6.1 INTRODUCTION

Risk Assessment involves the identification and assessment of risks the persons involved in the proposed project and the neighboring populations are exposed to as a result of hazard occurrence. This requires a thorough knowledge of failure probability, credible accident scenario, vulnerability of population etc. Consequently, the risk analysis is often confined to maximum credible accident scenario and the analysis of the potential effects of environmental hazards to human health.

These accidents can be minimized to a great extent by proper procedures, handling and training. But it may be difficult to reach zero risk or absolute safety level. Whenever such incidents do occur in order to prevent loss of lives and damage to property, it becomes necessary to take immediate steps to control the situation. This can be achieved through a planned advance preparation to face such a situation with respect to both on site and off site emergencies.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>List of Existing Products</th>
<th>Product(s)</th>
<th>List of Proposed Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Ferrous Glycine Sulphate</td>
<td>15</td>
<td>Iron Protein Succinylate</td>
</tr>
<tr>
<td>2</td>
<td>Ferrous Amminoate</td>
<td>16</td>
<td>Ferric Pyrophosphate</td>
</tr>
<tr>
<td>3</td>
<td>Ferrous Bis Glycinate</td>
<td>17</td>
<td>Ferrous Ascorbate</td>
</tr>
<tr>
<td>4</td>
<td>Peptone's/Tryptone (Bacteriological Media Ingredient)</td>
<td>18</td>
<td>Calcium Fumarate</td>
</tr>
<tr>
<td>5</td>
<td>Iron (III) Hydroxide Polymaltose Complex</td>
<td>19</td>
<td>Calcium Aspartate</td>
</tr>
<tr>
<td>6</td>
<td>Iron (III) Hydroxide Polysucrose Complex</td>
<td>20</td>
<td>Calcium Pidolate</td>
</tr>
<tr>
<td>7</td>
<td>Iron (III) Hydroxide Polysaccharide Complex</td>
<td>21</td>
<td>Ferric Gluconate</td>
</tr>
<tr>
<td>8</td>
<td>Glucosamine Hydrochloride</td>
<td>22</td>
<td>Iron Caseinate</td>
</tr>
<tr>
<td>9</td>
<td>Glucosamine Potassium Sulphate</td>
<td>23</td>
<td>Sodium Ferric EDTA</td>
</tr>
<tr>
<td>10</td>
<td>Glucosamine Sodium Sulphate</td>
<td>24</td>
<td>Casein Purified</td>
</tr>
<tr>
<td>11</td>
<td>Methyl Sulphonyl Methane</td>
<td>25</td>
<td>Casein Protein Hydrolysates</td>
</tr>
<tr>
<td>12</td>
<td>Alovera</td>
<td>26</td>
<td>Casamino Acid</td>
</tr>
<tr>
<td>13</td>
<td>Chitosan</td>
<td>27</td>
<td>Yeast Extract Bacteriological Grade</td>
</tr>
<tr>
<td>14</td>
<td>Malt Extract</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.2 SYSTEM FOR PROCESS SAFETY & OCCUPATION HEALTH

6.2.1 Process Safety:

1. Process plant will be made as per GMP requirements and safety will be the first priority to make plant full proof safe.
2. Safety measures will be adopted from the design stage.
3. Safety Valve and pressure gauge will be provided on reactor jacket.
4. PRV will be provided from steam boiler high pressure line to control required pressure in reactor jacket.
5. Utility like Chilling, cooling, vacuum, steaming and its alternative will be provided to control reaction parameters in a safe manner.
6. Control of addition of reactants in to reactor by gravity from day tank or by manual addition in continuous watching temperature and other critical reaction parameters.
7. Free Fall of any flammable material in the vessel is avoided.
8. Powder charging through man hole is avoided and safe hoper with slotting arrangement is provided.
9. Static earthing provision is made at design stage to all solvent handling equipments, reactors, vessels & powder handling equipments.
10. Any reaction upsets will be confined to the reaction vessel itself as defined quantity of charges of raw materials is issued to the reaction vessel/Day tank by metering pumps.
11. Stirrer On-Off position indicators is provided.
12. Reactor vent line is connected with reflux unit or condenser to avoid VOC.
13. All emergency valves and switches and emergency handling are easily accessible.
14. All the vessels are examined periodically by a recognized competent person under the Maharashtra Factory Rules 1963-Rule
15. All the vessels and equipments are well earthed and well protected against Static Electricity. Also for draining in drums proper earthing facilities are provided.
16. A material is transferred by pumping through pipeline or by vacuum from drums.
17. All solvents and flammable material storage tanks are away from the process plant and required quantity of material will be charge in reactor by pump.
18. Flammable material drum will be also charged by vacuum.
19. Temperature indicators are provided near all reactor and distillation systems.
20. Jumpers are provided on all solvent handling pipeline flanges.
21 Caution note, safety posters, stickers, periodic training & Updation in safety and emergency preparedness plan will be displayed and conducted.
22 Flame proof light fittings are installed in the plant.
23 All the Plant Personnel are provided with Personal Protection Equipments to protect against any adverse health effect during operations, leakage, spillages or splash. PPE like Helmets, Safety Shoes, Safety Glasses, Acid-Alkali Proof Gloves etc. All employees will be given and updated in Safety aspects through periodic training in safety.
24 Material Safety Data Sheets of Raw Materials & Products are readily available at the shop floor.

6.2.2 Transportation:

1. Class A petroleum products will be received through road tanker and stored in underground storage tank as per petroleum rules.
2. Road tanker unloading procedure will be in place and will be implemented for safe unloading of road tanker.
3. Static earthing provision will be made for tanker unloading.
4. Earthed Flexible Steel hose will be used for solvent unloading from the road tanker.
5. Fixed pipelines with pumps will be provided for solvent transfer up to Day tanks/reactors.
6. Double mechanical seal type pumps will be installed.
7. NRV provision will be made on all pump discharge line.
8. Some chemicals will be received at plant in drums by road truck and stored in a separate drum store.

6.2.3 For Drum Storage area:

1 FLP type light fittings will be provided.
2 Proper ventilation will be provided in godown.
3 Proper label and identification board /stickers will be provided in the storage area.
4 Drum pallets will be provided.
5 Drum handling trolley / stackers will be used for drum handling.
6 Separate dispensing room with local exhaust and static earthing provision will be made.
7 Material will be stored in compatible cans and separate area is used for storing flammable, corrosive and toxic chemical drums.
8 Smoking and other spark, flame generating item will be banned from the Gate.
6.2.4 **Safety Measures for Acid/Alkali storage area:**

1. To be stored away from the process plant.
2. Caution note and emergency handling procedure will be displayed at unloading area and trained all operators.
3. NFPA label will be provided.
4. Required PPEs like full body protection PVC apron, Hand gloves, gumboot,
5. Respiratory mask etc. will be provided to operator.
6. Neutralizing agent will be kept ready for tackle any emergency spillage.
7. Safety shower, eye wash with quenching unit will be provided in acid storage area.
8. Material will be handled in close condition in pipe line.
9. Bund will be provided to acid/alkali storage area, collection pit with valve provision.
10. Safety permit for loading unloading of hazardous material will be prepared and implemented.
11. TREM CARD will be provided to all transporters and will be trained for transportation
13. Fire hydrant system with jockey pump as per TAC norms is evident.

6.2.5 **Fire Fighting System:**

1. 100 cum capacity tank full of water along with a stand by pump for any emergency will be provided.
2. Sufficient numbers of Fire extinguishers are installed in plant and storage area Fire hydrant system
3. D.G. Sets is provided for emergency power.

6.2.6 **Pipelines:**

The various pipelines to transfer i.e. charging, draining etc. in the plant will be periodically inspected for Support, Vibration, Corrosion conditions, Painting, and Colour Code. Pipelines and Flexible pipeline (SS 316/MS) are appropriately earthed to avoid accumulation of Static Electricity. Periodic Checkups of the pipelines will be conducted to curb any chances of mishap due to leakages. Preventive Maintenance Schedules will be in practice.
6.2.6 Emergency Planning:

1. Transport Emergency planning and training to driver and cleaner will be provided.
2. TREM card will be provided to transporter.
3. On way emergency telephone number list will be provided to transporter.
4. Emergency siren and wind sock is provided.
5. Scenario base On Site emergency Plan will be prepared.
6. Tele Communication system and mobile phone will be used in case of emergency situations for communication.
7. First Aid Boxes and Occupational health centre is at site.
8. Hydrant system & sprinkler system will be provided as per requirements.
9. Emergency organization and team will be prepared as per On site-Off site emergency planning.

6.2.7 Occupation Health

Various precautions have been taken by the unit to reduce health hazardous and medical check-up is also carried out regularly to avoid occupational hazard.

➤ Drinking water supply for the employees is provided by the project proponent and the standard of the drinking water is as per WHO guidelines.

➤ Proper sanitary facilities are made available by the project proponent so that employees do not suffer from any health ailments.

➤ Training includes information on accident prevention, proper control and maintenance of equipment and safe material handling practices.

➤ Storage and process areas are posted with “No Smoking” signs. Smoking is prohibited throughout the factory. All management staff, Executives on their rounds to factory ensures the compliance.

➤ Pre-employment medical check-up at the time of employment.

➤ The unit has appointed the medical officer cum industrial hygienist for the regular medical examination and treatment of the employee.

➤ Certificate of fitness of employ is maintained.

➤ Occupational Health Surveillance (OHS) shall be under taken as regular exercise for all the employees specifically for those engaged in handling hazardous substances.

➤ Equipment required for personal safety like water jet blankets, gloves, helmets, safety belts, first aid boxes etc. are provided.
The noise levels in critical area shall be monitored regularly and the workers at high noise level generating areas will undergo audiometric tests once in six months.

Safety training will be provided by the safety officers to all the employees with the assistance of faculty members called from professional safety institutions and universities. In addition to regular employees, limited contractor labours are also provided with safety training.

6.3 HAZARD IDENTIFICATION

Risk assessment process rests on identification of specific hazards, hazardous areas and areas vulnerable to effects of hazardous situations in facilities involved in processing and storage of chemicals.

In fact the very starting point of any such assessment is a detailed study of materials handled & their physical / chemical / thermodynamic properties within the complex at various stages of manufacturing activity. Such a detailed account of hazardous materials provides valuable database for identifying most hazardous materials, their behavior under process conditions, and their inventory in process as well as storage and hence helps in identifying vulnerable areas within the complex.

Hazards posed by particular installation or a particular activity can be broadly classified as fire and explosive hazards and toxicity hazards. Whether a particular activity is fire and explosive hazardous or toxicity hazardous primarily depends on the materials handled and their properties.

It is evident from the above discussion that study of various materials handled is a prerequisite from any hazard identification process to be accurate. Based on this study the hazard indices are calculated for subsequent categorization of units depending upon the degree of hazard they pose.

In a Chemical plant main hazard handling of hazardous chemicals like, Flammable solvents, corrosive and toxic chemicals, the primary concern has always been, fire and explosion prevention and control as these are the main hazard posed by such unit. This concern has grown through the loss of life, property and materials experienced after experienced after major disasters, which have occurred over the years.

Identification of hazards is the most important step to improve the safety of any plant. The hazard study is designed to identify the hazards in terms of chemicals, inventories and vulnerable practices/operations.
The hazard evaluation procedures use as a first step by chemical process industries and petroleum refineries are checklists and safety reviews. Dow and Mond fire and explosion indices, which make use of past experience to develop relative ranking of hazards, is also extensively used. For predictive hazard analysis, Hazard and Operability studies (HAZOP), Fault tree analysis, Event tree analysis, Maximum credible accident and consequence analysis etc are employed.

6.3.1 Dow’s fire and Explosion Index (F & EI):

Steps in fire and explosion index calculation are given below:

- Select Pertinent Process
- Determine Material Factor
  - Calculate GPH(F1), General Process Hazards
  - Calculate SPH(F2), special process Hazards
    - Determine Hazard Factor
      - F1 x F2 = F3
    - F3 X Material Factor
      - F & E Index
    - Determine Exposure area
### Table 6.2: Hazardous Properties of the Chemicals

<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Haz</th>
<th>Flash point</th>
<th>BP</th>
<th>LEL %</th>
<th>UE L %</th>
<th>Sp. Grav</th>
<th>VD</th>
<th>Solubility with water</th>
<th>NFPA</th>
<th>Haz Combustion product</th>
<th>TLV/ TWA PPM</th>
<th>IDLH PPM</th>
<th>LD 50 LC50</th>
<th>Carcinogenic character</th>
<th>Antidote</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hydrogen peroxide</td>
<td>C</td>
<td>&gt;200 °F</td>
<td>108</td>
<td>-</td>
<td>-</td>
<td>1.1</td>
<td>1.1</td>
<td>Miscible</td>
<td>301</td>
<td>Non combustible</td>
<td>1 ppm</td>
<td>75</td>
<td>Skin, rat: LD50 = 3 gm/kg:</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2.</td>
<td>HCL</td>
<td>C</td>
<td>NF</td>
<td>108 °C</td>
<td>-</td>
<td>-</td>
<td>1.18</td>
<td>1.2</td>
<td>Soluble</td>
<td>301</td>
<td>Non combustible</td>
<td>3 mg/m3</td>
<td>50</td>
<td>3124 ppm, 1 hours [Rat].</td>
<td>No</td>
<td>Drink Large quality of water</td>
</tr>
<tr>
<td>3.</td>
<td>Dimethyl Sulphoxide (DMSO)</td>
<td>-</td>
<td>95 °C</td>
<td>189 °C</td>
<td>3.5</td>
<td>42</td>
<td>1.10</td>
<td>2.7</td>
<td>Soluble</td>
<td>110</td>
<td>combustible</td>
<td>50 ppm</td>
<td>-</td>
<td>LD50 Oral - rat - 14,500 mg/kg:</td>
<td>Rat - Oral</td>
<td>No</td>
</tr>
<tr>
<td>4.</td>
<td>Fumaric acid</td>
<td>C</td>
<td>230 °C</td>
<td>200 °C</td>
<td>15</td>
<td>28</td>
<td>1.6</td>
<td>-</td>
<td>Soluble</td>
<td>210</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>LD50 (Oral-Rat)(mg/Kg): 9300</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>5.</td>
<td>Acid EDTA</td>
<td>-</td>
<td>NA</td>
<td>NA</td>
<td>-</td>
<td>-</td>
<td>0.86</td>
<td>-</td>
<td>slightly</td>
<td>110</td>
<td>combustible</td>
<td>0.5</td>
<td>LD 50 3 0 mg/kg Mouse</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Phosphoric acid</td>
<td>C</td>
<td>-</td>
<td>158 °C</td>
<td>-</td>
<td>-</td>
<td>1.68</td>
<td>3.4</td>
<td>Soluble</td>
<td>300</td>
<td>combustible</td>
<td>3 mg/m3</td>
<td>1000 mg/m3</td>
<td>LD50: 1530 mg/kg</td>
<td>NA</td>
<td>No</td>
</tr>
</tbody>
</table>

**F = FIRE**

**E = EXPLOSIVE**

**BP = BOILING POINT**

**UEL = UPPER EXPLOSIVE LIMIT**

**ER = EVAPORATION RATE**

**R = REACTIVE**

**BR = BURNING RATE**

**TFPA = NATIONAL FIRE PROTECTION ASSOCIATION-usa**

**N.A = NOT AVAILABLE**

**C = CORROSIVE**

**STEL = SHORT TERM EXPOSURE LIMIT**

**PPM = PARTS PER MILLION**

**VD = VAPOUR DENSITY**

**F = FIRE HAZARD CLASS**

**TLV = THRESHOLD LIMIT VALUE over 8hrs**

**N.L = NOT LISTED**
6.3.2 Identification of Hazardous Areas:

1. Process plant will be Batch process and multipurpose and multi utility base plant due to that at a time inventory of raw material at production area will be very small.

2. All liquid raw material and finished product will be stored in tank farm area and required material will be charged in process through pump and in close circuit.

3. Batch size requirement chemicals will be charged in to day tank or reactor and empty drums will be sent back to RM store for neutralization and disposed off. Thus the inventory of the raw material in process area will be limited and for limited time.

4. Most of reactions are similar type and slight exothermic in nature

5. Various raw materials used in the manufacturing processes are listed in RAW material List in annexure along with mode / type of storage & storage conditions. It can be readily seen that raw materials even though hazardous in nature, will be used in small quantities & storage quantities will also very low at process plant.

6. All Class A petroleum products and flammable chemicals will be stored in aboveground storage tanks in dedicated Explosive license premises.

6.3.3 Hazard and Operability Studies (HAZOP):

- The basic concept of Hazop is to have an exhaustive review of the plant operation. Hazop study highlights the hidden operability problems and identifies hazards, which are likely to result from the expected intention of seemingly safe components or methods of operation.

- This work utilizes imagination of team members to visualize ways in which a plant can malfunction or mal-operated. Each part of the plant is subjected to a number of questions formulated around a number of guide words which are derived from method of study technique. In effect, the guide words are used to ensure that the questions which are posed to test integrity of each part of the design to explore every conceivable way in which that design could deviate from the design intention. This usually produces a number of theoretical deviations and each deviation is then considered how it could be caused and what would be consequences.
HAZOP is a brainstorming approach, which stimulates creativity and procedure for generating ideas. Possible results of this study are:
- Identify and examining many types of risks.
- Identifying non-optimum system reliability.
- Suggestive qualitative recommendations regarding control, strategy, material properties, material releases alternative design option, operation and maintenance.

The important terms pertaining to HAZOP study are:
- Intention: The intention defines how the part is expected to operate. This can take a number of forms and can be either descriptive or diagrammatic. In many cases, it will be a flow sheet (P & ID).
- Deviation: These are departures from the intention which are discovered by systematically applying the guide words.
- Causes: These are reasons why deviation might occur. Once a deviation has been shown to have a conceivable or realistic cause, it can be treated as meaningful.
- Hazards: These are the results of the deviations.

Consequences: These are the consequences, which can cause damage, injury or loss.

A List of guide words
Guidewords are applied to the design intention. The design intention informs us what the equipment is expected to do.

### Table 6.3: Showing List of guide words

<table>
<thead>
<tr>
<th>Guide words</th>
<th>Meanings</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Complete negation of the intention</td>
<td>No part of the intention is achieved e.g. no flow or reverse flow.</td>
</tr>
<tr>
<td>More of</td>
<td>Quantitative increase</td>
<td>More of any relevant physical properties than there should be e.g. higher flow (rate or total quantity), higher temperature, higher pressure, higher viscosity, more heat, more reaction etc.</td>
</tr>
<tr>
<td>Less of</td>
<td>Quantitative decrease</td>
<td>Less of any relevant physical property than there should be, e.g. Lower flow (rate or total quantity),</td>
</tr>
</tbody>
</table>
| Part of          | Quantitative decrease | Composition of system different from what it should be
|------------------|-----------------------|--------------------------------------------------|
| More than        | Quantitative increase | More components present in the system that there should be e.g. extra phase present (Vapor, solid), impurities (air, water, acids, corrosion products etc.)
| Other than       | Substitution          | What else can happen apart from normal operation e.g. Start up, shutdown, high/low rate running, alternative operation mode, failure of plant services, maintenance, catalyst change etc. |

A flow chart giving HAZOP procedure is given below:

HAZOP studies for the Process Activities is made and the Hazop study sheets are as under:
Environmental Impact Assessment Report of CBPL

Select node

Select deviation Eg. More flow

Move onto next deviation NO

Is more flow possible?

Is it hazardous or does it prevent efficient operation?

NO Consider other causes of more flow

YES

What change in the plant will tell him NO

Will the operator know that there is more flow?

YES

What change in plant or methods will prevent the deviation or make it less likely or protect against the consequences.

Consider other changes or agree to accept hazard.

NO Is the cost of change justified

Agree changes. Agree who is responsible for action.

Follow up to see that action has been taken.
### Conclusion:

Above study shown that company has to be adopted and implemented required safety measures to control process hazard and make it safe at maximum level.

### 6.3.4 Failure Frequencies:

Hazardous material release scenarios can be broadly divided into 2 categories

I) Catastrophic failures which are of low frequency and

II) Ruptures and leaks which are of relatively high frequency.

Releases from failure of gaskets, seal, rupture in pipelines and vessels fall in the second category whereas catastrophic failure of vessels and full bore rupture of pipelines etc. fall into the first category.
6.4 RISK ASSESSMENT

6.4.1 Effects Of Releases Of Hazardous Substances:

Hazardous substances may be released as a result of failures / catastrophes, causing possible damage to the surrounding area. In the following discussion, an account is taken of various effects of release of hazardous substances and the parameters to be determined for quantification of such damages.

In case of release of hazardous substances the damages will depend largely on source strength. The strength of the source means the volume of the substance released. The release may be instantaneous or semi-continuous. In the case of instantaneous release, the strength of the source is given in kg and in semi-continuous release the strength of the source depends on the outflow time (kg/s.).

In order to fire the source strength, it is first necessary to determine the state of a substance in a vessel. The physical properties, viz. Pressure and temperature of the substance determine the phase of release. This may be gas, gas condensed to liquid and liquid in equilibrium with its vapour or solids.

Instantaneous release will occur, for example, if a storage tank fails. Depending on the storage conditions the following situations may occur.

The source strength is equal to the contents of the capacity of the storage system.

In the event of the instantaneous release of a liquid a pool of liquid will form. The evaporation can be calculated on the basis of this pool.

6.4.2 Tank On Fire/ Pool Fire:

In the event of the instantaneous release of a liquid a pool of liquid will form. The evaporation can be calculated on the basis of this pool.

The heat load on object outside a burning pool of liquid can be calculated with the heat radiation model. This model uses average radiation intensity, which is dependent on the liquid. Account is also taken of the diameter-to-height ratio of the fire, which depends on the burning liquid. In addition, the heat load is also influenced by the following factors:
• Distance from the fire
• The relative humidity of the air (water vapour has a relatively high heat-absorbing capacity)
• The orientation i.e. horizontal/vertical of the objective irradiated with respect to the fire.

6.4.3 **Fire Ball:**
This happens during the burning of liquid, the bulk of which is initially over rich (i.e. above the upper flammable limit.). The whole cloud appears to be on fire as combustion is taking place at eddy boundaries where air is entrained (i.e. a propagating diffusion flame). The buoyancy of the hot combustion products may lift the cloud from the ground, subsequently forming a mushroom shaped cloud. Combustion rates are high and the hazard is primarily thermal.

6.4.4 **“UVCE”:**
UVCE stands for unconfined vapour cloud explosion. The clouds of solvent vapour mix with air (within flammability limit 3.0% to 11%) may cause propagating flames when ignited. In certain cases flame may take place within seconds. The thermal radiation intensity is severe depending on the total mass of vapour in cloud and may cause secondary fire. When the flame travels very fast, it explodes causing high over pressure or blast effect, resulting in heavy damage at considerable distance from the release point. Such explosion is called UVCE (Unconfined Vapor Cloud Explosion) and is most common cause of such industrial accident.

6.4.5 **DISPERSION CASES**

6.4.5.1 **Plumes:**
Plumes are continuous release of hazardous gases and vapours. Smoke from a chimney is an example. Plumes can cause FIRES AND EXPLOSIONS as secondary scenarios.

6.4.5.2 **Puffs:**
Puffs are instantaneous release of hazardous gases and vapours. Puffs can give rise to FIRE BALLS and vapour cloud explosions (VCE). A special case of vapour cloud explosion is the Boiling Liquid Evaporating Vapour Explosion (BLEVE).
6.4.5.3 Spills Pool:

Spills are liquid pools created by leaking liquid chemicals. Spills cause evaporation and dispersal of toxic gases and if the spilled liquid is flammable, then it can catch fire creating a pool fire also the vapors can cause explosion.

6.4.5. IDENTIFICATION OF HIGH RISK AREAS

It is observed that the storage areas pose fire/explosion hazards as it has a substantial inventory of Toluene, which may lead to major accident event.

Thus the quantitative risk assessment studies are limited to above ground storage tank farm area.

6.4.6 MODES OF FAILURE

- Liquid release due to catastrophic failure of storage vessel or road tanker.
- Liquid release through a hole/crack developed at welded joints/flanges / nozzles /valves etc.
- Vapor release due to exposure of liquid to atmosphere in the above scenarios.
- Based on the above the following accident scenarios were conceived as most probable failure cases:

<table>
<thead>
<tr>
<th>Event</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank on Fire</td>
<td>Ignition availability</td>
</tr>
<tr>
<td>Pool fire</td>
<td>Failure of pump outlet-inlet line + Ignition availability</td>
</tr>
<tr>
<td>Fire Ball/Flash fire</td>
<td>Catastrophic failure of road tanker/ storage tank</td>
</tr>
</tbody>
</table>

Considering the quantity of storages & nature of Toxic and Flammable storage, following scenarios were taken up for detailed analysis & safe distances computed:

- Catastrophic failure of storage tank which on ignition poses heat radiation hazards to nearby areas.
- Catastrophic failure of road tank and presence of ignition source poses heat radiation hazards to nearby areas.

Failure cases considered for consequence analysis are representative of worst-case scenarios. Probability of occurrence of such cases is negligible (less than 1 x 10^-6 per year) because of strict adherence to preventive maintenance procedures within the complex. General probabilities for various failure is provided in Tables but consequences of such cases can be grave & far reaching
in case such systems fail during life history of the company. Hence such scenarios are considered for detailed analysis. It is to be noted however that such situations are not foreseeable or credible as long as sufficient measures are taken. Also, consequence analysis studies help us evaluate emergency planning measures of the Company.

6.4.7 DAMAGE CRITERIA FOR HEAT RADIATION:

Damage effects vary with different scenarios. Calculations for various scenarios are made for the above failure cases to quantify the resulting damages.

The results are translated in term of injuries and damages to exposed personnel, equipment, building etc.

Tank on fire /Pool fire due to direct ignition source on tank or road tanker or catastrophic failure or leakage or damage from pipeline of storage facilities or road tanker unloading arm, can result in heat radiation causing burns to people depending on thermal load and period of exposure.

All such damages have to be specified criteria for each such resultant effect, to relate the quantifier damages in this manner, damage criteria are used for Heat Radiation.

TABLE -DAMAGE CRITERIA – HEAT RADIATION

<table>
<thead>
<tr>
<th>Heat Radiation</th>
<th>Incident Flux KW/m2 Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>100% lethality, heavy damage to tanks</td>
</tr>
<tr>
<td>37.5</td>
<td>100% lethality, heavy damage to equipment.</td>
</tr>
<tr>
<td>25</td>
<td>50% lethality, nonpiloted ignition</td>
</tr>
<tr>
<td>14</td>
<td>Damage to normal building</td>
</tr>
<tr>
<td>12.5</td>
<td>1% lethality, piloted ignition</td>
</tr>
<tr>
<td>12</td>
<td>Damage to vegetation</td>
</tr>
<tr>
<td>6</td>
<td>Burns (escape routes)</td>
</tr>
<tr>
<td>4.5</td>
<td>Not lethal, 1st degree burns</td>
</tr>
<tr>
<td>3.1</td>
<td>Degree burns possible (personnel only in emergency allowed)</td>
</tr>
<tr>
<td>2</td>
<td>Feeling of discomfort</td>
</tr>
<tr>
<td>1.5</td>
<td>No discomfort even after long exposure</td>
</tr>
</tbody>
</table>
6.5 CONSEQUENCE ANALYSIS

In the risk analysis study, probable damages due to worst case scenarios were quantified and consequences were analyzed with object of emergency planning. Various measures taken by the company and findings of the study were considered for deciding acceptability of risks.

6.5.1 Maximum Credible loss scenarios (MCLS):

MSCL assume maximum inventory of hazardous chemicals and worst weather condition prevailing at the time of failure. Further, no credit is given for the safety features provided in the facility to determine maximum possible damage from the scenario selected. In reality, leakage of hazardous chemical will be smaller in magnitude. Also the leakage will be detected immediately by plant operating staff then initiate various mitigation measures to prevent any disastrous situation.

The maximum credible loss Scenarios (MCLS) identified for plant base on above criteria are listed below:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Failure Type</th>
<th>Failure Mode</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,3 &amp; 4</td>
<td>Road tanker catastrophic failure.</td>
<td>Unloading arm 100% failure,</td>
<td>Un confined Pool Fire, Flash Fire, Ball Fire, UVCE(Over Pressure),</td>
</tr>
<tr>
<td>5</td>
<td>20 KL Class A petroleum above ground storage tank fire in A/G storage tank farm area</td>
<td>Direct ignition source</td>
<td>Tank On fire</td>
</tr>
<tr>
<td>6,7,8 &amp; 9</td>
<td>Catastrophic failure of 20 KL storage tank.</td>
<td>Catastrophic failure</td>
<td>Pool fire, Flash Fire, Ball Fire, UVCE(Over Pressure),</td>
</tr>
<tr>
<td>10,11</td>
<td>Drum storage area fire</td>
<td>Drum spillage</td>
<td>Pool Fire &amp; BLEVE in drums</td>
</tr>
<tr>
<td>12</td>
<td>FO storage tank pool fire</td>
<td>Catastrophic failure</td>
<td>Pool fire</td>
</tr>
</tbody>
</table>

6.5.2 Weather Data:

Average wind speed Average Ambient Temperature Average Humidity Atmospheric Stability
6.5.3 **Assumption:**

3 m/sec : 35 deg.c. : 60 % : D

6.5.3.1 **Basic assumptions For road tanker release scenario:**

100 % failure of Unloading arm is considered for 20 KL road tanker while unloading work. Total material drain will spread on floor. Immediate ignition will give unconfined pool fire. If there is no ignition source available nearby area, liquid will evaporate and vapor cloud will travel in wind direction, evaporated vapor mass comes in the contact with any ignition source there will be chances of Flash fire, UVCE and BLEVE in road tanker. Unconfined vapor Cloud boiling liquid expanding Vap-exp.

6.5.3.2 **Basic assumptions For 20 KL storage tank catastrophic failure**:

Catastrophic failure of 20 KL storage tank or 100 % bottom valve/ line failure and total material drain in dyke wall. Immediate ignition will give pool fire and delay ignition will give Flash Fire, UVCE and BLEVE.

**Heat Radiation Damage**

- 37.5 100% lethality, heavy damage to equipment.
- 12.5 1% lethality, piloted ignition
- 4.5 Not lethal, 1st degree burns
- 1.6 No discomfort even after long exposure

**Table 6.4: Evaporation rate calculation**

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Total capacity of storage (M³)</th>
<th>Maximum Spillage (KG)</th>
<th>Evaporation Rate (Kg/Sec.)</th>
<th>Vapour mass for 15 minutes (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A Petroleum Road tanker</td>
<td>20</td>
<td>17340</td>
<td>0.328</td>
<td>295</td>
</tr>
<tr>
<td>Road tanker Catastrophic failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catastrophic failure of 20 KL</td>
<td>20</td>
<td>17340</td>
<td>0.154</td>
<td>138</td>
</tr>
<tr>
<td>storage tank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.6 ON-SITE MANAGEMENT PLAN

The On-Site plan will be circulated to all concerned members of emergency teams. It is essential that all concerned familiarize themselves with the overall on-site emergency plan and their respective roles and responsibilities during and emergency. They should also participate regularly in the mock drills that will be conducted so as to keep themselves and the emergency organization in a state of perpetual preparedness at all times to meet any emergency.

6.6.1 Objectives of Onsite Emergency Plan:

Objectives of Emergency Planning are to maximize the resource utilization and combined efforts towards emergency operations and would broadly cover the following.

1. To localize the emergency and if possible eliminate it.
2. To minimize the effects of accidents on people and property.
3. To take remedial measures in the quickest possible time to contain the incident and control it with minimum damage.
4. To mobilize the internal resources and utilize them in the most effective way.
5. To get help from the local community and government officials to supplement internal manpower and resources.
6. To minimize the damage in other sections.
7. To keep the required emergency equipment in stock at right places and ensure that they are in working condition.
8. To keep the concerned personnel fully trained in the use of emergency equipment.
9. To give immediate warning to the surrounding localities in case of an emergency situation arising.
10. To mobilize transport and medical treatment of the injured.
11. To educate the public in the surrounding villages regarding hazards.
12. To arrange for rescue and treatment of casualties.
13. To safeguard the people.
14. To identify the casualities and communicate to relatives.
15. To render necessary help to concerned.
16. To rehabilitate area affected.
17. To provide information to media & government agencies.
6.6.2 Scope of Onsite Emergency Plan:

The plan covers information regarding the properties of the Industry, type of disasters and disaster/accident-prone zones, the actual disaster control plans with authority delegation, controlling and other details. General details like location, project layout, neighboring entities and the assistance they can render etc., are also provided.

The important elements considered in this plan are

- Statutory requirements
- Emergency organization
- Roles and Responsibilities
- Communications during emergency
- Emergency shutdown & control of situation
- Rescue & Rehabilitation
- Emergency facilities
- Important Information

The primary purpose of the on-site emergency plan or DMP is to control and contain the incident and so to prevent if from spreading. It is not possible to cover every eventuality in the plan and the successful handling of the emergency will depend on appropriate action and decisions being taken on the spot. Other important aspects needing to be considered include the following:

6.6.3 Emergency:

A major emergency in any situation is one, which has the potential to cause serious injury or loss of life, which may cause extensive damage to the structures in the vicinity and environment and could result in serious disruption to normal operation both inside and outside the industry premises. Depending on the magnitude of the emergency, services of the outside agencies may also be required for supplementing the internal effort to effectively handle the emergency and to contain the damage.

The Management has to take effective steps to assess, minimize and wherever feasible eliminate the risks to a large extent. Accidents may still occur and it is necessary to be fully prepared to tackle all such emergencies if and when they occur.
It is likely that the consequences of such emergencies will be confined to the units concerned or may affect outside. If the consequences are confined within the plant boundary, it is then termed as On Site Emergency and will be controlled by Chief Emergency Controller.

In order to generate the plans it is necessary to first determine the kinds of accidents leading to an emergency that can occur in the industry. The most widely used technique in practice is based on experience accumulated over many years and safety audits.

6.6.3.1 Methodology:

The considerations in an emergency planning include the following:

1. Identification and assessment of hazards and risks
2. Hazard, consequence analysis
3. Alarm and communication procedures
4. Identifying, appointment of personnel & assignment of responsibilities
5. Identification and equipping Emergency control centre, Identifying Assembly, Rescue points, Medical facilities.
6. Emergency preparedness plan, procedures, steps to be taken before, during and after emergency.
7. Formulation of plan and emergency sources.
8. Training, rehearsal, evaluation and updating the plan

6.6.3.2 Structure of Emergency Management:

a. Noticing the accidents
b. Informing declarer of emergency
c. Declaration of emergency
d. Functions of declarer
e. Interaction with outside agencies

6.6.4 Identification and Assessment of Hazards:

This stage is crucial to both on-site and off-site emergency planning and requires systematic identification of all possible emergencies that could arise in the plants.
These should range from small events, which can be dealt by plant personnel without any help from external agencies to the largest event that would require outside help. To tackle such emergencies effectively, it is essential to have clear-cut action plan. Experience has shown that for every occasion that the full potential of an accident is realized, there are many occasions when some lesser event occurs or when developing incident is made safe before reaching full potential.

6.6.5 *Infrastructure at Emergency Control Center:*

Emergency control center should therefore contain the following

- An adequate number of external telephones; if possible, one should accept only outgoing calls, in order to bypass jammed switchboards during an emergency.
- An adequate number of internal telephones
- Radio equipment
- A plan of the works, to show:
- Areas where there are large inventories of hazardous materials.
- Sources of safety and first aid equipment.
- The fire-fighting system and additional sources of water.
- Site entrance and roadways, including up-to-date information on road Traffic.
- Assembly points.
- Vehicle parking and rail sidings.
- Additional work and layout plans detailing alternate routes and affected areas, during an emergency.
- Note pads, pens and pencils.
- A nominal role of employees.
- A list of key personnel, with addresses, telephone numbers, etc.

The emergency control center should be sited in an area of minimum risk. Suitable location from where clear view of the plant is possible or the control room can be designated as Emergency Control Center. All the Site Controller/ Incident Controller, Officers, Senior Personnel would be located here or have access to the ECC.
6.6.6 Emergency Medical Facilities:

Stretchers, gas masks and general first aid materials for dealing with chemical burns, fire burns, etc., would be maintained in the medical center as well as in the Emergency Control Room. A range of medicines should be maintained in the ECC/Medical Center. Breathing apparatus and other emergency medical equipment should be provided and maintained.

The Medical Center should display poster for treating burns and first aid. Some medicines and facilities to be kept in the medical center are suggested. The list is indicative and the qualified doctors of the medical center should use their professional judgment for medical treatment.

6.6.7 EMERGENCY ACTION PLANS.

6.6.7.1 Emergency Action Plan for Electric Fire:

1. Disconnect the affected areas electric supply.
2. Attempt to extinguish fire with the help of CO₂/DCP
3. If fire is not extinguished, extinguish by spraying water with fog nozzle after ensuring complete isolation of electric circuit.

6.6.7.2 Emergency Action Plan for Office Fire:

1. Disconnect electric supply of the affected area.
2. Attempt to extinguish the fire with the help of CO₂, DCP and sand.
3. If large fire, use hydrant system.
4. Attempt to save the record.
5. Attempt fire extinguisher.

The proposed project will provide elaborate arrangements for managing any incidents of fire:

- Water Tender
- Foam Tender
- Portable Pump
- Wireless set
- Water Hoses
- Hot line Telephone etc.
6.6.7.3. Emergency Action Plan for Medical Aid:

i. Emergency Action Plan for Electric Shock Casualties:
   - Electric shock results in irreversible damage to brain cell begin followed by deterioration of the organs.
   - Rescue and first aid:
     - Do first aid quickly and without fuss and panic switch off the supply if this can be done at once.
     - If not possible use a dry stick, dry cloth or other non-conductor to separate the victim from electrical contact.
     - The rescuer must avoid receiving shock himself by wearing gloves or using a jacket to pull the victim.
     - Always keep in mind that delay in rescue and resuscitation may be fatal. Every sound counts.

ii. Artificial Respiration
   Give artificial respiration if breathing has stopped. There are several methods of artificial respiration, if the victim is not injured over the face, try mouth to mouth.
   If burns are present, cover them with a dry sterile dressing. Handle the causality gently. Do not allow people to crowd around and block fresh airflow. Arrange to remove the injured to the care of a doctor as early as possible.

6.6.8. NATURAL HAZARDS

6.6.8.1. Emergency Action Plan for High Winds:
   a. Weather reports shall be monitored from broadcast warnings regarding threatening conditions.
   b. If the tornado has been sighted or effect is felt, following steps should be taken by plant personnel. Persons shall be notified over public address system or through siren. Emergency services shall be alerted for assistance. Plant personnel should be advised to assemble in the administration building basement, staff room, recreation room and rest rooms. All safety systems should be kept on alert and all nonessential utilities should be put off.
   c. After the status is restored, personnel should inspect all the facilities for resource, first aid and damage control activities, damage assessment, and clean up, restoration and recovery.
6.6.8.2 Emergency Action Plan for Earthquakes:

a. When first tremors are sensed during an earthquake, all personnel should evacuate buildings and assemble at a safe place away from structures, walls and falling objects. Emergency shutdown should be declared.

b. Emergency services should be contacted for assistance.

c. After the status is restored, personnel should inspect all the facilities for rescue, first aid and damage control activities, damage assessment, cleanup, restoration and recovery.

In The Location Premises:
- Keep the Fire Hydrant System/all Fire Fighting and Personnel protective Equipment in readiness.
- Every one entering the Location must be frisked at the Gate/check all Hand Bags, Parcels etc., for suspected explosive/dangerous objects.
- Have thorough inspection of the Location for any suspected dangerous object.
- Materials and other Boxes to be brought in to the Location must be deposited at Gate for minimum curing period of 48 Hrs.
- Organize Employees Vigilance cell for round the clock observation of industry Premises.

If The Suspected object is found:
- In case of finding of suspected Article, do not disturb its position, but the area around it should be cordoned off to a distance of 100 meters and more depending upon the gravity of situation.
- Adequate Staff or Police Squad posted to prevent any unauthorized entry into the enforced cordon.
- Contact Controller of Explosives immediately, who on reaching the Site will decide suitable action for defusing and disposal of the suspected object.
- Evolution of thick billowing smoke is an indication of impending explosion and in such a case, withdraw or evacuates all personnel from the spot, which has been identified.
- As a general measure regulate the movement of the outsiders inside our Premises and restrict their entry with permits.

6.6.9 Training/Education

All the above measures are workable only when the people are well educated on these matters. The working staff like Environmental officer, security personnel, and pump operators shall be trained to handle the disaster situation. Mock-up drills will be conducted once in a year.