1.1 RISK ASSESSMENT

1.1.1 Objective of the study
The principle objective of this study is to identify major risks in the manufacturing process and to evaluate on-site & off-site consequences of identified hazard scenarios. Pointers are then given for effective mitigation of hazards in terms of suggestions for effective disaster management, suggesting minimum preventive and protective measures & change of practices to ensure safety.

1.1.2 AIDS and Software
The consequence analysis for the modeled scenarios has been done using DNV’s software PHAST (Process Hazard Analysis Software Tool) which allows assessment of situations which present potential hazards to life, property and the environment, and to quantify their severity. PHAST examines the progress of a potential incident from the initial release to far-field dispersion including modeling of pool spreading and evaporation, and flammable and toxic effects. It is recommended for use by the Ministry of Environment & Forests per its EIA Guidelines, dated January 2001.

PHAST Professionals sophisticated modeling calculates distances effect produced by hazardous events. With this information, you can evaluate the need for mitigating measures such as changes in design, operation or response. PHAST software can be used to model a proposed facility or operational change to ease the selection of the most effective solutions. With PHAST Professional, you can define special events, model the change in a leak over time, and investigate the details of behavior with special stand-alone models and much, much more.

PHAST is integrated into safety and meets regulatory requirements. It uses unified dispersion modeling to calculate the results of the release of material into atmosphere

The salient features of this package:

1. It gives the consequence results in terms of – Flammable, Toxic and Explosion effects.
2. Flammable parameters covered under this package is- Defines the LEL and UEL zone Jet fire and pool fire scenario along with their respective effect zones (risk contour).
Flash fire and fire ball envelope

3. Toxic parameters-
Cloud concentration at user defined time as well as location
Categorize the toxic results in terms of ERPG, IDLH and STEL values.
Summarize results in terms of equivalent toxic dose along with effect zones.

4. Explosion parameters-
Categorize the explosion effects in terms of overpressures levels along with distance covered.

BLEVE (Boiling Liquid Expanding Vapor Explosion)
1.1.3 Risk & Hazard Study

Elaborated Qualitative and Quantitative Risk assessment the methodology –
The methodology includes,

Hazard identification

Selection of potential loss scenarios

Simulation of release source model on DNV’s PHAST, Version 6.7

Plotting the damage contour on site map

These steps undertaken to carry out risk assessment for this project are described in Chapter Additional study.
### Details of Storage facilities

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of Chemical</th>
<th>Physical state</th>
<th>Number of storage tanks</th>
<th>Capacity of Storage Tank (KL) each</th>
<th>Above ground/Underground</th>
<th>Storage Temperature (°C)</th>
<th>Storage Pressure (bar)</th>
<th>Dyke/Bund area (m²)</th>
<th>Dyke/Bund Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chlorine gas</td>
<td>Liquid/gas</td>
<td>upto 9 cylinders</td>
<td>900 kgs each</td>
<td>Above Ground</td>
<td>Ambient</td>
<td>upto 10 bar</td>
<td>48 m² (chlorine shed)</td>
<td>5.7 m (ht of Chlorine shed)</td>
</tr>
<tr>
<td>2</td>
<td>MCB</td>
<td>Liquid</td>
<td>1</td>
<td>10 kl</td>
<td>Above Ground</td>
<td>Ambient</td>
<td>Atmospheric pressure</td>
<td>50</td>
<td>1.2</td>
</tr>
<tr>
<td>3</td>
<td>Caustic lye</td>
<td>Liquid</td>
<td>1</td>
<td>10 kl</td>
<td>Above Ground</td>
<td>Ambient</td>
<td>Atmospheric pressure</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>4</td>
<td>Oleic acid</td>
<td>Liquid</td>
<td>drums</td>
<td>200 kgs HDPE drums</td>
<td>Above Ground</td>
<td>Ambient</td>
<td>Atmospheric pressure</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>5</td>
<td>Xylene</td>
<td>Liquid</td>
<td>2</td>
<td>10 kl</td>
<td>Above Ground</td>
<td>Ambient</td>
<td>Atmospheric pressure</td>
<td>50</td>
<td>1.2</td>
</tr>
<tr>
<td>6</td>
<td>Glycol</td>
<td>liquid</td>
<td>drums</td>
<td>200 kgs HDPE drums</td>
<td>Above Ground</td>
<td>Ambient</td>
<td>Atmospheric pressure</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

### Physico-chemical properties of Chemicals

<table>
<thead>
<tr>
<th>S. No</th>
<th>Raw Materials/Products</th>
<th>Formula</th>
<th>CAS Number</th>
<th>State</th>
<th>Color</th>
<th>Odor</th>
<th>Mol. Wt (g/mole )</th>
<th>Flash Point (°C)</th>
<th>Melting Point (°C)</th>
<th>Boiling Point (°C)</th>
<th>IDLH ppm</th>
<th>Stability</th>
<th>Hazard</th>
<th>Specific Gravity (g/cc)</th>
<th>LEL %</th>
<th>UEL %</th>
<th>Odor threshold (ppm)</th>
<th>Vapour Density (air=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aluminum Chloride</td>
<td>AlCl₃</td>
<td>7446-70-0</td>
<td>Solid</td>
<td>White to yellowish</td>
<td>Not available</td>
<td>133.34</td>
<td>NA</td>
<td>Sublimes</td>
<td>NA</td>
<td>NA</td>
<td>Stable</td>
<td>Hazardous &amp; corrosive in case of eye &amp; skin contact. Non-flammable solid</td>
<td>2.44</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>CPC Blue</td>
<td>C₃₂H₈₄Cu₅N₈</td>
<td>147-14-8</td>
<td>Solid</td>
<td>Blue</td>
<td>Not available</td>
<td>576.05</td>
<td>NA</td>
<td>Not available</td>
<td>NA</td>
<td>100</td>
<td>Stable</td>
<td>Inhalation: Coughing and sneezing. Ingestion: pain and vomiting. Severe eye surface injury and skin irritation</td>
<td>1.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>3</td>
<td>Cupric Chloride</td>
<td>CuCl₂.2H₂O</td>
<td>10125-13-0</td>
<td>Solid</td>
<td>Bluish-green</td>
<td>Odorless</td>
<td>170.48</td>
<td>NA</td>
<td>100</td>
<td>Decomposition temperature: 992.78° C</td>
<td>100</td>
<td>Stable</td>
<td>Hazardous &amp; corrosive in case of eye &amp; skin contact. Inhalation will lead to irritation to gastrointestinal or respiratory tract</td>
<td>2.54</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>5.9</td>
</tr>
<tr>
<td>4</td>
<td>Chlorine gas</td>
<td>Cl₂</td>
<td>7782-50-5</td>
<td>Liquid/gas</td>
<td>Greensh gas</td>
<td>Pungent</td>
<td>71</td>
<td>NA</td>
<td>-101</td>
<td>-34.05</td>
<td>10</td>
<td>Stable</td>
<td>Highly toxic &amp; corrosive</td>
<td>1.424</td>
<td>NA</td>
<td>NA</td>
<td>3.5</td>
<td>9.26</td>
</tr>
<tr>
<td>5</td>
<td>MCB</td>
<td>C₂H₅C</td>
<td>108-90-7</td>
<td>Liquid</td>
<td>Colorles</td>
<td>Almond-like</td>
<td>112.56</td>
<td>29.44</td>
<td>-45.6</td>
<td>132</td>
<td>1,000</td>
<td>Stable</td>
<td>Combustible &amp; irritant</td>
<td>1.1058</td>
<td>1.3</td>
<td>7.1</td>
<td>0.2</td>
<td>3.88</td>
</tr>
<tr>
<td>6</td>
<td>Caustic lye</td>
<td>NaOH</td>
<td>1310-73-2</td>
<td>Liquid</td>
<td>White</td>
<td>Odorless</td>
<td>40</td>
<td>NA</td>
<td>318</td>
<td>1390</td>
<td>0.01</td>
<td>Stable</td>
<td>Corrosive &amp; Irritant</td>
<td>2.13</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>S. No.</td>
<td>Raw Materials/Products</td>
<td>Formula</td>
<td>CAS Number</td>
<td>State</td>
<td>Color</td>
<td>Odor</td>
<td>Mol. Wt (g/mole)</td>
<td>Flash Point (°C)</td>
<td>Melting Point (°C)</td>
<td>Boiling Point (°C)</td>
<td>IDLH (ppm)</td>
<td>Stabilit y</td>
<td>Hazard</td>
<td>Speciﬁc Gravity (g/cc)</td>
<td>LEL %</td>
<td>UEL %</td>
<td>Odour threshold (ppm)</td>
<td>Vapour Density (air=1)</td>
</tr>
<tr>
<td>-------</td>
<td>------------------------</td>
<td>---------</td>
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<td>-------</td>
<td>---------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>7</td>
<td>Oleic acid</td>
<td>C18H34O2</td>
<td>112-80-1</td>
<td>Liquid</td>
<td>Liquid</td>
<td>Peculiar Lard-Like odor</td>
<td>282.47</td>
<td>188.8 9</td>
<td>16.3</td>
<td>286</td>
<td>Not listed</td>
<td>Stable</td>
<td>Slightly flammable to flammable in presence of heat</td>
<td>0.895</td>
<td>NA</td>
<td>NA</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Xylene</td>
<td>C6H4(CH3)2</td>
<td>1330-20-7</td>
<td>Liquid</td>
<td>Clear</td>
<td>Sweetish</td>
<td>106.17</td>
<td>24</td>
<td>-47.4</td>
<td>138.5</td>
<td>900</td>
<td>Stable</td>
<td>Hazardous: skin contact (irritant, permeator), of eye contact (irritant), Toxic to blood, kidneys, liver, mucous membranes, bone marrow, central nervous system (CNS)</td>
<td>0.864</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>3.7</td>
</tr>
<tr>
<td>9</td>
<td>Hydro Chloric acid</td>
<td>HCL</td>
<td>Mixture</td>
<td>Liquid</td>
<td>Colorless to light yellow Pungent - Irritating (Strong.)</td>
<td>NA</td>
<td>NA</td>
<td>-62</td>
<td>108</td>
<td>50</td>
<td>Stable</td>
<td>Irritant to eye, skin, non flammable,</td>
<td>1.1</td>
<td>NA</td>
<td>NA</td>
<td>0.25 to 10</td>
<td>1.267</td>
<td></td>
</tr>
</tbody>
</table>

### Scenarios for Simulation

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Full name of the Raw Material</th>
<th>Hazard involved</th>
<th>No. of Container &amp; Size at Site</th>
<th>Maximum Operating Pressure</th>
<th>Types of Failure Possible</th>
<th>Consequences Studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chlorine tonner</td>
<td>Highly toxic &amp; corrosive</td>
<td>9 Nos. 900 kgs.</td>
<td>up to 10.0 kg/cm²</td>
<td>2 mm dia hole leak in tank</td>
<td>Jet Fire &amp; Pool Fire</td>
</tr>
<tr>
<td>2</td>
<td>Mono chlorobenzene</td>
<td>Flammable &amp; Irritant</td>
<td>1 No. 10 KL</td>
<td>Atmospheric (1.0 kg/cm²)</td>
<td>10 mm dia hole leak in tank</td>
<td>Jet Fire &amp; Pool Fire</td>
</tr>
<tr>
<td>3</td>
<td>Xylene</td>
<td>Flammable</td>
<td>2 No. 10 KL</td>
<td>Atmospheric (1.0 kg/cm²)</td>
<td>10 mm dia hole leak in tank</td>
<td>Jet Fire &amp; Pool Fire</td>
</tr>
</tbody>
</table>

- Catastrophic Rupture of storage tank
- Pool Fire & Explosion
1.1.4 Qualitative Risk Assessment

Many a times risk involved in various processes / process equipments cannot be addressed completely by consequence analysis. As a conservative approach, these risks have been considered separately under this topic. The approach is to identify hazards associated in operation of equipments as well as in processes, assessing its impacts, ranking the risk posed by it and finally to propose remedial actions/mitigation measures such that the risk is minimized to tolerable level. The Risk Matrix presented below should be referred in evaluating this assessment.

In Qualitative Risk Assessment, risk has been analyzed using methodology called HIRA-Hazards Identification & Risk Assessment. In HIRA, major manual activities carried out by plant personnel as well as contract labors have been considered.

Qualitative Risk Assessment has been carried out for the following areas:

- Storage and Handling of Solid Chemicals like Phthalic anhydride and Para Tertiary butyl Phenol
- Storage and Handling of Corrosive Chemicals like Acids, Maleic anhydride
- Storage and Handling of Toxic Chemicals like MEG, DEG, Phthalic anhydride

Risk involved in various processes / process equipment cannot be addressed completely by consequence analysis. As a conservative approach, these risks have been considered separately under this topic. The approach is to identify hazards associated in operation of equipment as well as in processes, assessing its impacts, ranking the risk posed by it and finally to propose remedial actions/mitigation measures such that the risk is minimized to tolerable level. The Risk Matrix presented in Table 7.1, is referred in evaluating the assessment. Risk acceptability criteria given in Table 7.2.

### Table 7.1: Risk Matrix for Qualitative Risk Assessment

<table>
<thead>
<tr>
<th>LIKELIHOOD/PROBABILITY</th>
<th>SEVERITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Catastrophic (Death/ System Loss)</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Almost Certain</td>
<td>E</td>
</tr>
<tr>
<td>Likely</td>
<td>D</td>
</tr>
<tr>
<td>Possible</td>
<td>C</td>
</tr>
<tr>
<td>Unlikely</td>
<td>B</td>
</tr>
<tr>
<td>Impossible</td>
<td>A</td>
</tr>
</tbody>
</table>

### Table 7.2: Risk Acceptability Criteria

<table>
<thead>
<tr>
<th>Risk Range</th>
<th>Risk Acceptability Criteria</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Medium</td>
<td>Generally Minor Impact. Acceptable with Management’s Review. Specific monitoring or SOP to be followed.</td>
</tr>
<tr>
<td>L</td>
<td>Low</td>
<td>Acceptable without Review. Manage through Routine Procedure.</td>
</tr>
</tbody>
</table>
### Storage and Handling of Solid Chemicals (like Aluminum Chloride, CPC Blue, Cupric Chloride)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Process Or Activity</th>
<th>Associated Hazards</th>
<th>Health &amp; Safety Impact (Risk)</th>
<th>Initial Risk</th>
<th>Mitigation Measures</th>
<th>Residual Risk</th>
</tr>
</thead>
</table>
| 1.     | Handling Chemical bags         | • Chemical Exposure                                  | • Skin/Eye irritation.              | 2            | C                                                                  | M                                                                                                           | Operators/Workers to be trained for Safe Work Practices.  
                                          |                          |                                      |                          |                                          | • Chemical handling bags to be labeled properly  
                                          |                          |                                      |                          |                                          | • Availability of Eye wash and Safety shower station nearby  
                                          |                          |                                      |                          |                                          | • Chemicals shall be stored in an isolated storage rooms having provision for natural & forced ventilation.  
                                          |                          |                                      |                          |                                          | • Certified Dust respirator shall be used.  
                                          |                          |                                      |                          |                                          | • Use of suitable protective clothing like apron, Helmet and hand gloves  
                                          |                          |                                      |                          |                                          | • Keep away from incompatibles such as oxidizing agents, acids.  
                                          |                          |                                      |                          |                                          | • Ground all equipment, Keep container dry.                                                                 | 1            | B | L |
| 2.     | Cleaning of Chemical Spillage. | • Fumes Inhalation.                                  | • Severe irritation to eyes, skin.  
                                          |                           | • Inhalation.                | 2            | C                                                                  | M                                                                                                           | Spillage shall be cleaned or neutralized with suitable media.  
                                          |                          |                                      |                          |                                          | • Self-containing breathing apparatus shall be used to avoid inhalation of the material  
<pre><code>                                      |                          |                                      |                          |                                          | • Suitable protective clothing.                                                                                         | 1            | B | L |
</code></pre>
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Process Or Activity</th>
<th>Associated Hazards</th>
<th>Health &amp; Safety Impact (Risk)</th>
<th>Initial Risk</th>
<th>Mitigation Measures</th>
<th>Residual Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Loading &amp; Unloading.</td>
<td>Exposure to acid fumes (due to leakage in pipe/container/valves etc.).</td>
<td>Skin/Eye irritation.</td>
<td>4 C M</td>
<td>Loading &amp; Unloading activity shall be carried out in well-ventilated area under proper supervision. Periodic Inspection of flanges/ferrule joints shall be carried out. Neutralization media shall be kept available in areas where acids are stored/handled/used. PPEs like chemical safety goggles or full face shield, Rubber or neoprene gloves and additional protection including impervious boots, apron shall be used. NIOSH approved respirators shall be used.</td>
<td>5 B L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spillage.</td>
<td>Toxic Vapor inhalation etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Storage and Handling of Corrosive Chemicals (like Caustic Iye, Hydro Chloric acid, Aluminum chloride solution)
2. Working in Storage Area.
   - Exposure to acid fumes.
   - Severe irritation to eyes, skin.
   - Body burns.

3. Leakage from joints etc.
   - Exposure to acid fumes.
   - Severe irritation to eyes, skin.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Process Or Activity</th>
<th>Associated Hazards</th>
<th>Health &amp; Safety Impact (Risk)</th>
<th>Initial Risk</th>
<th>Mitigation Measures</th>
<th>Residual Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage area shall be well ventilated.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In case of spillage, neutralization shall be done immediately with soda ash/lime or spill shall be absorbed in sand or by suitable adsorbent.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PPEs like chemical safety goggles or full face shield, Rubber or neoprene gloves and additional protection including impervious boots, apron shall be used.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NIOSH approved Respirators shall be used.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Acid proof floorings shall be constructed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eye wash stations &amp; Safety Shower shall be installed in near vicinity.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Only trained personnel shall be allowed to work in this area.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dyke wall shall be provided.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Leakage from joints etc.
   - Exposure to acid fumes.
   - Severe irritation to eyes, skin.

4. Storage and Handling of Toxic Chemicals like Chlorine

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Process Or Activity</th>
<th>Associated Hazards</th>
<th>Health &amp; Safety Impact (Risk)</th>
<th>Initial Risk</th>
<th>Mitigation Measures</th>
<th>Residual Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Level indicator shall be provided.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dyke wall shall be provided.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other measures remaining are same as above.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Severity</th>
<th>Likelihood</th>
<th>Risk</th>
<th>Severity</th>
<th>Likelihood</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eco Chem Sales & Services, Surat
2016_ECSS_EIAI2_1600111
8
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Process Or Activity</th>
<th>Associated Hazards</th>
<th>Health &amp; Safety Impact (Risk)</th>
<th>Initial Risk</th>
<th>Mitigation Measures</th>
<th>Residual Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chemical handling / Loading &amp; Unloading</td>
<td>• Exposure to fumes (due to leakage from joints, corroded lines failure etc.).</td>
<td>• Skin burn. • Eye irritation and respiratory disorder.</td>
<td>3 C M</td>
<td>• Shall be stored in well-ventilated area. • Eye wash station and Safety Shower shall be installed in nearby location. • Maintenance shall be carried as per schedule. • Employee will be provided with impervious clothes, gloves, face shield (eight-inch minimum), dust and splash proof safety goggles, chemically resistant safety shoes, etc. • Proper trainings to be provided to the operators/workers. • SOPs to be prepared and followed the same. • Spill control procedure is available. • Provision of Online Cl2 Gas detectors at conspicuous locations inside the plant. • Alarms shall be configured for detection of chlorine in office area and control room.</td>
<td>2 B L</td>
</tr>
<tr>
<td>2</td>
<td>Working in Storage Area</td>
<td>• Exposure to fumes due to spillage.</td>
<td>• Severe irritation to eyes, skin etc. • Internal body</td>
<td>3 C M</td>
<td>• Neutralization media shall be kept available for Caustic. • HCl torch shall be made available to be used for the</td>
<td>2 B L</td>
</tr>
<tr>
<td>S. No.</td>
<td>Process Or Activity</td>
<td>Associated Hazards</td>
<td>Health &amp; Safety Impact (Risk)</td>
<td>Initial Risk</td>
<td>Residual Risk</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>---------------------</td>
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<td>-------------------------------</td>
<td>--------------</td>
<td>---------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Severity</td>
<td>Likelihood</td>
<td>Risk</td>
</tr>
<tr>
<td></td>
<td>burns.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mitigation Measures:
- Detection of ammonia leakage.
- PPEs like face mask, gloves, goggles, etc. shall be worn by concerned person.
- Eye wash station or Safety Shower shall be installed in storage area.
- Provision of an automatic leak detection system.
- Display of Safety warning postures/signs inside the area.
1.1.5 Quantitative Risk Assessment

Quantitative Risk Assessment (QRA) is a structured approach to identifying and understanding the hazards and risks associated with Storage and Handling of flammable/ toxic chemicals. The assessment starts by taking into account an inventory of hazardous chemicals stored, likelihood of leakage/ spillage associated with it and selecting the worst case scenario for consequence estimation. Finally, suggesting the measures to minimize or mitigate risks to meet appropriate acceptability criteria. The planning for emergency evacuation shall be borne in mind whilst interpreting the results.

Consequence analysis

In a plant handling hazardous chemicals, the main hazard arises due to storage and handling of hazardous chemicals as mentioned above. If these chemicals are released into the atmosphere, it may cause damage due to resulting fires or vapor clouds. Blast overpressures depend upon the reactivity class of material between two explosive limits.

Damage criteria

In consequence analysis studies, in principal three types of exposure to hazardous effects are distinguished:

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

The chosen damage criteria are given and explained as per the Guidelines for QRA – PHAST Software, version 6.7 (DNV) & Purple Book for QRA released by Centre for Chemical Process Safety (CCPS).

1.1.6 Planning

Hazards that can lead to accidents in operations are discussed in this section. Important hazardous events are classified in Table 7.3.

<table>
<thead>
<tr>
<th>Type of Event</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLEVE</td>
<td>Boiling Liquid Evaporating Vapor Explosion; may happen due to catastrophic failure of refrigerated or pressurized gases or liquids stored above their boiling points, followed by early ignition of the same, typically leading to a fire ball</td>
</tr>
<tr>
<td>Deflagration</td>
<td>Is the same as detonation but with reaction occurring at less than sonic velocity and initiation of the reaction at lower energy levels</td>
</tr>
<tr>
<td>Detonation</td>
<td>A propagating chemical reaction of a substance in which the reaction front advances in the unreacted substance at or greater than sonic velocity in the unreacted material</td>
</tr>
<tr>
<td>Explosion</td>
<td>A release of large amount of energy that form a blast wave</td>
</tr>
<tr>
<td>Fire</td>
<td>Fire</td>
</tr>
<tr>
<td>Fireball</td>
<td>The burning of a flammable gas cloud on being immediately ignited at the edge before forming a flammable/explosive mixture.</td>
</tr>
<tr>
<td>Flash Fire</td>
<td>A flammable gas release gets ignited at the farthest edge resulting in flash-back fire</td>
</tr>
<tr>
<td>Jet Fire</td>
<td>A jet fire occurs when flammable gas releases from the pipeline (or hole) and the released gas ignites immediately. Damage distance depends on the</td>
</tr>
<tr>
<td>Type of Event</td>
<td>Explanation</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pool Fire</td>
<td>Pool fire is a turbulent diffusion fire burning above a horizontal pool of</td>
</tr>
<tr>
<td></td>
<td>vaporizing hydrocarbon fuel where the fuel has zero or low initial momentum</td>
</tr>
<tr>
<td>Spill Release</td>
<td>‘Loss of containment’. Release of fluid or gas to the surroundings from unit’s</td>
</tr>
<tr>
<td></td>
<td>own equipment / tanks causing (potential) pollution and / or risk of explosion</td>
</tr>
<tr>
<td></td>
<td>and / or fire</td>
</tr>
<tr>
<td>Structural Damage</td>
<td>Breakage or fatigue failures (mostly failures caused by weather but not</td>
</tr>
<tr>
<td></td>
<td>necessarily) of structural support and direct structural failures</td>
</tr>
<tr>
<td>Vapor Cloud</td>
<td>Explosion resulting from vapor clouds formed from flashing liquids or non-</td>
</tr>
<tr>
<td>Explosion</td>
<td>flashing liquids and gases</td>
</tr>
</tbody>
</table>

### Hazard and Damage Assessment

Toxic, flammable and explosive substances released from sources of storage as a result of failures or catastrophes, can cause losses in the surrounding area in the form of:

- Toxic gas dispersion, resulting in toxic levels in ambient air,
- Fires, fireballs, and flash back fires, resulting in a heat wave (radiation), or
- Explosions (Vapor Cloud Explosions) resulting in blast waves (overpressure).

### Consequences of Fire/Heat Wave

The effect of thermal radiation on people is mainly a function of intensity of radiation and exposure time. The effect is expressed in term of the probability of death and different degree of burn. The consequence effects studied to assess the impact of the events on the receptors are:

### Table 7.4: Damage due to Radiation Intensity

<table>
<thead>
<tr>
<th>Radiation (kW/m²)</th>
<th>Damage to Equipment</th>
<th>Damage to People</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>Solar heat at noon</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>Minimum level of pain threshold</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>PVC insulated cable damage</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td>Causes pain if duration is longer than 20 sec. But blistering is unlikely.</td>
<td></td>
</tr>
<tr>
<td>6.4</td>
<td>Pain threshold reached after 8 sec. Second degree burns after 20 sec.</td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td>Minimum energy to ignite wood with a flame; melts plastic tubing.</td>
<td>1% lethality in one minute. First degree burns in 10 sec.</td>
</tr>
<tr>
<td>16.0</td>
<td>Severe burns after 5 sec.</td>
<td></td>
</tr>
<tr>
<td>25.0</td>
<td>Minimum energy to ignite wood at identifying long exposure without a flame.</td>
<td>100% lethality in 1 min. Significant injury in 10 sec.</td>
</tr>
<tr>
<td>37.5</td>
<td>Severe damage to plant</td>
<td>100% lethality in 1 min. 50% lethality in 20 sec. 1% lethality in 10 sec.</td>
</tr>
</tbody>
</table>
Consequences of Overpressure
The effects of the shock wave vary depending on the characteristics of the material, the quantity involved and the degree of confinement of the vapor cloud. The peak pressures in an explosion therefore vary between a slight over-pressure and a few hundred kilopascals (kPa). Whereas dwelling are demolished and windows and doors broken at overpressures as low as 0.03 - 0.1 bar. Direct injury to people occurs at greater pressures. The pressure of the shock wave decreases rapidly with the increase in distance from the source of the explosion.
### Table 7.5: Overpressure Damage

<table>
<thead>
<tr>
<th>Overpressure (bar)</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>Annoying noise (137 dB if of low frequency 10-15 Hz)</td>
</tr>
<tr>
<td>0.002</td>
<td>Loud noise (143 dB, sonic boom glass failure)</td>
</tr>
<tr>
<td>0.003</td>
<td>Occasional breaking of large glass windows already under strain</td>
</tr>
<tr>
<td>0.007</td>
<td>Breakage of small windows under strain</td>
</tr>
<tr>
<td>0.010</td>
<td>Typical pressure for glass breakage</td>
</tr>
<tr>
<td>0.020</td>
<td>Projectile limit; some damage to house ceilings; 10% window glass broken</td>
</tr>
<tr>
<td>0.027</td>
<td>Limited minor structural damage</td>
</tr>
<tr>
<td>0.034 to 0.068</td>
<td>Large and small windows usually shattered; occasional damage to window frames</td>
</tr>
<tr>
<td>0.048</td>
<td>Minor damage to house structures</td>
</tr>
<tr>
<td>0.068</td>
<td>Partial demolition of houses, made uninhabitable</td>
</tr>
<tr>
<td>0.068 to 0.136</td>
<td>Corrugated asbestos shattered; corrugated steel or aluminum panels, fastenings fail, followed by buckling, wood panels (standard housing) fastenings fail, panels blown in</td>
</tr>
<tr>
<td>0.088</td>
<td>Steel frame of clad building slightly distorted</td>
</tr>
<tr>
<td>0.136</td>
<td>Partial collapse of walls and roofs of houses</td>
</tr>
<tr>
<td>0.136 to 0.204</td>
<td>Concrete of cinder brick walls, not reinforced, shattered</td>
</tr>
<tr>
<td>0.157</td>
<td>Lower limit of serious structural damage</td>
</tr>
<tr>
<td>0.170</td>
<td>50% destruction of brickwork of houses</td>
</tr>
<tr>
<td>0.204</td>
<td>Heavy machines (3,000 lb) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations.</td>
</tr>
<tr>
<td>0.204 to 0.272</td>
<td>Frameless, self-framing steel panel building demolished; rupture of oil storage tanks</td>
</tr>
<tr>
<td>0.272</td>
<td>Cladding of light industrial buildings ruptured</td>
</tr>
<tr>
<td>0.340</td>
<td>Wooden utility poles snapped; tall hydraulic press (40,000 lb) in building slightly damaged</td>
</tr>
<tr>
<td>0.340 to 0.476</td>
<td>Nearly complete destruction of houses</td>
</tr>
<tr>
<td>0.476</td>
<td>Loaded train wagons overturned</td>
</tr>
<tr>
<td>0.476 to 0.544</td>
<td>Brick panels, 8-12 inches thick, not reinforced; heavy machine tools (7,000 lb) moved and badly</td>
</tr>
<tr>
<td>0.612</td>
<td>Loaded trains boxcars completely demolished</td>
</tr>
<tr>
<td>0.680</td>
<td>Probable total destruction of buildings; heavy machines tools (7,000 lb) moved and badly damaged, very heavy machines tools (12,000 lb) survived.</td>
</tr>
<tr>
<td>20.414</td>
<td>Limit of crater lip</td>
</tr>
</tbody>
</table>

*Source: CCPS Consequence analysis of chemical release*

### Consequences of Toxic Release

The effect of exposure to toxic substance depends upon the duration of exposure and the concentration of the toxic substance. Short-term exposures to high concentration give Acute Effects while long term exposures to low concentrations result in Chronic Effects. Only acute effects are considered under hazard analysis. Since they are likely credible scenarios. These effects are:

- Irritation (respiratory system skin, eyes)
- Narcosis (nervous system)
- Asphyxiation (oxygen deficiency)
• System damage (blood organs)

Following are some of the common terms used to express toxicity of materials.

• Threshold Limit Value (TLV): it is the permitted level of exposure for a given period on a weighted average basis (usually 8 hrs. for 5 days in a week)
• Short Time Exposure Limit (STEL): it is the permitted short term exposure limit usually for a 15 minutes exposure.
• Immediately Dangerous to life and health (IDLH): It represents the maximum concentration of a chemical from which, in the event of respiratory failure, one could escape within 30 minutes without a respirator and without experiencing any escape/impairing (e.g. severe irritation) or irreversible health effects.
• Lethal Concentration Low (LCLo): It is the lowest concentration of a material in air, other than LC50, which has been reported to cause a death in human or animals.
• Toxic Concentration Low (TCLo): It is the lowest concentration of a material in air, to which humans or animals have been exposed for any given period of time that has produced a toxic effects in humans or produced carcinogenic, neoplastigenic or teratogenic effect in humans or animals.
• Emergency Response Planning Guidelines 1 (EPRG1): The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour (without a respirator) without experiencing other than mild transient adverse health effects or without perceiving a clearly defined objectionable odor.
• Emergency Response Planning Guidelines 2 (EPRG2): The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.
• Emergency Response Planning Guidelines 3 (EPRG3): The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

1.1.7 Meteorology

Atmospheric stability plays an important role in the dispersion of the chemicals. “Stability means, its ability to suppress existing turbulence or to resist vertical motion”. Atmospheric stability plays an important role in the dispersion of chemicals. “Stability means, its ability to suppress existing turbulence or to resist vertical motion”. Variations in thermal and mechanical turbulence and in wind speed are greatest in the atmospheric layer in contact with the surface. The air temperature has influenced these turbulences greatly and air temperature decreases with the height. The rate at which the temperature of air decreases with height is called Environment Lapse Rate (ELR). It will vary from time to time and from place to place. The atmosphere is said to be stable, neutral or
unstable according to ELR less than, equal to or greater than Dry Adiabatic Lapse Rate (DALR), which is a constant value of 0.98 °C per 100 meters.

**Pasquill Stability Classes**

Pasquill has defined Six (6) stability classes.
A - Extremely unstable.
B - Moderately unstable
C - Slightly unstable.
D - Neutral
E - Slightly stable.
F - Moderately stable.

Three prime factors that defines Stability
- Solar radiation
- Night-time sky over
- Surface wind

When the atmosphere is unstable and wind speeds are moderate or high or gusty, rapid dispersion of vapors will occur. Under these conditions, air concentrations will be moderate or low and the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and air concentration will be high.

**Weather Conditions**
Following Weather conditions are selected for consequence analysis

<table>
<thead>
<tr>
<th>Table 7-6: Weather Condition Selected</th>
<th>Time</th>
<th>Remarks</th>
<th>Temperature in °C</th>
<th>Wind speed m/s</th>
<th>Stability Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day Time</td>
<td>Prevalent during the day, most times of the year</td>
<td>32.4</td>
<td>3</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Night Time</td>
<td>Prevalent during the night, most times of the year</td>
<td>29.4</td>
<td>2.7</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Monsoon Period</td>
<td>Prevalent during the monsoon months</td>
<td>27.0</td>
<td>4</td>
<td>D</td>
</tr>
</tbody>
</table>
1.1.8 Consequences Analysis

The consequences of the release of Hazardous substances by failures or catastrophes and the damage to the surrounding area can be determined by means of models. Models help to calculate the physical effects resulting from the release of hazardous substances and to translate the physical effects in terms of injuries and damage to exposed population and environment. To assess the damage level caused by the various accidental events, it is essential to firm up the damage criteria with respect to different types of accidents e.g. thermal radiation, toxicity, explosion overpressure etc.

Consequence analysis involves the application of mathematical, analytical and computer models for calculation of effects and damages subsequent to a hydrocarbon release accident. Consequence models are used to predict the physical behavior of the hazardous incidents. The techniques used to model the consequences of hydrocarbon and other hazardous material releases cover the following:

Modeling of discharge rates when holes develop in process equipment/pipe work/pipeline.

Modeling of the size and shape of flammable and toxic gas clouds from releases in the atmosphere

Modeling of the flame and radiation field of the releases that are ignited and burn as jet fire, pool fire, flash fire and BLEVE/Fire ball

Modeling of the explosion fields of releases, which are ignited away from the point of release

The information normally required for consequence analysis includes meteorological conditions, failure data of equipment and components, ignition sources, population characteristics within and outside the plant, acceptable levels of risk etc.

About the software – PHAST, Version 6.7

The consequence analysis for the modeled scenarios has been done using DNV’s software PHAST (Process Hazard Analysis Software Tool) which allows assessment of situations which present potential hazards to life, property and the environment, and to quantify their severity. PHAST examines the progress of a potential incident from the initial release to far-field dispersion including modeling of pool spreading and evaporation, and flammable and toxic effects. It is recommended for use by the Ministry of Environment & Forests per its EIA Guidelines, dated January 2001.

PHAST Professionals sophisticated modeling calculates distances effect produced by hazardous events. With this information, you can evaluate the need for mitigating measures such as changes in design, operation or response. PHAST software can be used to model a proposed facility or operational change to ease the selection of the most effective solutions. With PHAST Professional, you can define special events, model the change in a leak over time, and investigate the details of behavior with special stand-alone models and much, much more.

PHAST is integrated into safety and meets regulatory requirements. It uses unified dispersion modeling to calculate the results of the release of material into atmosphere
The salient features of this package:

1. It gives the consequence results in terms of – Flammable, Toxic and Explosion effects.
2. Flammable parameters covered under this package is-
   - Defines the LEL and UEL zone
   - Jet fire and pool fire scenario along with their respective effect zones (risk contour).
   - Flash fire and fire ball envelope
3. Toxic parameters-
   - Cloud concentration at user defined time as well as location
   - Categorize the toxic results in terms of ERPG, IDLH and STEL values.
   - Summarize results in terms of equivalent toxic dose along with effect zones.
4. Explosion parameters-
   - Categorize the explosion effects in terms of overpressures levels along with distance covered.
   - BLEVE (Boiling Liquid Expanding Vapor Explosion)

Assumption
For consequence analysis, assumptions regarding Meteorological, Pasquill Stability Classes, Wind velocity, Ambient Temperature, Relative Humidity, Inventory, Ground Roughness, Model used etc. are very important. In this report, the following assumptions have been considered.

1. Meteorological Paste other tables
   - Atmospheric Conditions: No Inversion
   - Ambient Temperature: 35°C has been considered as MCA approach.
   - Relative Humidity: As the site is not in rainy zone RH of 50% has been considered.
2. Pasquill Stability Classes
   - Pasquill Stability category C/D is considered as conservative approach.
3. Other assumptions:
   - Ground Roughness: Ground Roughness has been considered as 0.3 M.
   - Dispersion model of both Heavy Model and also Gaussian distribution have been used as applicable/appropriate.
   - Inventory: Release of 100% of the inventory has been considered. For this, failure of the container has been considered from the bottom.
   - Storage conditions: Storage conditions have been considered as they are practically stored at site.

Input data for software (modeling)
For consequence analysis, input data considered are as below:
1. Volume inventory (Quantity of material)
2. Scenario
   - Leak
   - Catastrophic Rupture
3. Leak size
   - 10 mm hole
4. Storage conditions
   - Pressure
   - Temperature
5. Bund details
   - Bund height
   - Bund area
6. Weather condition:
   - Wind speed
   - Pasquil stability
   - Atmospheric temperature
   - Relative humidity

**MCAS Development Techniques**

As a first step towards risk assessment is to identify the possible release scenarios based on available information about scenario development for Maximum Credible Accident Scenarios (MCAS).

1.1.9 **Selection of Maximum Credible Loss Scenarios (MCLS’)**

Following points are considered while selecting the release scenarios:

- Flash point for flammable chemicals
- IDLH of Toxic chemicals
- Operating/ Storage Temperature and Pressure of the material
- Total inventory of the material

**Failure Rates**

A leak or rupture of the tank / pipe, releasing some or all of its contents, can be caused by brittle failure of the tank walls, welds or connected pipework due to use of inadequate materials, combined with loading such as wind, earthquake or impact. The failure rates are the deciding factor for selecting the MCAS’. The failure rates for selected MCAS’ are given in Table 1.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Catastrophic Rupture Frequency (per tank per year)</th>
<th>Leak Frequency (per year)</th>
</tr>
</thead>
</table>

**Table 1.7: Failure Frequencies for Storage Tanks**
<table>
<thead>
<tr>
<th>Categories</th>
<th>Catastrophic Rupture Frequency (per tank per year)</th>
<th>Leak Frequency (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric Storage Tank</td>
<td>$3.0 \times 10^{-6}$</td>
<td>$2.8 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

Reference: *International Association of Oil & Gas Producers (OGP); Report No. 434-3, March 2010*
1.1.10 Simulation of Release and Development of Contours

As the MCLS’ were developed for the selected set of chemicals, the next step is to carry out the consequence analysis. The consequence analysis results along with their contours are presented in the following sections. Contours are presented on plant layout map.

Map: Plant layout map

Chlorine tonner

Toxic dose level effect distance due to release of Chlorine from Chlorine tonner are presented below

<table>
<thead>
<tr>
<th>Chemical (Storage Tank)</th>
<th>Failure Scenario</th>
<th>Met Data</th>
<th>Effective Distance in meter to Toxic Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>EPRG 2 (3 ppm)</td>
</tr>
<tr>
<td>Chlorine tonner</td>
<td>2 mm leak</td>
<td>3.0/C</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.7/E</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0/D</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Catastrophic Rupture</td>
<td>3.0/C</td>
<td>912</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.7/E</td>
<td>2385</td>
</tr>
</tbody>
</table>
The contour for effect distance generated for the release of chlorine is presented below;

![Contour Diagram](image)

**Figure 7.1:** Toxic effect distance Contour due to 2 mm leak in chlorine tonner at weather condition 2.7/E.

**Mono Chlorobenzene (MCB)**

Radiation level effect distance and overpressure effect distance due to the release of MCB are presented below

**Table 7.3: Effect Distance due to Release of MCB**

<table>
<thead>
<tr>
<th>Chemical (Storage Tank)</th>
<th>Failure Scenario</th>
<th>Consequence</th>
<th>Met Data</th>
<th>Effective Distance in meter to Radiation Level</th>
<th>Overpressure Distances in Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mono Chlorobenzene</td>
<td>10 mm Leak</td>
<td>Late pool fire</td>
<td>3.0/ C</td>
<td>18 7 NR</td>
<td>0.0 2 bar 0.1 3 bar 0.2 4 bar</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.7/ E</td>
<td>17 7 NR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.0/ D</td>
<td>18 7 NR</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Late pool fire</td>
<td>3.0/</td>
<td>18 7 NR 17 12 11</td>
<td></td>
</tr>
<tr>
<td>Chemical (Storage Tank)</td>
<td>Failure Scenario</td>
<td>Consequence</td>
<td>Met Data</td>
<td>Effective Distance in meter to Radiation Level</td>
<td>Overpressure Distances in Meters</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 kW/m²</td>
<td>12.5 kW/m²</td>
</tr>
<tr>
<td>c Rupture</td>
<td></td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.7/E</td>
<td></td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0/D</td>
<td></td>
<td>18</td>
<td>7</td>
</tr>
</tbody>
</table>

NR: Not Reached

The contours for effect distance generated for the release of MCB are presented below;
Figure 7.2: Late Pool Fire effect distance Contour due to 10 mm leak in storage tank at weather condition 4/D.
Figure 7.3: Late Pool Fire effect distance Contour due to Catastrophic rupture of storage tank at weather condition 2.7/E
**Xylene**

Radiation level effect distance due to the release of Xylene are presented below

**Table 7.11: Effect Distance due to Release of MCB**

<table>
<thead>
<tr>
<th>Chemical (Storage Tank)</th>
<th>Failure Scenario</th>
<th>Consequence</th>
<th>Met Data</th>
<th>Effective Distance in meter to Radiation Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xylene</td>
<td>10 mm Leak</td>
<td>Late pool fire</td>
<td>3.0/C</td>
<td>13 10 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.7/E</td>
<td>13 10 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.0/D</td>
<td>13 10 6</td>
</tr>
<tr>
<td></td>
<td>Catastrophic Rupture</td>
<td>Late pool fire</td>
<td>3.0/C</td>
<td>11 7 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.7/E</td>
<td>10 7 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.0/D</td>
<td>11 7 3</td>
</tr>
</tbody>
</table>
The contours for effect distance generated for the release of MCB are presented below;

Figure 7.2: Late Pool Fire effect distance Contour due to 10 mm leak in storage tank at weather condition 3/C.
Figure 7.3: Late Pool Fire effect distance Contour due to Catastrophic rupture of storage tank at weather condition 4/D

1.1.11 Results of Consequence Analysis

- Summary of effect distance (in meter) for worst case scenario of hazardous chemical considered for consequence analysis are given below:

<table>
<thead>
<tr>
<th>Chemical/ Scenario</th>
<th>Effect Distance in Meters at specific Weather condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Radiation Level 4 kW/m²</td>
</tr>
<tr>
<td>Chlorine tonner</td>
<td>-</td>
</tr>
<tr>
<td>MCB</td>
<td>18 (3/C)</td>
</tr>
<tr>
<td>Xylene</td>
<td>13 (3/C)</td>
</tr>
</tbody>
</table>
• It can be seen from the summarized table above that the risk of late pool fire is highest in worst case scenario of release of Monochlorobenzene in 2.7/E weather condition for 4 KW/m² radiation level.
• The effect of late pool fire due to 10 mm leak scenario is confined to the site boundary for xylene

1.1.12 Mitigation Measures against Risk
Based on the risk assessment analysis following precautionary mitigation measures are recommended for the project.

• The installation of all the equipment will be as per guidelines of provision of Gujarat Factories Rule 1963.
• Hazardous chemicals will be stored in small sized multiple containers so as to avoid major hazard associated with large sized containers.
• Proper Control of the operating parameters, mainly temperature, vacuums, cooling media circulation, during plant operation and solvent recovery.
• For any case of fire emergency, standard type of Firefighting equipments and fire extinguishers will be provided in the storage area as well as required places in the plant.
• Smoking will be prohibited inside the factory.
• The adequate and suitable personnel protective equipments will be provide to the operating workers.
• First Aid facility and First-aid trained person will be available at the time of handling operation.

1.1.13 Safety Precautions / Preventive measures
Safety Measures for Transportation, Storage and Handling of Chemicals
General safety measures for transportation, storage & handling are listed below.

• Layout and location of hazardous chemical storage area will be based on natural and Mechanical ventilation.
• Spare barrels of sufficient quantity will be kept ready for any emergency spillage or leakage.
• Regular inspection of all the drums of hazardous chemicals will be carried out and damaged drums will be separated and disposed to avoid the possibility of catastrophic rupture.
• Display Boards will be provided on all storage drum which include the name of the chemicals, storage Material of construction, Calibration of tanks and date of Painting.
• The level indicators will be placed on all storage drums to know the exact liquid level inside the drum and to avoid the accidental spillage or overflow.
• All equipments related to hazardous chemical storage will be maintained and calibrated regularly.
• Drum trolley will be used for the movement of drums of hazardous chemicals to avoid accident due to manual error.
- SOP for handling will be displayed in local language for safe operating procedure.
- Proper inventory of hazardous chemicals will be maintained and buffer stock will be kept as minimum as possible.
- Standard procedure for unloading will be in place and will be implemented for safe unloading of road tanker.
- Static earthing provision will be made for tanker unloading.
- Muffler on the silencer of the tanker during entering in factory premises.
- Water showering system (Automated sprinkling system) will be provided to the flammable liquid storage area, wherever required to avoid the vaporization due to increase in atmosphere temperature.
- On-site detectors for fire based on heat &/or smoke detection with alarm system will be provided as required.
- Adequate firefighting system will be provided as required. Details of the same are elaborated in related section.
- First aids boxes will also be provided at prominent places in the plant.
- Area will be declared as “NO SMOKE ZONE”.

Specific Safety measures for storage and handling of flammable chemicals are given as follows.

1. **Storage and Handling of Flammable Chemicals**
   - Storage for sealed drums will be out of direct sunlight and remote from sources of heat to avoid generation of pressure.
   - Drums will be stored at ground level and measures taken to prevent corrosion of the drum base.
   - Adequate ventilation will be available to ensure that in case of incidental release of chemicals (vapour) the vapour concentration is as low as possible, and in any event within the regulatory requirements
   - Flammable will be transferred by mechanical seal pump through fixed pipeline as far as possible.
   - Emergency showers and eyewash fountains should be located in the storage and loading-unloading area in case of accidental skin or eye contact.

2. **Storage and Handling of reactive Chemicals**
   - It will be labeled properly and stored in a cool, well-ventilated and fire resistant area in a tightly closed container.
   - Empty containers pose a fire risk. Hence, residual phenol will be evaporated under fume hood.
   - Storage container will be properly grounded.
   - It will be made sure that it doesn’t get mixed with water.
   - Explosion proof electrical service will be installed in storage areas.
   - It will be kept away from incompatibles such as oxidizing agents and acids.
   - A self-contained breathing apparatus will be used to avoid inhalation of the product
3. Storage and Handling of other Chemicals

- Drums will be stored at ground level and measures taken to prevent corrosion of the drum base.

- It will be labeled properly and stored in a cool, well-ventilated and fire resistant area in a tightly closed container.

- Material Safety Data Sheet will be displayed in front of respective chemicals.

- Training and knowledge will be provided to workers for physical and chemical characteristics of each chemical they are using.

- Proper PPEs will be provided to the workers.

- Proper firefighting equipment will be installed at storage yard and maintenance and calibration for that equipment will be carried out on regular basis.

Process Safety Measures

Safety measures are the most important aspect of selection of process technology to ensure safety in production unit. For the safety in production area some important critical safety measures must be provided within the process technology/equipment itself.

The details of the general safety measures for process unit are as below:

- Process parameters control will be provided vide Standard Operating Procedures.

- All reaction vents will be connected to either vapor condensers system or gaseous scrubber system.

- Trained person will be engaged for handling of hazardous materials.

- Proper safety precautions will be taken during handling of hazardous materials.

- Further all the vessels will be examined periodically by a recognized competent person.

- All the vessels and equipments will be well earthed appropriately and well protected against Static Electricity. Also for draining in drums proper earthing facilities have been provided.

- Reaction column pressure and temperature data will be regularly monitored and assessment of properties of flammable chemicals will be evaluated to avoid fire/explosion scenarios.

- Temperature indicators will be provided near all reactors.

- Caution note, safety posters, stickers, periodic training & updation in safety and emergency preparedness plan will be displayed and conducted.

- Total reaction will be carried out in closed jacketed vessel having cooling water supply to control temperature in case of run-away reaction.

- Emergency reactor shutdown system will be implemented.

Safety Measures for Drum Storage and Handling

- Drums will be stored at designated location or secured in a safety storage cabinet.

- Approved methods of equipping a drum and dispensing liquids from it will be followed.
Drums, carboys and related accessories will be inspected on regular basis for maintenance purpose.
All the vessels and equipments will be earthed properly and protected against static electricity. Also, proper earthing facilities shall be provided for drums.
Materials will be transferred by pumping through pipeline or by vacuum, from drums.
Drums for flammable liquids will have proper closures that can withstand the expected handling conditions without leaking.

**Safety Precautions for Chlorine Tonner Storage**

Following mitigation measures shall be followed in case of Chlorine Leakage:

- Evacuate the area in down wind direction: Evacuate area in down wind direction up to 65 meter.
- Do not direct water at spill or source of leak.
- Use Chlorine emergency kit to attend the leak.
- Absorb the fumes through Chlorine Hood with blower.
- Only trained workers are allowed to work in this area.

Following Safety Measures will be made available to avoid Emergencies related to Chlorine Leakage:

- Chlorine handling area shall be well ventilated.
- Chlorine Emergency kit shall be kept ready at chlorine shed.
- Chlorine Hood with blower shall be provided with scrubbing arrangement.
- SCBA sets shall be kept ready at chlorine handling area.
- Empty & filled cylinders shall be stored separately.
- Oxygen Cylinder shall be available.
- Safety shower and eye wash stn. will be available in Chlorine shed area.
- Online Cl2 Gas detectors shall be installed at conspicuous locations inside the plant. Alarms shall be configured for detection of chlorine in office area and control room.
- Breathing air network shall be available in entire operational area.
- Full body protection suite and other PPEs shall be kept ready.
- Safe Operating procedures and Emergency Response Procedures will be followed strictly.
- Only trained workers and employers shall be allowed to work in this area.
- Regular worksite inspection will be carried out.

**Cylinders Storage and Handling**

- If gloves are greasy or oily, do not handle cylinders.
- All compressed gas cylinders will be stored in the upright position.
- Valve protection caps will be placed on compressed gas cylinders that are in storage or are not being used.
- Compressed gas cylinders will not be lifted by the valve protection cap.
• Compressed gas cylinders will not be stored in hazardous areas.
• Compressed gas cylinders will be hoisted on the cradle or compressed gas cylinder basket.
• Compressed gas cylinders shall not be placed against electrical panels or live electrical cords where the cylinder can become part of the circuit.
• The dented, cracked or other visibly damaged cylinders shall not be used.
• Cylinders shall not be transported without first removing the regulators and replacing the valve protection caps.
• While opening the valve, stand to the side of the regulator.
• Hoist or transport of cylinders by means of magnets or choker slings shall not be done.
• The cylinder valves will be opened slowly.

Safety Measures for Preventive Maintenance

The safety measures in form of the general Do's & Don'ts for safety in process & other plant area are as below:

• Make sure equipment is empty and fluxed with nitrogen and air.
• Use proper PPE.
• Check VOC content for flammable and make sure that no flammable vapour contents.
• Keep proper and adequate fire extinguisher near work area.
• Check all motors are disconnected and fuse pulled out before maintenance.
• Work in any equipment must be conducted in presence of supervisor.
• Make sure all process lines are disconnected.
• Do not work on equipments without permission from plant head and maintenance head.
• Do not allow any employment without pre medical checkup or without checking fitness.

Additional safety measures in form of the checklist covering Do's & Don'ts of preventive maintenance, strengthening of HSE, manufacturing utility staff for safety related measures will be updated timely and will be made available to all concern department & personnel.

Safety Measures to Prevent Spillage and Leakages

The preventive maintenance will be planned and carried out as per plan to avoid the failure of valve, pipe lines and other component of transferring line. The spillage will be confined to the dyke area underneath the vessel. The resultant splash of such chemicals will result in exposure of toxic chemicals to employees. Facilities like Safety shower and eye wash fountains will be provided in the plant area, which can be used to decontaminate the affected employees. The followings are some measures to be taken for handling the toxic chemicals safely;

• Safety equipments like electric siren, safety shower etc. will be provided at various places in plant and suitable personal protective equipment like splash goggles, gloves and protective clothes are provided while handling the toxic chemicals
• The storage of corrosive and toxic chemicals will be segregated from each other.
• The piping will be examined thoroughly every year for finding out any defects; and a defect will be removed forthwith. The record of such examination will be maintained.
• Smoking will be prohibited inside the factory. Employees will be properly trained for handling of toxic and corrosive chemicals.
• All pipe joints will be provided with heavy duty gaskets to prevent any leakage.
• Self-breathing apparatus will be provided and workers will be trained about their use also.
• Dyke wall will be provided to the hazardous chemicals storage area.
• Spare barrels of sufficient quantity will be kept ready for any emergency spillage or leakage.
• VOC detectors will be installed.

Fire Fighting System / Fire Control Plan

By looking to the hazardous nature of process and the chemicals that are handled and processed, the chances of outbreak of fire cannot be totally ignored. Hence to tackle such a situation, company has developed proposed, well-resourced and adequate fire protection system. The management has proposed to keep the following extinguishers at site:
• Flame detectors, smoke / temperature actuated heat detectors with alarms, automatic sprinkler system, shall be installed at conspicuous locations as per the requirements.
• Company will have Fire Water Tank of adequate capacity to combat the emergency, if arise, GIDC water reservoir shall also be made available, if required.
• Working staff will be trained to operate DCP and CO2 extinguishers.
• DG set will be available as a separate power backup for fire network.
• Company will do tie up with GIDC Fire Brigade and nearby companies, for handling emergency situations.
• Electric driven alarms & sirens will be placed at the conspicuous locations. Hand Bell shall be used in case of power failure.
• Factory Layout will be designed in such a way, that it will have a provision for separate entry and exist with adequate margin all around the periphery for unobstructed easy movement of the emergency vehicle / fire tenders without reversing back.

1.2 DISASTER MANAGEMENT PLAN

In order to be in a state of readiness to face any accident or disaster caused by the project operation, a Disaster management plan is required to be prepared. The plan will cover possible disaster, On and Off-site emergency preparedness plans, establishment of emergency Control Centre (ECC), Location of emergency services and duties of officers / staff during emergency.

1.2.1 Basic Contents of DMP

Basically, DMP contains following aspects
• Description of site
• Brief description of the plant
• On – site Emergency plan
• Off- site Emergency plan

1.2.2 Definitions and Classification of Emergency

An Incident:
Undesired event giving rise to death, ill health, injury, damage or other loss.

**A Major Incident:**
Is a sudden, unexpected, unplanned event, resulting from uncontrolled developments during an industrial activity, which causes or has the potential to cause. Serious adverse effects immediate or delayed (death, injuries, poisoning or hospitalization) to a number of people inside the installation and/or to persons outside the establishment, or significant damage to crops, plants or animals or significant contamination of land, water, air or an emergency intervention outside the establishment (e.g. Evacuation of local population stopping of local traffic) or significant change in the process operating conditions, such as stoppage or suspension of normal work in the concerned plant for a significant period of above, or any combination of the above effects.

**An Emergency:**
An emergency is an abnormal event, which could result in danger to personnel, property and environment. It could be due to fire, Explosion, Heavy spillage of hazardous liquid, toxic gas release etc.

**A Major Emergency:**
Is one that may affect several departments within it and/or may cause serious injuries, loss of life, and extensive damage to property or serious disruption outside the works? It will require the use of outside resources to handle it effectively.

NOTE: Emergency due to operating conditions, uncontrolled reaction, small fire, small gas leak, spill, failure of power, water, air, steam, cooling media, scrubbing media etc. and which can be locally handled by plant personnel alone (without outside help) is not considered as major emergency.

**Disaster:** Is a catastrophic situation in which the day-to-day life patterns are, in many instances, suddenly disrupted and people are plunged into helplessness and suffering and as a result need protection, clothing, shelter, medical and social care other necessities of life, such as: Disasters resulting from natural phenomena like earthquakes, volcanic eruptions, storm surges, cyclones, tropical storms, floods, landslides, fierce fires and massive insect infestation. Also in this group, violent drought which will cause a creeping disaster leading to famine, disease and death must be included.

Second group includes disastrous events occasioned by man, or by man's impact on the environment, such as armed conflict, industrial accidents, factory fires, explosions and escape of toxic releases of chemical substances, river pollution, mining or other structural collapses, air, sea, rail and road transport accidents, aircraft crashed, collisions of vehicles carrying inflammable liquids, oil spills at sea and dam failures.

**Hazard:** Source or situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment or a combination of these

**RISK:** Combination of the likelihood and consequence(s) of a specified hazardous event occurring
Classification of Emergency:
LEVEL – 1
The incident or emergency which are confinable, controllable within the plant premises, which under normal circumstances does not affect area outside the said plant battery limit and controlling does not involve / require external help. This situation is called emergency stand by and affected unit / plant have to handle emergency

It may be due to
Small pipe/valve rupture or similar leakages that do not affect outside premises.
Release of toxic chemicals for short duration.
Small fire in the plant.

LEVEL – 2
When the incident or emergency is not controlled within 10 to 15 minutes or does not come under control within 10 to 15 minutes, incident controller, site main controller reviews the situation and decides if situation is Worsening.

It may arise due to -
Leakage of toxic chemicals for long duration.
Medium scale explosion confined to the factory premises.
Medium scale fire inside the factory premises.

LEVEL – 3
After surveying off-site implications of level – 2 emergencies if there is a likely hood of chemical/material gas cloud formation and spreading of cloud in down wind direction affecting neighboring population of industry and villagers and / or in case of following incident IC and SMC are of the opinion that there will be off-site implications.

It may arise due to -
Heavy / Profuse leakage of toxic / Flammable gases for a long duration.
Explosion of high magnitude affecting the adjacent area.
Major fire inside the factory premises.

Note: Level-I and Level- II shall normally be grouped as onsite emergency and Level- III as off-site emergency.

Mode of Emergency

<table>
<thead>
<tr>
<th>Man made</th>
<th>Natural Calamities</th>
<th>Extraneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Toxic Leakage/ Spillage</td>
<td>Flood</td>
<td>Riots/Civil Disorder/Mob</td>
</tr>
<tr>
<td>Fire</td>
<td>Earthquake</td>
<td>Attack</td>
</tr>
<tr>
<td>Explosion</td>
<td>Cyclone</td>
<td>Terrorism</td>
</tr>
<tr>
<td>Failure of Critical Control system</td>
<td>Outbreak of Disease</td>
<td>Sabotage</td>
</tr>
<tr>
<td>Design deficiency</td>
<td>Tsunami</td>
<td>Bomb Threat</td>
</tr>
<tr>
<td>Unsafe acts</td>
<td></td>
<td>War/Hit by missiles</td>
</tr>
<tr>
<td>In-a-dequate maintenance</td>
<td></td>
<td>Food Poisoning/Water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poisoning</td>
</tr>
</tbody>
</table>
On-Site Emergency
The On-site emergency plan: deals with, measures to prevent and control emergencies within the factory and not affecting outside public or Environment.

Off-Site Emergency
The Off-site emergency plan: deals with, measures to prevent and control emergencies affecting public and the environment outside the premises

1.2.3 Objectives of Emergency Management System
The objectives of the emergency management system are summarized as under.

- To identify and assess types of emergencies due to different types of hazards.
- Emission of chemical vapors into the shop floor ambience and any injurious effects of physical contact with corrosive chemicals, inhalation of fumes, vapors.
- The consequences will be off minor type and major emergency in this case is not perceived.
- Fire preceded or followed by explosion. Explosion could be in tanks, barrels, drums and cylinders due to pressure build up. A safety arrangement will be made in pressure vessels.
- To work out plan with all provisions to handle emergencies and safeguard employees and people in the vicinity of the factory.
- To provide for emergency preparedness and the periodical rehearsal of the plan.
- To plan mode of proper communication and actions to be followed in the event of emergency.
- To keep all necessary information with respect to hazard/accident control and emergency contacts in one document for easy and speedy reference.
- To inform employees, general public and the authorities about the hazards/risk if any and the role to be played by them in the event of emergency.
- To control and contain the accident.
- To effect rescue and treatment of casualties.
- To inform and help relatives of casualties.
- To secure rehabilitation of affected area and restore normalcy.
- To provide information to media and government agencies.
- To preserve record, equipment etc. for investigating cause of emergency.
- To be ready for “mutual aid” if need arises to help neighboring units.

1.2.4 Structure of Emergency Management System
TP shall develop an Emergency Management Team. The management structure shall include the following personnel’s;

- Site Main Controllers
- Incident Controllers and Deputy Incident Controllers
- Key Personnel’s
- Essential Workers

The other elements of Emergency Plan shall be:
- Assembly points
- Emergency control center
- Fire control arrangements
- Medical arrangements
- Other arrangements

Figure 7.5: Emergency Organization Chart

A. Role & Responsibility of Emergency Management Team

Site Main Controller (SMC)
Senior most Executives (i.e. Director & Supervisor) of the company shall be nominated as SMC. His task will be to co-ordinate all internal and external activities from the Emergency Control Centre (ECC) at Main Security Gate, from where all operations will be directed. He shall:

- Immediately on being informed of the emergency and its location, will arrive at the site, review the situation and control further actions.
- Direct all Emergency Operations within the approved area with the following priorities:
  - Personnel Safety,
• Plant, Property and Environment Safety and
• Minimum loss of production.
• Co-ordinate to avail services from external agencies like fire brigade, hospitals etc, if called for, following the declaration of major emergency. If necessary, major installations in the vicinity may also be informed of the situation.
• Exercise direct operational control of the unaffected section of the plant.
• In consultation with the advisory team, expedite the shutting down of loading / unloading operations of tankers and if necessary, instruct the supervisor / security personnel to evacuate tankers.
• Ensure that all employees are evacuated from the affected area and the casualties, if any, are given necessary medical attention. Instruct P & A Assistant / Security for rushing casualties to hospitals if required.
• Liaise with fire and police officials, pollution control board officials and other statutory bodies and advise them of all possible consequence effects outside the premises.
• Arrange for relief of personnel when emergency is prolonged.
• Issue authorized statement or press release to the news – media.
• Ensure preservation of evidence for enquiries to be conducted by statutory authorities.
• Authorize the sounding of “All Clear” and “Evacuation Siren”.
• Arrange for obtaining the head – count of all personnel within the premises and cross-checking with the data from records available for no. of persons within the premises.
• Nominate a person from advisory team, to maintain chronological log of event during the entire period of emergency.

Role of Incident Controller (IC) and Deputy Incident Controller (DIC)

Respective Shift In-charge of the Plant (Site) & Department holds the responsibility of the Incident Controller, if the incident is in their plant/area. Two Production officers in each shift will be identified as Deputy Incident Controllers.

His primary duties shall be to take charge at the scene of the incident. In the initial stage he may be required to take decisions involving the operation of the other plants or to stop or continue any process and to take technical decisions to control the incident. The deputy incident controller will take the charge of incident controller, if he is not available due to any reason. They will be always available in each shift and can take charge of the incident.

Responsibilities/Duties of Incident Controller and Deputy Incident Controller:

• He shall take charge at the scene of incident.
• He shall immediately assess the gravity of risk and alert panel and field operators to start controlling their respective section.
• if the emergency is minor, try to prevent by using internal resources like fire extinguishers in case of fire, and cover the spillage by sand in case of liquid spillage.
• He will work under the direction of the SMC, but till his arrival he may have to execute following responsibilities.
• He will ensure that all the Key Personnel are called.
• Direct for evacuation of plant and areas likely to be affected by the emergency.
• He shall communicate to the SMC the type of outside help needed.
• He shall direct all emergency operations within the affected area with the following priorities.
• Personnel safety, including of surrounding community.
• Minimum damage to Plant, Property and Environment.
• Appropriate actions to minimize loss of Production and Material.
• Give information to the head of firefighting and rescue team and other emergency services.
• Depending on the incident, instruct partial or total shut down, isolations, depressurization, Nitrogen purging, firefighting and rescue operations.
• Instruct upstream/downstream units to take emergency shutdown /cutting off supply and other appropriate actions and emergency evacuation help etc.
• Direct for search of casualties.
• Evacuate non-essential workers/visitors/contractors to safe assembly points.
• Brief site main controller and keep him informed about the developments.
• Preserve evidences. This will be necessary for investigation for cause and concluding preventive measures.

Key Personnel
Senior officers of various departments like Fire, Security, Safety, Administration, Engineering, Project, Production, Transport, Pollution control, Technical Services and Stores shall be nominated as Key Personnel in their respective fields. As necessary, they shall decides the actions needed to shutdown plants, evacuate personnel, carryout emergency engineering work, arrange for supplies of equipment’s, utilities, carryout environment monitoring, provide catering facilities, liaise with police, fire brigade and other local authorities, relative of casualties, hospital, press & neighboring industries, action at assembly points, outside shelters and mutual aid center under the direction of the SMC. All the key personnel and other called in so to assist, shall report to the ECC. They shall be available at any time on duty or on call or on holidays.

The responsibilities and duties of key personnel are as follows.

Production Manager
• To keep in touch with IC & SMC in assessing/ controlling the emergency.
• To guide essential personnel team.
• To guide personnel for safe close down of the plant.
• To guide transport for safe shifting of materials from one place to other.
• To guide mutual aids services and the teams.
• To keep informed the SMC about developments.
• To make arrangement like emergency light, water etc.
• To assess the emergency & evacuate the neighboring factory workers and neighboring population through SMC.
• To inform the effect of emergency and steps to be taken to avoid the effects of a radiation etc.

Safety Manager
• To assist incident controller in controlling emergency
- To help site main controller in communication.
- To provide necessary equipment like FFE (Firefighting Equipments), PPE & RPE.
- To guide transport for safe shifting of materials from one place to other.
- To guide mutual aids services and the teams.
- To keep informed the site main controller about developments.
- To make arrangement like emergency light, water etc.
- To assess the emergency & evacuate the neighboring factory workers and neighboring population through SMC.
- To inform the effect of emergency and steps to be taken to avoid the effects of a Fire etc.

Security officer
- To help incident controller & site main controller at the time of emergency.
- To cordon the area and inform incident controller or site main controller about the development of emergency.
- To fight the fire with available internal FFE.
- To make arrangement for evacuating workers from the place of accident and guide non-essential workers towards company assembly point.
- To carry out head counting at assembly point & search of missing persons.
- To ensure that the roadway to plant is clear for emergency vehicles. Obtain assistance to keep roadway clear and to stop non-emergency traffic from entering.
- To direct their personnel (Response force & Task force) for evacuation of non-essential workers & Crowd control.
- To liaise with mutual aid services for their help and guide to them.
- To blow emergency siren & all clear siren on receiving message from IC/SMC through telephone office.

Factory Medical Officer
- To take charge of Occupational Health Centre.
- To provide treatment/ first aid to the affected persons and if necessary, send them to hospitals for further treatment.
- To keep liaison with hospitals and inform them about the type of emergency help required as per discussion with Site main control.
- Arrangement for adequate stock of antidotes, lifesaving drugs and special medicines.
- To keep the record of persons given first aid/ treatment and send them to hospitals with their name.
- To keep ready the list of blood groupings.
- To inform site main controller about the developing situation.
- To guide/instruct first aider, first aid & Rescue team in case of any emergency.
- To keep ready the list of first aider.
- To identify of all the hospitals for facilities to render medical aid to victims of exposure to dangerous chemical substances, burns and other specific injuries. (State authorities, local authorities, ESICS, Private, Railways/Voluntary institutions, trusts etc.) & report to SMC
- To keep provisions of buffer stock of essential medicines like intravenous fluids, dressing materials, splints, oxygen cylinders, suction apparatus etc. Keeping in view the large number of third degree burns, heat radiation.

**General Manager-IR**
- To assist site main controller & incident controller in controlling emergency.
- To guide mutual aids services and the teams.
- To keep informed the site main controller about developments.
- To make arrangement like emergency light, water, etc.
- To arrange external help like Medical, Fire, etc.
- To assess the emergency & evacuate the neighboring factory workers and neighboring population through SMC.
- To inform the effect of emergency and steps to be taken to avoid the effects of a Fire etc.
- To deal with external communication like media & external agencies

**Adjacent Plant incharge**
- To assist site main controller & incident controller in controlling emergency
- To help site main controller in communication.
- To guide mutual aids services and the teams.
- To keep informed the site main controller about developments.

**Telephone Operator**
- He will guide all visitors of admin building to move at assembly point.

**Essential Workers (EW)**
Essential Workers shall be those who shall be trained in Fire Fighting and First Aid. One Supervisor and two helpers from each shift will be identified as EW’s & shall supposed to report at EMERGENCY SITE to take instructions from IC or DY. IC Such work instructions will include:

- To rush at the site for help with fully equipped. I.e. firefighting equipment, SCBA sets, etc.
- To decide line of action in consultation with incident controller & Key personnel and take appropriate measures to extinguish the fire & to control spillage.
- Firefighting and spill control till a Fire Brigade takes the charge.
- To help the Fire Brigade and mutual aid teams, if it is required.
- Shutting down plant and making it safe.
- Emergency engineering work e.g. isolating equipment, material process, providing temporary by-pass lines, safe transfer of materials, urgent repairing or replacement, electrical work, etc.
- Provision of emergency power, water, lighting, instruments, equipments, materials, etc.
- Movement of equipment, special vehicle and transport to or from the scene of the accident.
- Search, evacuation, rescue and welfare.
• The injured will be given First Aid.
• To help & assist Factory Medical officer.
• Moving tankers or other vehicles from area of risk.
• Carrying out atmospheric test and pollution control.
• Manning of assembly points to record the arrival of evacuated personnel. Manning for outside shelters and welfare of evacuated persons there.
• Assistance at causalities reception areas to record details of causalities.
• Assistance at communication centers to handle outgoing and incoming calls and to act as messengers if necessary.
• Manning of works entrances in liaison with the police to direct emergency vehicles entering the work, to control traffic leaving the works and to turn away or make alternative safe arrangements for visitors, contractors and other traffic arriving at the works.
• Informing surrounding factories and the public as well as directed by the Site Main Controller.
• Any special help required.

A. Other Elements of DMP

Assembly Point:
In affected and vulnerable plants, all nonessential workers (who are not assigned any emergency duty) will be evacuated from the area & they shall report to specified assembly points. Assembly Points shall be located at a safe place, well away from area of risk and least affected by the down wind direction.

To ensure that workers will not have to approach the affected area to reach the assembly points, proper location and numbers will be marked at assembly points. Each assembly point shall be manned by a nominated person to record the names and dept. At each assembly point, duties of assembly point In-charge will also be displayed in brief. Before reaching an assembly point or subsequently, if it is required to pass through an affected area or due to presence of toxic substances, suitable PPE’s including respirators, helmet etc., shall be issued & made available with workers.

Emergency Control Center (ECC):
The Emergency Control Center is the place or room from where the operations to handle the emergency are directed and coordinated. Safe and easily approachable room has been earmarked/identified as the Emergency Control Room.

Telephone and other facilities required with necessary documents shall be displayed in ECC for ready reference. Designated trained personnel will operate ECC. In case of Major Emergency, the Site Main Controller will operate from ECC.
The ECC center will be equipped with the following facilities.

- Internal and external telephone including STD facility
- Telephone directory/ Telephone nos. of mutual aid centers
- First Aid
- Muster roll of workers
- Identity card register
- Layout plan of the factory showing the location of hazardous materials, assembly point, first aid centers etc.
- Map of surrounding area with fire extinguishers location
- M.S.D.S
- Copy of ON SITE OFF SITE PLAN
- Stationeries like- note book, pen, pencils etc.
- S.B. Apparatus
- List of Government Agencies /Local press agencies with phone no.
- Sand Buckets & Hydrant Network
- Adequate numbers of PPE’s

Fire Control Arrangements (Fire Fighting, Gas Leak Control and Rescue Operation)
Fire is classified in following three classes. The appropriate fire extinguishers are used to extinguish the different class of fire.

**Class A:** General Fire - Cotton Waste, Paper, Rubbish and Scrap: water, ABC powder type  
**Class B:** liquid Fire - All solvents, Resin, Paints, LDO, HSD: Mechanical foam, ABC type  
**Class C:** Gaseous /Electrical fire - Gaseous fire & panels etc.: CO2, DCP/ABC 
Sufficient number of fire hydrant valves and riser valves will be arranged to fulfill fire extinguishing need of the plant. Apart from this, fire extinguishers will be kept at various locations inside plant and those will be hydrostatically tested and refilled at intervals as specified by statutory body.

- Foam type  
- Dry chemical powder type  
- CO2 type

Fire drill will be carried out by all the security guards apart from safety persons to keep them ready fortnightly. Sufficient amount of firefighting water will always be stored in storage tank for firefighting works. In case of power failure, diesel driven fire engine pump has arranged to generate the power for emergency lighting and to run water pump.

**Role of Manager (Fire and Safety)/Shift In-Charge (Fire & Safety)**
- Incident Controller shall direct the firefighting and Emergency operation. His duties include…  
- Keep the constant touch with the SMC/In-charge - EHS.  
- Direct the crew members to the scene of emergency and arrange replenishment of Manpower/ equipment/ extinguishing media etc.
Role of EHS Representative:
- On being notified about the location of fire/ gas leakage, he shall immediately proceeds to the help.
- Decides his line of action in consultation with Incident controller and takes appropriate measures to handle the emergency.
- Shall assess the severity of the incident & shall immediately report to emergency controller about the gravity of the situation.
- He shall also assess the extra requirement required if any, from the neighboring industry.

Fire crew members
- On hearing fire alarm & emergency siren, they shall immediately reports to control room and proceed to the scene of emergency and work under the direction of IC/ Dy IC.
- The personnel availability at the scene of incident shall be made optimize.

Emergency Squad Members
- On hearing Emergency Siren, they shall immediately reports to site main controller, safety in charge or incident controller.
- They shall combat the emergency situation as per the direction of site main controller, safety in charge or incident controller.
- They will help for safe evacuation.

Medical Services
- The roles of Medical officers are as follows;
- He will report immediately to the SMC/IC.
- He will render necessary treatment, at Occupational Health Center.
- He will arrange for Hospitalization and Treatment at outside hospitals, if required.
- He will mobilize in getting the services of External medical agencies, other Para – medical services etc. and transportation services etc.
- He will arrange for extra medical assistance/antidotes, from out, if required.
- He will arrange for first-aid trained volunteers for necessary help.
- He will liaise with the Government Health Authorities for treatment of the affected persons nearby.

Role of Security In-Charge (Security Officer)
- On hearing the emergency siren, he shall find out the location of the incident (fire / gas leak / spill / explosion) and inform the location of the same to the key personnel coming to the plant.
- He will depute the security guards for managing gates and traffic control at the incident site & send remaining guards to the site of incident.
- He will prevent unauthorized entry in to the site.
- He will render assistance as demanded by the safety in-charge.
- He will mobilize additional security force for help, if required.
- He will direct ambulance(s) and emergency vehicle(s) to the scene of incident.
- He will help evacuate persons within the scene of incident.
- As directed by the site main controller, he may be required to address the public of surrounding villages for warning / evacuation.

**Role of Mutual-Aid Members**

- Company will have Mutual Aid with various nearby factories.
- On receiving the call, they shall proceed immediately with fire squad & fire tenders.
- They will be guided to the place of the incident by the main gate security guard.
- The fire squad in-charge will report to the safety in-charge of the unit in which the incident has occurred.

**Other Arrangements**

Other arrangements include external transport (transport center), heavy vehicles, lift/cranes, generator sets to supply emergency power, environment monitoring equipment, special instruments/equipment’s, rescue items etc. shall be made available (if required) from nearby Industries /locations, when available resources do not meet the requirements.

**Standard Operating Procedure (Shall Be Followed During Emergency)**

- As soon as emergency alarm is heard, all essential workers shall report to IC or SMC.
- They shall carefully listen to the instructions given by IC or SMC.
- According to the type of emergency/accident, they shall get equipped with PPE/Firefighting equipment and devices.
- The runner among the workers shall inform SMC/IC and key personnel if they are not at site.
- The messenger amongst the workers shall deliver messages to nearby units as per the instructions of SMC/IC.
- The in-charge of medical arrangements shall prepare first-aid and other required facilities for the injured.
- The other essential workers shall try to control the emergency as per the instructions given to IC.
- IC would keep SMC informed about the status of control measures being taken at the site and ask for other requirements eg. Mutual aid, equipment etc. if he find necessary.
- SMC would co-ordinate with outside agencies regarding control measures being taken, need for external help, evacuation, medical treatment etc.

**Security system**

- A premise is covered by fully fencing and Main gate is secured by guard for 24 hours.
- All transport vehicles are checked at the gate for driver licenses, MSDS, Emergency Information Panel and for any unwanted / undesired threat material etc.
- Security staff takes round throughout the factory for security of plant & others.
- CCTV camera installed at all critical locations.

**Communication System**

Communication System is a Crucial Factor while handling emergency. Company has quick & effective Communication System through which, any situation, which can lead to emergency, can be informed or known to...

- All persons working inside the plant.
- Key Personnel outside during normal working hours & during off-duty hours.
- Outside emergency services, Statutory and Local Authorities &
- Neighboring facilities and public leaving in vicinity.
- Each and every section, Plant & Department of the Factory will be connected by internal telephones with SMC, Supervisor or IC’s. External Phone at Office and Residence and Mobile shall also be made available with Key Personnel and top executive of the factory. The Communication System shall begin with raising the alarm declaring the emergency, Telephone messages and Procedure to communicate the emergency to other persons & General Public.

**Raising the Alarm**

As soon as incident takes place inside the factory and is noticed by someone, the first step shall be to raise the nearest manual emergency bell to alert the nearby people. Next, he/she shall inform the security persons to raise the emergency siren located at the factory gate. The security personnel sound the siren.

The alarm sound informs the I.C and the S.M.C that an emergency has been created and emergency organization plan to be activated. The I.C. rushes to the site and shall takes charge of the scene.

**Telephone Message**

A Telephone operator who is precise, sharp, attentive and quick in receiving and noting the message and subsequently effective in further Communication, shall be appointed. A form to record emergency telephone calls will be available with telephone operator or Person available in Emergency Control Center, who shall record such calls during emergency. Telephonic messages shall be given out by the telephone operator to Site main Controller and key personnel as per the instructions of the Incident Controller. Telephonic messages will also be given to authorities and external agencies to describe the type of emergency. All details of emergency will be collected/ delivered according to this format, available with the telephone operator.

**Emergency Time Activities**

The probable emergency situation that can arise in the unit and the corresponding control actions as described below shall be followed:

**Toxic Releases**

Following Control Actions will be taken –

- Anyone who notices the release shall sound emergency alarm.
- SMC/IC who is at site, shall immediately rush to the scene and assess the situation. For toxic release from a reactor, he activates the on-site plan as -
- He evacuates all the persons to safe assembly point.
• He calls in DIC (if DIC is not present there) and asks essential workers to wear self-breathing apparatus and if the reaction is exothermic, start cooling water flow in the reactor jacket and cool the reactor as soon as possible.
• The essential workers stop all the charging pumps of that reactor and the nearby reactors.
• He informs mutual aid teams and asks for necessary help.
• He arranges first-aid / hospitalization for the affected persons.
• Mutual aid teams shall be asked for help in the form of first-aid, transport etc.
• When the leak stops and the air shall clear of toxic release, IC tells essential workers to sound all clear.
• The incident shall be recorded
• SMC arranges to inform families / relatives of injured / dead.
• SMC issues authorized statement to press / media.
• SMC informs Factories Inspector about the incident and related information

Chemical Spill
Most of the drums/bags shall be located in storage yards. Neutralizing material shall be kept available. For dilution, water connection will be provided on all sides of storage area. Sand buckets shall be available for covering spillage of flammable / corrosive materials.

Safety Awareness among the workers
Details of training and periodic retraining programs for the personnel of safety and fire department
Security guards who act as firemen during fire emergency are trained, retrained and refreshed on regular basis. Safety professional is sent for external training and some training program also conducted at works site by external experts of the field.

Details of Training and retraining programs for the workers
Training programs on safety aspects with special attention to firefighting are regular feature of company. Plant organizes 3-4 sessions every month on safety aspects and cover good number of workmen in these programs.

All these training programs would at least include the following:
• Lectures
• Seminars and workshop
• Practical Exercises
• Distribution and practice safety instructions
• Safety quiz contests/competitions for individual as also for groups
• Display of safety posters and safety slogans at convenient and conspicuous places.
• Explanation of instructions (in the language easily understood by workers) about the possible hazards involved in handling of chemicals and methods to deal with such hazards failing which possible emergency situation are likely to arise.
• Developing safety instructions for every job and ensuring practice to these instructions/ booklets or manuals by workers.
• Educating workers about the
• Physical and health hazards arising out from the exposure of handling substance
• Measures taken to ensure safety and control physical and health hazards.
• Measures to be taken by workers to ensure safe handling, loading and unloading.
• Storage and transportation of hazardous substances
• Meaning of various labels and marking used on containers of hazardous substances and
  to whom to report
• Measures to be taken in case of any spillage or leakage.

1.3 OCCUPATIONAL HEALTH & SAFETY PROGRAMME
TP has prepared the Occupational Health Surveillance Programme which shall be followed right
from the project construction & erection phase and the same shall be updated for the upcoming
new facility, if required.

The details of the same are described in the following sections.

1.3.1 Occupational Health
Occupational health needs attention both during construction & erection and operation &
maintenance phases. However, the problem varies both in magnitude and variety in the above
phases.

1.3.2 Hospital Facilities /Factory Medical Officer & OHC
• Company shall made formal agreements with nearby hospitals having facilities to attend
  fire and toxic effect cases, emergency cases, attending the affected persons in the
  emergency arising out of accidents, if any, etc.
• A qualified doctor will be appointed as FMO on retainer ship basis. Apart from him,
  required medical facilities applicable as per Gujarat Factories Rules and Factories Act
  shall also be made available.
• All types of first aid related accessories, Medicines & Antidotes as prescribed by FMO,
  etc. shall be made available at conspicuous locations.

1.3.3 Ambulance Van & First Aid Box
  o An Emergency Vehicle shall be made available round the clock to be used as an
    Ambulance during emergency.
  o First Aid Boxes will be made available at the different location in the plant. Training shall
    be given to employees for First Aid.

1.3.4 Plan for Periodic Medical Checkup
• Periodic Medical Examination shall be conducted as per the following schedule;
• Workers employed will be examined by a Qualified Medical Practitioner/ Factory Medical
  Officer, in the following manner:
• Before employment, to ascertain physical fitness of the person;
During employment, every six months (blood & physical examination) as per Gujarat Factories Rules, to ascertain physical fitness of the person to do the particular job;

1.3.5 Details of Occupational Health Impacts and Safety Hazards

<table>
<thead>
<tr>
<th>Occupational Hazards Identification</th>
<th>Occupational Health Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure to Toxic &amp; Corrosive Chemicals</td>
<td>Toxification, Irritation,</td>
</tr>
<tr>
<td>Exposure to Chemical Dust, Spillage/leakage, Overflow</td>
<td>Severe irritation to eyes &amp; skin, Respiratory disorder, Fatality, etc.</td>
</tr>
<tr>
<td>Slip/trip, fall, electric shock, etc.</td>
<td>Body Injury, Burns, Skin sensitization, Fall Injury, Electrocution, Damage to nearby equipment’s, Fatality, etc.</td>
</tr>
</tbody>
</table>

Mitigation measures/ Safety Measures proposed to avoid the human health hazards are mentioned in additional studies. In addition to these safety measures, personal protective equipment (IS approved) like safety Helmet, Safety shoes/ Gumboots Hand gloves, Gas Mask / Nose Mask, PVC apron, SCBA Set, PVC pressure suit, goggles, hood, etc. will also be provided to the required personnel.

1.3.6 Details of Work Place Ambient Air Quality Monitoring Plan

Work zone monitoring will be carried out by independent competent third party every month. Records will be kept in Form No. 37 as per Gujarat Factories Rules. Location for samplings shall be identified. Ambient Air & Noise Monitoring shall be done every 3 months as per GPCB CCA requirements. Following information will be incorporated in the format for maintaining records of work zone monitoring:

A. Location/ Operation monitored
B. Identified contaminant
C. Sampling instrument used
D. Number of Samples
E. Range of contaminant concentration as measured in sample
F. Average concentration
G. TWA concentration of contaminant (As given in Second Schedule of Factories Act)
H. Reference method used for analysis
I. Number of workers exposed at the location being monitored
J. Signature of the person taking samples
K. Other relevant details

1.3.7 Monitoring of The Occupational Injury & It’s Impact on Workers

Following action plan will be prepared & followed to monitor the occupational injury to workers:

A. Each workplace will be evaluated for the existing work conditions.
B. Unsafe Act & Unsafe Practices will be identified.
C. Unsafe equipment’s, unsafe areas, etc., will be identified.
D. Area will be checked for proper Ventilation and Illumination.
E. Air-borne concentration of toxic chemicals will be measured and records will be kept.
F. Evaluation of training & on the job work.
G. Impact of the above mentioned unsafe conditions on workers will be studied and remedial measures for the same will be adopted.

1.3.8 Safety Trainings & Mock Drills
Safety trainings (on Safe Material Handling, First Aid, & all Safety Aspects) shall be provided every 15 days by the Safety Officers with the assistance of faculty members called from other Professional Safety Institutions and Universities. In addition to regular employees, limited contractor labors will also be given safety training. To create safety awareness, safety films shall be shown to workers and leaflets shall be distributed.

Mock Drills
To evaluate the effectiveness of emergency preparedness and to spread the awareness among employees mock drill will be carried out at the interval of every six months.

After completion of the mock drill, summary report shall be made and corrections will be done if any weakness has been observed.

Frequency of Mock Drills
On-site emergency: Once every 6 months
Off-site emergency: Once every year

1.3.9 Occupational Health and Safety Program
The main effects of chemicals especially VOCs are anticipated in proposed expansion project. No other source of adverse effects on occupation health & safety is likely to occur. However, MSDS of hazardous chemicals will be prepared & made available with the management as well as concern personnel working with the materials or area likely to be affected by the materials. In general following are the key safety measure recommended for the proposed project.
- Provision of drinking water supply for the employees as per standard of the drinking water as per WHO guidelines.
- Availability of proper sanitary facilities for the employees so that they do not suffer from any health ailments.
- Provision of all necessary equipment like portable detector, online detectors and other laboratory equipments as proposed for regular monitoring of workplace air and other conditions.
- Establish the safety policy.
- Provision of proximity suits and self-breathing apparatus.
- Provision and compulsory use of necessary PPEs like helmet, safety goggles, face mask, hand gloves and safety shoes etc. for all workers.
- Provision of ear muffs/ ear plugs to the workers exposed to higher noise level.
• Provision of first-aid boxes (Containing Tincture iodine, Eye Drops, Burnol, Soframycin (ointment), Sterilized cotton wool, Band-aid, Antiseptic Solution (Sevlon), Bandage etc) at various places in the premises.
• Organize training program for information on accident prevention, proper control and maintenance of equipment, first aid training and safe material handling practices.
• Monitoring of occupational hazards like noise, ventilation, chemical exposure will be carried out at frequent intervals.

1.4 SUMMARY
Kunder Chemicals handles some hazardous chemicals. Details about their storage, quantity to be stored, possible hazards and control measures are given in detail. Quantitative Risk Assessment (QRA) has been carried out for both the chemicals. Two major scenarios were identified for consequence analysis i.e Release of Xylene and Release of MCB. Chemical properties or their operating temperatures or pressures or a combination of them. Fire, explosion, toxic release or combinations of them are the hazards associated with industrial plants using hazardous chemicals. Hazard Identification and Qualitative/Quantitative Risk Assessment have been developed to improve upon the integrity, reliability and safety of industrial plants, the same has been discussed in detail.

Further KCPL has prepared the Disaster Management Plan (onsite/offsite emergency plan) to effectively utilize all the resources at its disposal for the protection of life, environment and property. KCPL has developed an emergency management team.

KCPL is very much concerned in terms of health, safety and environment protection. KCPL has prepared Occupational Health Surveillance Programme which shall be followed right from the project construction & erection phase