory management on all matters connected with the health and welfare of the workers. For studies of this kind the physician should enlist the cooperation of safety engineers. Industrial hygienists and psychologists.

7.10.4.1.6 Maintenance and Analysis of Records

Proper records are essential for the planning, development and efficient operation of an occupational health service. The worker's health record and occupational disability record will be maintained. Their compilation and review will enable the service to watch over the health of the workers, to assess the hazards Inherent in certain types of work and to devise or improve preventive measures.

7.10.4.1.7 Health Education & Counselling

Ideally, health education will start before the worker enters the factory. All the risks Involved In the industry in which he Is employed and the measures to be taken for personal protection would be explained to him. The correct use of protective devices like masks and gloves will be explained. Simple rules of hygiene such as hand washing, paring the nails, bodily cleanliness and cleanliness of clothes, should be impressed upon him. He will be frequently reminded about the dangers in Industry through the media of health education such as charts, posters and hand bills. The purpose of health education is to assist the worker in his process of adjustment to the working, home and community environment.

### 7.10.5 Engineering Measures

#### *7.10.5.1 Design Of Building*

Measures for the prevention of occupational diseases will commence in the blue-print stage. The type of floor, walls, height, celling, roof, doors and windows, cubic space, are all matters will receive attention in the original plan of the building which is put up by the industrial

architect. Once the building is constructed, It would be difficult to introduce alterations without' much trouble and expense.

#### *7.10.5.2 Good Housekeeping*

Good housekeeping is a term often applied to industry and means much the same as when used domestically. It covers general cleanliness, ventilation, lighting, washing, food arrangements and general maintenance. Good house-keeping is a fundamental requirement for the control or elimination of occupational hazards. It also contributes to efficiency and morale in industry. The walls, ceilings, and passages should be white washed at least once a year. The dust which settles down on the floor, ledges, beams, machinery and other stationery objects should be promptly removed by vacuum cleaners or by wetting agents. Masks, gloves, aprons and other protective equipment should be kept clean and in a state of good repair. To prevent accidents, the right thing should be in the right place. Not only the inside, but the outside of the plant should also be kept clean and tidy.

#### *7.10.5.3 General Ventilation*

Good general ventilation will be provided. It would be recommended that in every room of a factory ventilating openings shall be provided in the proportion of 5 sq. feet for each worker employed in such room, and the openings shall be such as to admit of a continued supply of fresh air. In rooms where dust is generated an efficient exhaust ventilation system will be provided. Good, general ventilation decreases the air-borne hazards, to the workers, especially hazards from dusts and gases. The Indian Factories Act has prescribed a minimum of 500 c. ft. of air space for each worker.

#### *7.10.5.4 Mechanization*

The plant will be mechanized to the fullest possible extent to reduce the hazard of contact with harmful substances. Dermatitis can be prevented if hand-mixing is replaced by mechanical devices. Solvents / Acids from one place to another can be conveyed through pipes. There may be other similar situations where mechanization can be substituted to hand-operation.

#### *7.10.5.5 Substitution*

By substitution is meant the replacement of a harmful material by a harmless one or one of lesser toxicity A classical example is the substitution of white phosphorus by phosphorus sequin I sulphide in the match Industry, which resulted in the elimination of necrosis of jaw (Phossy jaw). Zinc or Iron paints can be used in the place of harmful lead paints; silver salts can be used

in the place of mercury salts; acetone can be used in the place of benzene. But substitution is not always possible in industry. Where possible, it should be used to the fullest possible extent.

#### *7.10.5.6* Dusts

Dusts can be controlled at the point of origin by water sprays, e.g., wet drilling of rock. Inclusion of a little moisture in the materials will make the processes of grinding, sieving and mixing comparatively dust-free. In the lead industry, the Bombay Factory Rules 1950 enjoin that the floor and work benches be kept wet when the work is progressing. Wet methods should by tried to combat dust before more elaborate and expensive methods are adopted.

#### 7.10.5.7 Enclosure

Enclosing the harmful materials and processes will prevent the escape of dust and fumes into the factory atmosphere. For example, grinding machinery can be completely, enclosed. Such enclosed units are generally combined with exhaust ventilation.

#### 7.10.5.8 Isolation

Sometimes it may be necessary to isolate the offensive process in a separate building so that workers not directly connected with the operation are not exposed to the hazard. Isolation may not be only in space, but also in the fourth dimension of time. Certain operations can be done at night in the absence of the usual staff.

#### 7.10.5.9 Local Exhaust Ventilation

By providing local exhaust ventilation dusts, fumes and other injurious substances can be trapped and extracted "at source" before they escape into the factory atmosphere. The heart of the local exhaust ventilation is the hood which is placed as near as possible to the point or origin of the dust or fume or other impurity. Dusts, gases and fumes are drawn into the hood by suction and are conveyed through ducts into collecting units. In this way, the breathing zone of workers may be kept free of dangerous dust of poisonous fumes.

#### 7.10.5.10 Protective Devices

Respirators and gas masks are among (he oldest devices used to protect workers against air-borne contaminates and they are still used for that purpose. There are two classes of respirators: (i) those which remove contaminants from air, (ii) those to which fresh air is supplied. The workers should know what kinds to use, and when and how to use. Respiratory devices should not be used as substitute for other control methods. The other protective devices comprise ear plugs, ear muffs, helmets, safety shoes, aprons, gloves, gum boots, barrier

creams, screens and goggles. The worker should be instructed in the correct use of protective devices.

#### 7.10.5.11 Environmental Monitoring

An important aspect of occupational health programme is environmental monitoring. It is concerned with periodical environmental surveys, especially sampling the factory atmosphere to determine whether the dusts and gases escaping into the atmosphere are within the limits of permissible concentration. The use of "permissible limits" has played an important part in reducing occupational exposure to toxic substances. Thermal environment, ventilation, lighting, would also have to be monitored. Such monitoring should be done by joint collaboration of doctors and engineers.

#### 7.10.5.12 Statistical Monitoring

Statistical monitoring comprises the review at regular intervals of collected data on the health and environmental exposure of occupational groups. The main objective of these reviews' is to evaluate the adequacy of preventive measures and occupational health criteria, including permissible exposure levels.

#### 7.10.5.13 Research

Research in occupational health affords fertile ground for study which can provide a better understanding of the industrial health problems. There are two kinds of research — pure research and research for the improvement of, or in connection with a manufactured product. Both are important. Study of the permissible limits of exposure to dust and toxic fumes, occupational cancer, accident prevention, industrial fatigue and vocational psychology are some aspects of research in occupational health.

### 7.11 Legislation

Society has an obligation to protect the health of the worker engaged in diverse occupations. It has grown out of the realization that the worker is more important than the machine which he operates. The worker cannot be permitted to endanger his life and limb in an occupation, while the employer makes a fortune. Factory laws, therefore, have been framed In every country to govern the conditions In industry and to safeguard the health and welfare of the worker. The most important factory laws in India today are:

(1) The Factories (Amendment) Act, 1976.

(2) The Employees' State Insurance (Amendment) Act, 1975.

There are other specialized Acts adapted to the particular circumstances of the Industry, e.g.. The Mines Act, The Plantation Act, The Minimum Wages Act, The Maternity Benefit Act, etc. All these Acts lay down certain standards to which the employer must comply to ensure health and safety to workers.

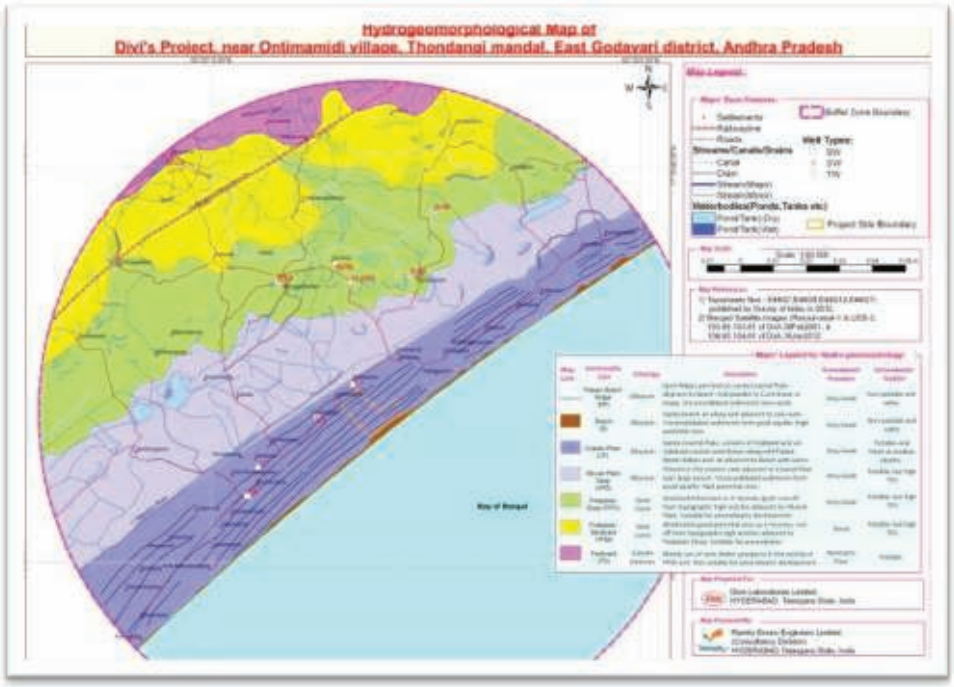
## 7.12 Hydrological and Geo-Hydrological Conditions of the Project Area

Divi's Laboratories Limited is proposing to establish Unit –IV as a commercial facility for manufacturing of APIs & intermediate products. This manufacturing facility is going to be located at Ontimamidi, Thondangi (M), East Godavari district at Andhra Pradesh. In order to assess the likely impacts from this facility on soils, ground water & surface water environs studies were conducted by focusing the Hydrogeolgical conditions in and around the project site. The details of the study are presented below.

### 7.12.1 Geomorphology

Proposed site area lies near the sea coast of Bay of Bengal. The site area is marked with undulating plains covered with Coastal Sandy Soils. Study area comprise of Eastern Ghats in North & is thickly wooded, slight upland plains with scattered hills in the central part also found in southern & Eastern parts .The altitudes of land surface vary from 27m above in west to sea level in the east. The major landforms in study area are marine origin. The marine landforms including palaeo beach ridges, paleotidal flats, active beach and spit. The general drainage pattern of the study area is dendritic to sub dendritic. The detailed Hydro-Geomorphological map is given in **Figure 7.2**.

**Figure 7.2**
**Hydro-Geomorphological map**

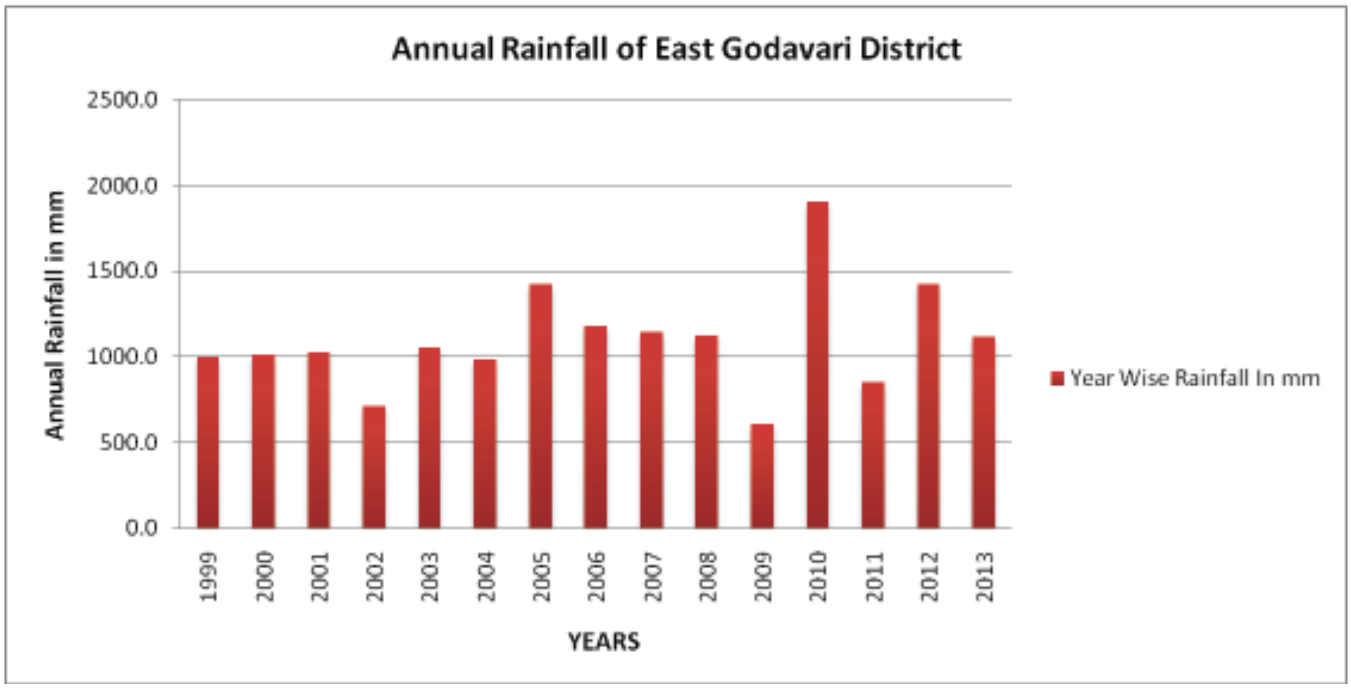



### 7.12.2 Rainfall & Climate

The climate of the district is hot subtropical with very hot summer. The average annual rainfall in the district is 1118 mm. which ranges between nill rainfall in January and 235 mm in July. July and October are the wettest months of the year. Annual rainfall of past 15years given in **Figure 2.**December is the coldest months with normal mean maximum temperature of about $27^0$ c and mean minimum temperature of $19^0$ c. Temperature begins to rise after February, May is the hottest month with mean daily maximum temperature of about $37^0$ c a mean daily minimum temperature is $29^0$ c. The relative humidity is generally high throughout the year & is of the order of 80% in the mooring & 75% in the evening. The wind speed in the district is generally light to moderate throughout the year.

**Figure7.3**

**Annual Rainfall of East Godavari District**




### 7.12.3 Surface Soils

The predominate soil types are observed in the study area are Red clayey soil & coastal sandy soil. Red clayey soil with sandy loam to clayey loam in texture and it occurs around Tondangi, Paidiagraharam, and Kothuru villages. The coastal sandy soils occur all around the coast which is highly porous & lack of binding material.

### 7.12.4 Geology

The district is underlain by different geological formations comprising oldest Archaeans to Recent Alluvium. The rock types are classified as consolidated, semi-consolidated and unconsolidated formations. The consolidated formations include khondalites, charnockites& granitic gneisses of Archaean group, deccan traps of Tertiary period. The semi consolidated formations are represented by tertiary and upper gondwana formations like Rajahmundry &Tirupati sandstones and unconsolidated formations comprise deltaic and river alluvial deposits of Quaternary period.

Geologically, the proposed site and its surroundings are covered with Quaternary Alluvium of coastal origin and is acting as top surface layer. The alluvium is mainly composed of Sand, Silt

and Clay with varying depths in different locations on all along the narrow coastal stretch of the area. These sandy coastal soils are saline and the Project Site is falling in this saline soil zone. A narrow of saline soil cover is present on the Eastern side of the Project site i.e., adjacent to sea.

| **Geological Formations** | |
|---|---|
| **Geological Age** | **Formation** |
| Recent | Alluvium |
| Sub-Recent | Laterite |
| Miocene | Rajahmundry Sandstones |
| Eocene | Deccan Traps |
| Jurassic | Tirupati Sandstone |
| Archaean | Migmatite,Charnokite, Khondalite |

### 7.12.5 Hydrogeolgical Studies

In-order to evaluate the hydrogeological setup of the proposed site, a study was conducted towards observation of groundwater conditions in and around the study area. The site is a virgin land without any presence of wells. Groundwater is mainly being extracted by way of dug wells **(Figure 3&3a)**. There are few bore wells also present. The data collected through systematic well inventory within 5km radius of the proposed site is analyzed for making a meaning full representation of the occurrence and movement of groundwater. All these observations are detailed below.

**Figure 7.4**

**Measurements of Groundwater levels within the Dug Wells**

### 7.12.6 Occurrence of Ground Water

Groundwater occurs in the study area in the unconsolidated formations comprising coastal alluvium, andwind blown sand deposits. The depth of the dug wells tapping these formation ranges from 3.0 to 11.0 m bgl. The yield of the tube well tapping fresh water zones in the study area varies from < 1 lps to 13 lps. The depth of fresh water aquifer varies considerably place to place. Locally, proposed site and its surroundings are mostly having saline aquifers due to its close proximity to the sea.

### 7.12.7 Groundwater Levels

During systematic well inventory conducted around the proposed sites it is observed that the groundwater level is between 3 to 6m bgl within the shallow aquifers i.e. in dug wells. Similarly it is observed that the groundwater levels are between 10 to 20m bgl in deeper aquifers i.e. in bore wells. The observation made during well inventory is given in below **Table7.10.**

**Table 7.10**

**Well Inventoried within 5km Radius of the proposed site**

| Well No. | Location Name | Location Coordinates (Lat& Long) | Type of Well | Measuring Point, m agl. | Depth, m bgl. | Depth to Water, m bgl. | Quality | Use |
|---|---|---|---|---|---|---|---|---|
| 1 | Gaddipet | N: $17^0$ 1119.4' E: $82^0$ 26 03.4' | Tube Well | 1.5 m E | 1 | 7 | Potable | Drinking & Domestic |
| 2 | Vakadaripeta | N: $17^0$12 15.3' E: $82^0$27 06.0' | Dug well | 1.8 m S | 3 | 8 | Dirty | Not in Use |

| Well No. | Location Name | Location Coordinates (Lat& Long) | Type of Well | Measuring Point, m agl. | Depth, m bgl. | Depth to Water, m bgl. | Quality | Use |
|---|---|---|---|---|---|---|---|---|
| 3 | Kotapakala | N: 17°12 49.8' E: 82°27 47.2' | Tube Well | 1.5 m N | 1 | 7 | Potable | Drinking & Domestic |
| 4 | Vantimamidi | N: 17°14 41.3' E: 82°27 43.8' | Bore Well | 0.3 m E | 11.5 | 63 | Fresh | Agricultural |
| 5 | Jittlapadu | N: 17°15 58.5' E: 82°29 15.6' | Dug well | 1 m N | 2 | 10 | Fresh | Drinking |
| 6 | Tondangi | N: 17°1502.2' E: 82°2726.6' | Bore Well | 0.3 m W | 10 | 70 | Fresh | Drinking & Domestic |
| 7 | SungaVruksham | N: 17°1441.3' E: 82°26 24.5' | Dug well | 2 m E | 3 | 12 | Fresh | Drinking |
| 8 | Kommanapalle | N: 17°12 53.5' E: 82°14 48.3' | Bore Well | 0.5 m N | 11 | 70 | Fresh | Agricultural |
| 9 | Jittedupadu | N: 17°14 48.5' E: 82°28 49.3' | Dug well | 1.5 m W | 2 | 10 | Potable | Drinking & Domestic |
| 10 | Permullaupuram | N: 17°10 48.3' E: 82°25 51.6' | Tube Well | 1.5 m E | 1 | 6 | Potable | Drinking & Domestic |
| Note: m: meters; MP: measuring point with direction of measurement; agl: above ground level; bgl: below ground level; GL: ground level; Directions: East, West, North and South are indicated by E, W, N and S | | | | | | | | |

### 7.12.8 Groundwater Resources and Status of Groundwater Development:

Groundwater availability in hard rock formation is mainly depending on secondary porosity such as fractures, joints and weak planes. The quantity of groundwater in the water bearing formation (aquifers) depends on the fractures opening, intersection and intensity. The conventional approach to find out potential zones is always surface and sub-surface investigation which includes remote sensing techniques, hydro-geological conditions, historical and geo-physical investigation.

Generally, the ground water extraction in the area is by dug well, tube wells and bore well. The depth of bore-wells used for irrigation is ranging from 17 m to 80 m. The yield of these bore wells varies from 1 to about 15 litres per second (lps).

As per groundwater resource estimation studies carried out by the Central Ground Water Board (CGWB) in the Thondangi taluk.

| | |
|---|---|
| Total net groundwater availability | 3142 ham |
| Existing gross ground water draft for all uses | 16 ham |
| Provision of domestic and industrial requirements | 304 ham |

**7.12.9 Status of ground water development:**

- Except few areas, all the taluks in East Godavari district comes in Safe category.
- Thondangi taluk which also comes under Safe zone Category with 1% in groundwater development stage.
- The ground water resources of Thondangi taluk comprising the proposed site area near Ontimamidi village is given in **Table 7.11** (CGWB,2013)
- In the area, the scope for further development of ground water varies from place to place. Hence, a scientific and judicious development and management of these available water resources will contribute to the over- all planned development in improving the situation.
- As the proposed project site is near the sea coast, the scope for ground water development near the coast is to be carried out judiciously, by installing low capacity pumps as the thickness of fresh water aquifer is limited and also due to high tidal effects saline water intrusions occurs affecting the water quality thus creating salinity problems.
- Shallow wells should be constructed away from the coast for continuous fresh water supply.
- Further, in the site, piezometers should be constructed near the coast, to monitor the groundwater quality, groundwater levels and also to monitor sea water intrusion, if any, for further groundwater extraction and development.

**Table 7.11**

**Dynamic Ground Water Resources of Tondangi Taluk, East Godavari District, Andhra Pradesh**

| S. No. | Item | Total (in ham) |
|---|---|---|
| 1 | Net Annual Ground Water Availability | 3142 |
| 2 | Existing Gross Ground Water Draft for all uses. | 16 |
| 3 | Provision for Domestic and Industrial Requirement Supply. | 304 |

| | | |
|---|---|---|
| 4 | Net Ground Water Availability for Future Irrigation Development | 2834 |
| 5 | Stage of Ground Water Development and Category | 1% (Stage)<br>Safe (Category) |

### 7.12.10 Water Conservation Measures:

- Groundwater is the main source for drinking, irrigation, livestock and other purposes, with minor supplements from surface water bodies.
- As per the groundwater resource assessment data, the Thondangi taluk is in Safe category (except some all the areas of the district are in Safe category).
- Use of water resources for domestic, irrigation and other uses augmenting with erratic and decreasing volume of rainfall may result in declining of water levels in the future, so it requires intervention for conservation and development of artificial recharge structures for groundwater levels to increase and implementation of control mechanisms to arrest further declining of the water levels trends.
- Artificial recharge structures like percolation tank, check dams, nala bunds and water conservation structures like sub-surface dykes should be constructed for further groundwater resource development.
- The rejuvenation of surface water tanks by de-silting and by construction of additional percolation tanks will help in recharging the phreatic zone.
- Even though, the majority of the study area is almost flat with some undulating terrain at places which is contributing less run-off, but because of soil conditions like presence of sandy loamy and sandy clay soils present in some areas, the run-off will be more from these areas, so there will be more surplus amount of rainwater going waste by run-off from these areas and this can be prevented by diverting the run-off storm water to abandoned dug-wells and bore-wells to recharge the aquifer zones. Good watershed treatments can also help in augmenting the water resources of the area, for present and future use.

# CHAPTER 8

# PROJECT BENEFITS