CHAPTER- 6
ADDITIONAL STUDIES
RISK ASSESSMENT

6.1 BACKGROUND
Identification analysis and assessment of hazards and risks provide vital information to the risk management, that what should be the type & capacity of any on-site and off-site emergency plan & what type of safety measures and maintenance is required. Risk and consequence analysis is carried out considering storage and handling of various hazardous raw materials, intermediates and product as well as manufacturing process.

6.2 METHODOLOGY
Quantitative risk assessment (QRA) is a means of making a systematic analysis of the risks from hazardous activities, and forming a rational evaluation of their significance, in order to provide input to a decision-making process. The term ‘quantitative risk analysis’ is widely used, but strictly this refers to the purely numerical analysis of risks without any evaluation of their significance. The study has been conducted based on the premises of a traditional Quantitative Risk Assessment. The key components of a QRA are explained below, and illustrated in Figure 1.
The purpose of **Risk Assessment** is to develop mitigation measures for unacceptable generators of risk, as well as to reduce the overall level of risk to As Low as Reasonably Practical.
In order to help assess the viability of Risk Reduction Measures (RRM), the economic costs of the measures can be compared with their risk benefits using **Cost Benefit Analysis (CBA).**

### 6.3 STORAGE AND HANDLING OF HAZARDOUS CHEMICALS

The details of storage of Hazardous chemicals along with measures taken during storage are given in Table 6-1.
### TABLE-6.1

**STORAGE DETAILS OF HAZARDOUS CHEMICALS**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of the Hazardous Substance</th>
<th>Maximum Storage</th>
<th>Mode of Storage</th>
<th>Actual Storage</th>
<th>State &amp; Operating pressure &amp; temperature</th>
<th>Possible type of Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sulphuric Acid</td>
<td>30 MT</td>
<td>Tank (2 Nos.)</td>
<td>15 MT</td>
<td>NTP</td>
<td>Corrosive</td>
</tr>
<tr>
<td>2</td>
<td>Thionyl Chloride</td>
<td>40 MT</td>
<td>Tank (2 Nos.)</td>
<td>20 MT</td>
<td>NTP</td>
<td>Corrosive</td>
</tr>
<tr>
<td>3</td>
<td>N-Butanol</td>
<td>1 MT</td>
<td>Drum (5 Nos.)</td>
<td>200 Lit</td>
<td>NTP</td>
<td>Flammable</td>
</tr>
<tr>
<td>4</td>
<td>Iso-Butanol</td>
<td>1 MT</td>
<td>Drum (5 Nos.)</td>
<td>200 Lit</td>
<td>NTP</td>
<td>Flammable</td>
</tr>
<tr>
<td>5</td>
<td>Benzene</td>
<td>2 MT</td>
<td>Drum (5 Nos.)</td>
<td>200 Lit</td>
<td>NTP</td>
<td>Flammable</td>
</tr>
<tr>
<td>6</td>
<td>Aniline</td>
<td>1 MT</td>
<td>Drum (5 Nos.)</td>
<td>200 Lit</td>
<td>NTP</td>
<td>Flammable / Toxic</td>
</tr>
<tr>
<td>7</td>
<td>Tri Ethyl Amine</td>
<td>1 MT</td>
<td>Drum (5 Nos.)</td>
<td>200 Lit</td>
<td>NTP</td>
<td>Flammable</td>
</tr>
<tr>
<td>8</td>
<td>Propionic acid</td>
<td>2 MT</td>
<td>Drum (10 Nos.)</td>
<td>200 Lit</td>
<td>NTP</td>
<td>Corrosive</td>
</tr>
<tr>
<td>9</td>
<td>Isobutyric acid</td>
<td>1.5 MT</td>
<td>Drum (8 Nos.)</td>
<td>200 Lit</td>
<td>NTP</td>
<td>Corrosive</td>
</tr>
<tr>
<td>10</td>
<td>1,3-Dichlorobenzene</td>
<td>1 MT</td>
<td>Drum (5 Nos.)</td>
<td>200 Lit</td>
<td>NTP</td>
<td>Flammable</td>
</tr>
</tbody>
</table>
Table - 6.2

<table>
<thead>
<tr>
<th>S.R. No.</th>
<th>Name of the Raw Materials</th>
<th>Hazard</th>
<th>FP deg C</th>
<th>BP deg C</th>
<th>Sp.GR. at 20 deg C</th>
<th>VD vs air</th>
<th>Solubility with Water at 20 deg C</th>
<th>VP mm Hg at 20C</th>
<th>TLV ppm</th>
<th>LEL%</th>
<th>UEL%</th>
<th>LD50 Oral mg/kg</th>
<th>LD50 Dermal mg/kg</th>
<th>LC 50 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sulphuric Acid</td>
<td>Corrosive</td>
<td>-</td>
<td>100</td>
<td>1.3</td>
<td>3.4</td>
<td>Soluble</td>
<td>2.3 kPa</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>4280 Rat</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Thiouryl Chloride</td>
<td>Corrosive</td>
<td>--</td>
<td>76</td>
<td>1.638</td>
<td>4.1</td>
<td>Insoluble</td>
<td>13.3 kPa</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>500 ppm 1Hr Rat</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Butanol</td>
<td>Flammable</td>
<td>35</td>
<td>117.6</td>
<td>0.8100</td>
<td>2.55</td>
<td>80</td>
<td>-</td>
<td>20</td>
<td>1.4</td>
<td>11.2</td>
<td>790 mg/kg, rat</td>
<td>3400 mg/kg, rabbit</td>
<td>8000 ppm 4h</td>
</tr>
<tr>
<td>4</td>
<td>Benzene</td>
<td>Flammable</td>
<td>-11</td>
<td>80.1</td>
<td>0.878</td>
<td>2.8</td>
<td>Soluble</td>
<td>10 kPa</td>
<td>0.1</td>
<td>1.2</td>
<td>7.8</td>
<td>930 mg/kg, rat</td>
<td>9400 mg/kg, rabbit</td>
<td>10000 ppm 7hrs</td>
</tr>
<tr>
<td>5</td>
<td>Aniline</td>
<td>Flammable</td>
<td>70</td>
<td>184.1</td>
<td>1.0216</td>
<td>3.22</td>
<td>Soluble</td>
<td>0.1 kPa</td>
<td>2</td>
<td>1.3</td>
<td>23</td>
<td>250 Rat</td>
<td>820 Rabbit</td>
<td>175 mg/kg 7 hr</td>
</tr>
<tr>
<td>6</td>
<td>Tri Ethyl Amine</td>
<td>Flammable</td>
<td>-8.3</td>
<td>89.7</td>
<td>0.73</td>
<td>3.48</td>
<td>Soluble</td>
<td>54</td>
<td>10</td>
<td>1.2</td>
<td>8</td>
<td>460 Rat</td>
<td>570 Rabbit</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Propionic Acid</td>
<td>Corrosive</td>
<td>53</td>
<td>140.99</td>
<td>0.9954</td>
<td>2.56</td>
<td>Soluble</td>
<td>2.9</td>
<td>10</td>
<td>2.9</td>
<td>12.1</td>
<td>3500 Rat</td>
<td>500 Rabbit</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Isobutyric acid</td>
<td>Flammable</td>
<td>55</td>
<td>154</td>
<td>0.95</td>
<td>3.04</td>
<td>Soluble</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>9</td>
<td>266 Rat</td>
<td>475 Rabbit</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>1,3-Dichlorobenzene</td>
<td>Flammable</td>
<td>67</td>
<td>172</td>
<td>1.2285</td>
<td>5.07</td>
<td>Insoluble</td>
<td>1.8 kPa</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1062 Rat</td>
<td>-</td>
<td>--</td>
</tr>
</tbody>
</table>

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**M/s. Bromchem Laboratories Pvt. Ltd.**

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Tank Farm Area

12 meter

10 meter
6.4 Facilities / System for process safety, Storage, transportation, fire fighting system and emergency capabilities to be adopted.

6.4.1 Process Safety:

- Flameproof equipments and fittings will be provided for handling of hazardous chemicals.
- Tanks and all pump motors will be earthed.
- Road tanker earthing lines will be provided near the unloading pumps.
- Independent dykes will be provided for hazardous chemicals storage to contain leakages. Floors of the dyke area have impervious finish.
- Housekeeping of the plant will be carried out regularly. Floors, platforms, staircases, passages will be kept free of any obstruction.
- All hazardous operations will explain to the workers. They are periodically trained on the hazardous processes.
- Dedicated supply of firewater will available in the plant.
- Only authorized persons will allow inside the plant.
- All instrument and safety devices will be checked and calibrated during installation. They will be also calibrated, checked at a frequent interval. Calibration records will be maintained.
- All electrical equipments will be installed as per prescribed standards.
- All the equipments of the plant are periodically tested as per standard and results will be documented. All equipments undergo preventive maintenance schedule.
- Hydrant system will be pressured with a Jockey Pump.
- Flame arrestor will be provided on each tank.
- Pressure gauge will be provided on each tank.
- In addition to fire hydrant system, nos. of fire extinguishers will also install at different locations within premises as per requirement.
- Retention basin will be provided to collect the contaminated water used during fire fighting.
- Adequate ventilation arrangement will be provided for safe and better working in the plant as per the standard.
Process, equipments, plant involving serious fire hazards will be designed as per prescribed guideline.

6.4.2 For Underground and above ground storage tank farm:

- Class A petroleum products will be received through road tanker and stored in underground storage tank as per petroleum rules.
- Tank farm will be constructed as per explosive department requirement and separation distance will be maintained.
- Static earthing provision will be made for road tanker as well as storage tank.
- Flame arrestor with breather valve will be provided on vent line.
- Road tanker unloading procedure will be prepared and implemented.
- Fire load calculation will be done and as per fire load Hydrant System will be provided as per NFPA std. and Fire extinguishers will be provided as per fire load calculation.
- Spark arrestor will be provided to all vehicles in side premises.
- Flame proof type equipments and lighting will be provided.
- Lightening arrestor will be provided on the top of chimney.
- Trained and experience operator will be employed for tank farm area.
- NFPA label (hazard identification) capacity and content will be displayed on storage tank.
- Solvents will be transferred by pump only in plant area and day tank will be provided. Overflow line will be return to the storage tank or Pump On-Off switch will be provided near day tank in plant.
- Jumpers will be provided on solvent handling pipe line flanges.
- Flexible SS hose will be used for road tanker unloading purpose and other temperature connection.
6.4.3 For Drum Storage area:

Some chemicals will be received at plant in drums by road truck and stored in a separate drum storage area.

- FLP type light fittings will be provided.
- Proper ventilation will be provided in godown.
- Proper label and identification board /stickers will be provided in the storage area.
- Conductive drum pallets will be provided.
- Drum handling trolley / stackers/fork lift will be used for drum handling.
- Separate dispensing room with local exhaust and static earthing provision will be made.
- Materials will be stored as per its compatibility study and separate area will be made for flammable, corrosive and toxic chemical drums storage.
- Smoking and other spark, flame generating item will be banned from the Gate.

6.4.4 Transportation

- Class A petroleum products will be received through road tanker and stored in underground storage tank as per petroleum Act & Rules.
- Road tanker unloading procedure will be in place and will be implemented for safe unloading of road tanker.
- Static earthing provision will be made for tanker unloading.
- Earthed Flexible Steel hose will be used for solvent unloading from the road tanker.
- Fixed pipelines with pumps will be provided for solvent transfer up to Day tanks/reactors.
- Double mechanical seal type pumps will be installed.
- NRV provision will be made on all pump discharge line.
## 6.4.5 Transportation, Unloading and handling procedure for Methanol, IPA, Xylene and Butanol

<table>
<thead>
<tr>
<th>SR.NO.</th>
<th>ACTIVITY</th>
<th>TYPE OF POSSIBLE HAZARD</th>
<th>MITIGATION MEASURES</th>
</tr>
</thead>
</table>
| 1      | Transportation of Chemicals like H₂SO₄ & Thionyl Chloride by road tanker | Leakage & Spillage, Toxic release | • Check the source of leakage point.  
• Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.  
• Stop leak if you can do it without risk.  
• Isolate the area  
• Isolate the container  
• Training will be provided to driver and cleaner regarding the safe driving, hazard of Flammable chemicals, emergency handling.  
• TREM card will be kept with TL.  
• Fire extinguishers will be kept with TL.  
• Flame arrestor will be provided to TL exhaust.  
• Instructions will be given not to stop road tanker in populated area.  
• Clear Hazard Identification symbol and emergency telephone number will be displayed as per HAZCHEM CODE.  
• Appropriate PPEs will be kept with TL. |
| 2      | H₂SO₄ and Thionyl Chloride Road tanker unloading at project site. | Leakage & Spillage, Toxic release | • Check the source of leakage point.  
• Do not touch damaged containers or spilled material unless wearing appropriate protective clothing.  
• Stop leak if you can do it without risk.  
• Isolate the area  
• Isolate the container  
• Check the source of leakage point.  
• Isolate the area  
• Isolate the container  
• Spray the water on leakage  
• Priority will be given to Tanker to immediately enter the storage premises at site and will not be kept waiting near the gate or the main road.  
• Security person will check License, TREM CARD, Fire extinguisher condition; Antidote |
| 3 | H₂SO₄ and Thionyl Chloride transfer from Day tank to reactor. | Leakage, Spillage due to Line rupture, Flange Gasket failure, Toxic release. | Kit, required PPEs as per SOP laid down.  
- Store officer will take sample as per sampling SOP from sampling point.  
- After approval of QC department unloading procedure will be allowed be started.  

**Following precautions will be adopted during unloading**  
- Wheel stopper will be provided to TL at unloading platform.  
- Static earthing will be provided to road tanker.  
- Tanker unloading procedure will be followed according to check list and implemented.  
- Flexible SS hose connection will be done at TL outlet line.  
- The quantity remaining in the hose pipeline will be drained to a small underground storage tank, which will be subsequently transferred by nitrogen pressure to the main storage tank thus ensuring complete closed conditions for transfer from road tanker.  
- All TL valves will be closed in TL.  
- Finally earthing connection and wheel stopper will be removed.  
- Only day time unloading will be permitted.  

6.4.6 **OCCUPATIONAL HEALTH AND SAFETY PROGRAM FOR THE PROJECT.**  
Occupational Health is eventually a branch of preventive medicine which examines the relationship between work and health and effects of work on the health of the worker. Occupational health service is operated to achieve the statutory declared aim of occupational health by medical and technical measures. Its role is mainly preventive and to give first aid and emergency treatment. It is certainly useful in early detection of any
occupational or non-occupational disease or any man-adjustment of the man-job relationship.

**OCCUPATIONAL HEALTH AND SAFETY PROGRAM:**
1. Medical examinations: Pre-employment, periodic and others.
2. Supervision of the working environment industrial hygiene, safety, job analysis and adaptation of the job to the worker in good working conditions.
3. Advice to management and worker.
4. Health education and training.
5. Health statistics.
7. Health counseling-individual.
9. Co-operation with other services in the undertaking.
10. Collaboration with external services.

Other purposes of industrial medical services are:

I) Identifying the Hazards
II) Preventing or minimizing the Hazards
III) Curative treatment in case of exposure
IV) Determining the Compensation for damages

**Expected Occupational Health & Safety Hazards**

- Physical Hazards: Noise, Heat, Dust,
- Chemical Hazards: Corrosive, Toxic Substances, Irritants, Carcinogens, Chemical emissions
- Psychological hazards resulting from stress and strain
- Hazards associated with the non-application of ergonomic principles, for example badly designed machinery, mechanical devices and tools used by workers, improper seating and workstation design, or poorly designed work practices.
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Expected chemical hazards in work environment

<table>
<thead>
<tr>
<th>Name of Chemical</th>
<th>Health Hazard due to exposure to these chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thionyl Chloride</td>
<td>Irritant: may be irritating to Respiratory tract, skin and eyes. May cause central nervous system effects. May cause kidney and liver damage.</td>
</tr>
<tr>
<td>Solvent</td>
<td>Hazardous in case of skin contact (irritant, permeator), of eye contact (irritant), of ingestion, of inhalation.</td>
</tr>
</tbody>
</table>

Mitigation Measures for OSH: It is proposed to formulate and implement a structure for Occupational Safety and Health with following aims...

- To keep air-borne concentration of toxic and hazardous chemicals below PEL and TLV.
- Protect general health of workers likely to be exposed to such chemicals
- Providing training, guidelines, resources and facilities to concerned department for occupational health hazards.
- It is proposed that this EMP be formulated on the guidelines issued by Bureau of Indian Standards on OH&S Management Systems: IS 18001:2000 Occupational Health and Safety Management Systems
- Proposed EMP will be incorporated in Standard Operating Procedure also.

The proposed EMP will also include measure to keep air-born concentration of toxic and hazardous chemicals below its PEL and TLV, like...

- Leak Surveys
- Separate storage for toxic chemicals
- Exhaust Ventilation
- Proper illumination
- On-line detectors toxic chemicals
- Close processes to avoid spills and exposures
- Atomization of process operations to hazards of manual handling of chemicals
- Supply of proper PPEs like Air mask, Berating canisters, SCBA sets, On-line breathing apparatus at the places where there is possibility of presence of toxic chemicals
- Decontamination procedure for empty drums and carboys.
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– Regular maintenance program for pumps, equipment, instruments handling toxic and corrosive chemicals
– Display of warning boards
– Training to persons handling toxic and corrosive chemicals

6.5 HAZARD IDENTIFICATION
The major hazards in the M/s. Bromchem Laboratories Pvt. Ltd. are described below.

- Toxic hazard due to leakage of hazardous chemicals Thionyl Chloride.
- Fire and Explosive hazard due to leakage of chemicals like Butanol, Benzene etc from storage tank.
- Corrosive hazard due to leakage of chemicals like H\textsubscript{2}SO\textsubscript{4}, Propionic acid etc from storage tank.
- Electrical hazards due to the electrical major equipment/ machinery, operations, welding, motors, and heavy lift devices, cabling, human intervention (short circuit possibility), maintenance work (due to machinery breakdown etc.), plant lighting related electrical hazards.
- Possibility of human injury due to working with mechanical machines, manual handling etc.
- Possibility of injury during chemicals handled, during operations and due to intoxication.
- Major dropped objects hazard due to large number of physical handling steps / operations involved with crane/ overhead lifting/ hoisting equipment.
- Fires in any part of the plant working areas – there is a possibility of rapid escalation if it is not brought under control quickly.
- Possibilities of fire hazards at transformers, switchgear and other electrical equipment etc.

6.6 Determining Significance
Determining Significance is evaluation of the significance of the risk estimation and each of the components of the risk assessment process, including elements of risk perception and cost/benefit consideration.
6.7 Risk Management

M/s. Bromchem Laboratories Pvt. Ltd. will be managed the economical and social aspects of risk. Improvement in scientific and factual basis for risk assessment is necessary for better risk management decisions and public creditability of those decisions.

M/s. Bromchem Laboratories Pvt. Ltd. will be considered the Risk management strategies including all the specific activities. First step involves taking a decision about the weather any actions are necessary and if so, what nature of the action should it be.

The fatality probability is function of:

- Probability of occurrence of hazardous events
- Probability of weather condition, wind direction
- Probability of number of persons exposed which depends on the severity of the consequences
- Lethality factor
- Probability of ignition source

Probability exposed weather conditions; wind directions, ignition sources and lethality factors cannot be changed or controlled. The only factor possible to reduce is the probability of occurrence of hazardous event. M/s. Bromchem Laboratories Pvt. Ltd. could be achieved by reducing the failure probabilities of system components through proper maintenance or in some cases providing redundancies and also providing adequate safety measures in the form of protective system such as alarms, trips, sprinkles etc.

6.8 Risk Acceptance

The acceptance of risk by individuals and collectively by society in M/s. Bromchem Laboratories Pvt. Ltd. is affected by many parameters. Some people may accept the risk voluntarily while some may do so involuntarily. The general public acceptance also depends on their understanding and knowledge of risks. Finally each individual has a different perception for risk acceptance. The lowest level for involuntary uses is set by the risk of death from natural events such as lightening, flood, earthquakes, etc. M/s. Bromchem Laboratories Pvt. Ltd. is carried out survey of risks in this range which is shown in Table
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Risk level for various activities commonly encountered

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Activities/Resources</th>
<th>Estimated Risk * $10^{-6}$ fatalities per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Run over by Road Accidents</td>
<td>55</td>
</tr>
<tr>
<td>2.</td>
<td>Natural Disasters (Floods, Storm)</td>
<td>1.8</td>
</tr>
<tr>
<td>3.</td>
<td>Falling Aircrafts</td>
<td>1.2</td>
</tr>
<tr>
<td>4.</td>
<td>Explosions of vessels</td>
<td>0.5</td>
</tr>
<tr>
<td>5.</td>
<td>Transportation of Chemicals</td>
<td>0.7</td>
</tr>
</tbody>
</table>
The level of risk above the order of annual fatality risk level of $10^{-4}$ per year is unacceptable, as shown in Table.

### Acceptance of annual fatality risk levels

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Annual Fatality risk level per year</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>$10^{-6}$</td>
<td></td>
</tr>
</tbody>
</table>
  - Not of great concern to average person.  
  - People are aware of these accidents but feel that they can't happen to them.  
  - Phrases associated with these hazards have element of resignation: “lighting never strikes twice”, an act of God”.

#### 6.9 Quantitative Risk Assessment

- Start  
  - Identify Risk Areas  
    - Select a Risk Area  
      - Identify Failure Cases  
        - Select a Failure Cases  
          - Identify Consequence  
            - Select Consequence Outcomes  
              - Determine Frequency  
                - Estimate  
                  - Record Frequency and Consequence in a summary  
                    - Have all Consequence outcomes been studied?  
                      - Have all failure cases been  
                        - Have all risk areas been studied?  
                          - Draw Risk Contours  
                            - Yes  
                              - Finish
6.9.1 Identification of Hazardous Areas

The procedure for QRA starts with identification of major risk areas in the installation. Operation carried out in pesticide Industries usually come under certain board, general categories. In M/s. Bromchem Laboratories Pvt. Ltd. major risk areas will storage tank area, plant area and utility area.

- Bulk storage of liquids (e.g. Sulphuric Acid, Thionyl Chloride etc) area in M/s. Bromchem Laboratories Pvt. Ltd. at ambient temperature and atmospheric pressure.
- Process Plant involving pumping, transportation, reactors, distillation, heating, cooling, etc.
- Bulk loading from storage tanks into road or rail tankers.
- Drum Storage Area.

6.9.2 Identification of Failure cases for Hazardous areas

- Release due to catastrophic failure of storage tanks or process vessels.
- Rupture of connected pipe with storage tank or process vessels.
- Continuous release at significant rates for long durations transfer pipelines caused by sudden, major break of the pipeline.
- Continuous release at low rate through small holes or cracks in piping and vessels, flange leaks, and leakage from pump glands and similar seals.
6.10 CONSEQUENCE ANALYSIS

In a plant handling hazardous chemicals, the main hazard arises due to storage, handling & use of these chemicals. If these chemicals are released into the atmosphere, they may cause damage due to resulting fires or vapour clouds. Blast Overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits.

Operating Parameters

Potential vapour release for the same material depends significantly on the operating conditions. Especially for any liquefied gas, the operating conditions are very critical to assess the damage potential.

Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role in regard to the potential hazard. Larger the inventory of a vessel or a system, larger the quantity of potential release. The potential vapour release (source strength) depends upon the quantity of liquid release, the properties of the materials and the operating conditions (pressure, temperature). If all these influencing parameters are combined into a matrix and vapour source strength estimated for each release case, a ranking should become a credible exercise.

Loss of Containment

Plant inventory can get discharged to Environment due to Loss of Containment. Certain features of materials to be handled at the plant need to be clearly understood to firstly list out all significant release cases and then to short list release scenarios for a detailed examination. Liquid release can be either instantaneous or continuous. Failure of a vessel leading to an instantaneous outflow assumes the sudden appearance of such a major crack that practically all of the contents above the crack shall be released in a very short time. The more likely event is the case of liquid release from a hole in a pipe connected to the vessel. The flow rate will depend on the size of the hole as well as on the pressure, which was present, in front of the hole, prior to the accident. Such pressure is basically dependent on the pressure in the vessel. The vaporisation of released liquid depends on the vapour pressure and weather conditions. Such consideration and others have been kept in mind both during the initial listing as well as during the short-listing procedure. In the study, Maximum Credible Loss accident methodology is to be used, therefore, the largest potential
hazard inventories have been considered for consequence estimation.

6.10.1 DAMAGE CRITERIA

In consequence analysis, use is made of a number of calculation models to estimate the physical effects of an accident (spill of hazardous material) and to predict the damage (lethality, injury, material destruction) of the effects. The calculations can roughly be divided in three major groups:

a) Determination of the source strength parameters;
b) Determination of the consequential effects;
c) Determination of the damage or damage distances.

The basic physical effect models consist of the following.

Source strength parameters

- Calculation of the outflow of liquid, vapour or gas out of a vessel or a pipe, in case of rupture. Also two-phase outflow can be calculated.
- Calculation, in case of liquid outflow, of the instantaneous flash evaporation and of the dimensions of the remaining liquid pool.
- Calculation of the evaporation rate, as a function of volatility of the material, pool dimensions and wind velocity.
- Source strength equals pump capacities, etc. in some cases.

Consequential effects

- Dispersion of gaseous material in the atmosphere as a function of source strength, relative density of the gas, weather conditions and topographical situation of the surrounding area.
- Intensity of heat radiation [in kW/ m²] due to a fire or a BLEVE, as a function of the distance to the source.
- Energy of vapour cloud explosions [in N/m²], as a function of the distance to the distance of the exploding cloud.
- Concentration of gaseous material in the atmosphere, due to the dispersion of evaporated chemical. The latter can be either explosive or toxic.

It may be obvious, that the types of models that must be used in a specific risk study strongly depend upon the type of material involved:
Selection of Damage Criteria

The damage criteria give the relation between extent of the physical effects (exposure) and the percentage of the people that will be killed or injured due to those effects. The knowledge about these relations depends strongly on the nature of the exposure. For instance, much more is known about the damage caused by heat radiation, than about the damage due to toxic exposure, and for these toxic effects, the knowledge differs strongly between different materials.

In Consequence Analysis studies, in principle three types of exposure to hazardous effects are distinguished:

- Heat radiation, from a jet, pool fire, a flash fire or a BLEVE.
- Explosion
- Toxic effects, from toxic materials or toxic combustion products.

In the next three paragraphs, the chosen damage criteria are given and explained.

**6.10.2 MAXIMUM CREDIBLE LOSS ACCIDENT SCENARIOS**

A Maximum Credible Accident (MCA) can be characterised as the worst credible accident. In other words: an accident in an activity, resulting in the maximum consequence distance that is still believed to be possible. A MCA-analysis does not include a quantification of the probability of occurrence of the accident. Another aspect, in which the pessimistic approach of MCA studies appears, is the atmospheric condition that is used for dispersion calculations. As per the reference of the study, weather conditions having an average wind speed of 2.0 m/s have been chosen.

The Maximum Credible Loss (MCL) scenarios have been developed for the Facility. The MCL cases considered, attempt to include the worst “Credible” incidents- what constitutes a credible incident is always subjective. Nevertheless, guidelines have evolved over the years and based on basic engineering judgement, the cases have been found to be credible and modelling for assessing vulnerability zones is prepared accordingly. Only catastrophic cases have been considered and not partial or small failures (as is the case in Quantitative Risk
Assessment where contributions from low frequency - high outcome effect as well as high frequency - low outcome events are distinguished). The objective of the study is emergency planning; hence only holistic & conservative assumptions are used for obvious reasons. Hence though the outcomes may look pessimistic, the planning for emergency concept should be borne in mind whilst interpreting the results.

6.10.3 CONSEQUENCE ANALYSIS CALCULATIONS
The Consequence Analysis has been done for selected scenarios. This has been done for weather conditions having wind speed 2.0 m/s. In Consequence Analysis, geographical location of the source of potential release plays an important role. Consideration of a large number of scenarios in the same geographical location serves little purpose if the dominant scenario has been identified and duly considered.
6.10.4 SOFTWARE USED FOR CALCULATIONS

6.10.4.1 Phast Micro:
Phast is the most comprehensive software available for performing Process Hazard Analysis (PHA), Quantitative Risk Assessment (QRA) and Financial Risk Analysis (FRA). Our extensively validated software for consequence and risk analysis is used by governments and industry helping them to comply with local safety regulation and their own corporate best practice. Phast contains all the discharge, dispersion, effects and risk models you will need to accurately assess all your major hazards and associated risks. Phast Consequence provides you with comprehensive hazard analysis facilities to examine the progress of a potential incident from the initial release to its far-field effects.

Toxic and Flammable Impact
It calculates the initial discharge, as the material expands from its storage conditions to atmospheric, through dispersion, as the material mixes with air and dilutes, and the subsequent toxic or flammable effects. Phast includes a wide range of models for discharge and dispersion as well as flammable, explosive and toxic effects.

Discharge
- Phast requires basic information about storage or process conditions and material properties in order to perform discharge calculations
- The software comes with an integrated material property database containing more than 1,600 pre-defined pure component chemicals
- Various discharge scenario options have been implemented to represent common process failures, and model their behavior. These include:
  - Leaks and line ruptures from long & short pipelines
  - Catastrophic ruptures
  - Relief valve and disc ruptures
  - Tank roof collapse
  - Vent from vapour spaces
  - In building release effects
Dispersion

The dispersion models within Phast are able to model the following phenomena

- Dispersion of gas, liquid and two-phase releases
- Liquid droplet thermo dynamics calculations and liquid droplet rainout
- Pool spreading and vaporization
- Building wake dispersion effects for vapour releases

Flammable Effects

For releases of flammable material Phast calculates

- Radiation profiles and contours from a range of fire scenarios including pool fires, flash fires, jet fires and fire balls, including cross-wind effects on a jet fire
- Vapour Cloud Explosion modeling using industry standards models including the TNO Multi-energy, Baker Strehlow Tang and TNT Equivalence models
- Overpressure contours from Boiling Liquid Expanding Vapour Explosions

Toxic Effects

- Graphs of toxic concentration profile
- Indoor and outdoor toxic dose prediction
- Reporting of distance to specific dose and concentration
- Calculated exposure time and use as “averaging time” for passive dispersion effects

Phast Risk

Phast Risk allows you to combine the flammable and toxic consequences from each scenario in your QRA model with their likelihood to quantify the risk of fatalities. Phast Risk allows you to take account of local population distribution, sources of ignition, land usage and local prevailing weather conditions. It is designed to perform all the analysis, data handling and results presentation elements of a QRA within a structured framework.

Phast Risk allows you to quickly identify major risk contributors so that time and efforts can be directed to mitigating these highest risk activities. Based on effects calculations and population vulnerabilities, Phast Risk can integrate over all scenarios and weather
conditions to estimate the total risk. The established individual and societal risk indicators are predicted by Phast Risk across your facility and surrounding area using the classical QRA methodology. Risk ranking reports can be produced at points of strategic importance to show the relative influence of the various failure scenarios and their contribution to both the individual and societal risk metrics.

A key benefit of Phast Risk is the ability to identify major risk contributors and differentiate these from incidents with worst case consequences which might otherwise dominate the safety reviews. Whilst medium scale incidents have lesser consequences, they may have a higher frequency, which, when combined with their hazardous effects, generate a higher level of risk. Time and effort directed to mitigating high consequence but often low frequency events may not be well spent. Phast Risk helps you direct this effort more effectively.

Phast Risk also provides facilities to help you manage large quantities of input data, including scenarios, parameters, wind roses, ignition and population, and combine these in many ways. This is critical when looking at sensitivity analyses and assessing the merits of a range of risk reduction measures.

Benefits

- Facilitates cost reduction in terms of losses and insurance
- Allows optimization of plant and process design
- Assist in compliance with safety regulators
- Enables quicker response to hazardous incidents
- Improve engineer’s understanding of potential hazards
- Regular software upgrades incorporate industry experience and expertise, and advances in consequence modeling technology

Financial Extension

The Financial Consequence extension is used to assess situations which present potential hazards not only to life but also to the environment, property and business and help
quantifying their severity in financial terms. Phast Financial helps you to estimate the cost of a particular release of a given material under specified conditions. The Financial Risk extension helps you to calculate the broader financial risks associated with accidents and can be used to help manage your business risk and assess appropriate levels of insurance.

**Blast Extension for Explosion Risk**

The Blast extension permits more accurate explosion modeling and thus better risk predictions. It provides all the extra functionality required to assess overall risks taking account of protection provided by different types of structure and areas of congestion on your plant. Models supported include the Multi Energy and Baker Strehlow Tang explosion models and a number of industry standard vulnerability models.

**Multi-Component Extension**

The multi-component extension to Phast provides greater accuracy for liquid or two-phase mixture releases compared to the standard pseudo-component approach. The composition of each component of the mixture is calculated throughout the discharge and dispersion phases of the release.

### 6.11 SCENARIOS

**TABLE – 6.3**

**POSSIBLE ACCIDENT SCENARIOS**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>MCL Scenario</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Release of H₂SO₄</td>
<td>15 KL</td>
</tr>
<tr>
<td>2</td>
<td>Release of Thionyl Chloride</td>
<td>20 KL</td>
</tr>
<tr>
<td>3</td>
<td>Release of Drum</td>
<td>200 Kg</td>
</tr>
</tbody>
</table>
**Consequence Analysis**

**Introduction**

In this, the source terms for each defined failure cases are presented, including calculated release rate, release duration and total released mass of fluid. Subsequently consequence results from selected failure cases are also presented in order to give overview on the extent of impact from potential major accident scenarios. Five types of consequences are presented, i.e. jet fire, pool fire, flash fire, explosion and toxic impact.

**Consequence Distances**

**Pool Fire, Fire ball, Flash Fire**

The extent of the consequence of a Pool fire is represented by the thermal radiation envelope. Three levels of radiation are presented in this report, i.e.:

- 4 kW/m\(^2\); this level is sufficient to cause personnel if unable to reach cover within 20s; however blistering of the skin (second degree burn) is likely; 0: lethality.
- 12.5 kW/m\(^2\); this level will cause extreme pain within 20 seconds and movement to a safer place is instinctive. This level indicates around 6% fatality for 20 seconds exposure.
- 37.5 kW/m\(^2\); this level of radiation is assumed to give 100% fatality as outlined above.
6.11.1 DETAILED SUMMARY OF RESULTS:
Detailed Results of the consequence analysis of above-mentioned scenarios have been given below:

Scenario # 1: Release of Sulphuric Acid
This scenario considers release of Sulphuric Acid from Storage Tank:

Results indicate:

<table>
<thead>
<tr>
<th>Spill pool evaporation module for Sulphuric Acid due to Catastrophic Rupture of 15 KL Storage Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Data</strong></td>
</tr>
<tr>
<td>Stored quantity - 15 KL</td>
</tr>
<tr>
<td>Molecular weight - 98.08</td>
</tr>
<tr>
<td>Wind speed – 2.00 m/s</td>
</tr>
<tr>
<td>Failure Mode: Catastrophic failure of 4” bottom nozzle and loss of containment</td>
</tr>
<tr>
<td>Density (Air) – 1840 kg/m³</td>
</tr>
<tr>
<td>Release rate: 1000 g/s</td>
</tr>
<tr>
<td><strong>Results indicate</strong></td>
</tr>
<tr>
<td>LC50 – 510 ppm</td>
</tr>
<tr>
<td>IDLH – 3 ppm</td>
</tr>
<tr>
<td>TLV – 1 ppm</td>
</tr>
<tr>
<td>38.26 meter</td>
</tr>
<tr>
<td>528.56 meter</td>
</tr>
<tr>
<td>792.29 meter</td>
</tr>
</tbody>
</table>

Results:-

- LC50 HUMAN (510 ppm) area is up to 38.26 meter,
- IDLH (3 ppm) concentration area is up to 528.56 meter and
- TLV (1 ppm) area is up to 792.29 meter.

Therefore, 528.56 meter area in wind direction is considered as evacuation area.
Scenario:
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MITIGATION MEASURES FOR SULPHURIC ACID LEAKAGE:
✓ Isolate the source if possible without risk.
✓ If leakage is small, dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.
✓ Absorb with DRY earth, sand or other non-combustible material.
✓ Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift.
✓ Use water spray to reduce vapors.
✓ Prevent entry into sewers, basements or confined areas.
✓ Neutralize the residue with a dilute solution of sodium carbonate.

PREVENTIVE MEASURES TO AVOID SULPHURIC ACID LEAKAGE:
✓ A dike will be provided to accommodate the full quantity in tank.
✓ Periodic testing of storage tank will be done by competent person.
✓ Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective TLVs. Storage tank vent is connected to scrubber system.
✓ Flange guard provided to prevent splash of material.
✓ Level interlock
✓ Keep container dry. Never add water to this product.
✓ In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label.
✓ Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, organic materials, metals, alkalis, moisture.
✓ Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.
✓ While handling always use face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent.
✓ Ensure that eyewash stations and safety showers are proximal to the work-station location.
Scenario # 2: Release of Thionyl Chloride
This scenario considers release of Thionyl Chloride from Storage Tank:

Results indicate:

<table>
<thead>
<tr>
<th>Spill pool evaporation module for Thionyl Chloride due to Catastrophic Rupture of 20 KL Storage Tank</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Data</strong></td>
</tr>
<tr>
<td>Stored quantity - 20 KL</td>
</tr>
<tr>
<td>Molecular weight -119</td>
</tr>
<tr>
<td>Wind speed – 2.00 m/s</td>
</tr>
<tr>
<td>Failure Mode: Catastrophic failure of 4” bottom nozzle and loss of containment</td>
</tr>
<tr>
<td>Density (Air) – 1640 kg/m³</td>
</tr>
<tr>
<td>Release rate: 1000 g/s</td>
</tr>
<tr>
<td><strong>Results indicate</strong></td>
</tr>
<tr>
<td>LC50 (HCl) – 3940 ppm</td>
</tr>
<tr>
<td>IDLH (HCl) – 50 ppm</td>
</tr>
<tr>
<td>TLV (HCl) –5 ppm</td>
</tr>
<tr>
<td>LC50 (SO2) – 5784 ppm</td>
</tr>
<tr>
<td>IDLH (SO2) – 100 ppm</td>
</tr>
<tr>
<td>TLV (SO2) –2 ppm</td>
</tr>
</tbody>
</table>
### Scenario:

<table>
<thead>
<tr>
<th>Reference: YOUR REF.</th>
<th>0 m</th>
<th>250 m</th>
<th>500 m</th>
<th>750 m</th>
<th>1000 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ppm</td>
<td></td>
<td>6895.99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td></td>
<td>68.76 sqm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **6895.99 ppm, Area = 68.76 sqm**
- **50.00 ppm, Area = 580.76 sqm**
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Reference: YOUR REF.

Graphs of 5-Isoplet

100 ppm, Area = 4,000 m²

50.00 ppm, Area =
### Scenario -3 Unconfined Pool Fire Simulations for Drum Storage Area

#### Catastrophic Rupture

**Input Data**

- **Stored quantity** - 10 KL
- **Wind speed** - 2.00 m/s
- **Density (Air)** – 0.867 g/cm³

Results indicate

#### Pool Fire Scenario

<table>
<thead>
<tr>
<th>Radiation Level (KW/m²)</th>
<th>Distance in meter</th>
<th>Effect if IHR at Height of simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>48.2</td>
<td>This level is sufficient to cause personnel if unable to reach cover within 20s; however blistering of the skin (second degree burn) is likely; 0: lethality</td>
</tr>
<tr>
<td>12.5</td>
<td>35.8</td>
<td>This level will cause extreme pain within 20 seconds and movement to a safer place is instinctive. This level indicates around 6% fatality for 20 seconds exposure.</td>
</tr>
<tr>
<td>37.5</td>
<td>12.40</td>
<td>This level of radiation is assumed to give 100% fatality as outlined above.</td>
</tr>
</tbody>
</table>

#### Fire Ball Scenario

<table>
<thead>
<tr>
<th>Radiation Level (KW/m²)</th>
<th>Distance in meter</th>
<th>Injury Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>52.0</td>
<td>Pain after 20secs.</td>
</tr>
<tr>
<td>12.5</td>
<td>39.1</td>
<td>1st degree Burn</td>
</tr>
<tr>
<td>37.50</td>
<td>14.2</td>
<td>100% Fatal</td>
</tr>
</tbody>
</table>
Scenario:

Pool Fire:
Fire Ball:
Measures to be taken to prevent such accident:

- Priority will be given to Tanker to immediately enter the storage premises at site and will not be kept waiting near the gate or the main road.
- Security person will check License, TREM CARD, Fire extinguisher condition, Antidote Kit, required PPEs as per SOP laid down.
- Store officer will take sample as per sampling SOP from sampling point.
- After approval of QC department unloading procedure will be allowed be started.

Following precautions will be adopted during unloading

- Wheel stopper will be provided to TL at unloading platform.
- Static earthing will be provided to road tanker.
- Tanker unloading procedure will be followed according to check list and implemented.
- Flexible SS hose connection will be done at TL outlet line.
- The quantity remaining in the hose pipeline will be drained to a small underground storage tank, which will be subsequently transferred by nitrogen pressure to the main storage tank thus ensuring complete closed conditions for transfer from road tanker.
- All TL valves will be closed in TL.
- Finally earthing connection and wheel stopper will be removed.
- Only day time unloading will be permitted.

Following precautions will be adopted Storage of such chemicals

- Storage tank will be stored away from the process plant.
- Tanker unloading procedure will be prepared and implemented.
- Caution note and emergency handling procedure will be displayed at unloading area and trained all operators.
- NFPA label will be provided.
- Required PPEs like full body protection PVC apron, Hand gloves, gumboot, Respiratory mask etc. will be provided to operator.
- Neutralizing agent will be kept ready for tackle any emergency spillage.
- Safety shower, eye wash with quenching unit will be provided in acid storage area.
- Material will be handled in close condition in pipe line.
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- Dyke wall will be provided to all storage tanks, collection pit with valve provision.
- Double drain valve will provided.
- Level gauge will be provided on all storage tanks.
- Safety permit for loading unloading of hazardous material will be prepared and implemented.
- TREM CARD will be provided to all transporters and will be trained for transportation Emergency of Hazardous chemicals.
- Fire hydrant system with jockey pump as per TAC norms will be installed.

**For Storage tank farm area:**

- Under N2 pressure storage.
- Safety valve provided and storage facility to ensure safe release of HC in case of over pressure.
- Dyke with separate fencing area is provided.
- SOP prepared
- Road tanker unloading procedure prepared
- Work permit followed
- PPEs used
- Safety shower, eye wash provided.
- NFPA labeling system adopted for storage tanks.
- Level indicator at local.
- Alarm for high level & high pressure.
- Automatic fire fighting indication provided for around the storage area
- Sprinkler system will be provided
6.12 HAZARDOUS MATERIALS TRANSPORTATION SAFETY GUIDELINES

Introduction
Transportation typically involves carrying of small amounts of materials over short distances. Transportation does, however, pose significant risks from the frequency of the activity and the lack of observance of prescribed regulations. The hazardous materials should be packaged, based on the composition in a manner suitable for handling, storage and transport. Labelling and packaging is required to be easily visible and be able to withstand physical conditions and climatic factors. These guidelines are issued to facilitate safe transportation of the hazardous material in compliance of the regulations. In view of the stringent product quality requirement, various complex processes are introduced involving the handling of hazardous chemicals. These chemicals pose various types of hazards like flammability, toxicity, explosives, corrosives etc. Inadequate awareness about the hazardous properties of these chemicals may lead to serious accidents which will affect the men at work and the environment.

Scope
This document applies to the vehicular transportation, within geographically contiguous, of hazardous materials, substances, and wastes. Hazardous materials include chemical materials, substances or wastes. Transportation shall be performed in a manner which minimizes risk to the health and safety of employees, the public and the environment.

Guidelines for Transportation

General
It will be ensured that during the transportation contents are not spilled, packaging is not damaged and personnel are properly trained to generate, transport and receive such materials. In general, the traffic control program at Bromchem Laboratories Pvt. Ltd. requires that an on site driver possess a valid driver’s license. The maximum speed limit is 16 KMPH. TREM (Transport Emergency) cards are to be provided to the drivers.
Packing

The containers must be able to withstand normal handling and retain integrity for a minimum period of six months. In general, packaging for hazardous substances must meet the following requirements:

- All packaging materials including containers shall be of such strength, construction and type as not to break open or become defective during transportation.
- All packaging materials including containers shall be so packaged and sealed that spillages of hazardous materials/substances are prevented during transportation due to jerks and vibrations caused by uneven road surface.
- Re-packaging materials including that used for fastening must not be affected by the contents or form a dangerous combination with them.
- Packaging material should be such that there will be no significant chemical or galvanic action among any of the material in the package.
- Ensure that any cushioning or absorbent material used for packaging is also compatible with the hazardous material.

The containers when used for packaging of the hazardous Material shall meet the following requirements:
- Modes of packaging, like collection in 200-litre plastic drums, cardboard cartons, PP and HDPE/LDPE containers etc., also work for variety of materials. However, all such container should be amenable to mechanical handling.
- It should be leak proof.
- Use drums that are in good condition and free of rust and major dents.
- Ensure that drums are not leaking or overfilled before transporting them.
- Ensure that drum bungs are tight.
- Carefully inspect pallets before they are loaded.
- Do not use pallets with cracked or broken slats.
- Use a drum dolly to place drums on pallets.
- Secure all drums to the pallet with appropriate strapping material.
- In general, the containers for liquid HM should be completely closed, in fact sealed. There should be no gas generation due to any chemical reaction within the container, and, hence, there should not be any need for air vents; expansion due to increase/decrease in temperature normally does not need air vents.

- Container should be covered with a solid lid or a canvas to avoid emissions of any sort including spillage, dust etc. and to minimize odour generation both at the point of loading as well as during transportation.

- Container used for transportation of Material should be able to withstand the shock loads due to vibration effect/undulations of pavements etc.

- Container should be easy to handle during transportation and emptying.

- As far as possible, manual handling of containers should be minimized. Appropriate material handling equipment is to be used to load, transport and unload containers. This equipment includes drum, dollies, and forklifts, drum handling equipment, lift gates and pallets. Drums should not be rolled on or off vehicles.

- Where two-tier or three-tier storage is envisaged, the frame should have adequate strength to hold the containers.

- One-way containers are also allowed. The multi-use containers should be re-usable provided it should be cleaned and free from deterioration or defects.

- Loads are to be properly placed on vehicles. HM containers are not to overhang, perch, lean or be placed in other unstable base. Load should be secured with straps, clamps, braces or other measures to prevent movement and loss. Design of the container should be such that it can be safely accommodated on the transport vehicle.

- Dissimilar materials shall not be transported in the same container.

**Labelling**

There are two types of labeling requirements:

i. Labeling of individual transport containers [ranging from a pint-size to a tank], and

ii. Labeling of transport vehicles.

   - All hazardous Material containers must be clearly marked with current contents. The markings must be waterproof and firmly attached so that they cannot be removed.
Previous content labels shall be obliterated when the contents are different. Proper marking of containers is essential.

- Color code is to be provided to the tanker to indicate the type of material present in that.

- Containers that contain HM shall be labeled with the words "HAZARDOUS MATERIAL" in Vernacular language, Hindi / English. The information on the label must include the code number of the Material, the Material type, the origin (name, address, telephone number of the supplier and receiver), hazardous property (e.g. flammable, corrosive), and the symbol for the hazardous property.

- The label must withstand the effects of rain and sun. Labeling of containers is important.

The following are the requirements for labeling:

Emergency contact phone numbers shall be prominently displayed viz. the phone number of concerned Regional Officer of the SPCB, Fire Station, Police Station and other agencies concerned.

**Unloading of Tank Trucks / Tank Wagons**

- Before the tanker enters the industry premises, the tanker is to be inspected for authorized entry and safe & sound condition of the tanker, its contents and that of the prime mover.

- Tankers entering plant are to be fitted with flare arresters on their exhaust.

- The quality of the chemical in the tanker should be ascertained before unloading to avoid contamination of chemical already at storage.

- In case of flammable chemicals, the prime mover (engine) should be kept off. The tanker should be properly blocked from movement before connections are made for unloading hazardous chemicals.

- In case of flammable chemicals, the unloading point should be located at a safe distance outside the storage dyke.

- Pressurizing with air / inert gas for unloading should be avoided. It is recommended to use pumps / vacuum systems for unloading. Pumps should preferably be of seal
less type and valves should be of glandless types. Solid chemicals in bulk should be handled with lifting machines and conveyors.

- Coupling used for connecting hose to tanker must be leak proof. Flange connections are preferred. Where threaded connections are used, the threaded portion should be properly preserved against corrosion / wearing of threads and thoroughly inspected before connections are made.

- The unloading hose should be devoid of cracks & blisters and should be capable of withstanding whatever pressure developed during unloading operation. The hose should be hydro-tested at a frequency guided by experience. Proper records of hydro-test should be maintained.

- Same hose should not be used for unloading different chemicals. Hoses for different chemicals should be marked with different color stripes for easy identification.

- For flammable chemicals, the tanker and the hose are to be properly earthed before starting unloading operation.

- Unloading should preferably be done in day time.

- Unloading should be done under personal supervision of responsible staff authorized by the management.

- The operating staff must use suitable personal protective clothing / equipment. Suitable breathing canisters and first aid box must be available at site for use in case of emergency.

- Provision of sample quantity of water / neutralizing medium to take care of leakage / spillage must be made. Also steam and inert gas hose stations must be available at unloading point.

- There must be adequate illumination at site. Flame proof fittings should be used wherever necessary.

- The unloading systems should have facility to vent / drain the remaining chemical in the hose to a suitable safe point. The hose should be kept blinded when not in use. Thermal safety valve discharging to safe disposal or handling facility should be provided.

- Before starting unloading, the silage of the receiving tank should be checked. Care should be taken to avoid overflow of tanks. Gas / chemical leak detection system to
sound an alarm at the control room/site may be provided wherever possible, so that quick remedial measures can be taken. Wherever necessary, quick/remote isolation valves should be provided.

- Fire fighting facility commensurate with the chemical – as mentioned in the data sheet should be provided at the unloading point.

- Effective communication system like telephone must be available for communicating with the control room / fire station / health unit.

**Unloading of Drums / Containers**

- Manual handling of drums / containers should be minimized. It is preferable fork-lifters and suitable cradles are used to handle drums.

- Carboys containing hazardous chemicals should not be subjected to impact.

- Suitable protective clothing should be used while handling drums / containers and the operators should position him such that he is in the upwind direction so that even in case of accidental release of chemical, he is safe.
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6.13 RECOMMENDATIONS

The following actions are particularly recommended to be implemented in order to ensure ALARP (As Low As reasonably practical) performance in the operation: Maintain and ensure effectiveness of all the safety measures, among others through the following actions:

Raw Material Storage Area (Ware House I&II)
- The raw material storage area, i.e. ware house, should be declared as a prohibited area and should be provided having at least two exits, “No Smoking” and “Prohibited Area” display boards, as applicable should be provided at site.
- Regular inspection of drums containing raw material to be done to take care.
- Periodic site inspection should be carried out to ensure that there is no leakage from any of the drums in the ware house.
- Fire hydrant system needs to be provided in ware house area as per TAC standards.
- Smoke detector and fire alarm systems need to be provided.
- Provision of fire doors in ware house area.

Fire access for Tank Farm area and Ware Houses
- Fire access roads should be provided to storage area. The storage tanks / area should have suitable fire protection and fire fighting facility.

The following features are also important for the project by taking the layout into consideration:-

- Hinged doors swing outward in an explosion.
- Window panes (if installed) are shatterproof or plastic in frame.
- Floors, walls and ceilings are designed and installed to limit the generation and accumulation of static electricity.
- All doors must be fire resistant. Floors, walls and ceilings are designed for at least 2 h of fire resistance.
- Walls or partitions are continuous from floor to ceiling, and securely anchored.
- Integrity of the wall should be ensured i.e. blast wall not to be broken or drilled as that can leads to weak spots.
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- The building is constructed of non-combustible materials, on a substantial frame.
- Restrained deflagration vent panels are present.
- There is adequate ventilation, and any heating in rooms is limited to steam, hot water, or other indirect means.

**Electrical Safety for Whole Facility**

- Electrical Safety: All cables and electric fittings shall be constructed, installed, protected, operated and maintained in such a manner so as to prevent risk of open sparking.
6.14 DISASTER MANAGEMENT PLAN

6.14.1 DEFINING THE NATURE OF EMERGENCY

1. Hazop study will be conducted before setting up of the expansion pant.
2. Onsite Emergency Plan is to be upgraded and mock drills will be conducted.
3. Emergency Response Team (ERT) activities will be continued.
4. Training to be imparted to all employees on safety and health aspects of chemicals handling.

LEVEL OF EMERGENCY CAN BE CLASSIFIED IN THREE CATEGORIES.

LEVEL - 1:
The leakage or emergency, which is confinable within the plant, premises. It may be
Due to -
   a) Small fire in the plant
   b) Low toxic gas release for short duration.
   c) Collapsing of equipment that do not affect outside premises.

LEVEL - 2:
The emergency, which is confinable within the factory premises. It may arise due to -
   a) Major fire inside the factory premises.
   b) Medium scale explosion confined to the factory premises.
   c) Heavy toxic / flammable gas leakage for short duration.

LEVEL - 3:
The emergency, which is not confinable within the factory premises and general public in the vicinity likely to be affected. It may arise due to -
   a) Explosion of high magnitude affecting the adjacent area
   b) Heavy / Profuse leakage of toxic / flammable gases for a long duration.
6.14.2 OBSERVER

DUTIES OF OBSERVER

Any person noticing a fire, leakage of chemicals or an unusual occurrence will contact the security personnel at the main gate and Plant Supervisor by:

1. Giving a telephone message
2. Sending message through a messenger
3. Rush personally

While giving the message, he will:

1. Identify himself
2. State briefly type of emergency
3. Location of Incident / accident
4. Severity of emergency

After giving message, he will return to the scene / area of emergency by taking all personnel protection measures, if possible and awaits instructions from Plant Supervisor (Incident Controller).
6.14.3 CHIEF EMERGENCY CONTROLLER

Responsibility of Site Main Controller
Immediately when he is aware of the emergency, the Site Main Controller will proceed to the Emergency Control Room, where he will meet Communications Officer, Liaison Officer and Safety Officer.

1. The Site Main Controller will assess the magnitude of the situation, in consultation with the Incident Controller and decide if staff needs to be evacuated from their roll call points. He will announce the emergency through Messenger or via Intercom line and will give an order for evacuation.

2. Ensure that outside emergency services are called. (Fire Brigade, Police, Doctors, etc.)

3. Ensure that KEY PERSONNEL are called.

4. Exercise direct operational control of those parts of the works, outside the affected area.

5. Maintain a speculative continuous review of possible developments and assess these to determine the most probable course of events.

6. Ensure that the emergency is intimated to District Emergency Authorities

7. Issue authorized statements to the news media. Where appropriate, inform the seniors.

8. Ensure that proper consideration is given to the preservation of evidence.

9. Control rehabilitation of affected areas on cessation of emergency.

10. Determine what investigations and reporting should be carried out, and by whom, to determine cause and (if appropriate) prevention of recurrence.