1.0 RISK ASSESSMENT

1.1 INTRODUCTION

Risk assessment of the proposed Sindri Fertilizer project has been done keeping in view the hazardous nature of materials stored, handled and processed for production of Ammonia & Urea.

The Fertilizer Plant of M/s HURL at Sindri will pose fire, explosion and toxic hazards due to unwanted or accidental release of process gas containing CO, H₂ and toxic gases like, NH₃ and Cl₂. The effect zones of the fire and explosion hazard are generally restricted within the plant boundary limits and near the source of generation itself. However, effect of release of ammonia and other toxic gases may go outside the factory premises. This section deals with the failure modes, listing of failure cases leading to different hazard scenarios, consequence modeling and the risk evaluation.

Consequence analysis is basically a quantitative study of the hazard due to various failure scenarios to determine the possible magnitude of damage effects and to determine the distances up to which the damage may be affected using internationally accepted mathematical models. For the purpose of risk evaluation and Consequence Analysis PHAST-RISK MICRO Software of DNVGL (UK) has been used. The reason and purpose of consequence analysis are manifold like:

- For computation of risk
- To aid-in better plant layout to reduce hazards
- For evaluating damage and protection of other plants
- To ascertain damage potential to public and evolve mitigation measures
- For preparation of effective ON-SITE and OFF-SITE Disaster Management Plan

The results of consequence analysis are useful for getting information about all known and unknown effects that are of importance when some failure scenario occurs and to get information about how to deal with possible catastrophic events. It also gives the plant authorities, workers and the public living outside in the vicinity of the plant an understanding of the hazard potential and remedial measures.
1.2 FAILURE MODE ANALYSIS

There are various potential sources of large/ small leakages, which may release the hazardous flammable, explosive and toxic materials to the surrounding atmosphere. Leakage from failure of pipes, flanges and holes of different sizes has been considered for risk analysis study. Some typical modes of failure and their possible causes are discussed in Table- 1.1.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Failure Mechanism</th>
<th>Probable cause</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Flange/ gasket failure</td>
<td>Incorrect gasket, Incorrect Installation.</td>
<td>Careful attention to be paid during selection of gasket &amp; installation.</td>
</tr>
<tr>
<td>2.</td>
<td>Weld failure</td>
<td>Incorrect use of welding material, Incorrect welding procedure, lack of inspection during welding.</td>
<td>Welding to be done by certified welder only with proper quality of welding rod under strict inspection with stepwise checking &amp; acceptance after final radiography.</td>
</tr>
<tr>
<td>3.</td>
<td>Pipe over stress causing fracture</td>
<td>Error in stress analysis, Improper pipe material, Inappropriate design code and incorrect supports, Lack of inspection during erection</td>
<td>Pipe stress may also cause flange leakage unless there exists a combination of cause. Stress analysis of piping &amp; proper support selection to be done during design. Strict inspection to be ensured during erection.</td>
</tr>
<tr>
<td>4.</td>
<td>Over-pressurization of pipeline causing rupture</td>
<td>Incorrect selection of safety relief valves, Incorrect setting of SRVs. SRV fails to operate</td>
<td>Careful attention is needed for selection and setting of SRV. SRV to be maintained properly.</td>
</tr>
<tr>
<td>5.</td>
<td>Failure of pipeline due to corrosion/erosion</td>
<td>Failure of Corrosion protective layer and poor corrosion allowance in design</td>
<td>Thickness monitoring to be done at regular intervals.</td>
</tr>
<tr>
<td>6.</td>
<td>Leaking valve to atmosphere</td>
<td>Gland failure, packing failure, spindle/plug cock flow-out</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Instrument connection failure</td>
<td>Bourdon tube failure, level gauge glass failure, Failure of instruments connection etc.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Internal</td>
<td>Air ingress due to</td>
<td></td>
</tr>
</tbody>
</table>
### 1.3 DAMAGE CRITERIA

The damage effects are different for different failure cases. In order to visualize the damage effects produced by various failure scenarios, it shall be prudent to discuss the physical effects of release of flammable, explosive and toxic materials e.g. thermal radiation, blast wave and physiological response to toxic release.

i) Flammable and explosive vapours released accidentally will normally spread out in the direction of wind. If it comes in contact with any source of ignition between its lower and upper flammability limit, a flash fire is likely to occur and the flame may travel back to the source of leakage. Any person caught in the flash fire is likely to suffer from severe burn injury. Therefore in consequence analysis, the distance to LFL value is usually taken to indicate the area, which may be affected by flash fires. Any other combustible material within the flash fire is likely to catch fire and may cause secondary fires. In the area close to the source of leakage of flammable vapour, there is possibility of depletion of oxygen, if the flammable vapour is heavier than air. A minimum of 16% oxygen in air is considered essential for human lives.

ii) Thermal radiation due to pool fire, jet flame or fireball may cause various degree of burn on human bodies. Also its effects on inanimate objects like equipment, piping, building and other object need to be evaluated. The damage effect with respect to thermal radiation is given in Table - 1.2.
Table 1.2

DAMAGE DUE TO INCIDENT THERMAL RADIATION INTENSITY

<table>
<thead>
<tr>
<th>Thermal radiation intensity (KW/m²)</th>
<th>Type of damage</th>
<th>Casualty Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5</td>
<td>100% lethality can cause heavy damage to process equipment, piping, building etc.</td>
<td>1.0</td>
</tr>
<tr>
<td>32.0</td>
<td>Maximum heat flux for insulated Thermally protected tanks.</td>
<td>-</td>
</tr>
<tr>
<td>12.5</td>
<td>50% lethality. Minimum energy required for piloted ignition of wood, melting of plastic tubing etc.</td>
<td>0.5</td>
</tr>
<tr>
<td>8.0</td>
<td>Maximum heat flux for un-insulated tanks.</td>
<td>-</td>
</tr>
<tr>
<td>4.5</td>
<td>First degree burn. Sufficient to cause pain to personnel if unable to reach cover within 20 seconds.</td>
<td>0.0</td>
</tr>
<tr>
<td>1.6</td>
<td>Will cause no discomfort to long exposure.</td>
<td>0.0</td>
</tr>
<tr>
<td>0.7</td>
<td>Equivalent to solar radiation.</td>
<td>0.0</td>
</tr>
</tbody>
</table>

In case of transient fires, total thermal dose level is used to estimate threshold damage level.

iii) In the event of dispersion of flammable and explosive vapours, if the cloud comes in contact with an ignition source between its flammability limits and the mass of the explosive materials is sufficient, an explosion may occur. The resultant blast effect may have damaging effects on the equipments, buildings, structures etc. The collapse of buildings and structures may cause injury or fatality. Damage effects of blast overpressures are given in Table 1.3.

Table 1.3

DAMAGE EFFECTS OF BLAST OVERPRESSURE

<table>
<thead>
<tr>
<th>Blast Over-pressure (PSI)</th>
<th>Damage Type</th>
<th>Casualty Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td>Major Structural damage (assumed fatal to the people inside building or within other structure)</td>
<td>0.25</td>
</tr>
<tr>
<td>0.20</td>
<td>Storage tank failure</td>
<td>-</td>
</tr>
<tr>
<td>0.17</td>
<td>Eardrum damage</td>
<td>0.10</td>
</tr>
<tr>
<td>0.10</td>
<td>Repairable damage, pressure vessels remain intact, light structure collapse</td>
<td>0.0</td>
</tr>
<tr>
<td>0.03</td>
<td>Window breakage, possibly causing some injury</td>
<td>0.0</td>
</tr>
</tbody>
</table>
iv) In the event of release of toxic gases, the released gases shall disperse in the direction of wind. As the gases disperse downwind, mixing with the surrounding air takes place and the concentration of the gases in air comes down. Toxic gas may have damaging effects on the people in the neighborhood of the plant. The physiological effects of Ammonia & Chlorine are toxic gases that may accidentally release from the Fertilizer plant are given in following tables.

### Table - 1.4

**PHYSIOLOGICAL EFFECTS OF AMMONIA ON HUMAN BODIES**

<table>
<thead>
<tr>
<th>Vapour Concentration (ppm by v/v)</th>
<th>General Toxic Effect</th>
<th>Exposure Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Odour detectable by most persons</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>No adverse effect</td>
<td>Recommended exposure limit – long term 8 hours TLV</td>
</tr>
<tr>
<td>35</td>
<td>No adverse effect</td>
<td>Recommended exposure limit – short term 15 minutes</td>
</tr>
<tr>
<td>50</td>
<td>Irritation just detectable by most person but not persistent</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>No prolonged effect for average worker</td>
<td>Maximum exposure for long periods not permitted</td>
</tr>
<tr>
<td>400-700</td>
<td>Immediate nose &amp; throat irritation</td>
<td>½ - 1 hr. exposure causes no serious effect</td>
</tr>
<tr>
<td>1700</td>
<td>Severe coughing, severe eye, nose &amp; throat irritation</td>
<td>Could be fatal after ½ hrs.</td>
</tr>
<tr>
<td>2000-5000</td>
<td>Severe coughing, severe eye, nose &amp; throat irritation</td>
<td>Could be fatal after ¼ hrs.</td>
</tr>
<tr>
<td>5000-10000</td>
<td>Respiratory spasm, rapid asphyxia</td>
<td>Fatal within minutes</td>
</tr>
</tbody>
</table>

For consequence analysis of ammonia discharge 15 minutes exposure time has been considered. The consequences of this exposure period to various concentrations are as follows:

- $8484 \text{ mg/m}^3$ (12177 ppm) : $\text{LC}_{50}$ for 15 min. exposure time
- $5574 \text{ mg/m}^3$ (8001 ppm) : $\text{LC}_{20}$ for 15 min. exposure time
- $4474 \text{ mg/m}^3$ (6421 ppm) : $\text{LC}_{10}$ for 15 min. exposure time

*(Ref. probit equation as per TNO green book)*
Table - 1.5

<table>
<thead>
<tr>
<th>Vapour Concentration (ppm by v/v)</th>
<th>General Toxic Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 TLV</td>
<td>No adverse effect</td>
</tr>
<tr>
<td>3.0 STEL</td>
<td>Least detectable odour</td>
</tr>
<tr>
<td>4.0</td>
<td>No serious disturbance</td>
</tr>
<tr>
<td>5.0</td>
<td>Noxiousness, impossible to breath</td>
</tr>
<tr>
<td>15.0</td>
<td>Irritation of throat</td>
</tr>
<tr>
<td>30.2</td>
<td>Cause coughing</td>
</tr>
<tr>
<td>40 – 60</td>
<td>Dangerous for exposure ranging from 30-60 min.</td>
</tr>
<tr>
<td>100</td>
<td>May be lethal</td>
</tr>
<tr>
<td>1000</td>
<td>Dangerous to life even with a few deep inhalation</td>
</tr>
</tbody>
</table>

For consequence analysis of chlorine leakage, 10 minutes exposure time has been considered. The consequences of exposure period to various concentration of chlorine are as follows:

- 1620 mg/m³ (557 ppm) : LC₅₀ for 10 min. exposure time
- 1124 mg/m³ (386 ppm) : LC₂₀ for 10 min. exposure time
- 929 mg/m³ (319 ppm) : LC₁₀ for 10 min. exposure time

*(Ref. probit equation as per TNO green book)*

**Dispersion and Stability Class**

In calculation of effects due to release of hydrocarbons, dispersion of vapour plays an important role as indicated earlier. The factors which govern dispersion are mainly Wind Velocity, Stability Class, Temperature as well as surface roughness. One of the characteristics of atmosphere is stability, which plays an important role in dispersion of pollutants. Stability is essentially the extent to which it allows vertical motion by suppressing or assisting turbulence. It is generally a function of vertical temperature profile of the atmosphere. The stability factor directly influences the ability of the atmosphere to disperse pollutants emitted into it from sources in the plant. In most dispersion, problems relevant to atmospheric layer is that nearest to the ground. Turbulence induced by buoyancy forces in the atmosphere is closely related to the vertical temperature profile.

Temperature of the atmospheric air normally decreases with increase in height. The rate of decrease of temperature with height is known as the *Lapse Rate*. It varies from time to time and place to place. This rate of change
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of temperature with height under adiabatic or neutral condition is approximately \(1^\circ\text{C} \times 100 \text{ metres}\). The atmosphere is said to be stable, neutral or unstable according to the lapse rate is less than, equal to or greater than dry adiabatic lapse rate i.e. \(1^\circ\text{C} \times 100 \text{ metres}\).

Pasquill has defined six stability classes ranging from A to F.

\begin{align*}
A &= \text{Extremely unstable} \\
B &= \text{Moderately unstable} \\
C &= \text{Slightly unstable} \\
D &= \text{Neutral} \\
E &= \text{Stable} \\
F &= \text{Highly stable}
\end{align*}

1.4 Properties of Hazardous Materials

**Ammonia**

Ammonia is a highly toxic gas. It is also a combustible gas and explodes under certain circumstances. It forms an explosive mixture between 16% to 25% (v/v) in air and its auto ignition temperature is 650\(^{\circ}\text{C}\). As the minimum ignition energy requirement of ammonia is quite high, more than 100 MJ and flammability limit is high, it catches fire with much difficulty. Also it is lighter than air and hence, disperses quickly to below its lower flammability limit (LFL). The main hazard with ammonia is toxic hazard.

Ammonia causes damage on contact with skin and eye. Its TLV is 25 ppm and may be fatal for short time exposure above 5000 ppm concentration.

**Chlorine**

Chlorine is a highly toxic gas. Its TLV is 1 ppm. It may be fatal for short time exposure above 500 ppm.

Chlorine is used for the treatment of water in the plant and shall be stored in chlorine tonners. Chlorine tonners present in the plant are kept in the storage shed at a time and thus the amount of chlorine stored in the plant would not be significant. Nevertheless, because of its high toxicity, a leakage even in a tonner holding 900 Kg of chlorine may be hazardous.

**Hydrogen**

Hydrogen is present in the process gas and its concentration in process gas varies from about 52% to 75% at different stages of the process. Hydrogen is highly inflammable gas and its flammability limit is in between 4% to 74% (v/v) in air, with auto ignition temperature of 400\(^{\circ}\text{C}\). The minimum ignition energy requirement of hydrogen is 0.019 MJ and burns with an invisible flame. As the ignition energy requirement is quite low, it catches fire easily.
Carbon Monoxide

Carbon monoxide is present in process gas is about 14.1% before it is converted to CO₂ and H₂ in shift conversion section where its concentration is reduced to about 0.2%. Carbon monoxide is an extremely toxic gas and may be fatal for short time exposure above 1000 ppm. Its TLV is 50 ppm. The gas is flammable and forms explosive mixture in between 12.5% to 74% (v/v) in air. Its auto ignition temperature is 615°C. As mentioned above, the gas is quickly converted into CO₂ and H₂, and the risk posed by it may at best be considered as transient risk only.

1.5 FAILURE CASE LISTING

The mode of approach adopted for the study is to first select the failure cases and then to conduct the consequence analysis of the same which are listed in Table-1.6. Failure cases and consequence analysis are mainly confined to the equipment for the proposed Sindri Fertilizer project.

Table - 1.6
SELECTED FAILURE CASES

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Failure Cases (For Ammonia Plant)</th>
<th>Failure Mode</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>High Pressure Natural Gas (HPNG) Feed Line Holes i) 25 mm dia. hole ii) 15 mm dia. hole iii) 10mm dia. hole</td>
<td>Random failure</td>
<td>Jet fire, UVCE</td>
</tr>
<tr>
<td>02.</td>
<td>Make-up synthesis gas to Ammonia synthesis section Holes i) 25 mm dia. hole ii) 15mm dia. hole iii) 10mm dia. hole</td>
<td>Random failure</td>
<td>Jet fire, UVCE</td>
</tr>
<tr>
<td>03.</td>
<td>Ammonia Converter outlet line Holes i) 25 mm dia. hole ii) 15 mm dia. hole iii) 10 mm dia. hole</td>
<td>Random failure</td>
<td>Toxic Dispersion, Jet fire, UVCE</td>
</tr>
<tr>
<td>04.</td>
<td>Ammonia Re-circulator Outlet line Holes i) 25 mm dia. hole ii) 15 mm dia. hole iii) 10 mm dia. hole</td>
<td>Random failure</td>
<td>Jet fire, UVCE</td>
</tr>
<tr>
<td>05.</td>
<td>Liquid Ammonia Line Inlet to Liquid Ammonia Reservoir Holes i) 25 mm dia. hole ii) 15 mm dia. hole iii) 10 mm dia. hole</td>
<td>Random failure</td>
<td>Toxic Dispersion</td>
</tr>
<tr>
<td>06.</td>
<td>HP liquid NH₃ pump outlet line to</td>
<td>Random</td>
<td>Toxic Dispersion</td>
</tr>
</tbody>
</table>
The purpose of listing of failure cases as given in Table-7.6 is to examine the consequence of the failure individually or in combination. The frequency of occurrence of failure varies and can be estimated. Generic data could be used, as it is available for almost every component. However, their use may sometimes give erroneous result, if not used judiciously. It has been observed that the guillotine failure of pipelines of higher sizes has a lower frequency of occurrence. On the other hand, failure frequency of small bore pipelines up to say 10 mm pipe size, development of cracks equivalent to say 5% or 10% of the cross sectional area of the pipe, failure of pump mechanical seal, gasket etc. are relatively high and may be considered “foreseeable” or “credible” and may contribute higher risk, though the release rate may be small in these cases and consequences will not be given.

### 1.6 FAILURE FREQUENCY

The failure frequencies are given below in Table-1.7.

#### Table - 1.7

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Item</th>
<th>Failure Frequency/10^6 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>1]</td>
<td>Shell Failure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) Process/pressure vessel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Pressurised Storage Vessel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2]</td>
<td>Full Bore Vessel Connection Failure (Diameter mm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; 25</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>4</td>
</tr>
</tbody>
</table>
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Consequence Analysis of selected failure cases as listed in Table-7.6 are detailed below:

1.7.1 High Pressure Natural Gas (HPNG) Feed Line Holes

<table>
<thead>
<tr>
<th>Line Size (&quot;&quot;)</th>
<th>Pressure (bar)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>40</td>
<td>40</td>
</tr>
</tbody>
</table>

Natural Gas (NG) shall be received through GAIL’s Jagdishpur-Phulpur-Haldia pipeline at a flow rate of 51000 Nm³/hr. The length of this pipeline to receive NG shall be approximately 1,128 km which shall be a spur line from the main line i.e. 36" Jagdishpur-Phulpur-Haldia pipeline. In case of failure or leakage in the NG pipeline, there can be huge dispersion of NG till the action for terminating the supply of NG is initiated. If the source of ignition is available in leakage area, there is possibility of jet fire and vapor cloud explosion upon delayed ignition.

The Composition of HPNG has been considered as follows:

<table>
<thead>
<tr>
<th>Components</th>
<th>Composition (Mole %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>92.48</td>
</tr>
<tr>
<td>Ethane</td>
<td>1.69</td>
</tr>
<tr>
<td>Propane</td>
<td>0.13</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>5.69</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.01</td>
</tr>
</tbody>
</table>

For consequence analysis following cases has been considered:

i) 25 mm dia. hole
ii) 15mm dia. Hole
iii) 10 mm dia. hole

Consequence distances due to jet fire, LFL and overpressure are given in the following tables:
## Table - 1.8

### HAZARD DISTANCES OF THERMAL RADIATION DUE TO JET FIRE & LFL

<table>
<thead>
<tr>
<th>Case</th>
<th>LFL</th>
<th>2F</th>
<th>2B</th>
<th>3D</th>
<th>5D</th>
<th>7D</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td>13</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Thermal Radiation KW/M²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LFL</td>
<td>2F</td>
<td>2B</td>
<td>3D</td>
<td>5D</td>
<td>7D</td>
</tr>
<tr>
<td></td>
<td>25 mm dia. hole (RR:3.19 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37.5</td>
<td>16</td>
<td>15</td>
<td>16</td>
<td>18</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>32.0</td>
<td>18</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td>23</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>27</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>29</td>
<td>29</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Case-II</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LFL</td>
<td>2F</td>
<td>2B</td>
<td>3D</td>
<td>5D</td>
<td>7D</td>
</tr>
<tr>
<td></td>
<td>15 mm dia. hole (RR: 1.15 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37.5</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>32.0</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>14</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Case-III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LFL</td>
<td>2F</td>
<td>2B</td>
<td>3D</td>
<td>5D</td>
<td>7D</td>
</tr>
<tr>
<td></td>
<td>10 mm dia. hole (RR: 0.51 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37.5</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>32.0</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>12.5</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>8.0</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

RR: Release Rate; NR: Not Reached

It may be observed from the above table that, hazard distances for thermal radiation due to jet fire of 4.5 KW/m² (1<sup>st</sup> degree burn) in case of 25mm dia. hole in the line will go up to a maximum distance of 30 m and can cause superficial burn to the nearby working personnel.
Table - 1.9
HAZARD DISTANCES TO OVERPRESSURE DUE TO UVCE

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Wind Speed (m/sec)/Stability Class</th>
<th>Hazard distances (m)</th>
<th>0.3 Bar</th>
<th>0.1 Bar</th>
<th>0.03 Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case-I 25 mm dia. hole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>24</td>
<td>28</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>24</td>
<td>28</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>24</td>
<td>28</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>24</td>
<td>27</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>13</td>
<td>17</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Case-II 15 mm dia. hole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>12</td>
<td>15</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>12</td>
<td>15</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>12</td>
<td>15</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>12</td>
<td>14</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>12</td>
<td>14</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Case-III 10 mm dia. hole</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

It is evident from the above table that the hazard distance to overpressure of 0.3 bar goes up to a maximum distance of 24 m for 25mm dia. hole in the line and may lead to damage to the nearby structures in the plant.

1.7.2 Make-up Synthesis Gas to Ammonia Synthesis Section Line Holes

<table>
<thead>
<tr>
<th>Line Size (&quot;)</th>
<th>Pressure (bar)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>32.9</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Make-up synthesis gas comes from preceding section i.e. gasification & synthesis gas preparation section. The synthesis gas enters the synthesis section through a 30" dia. line and the compositions of the gases shall be as follows:

<table>
<thead>
<tr>
<th>Components</th>
<th>Composition (Mole %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>74.76</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>24.94</td>
</tr>
<tr>
<td>Argon</td>
<td>0.31</td>
</tr>
</tbody>
</table>

For consequence analysis the following phenomena have been considered:

i) 25mm dia. Hole
ii) 15mm dia. Hole
iii) 10mm dia. Hole
In case of any holes as stated above in the pipeline, the gas shall come out as gas jet and may disperse in atmosphere which on getting any source of ignition may form jet fire and/ or UVCE. The Hazard distances due to jet fire, LFL and UVCE are given in Table-1.10 and 1.11.

Table - 1.10
HAZARD DISTANCES OF THERMAL RADIATION DUE TO JET FIRE & LFL

<table>
<thead>
<tr>
<th>Thermal Radiation KW/M²</th>
<th>Hazard distances (m) for Wind speed (m/sec) and stability classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LFL 2F</td>
</tr>
<tr>
<td>Case-I 25 mm dia. hole (RR:1.90 Kg/sec, Duration: 180 sec)</td>
<td></td>
</tr>
<tr>
<td>LFL</td>
<td>16</td>
</tr>
<tr>
<td>Thermal Radiation KW/M²</td>
<td>2F</td>
</tr>
<tr>
<td>37.5</td>
<td>NR</td>
</tr>
<tr>
<td>32.0</td>
<td>NR</td>
</tr>
<tr>
<td>12.5</td>
<td>15</td>
</tr>
<tr>
<td>8.0</td>
<td>17</td>
</tr>
<tr>
<td>4.5</td>
<td>20</td>
</tr>
<tr>
<td>Case-II 15 mm dia. hole (RR: 0.68 Kg/sec, Duration: 180 sec)</td>
<td></td>
</tr>
<tr>
<td>LFL</td>
<td>10</td>
</tr>
<tr>
<td>Thermal Radiation KW/M²</td>
<td>2F</td>
</tr>
<tr>
<td>37.5</td>
<td>NR</td>
</tr>
<tr>
<td>32.0</td>
<td>NR</td>
</tr>
<tr>
<td>12.5</td>
<td>NR</td>
</tr>
<tr>
<td>8.0</td>
<td>NR</td>
</tr>
<tr>
<td>4.5</td>
<td>11</td>
</tr>
<tr>
<td>Case-III 10 mm dia. hole (RR: 0.30 Kg/sec, Duration: 180 sec)</td>
<td></td>
</tr>
<tr>
<td>LFL</td>
<td>7</td>
</tr>
<tr>
<td>Thermal Radiation KW/M²</td>
<td>2F</td>
</tr>
<tr>
<td>37.5</td>
<td>NR</td>
</tr>
<tr>
<td>32.0</td>
<td>NR</td>
</tr>
<tr>
<td>12.5</td>
<td>NR</td>
</tr>
<tr>
<td>8.0</td>
<td>NR</td>
</tr>
<tr>
<td>4.5</td>
<td>NR</td>
</tr>
</tbody>
</table>

RR: Release Rate; NR: Not Reached

It is evident from the above table that hazard distance to thermal radiation of 4.5 KW/m² (1st degree burn) will go up to a maximum distance 22 meters in case of 25mm dia. hole in synthesis gas line. The jet may impinge other pipelines & equipments causing domino effects.
### Table – 1.11
HAZARD DISTANCES TO OVERPRESSURE DUE TO UVCE

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Wind Speed (m/sec)/Stability Class</th>
<th>Hazard distances (m)</th>
<th>0.3 Bar</th>
<th>0.1 Bar</th>
<th>0.03 Bar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Case-I 25 mm dia. hole</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>33</td>
<td>37</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>23</td>
<td>27</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>23</td>
<td>26</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>23</td>
<td>26</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>23</td>
<td>26</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td><strong>Case-II 15 mm dia. hole</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>12</td>
<td>14</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>12</td>
<td>14</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>12</td>
<td>14</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>12</td>
<td>14</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>12</td>
<td>14</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td><strong>Case-III 10 mm dia. hole</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>11</td>
<td>13</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>11</td>
<td>13</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>11</td>
<td>13</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

It is evident from the above table that the hazard distance to overpressure of 0.3 bar goes up to a maximum distance of 33 m for 25mm dia. hole in the synthesis gas inlet line and can damage other equipments and pipelines downwind.

### 1.7.3 Ammonia Converter Outlet Line Holes

<table>
<thead>
<tr>
<th>Line Size (&quot;)</th>
<th>Pressure (Kg/cm²g)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>154</td>
<td>439</td>
</tr>
</tbody>
</table>

Ammonia converter outlet gas shall enter the waste heat boiler. The composition of the gas entering waste heat boiler has been considered as follows:

<table>
<thead>
<tr>
<th>Components</th>
<th>Composition (Mole %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>57.02</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>19.07</td>
</tr>
<tr>
<td>Methane</td>
<td>0.03</td>
</tr>
<tr>
<td>Ammonia</td>
<td>19.79</td>
</tr>
</tbody>
</table>

The gas enters the waste heat boiler at a temperature of 439°C and pressure of 154 Kg/cm²g. Full Bore failure of 30" dia. pipeline is an incredible...
phenomenon, hence the following cases have been considered for consequence analysis:

i) 25mm dia. Hole
ii) 15mm dia. Hole
iii) 10mm dia. Hole

In case of any hole as stated above in the Ammonia converter outlet line, the gas shall come out as jet which on getting any source of ignition may form jet fire and/ or UVCE. Since the gas contains ammonia, it may also result in toxic effects. The toxic hazard, jet fire, LFL and overpressure distances due to Overpressure are given in Table-1.12, 7.13 & 1.14.

<table>
<thead>
<tr>
<th>Wind speed (m/s)/ Stability Class</th>
<th>LC&lt;sub&gt;50&lt;/sub&gt; (12177 ppm)</th>
<th>LC&lt;sub&gt;20&lt;/sub&gt; (8001 ppm)</th>
<th>LC&lt;sub&gt;10&lt;/sub&gt; (6421 ppm)</th>
<th>IDLH (300 ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dis.(m)/ Area(m&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>Dis.(m)/ Area(m&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>Dis.(m)/ Area(m&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>Dis.(m)/ Area(m&lt;sup&gt;2&lt;/sup&gt;)</td>
</tr>
<tr>
<td>Case-I 25 mm dia. hole</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>52.9/425.375</td>
</tr>
<tr>
<td>2F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>77.5/876.807</td>
</tr>
<tr>
<td>3D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>78/851.015</td>
</tr>
<tr>
<td>5D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>99/1189.07</td>
</tr>
<tr>
<td>7D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>121/1424.82</td>
</tr>
<tr>
<td>Case-II 15 mm dia. Hole</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>40.5/204.08</td>
</tr>
<tr>
<td>2B</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>58.8/487.773</td>
</tr>
<tr>
<td>3D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>61.9/479.355</td>
</tr>
<tr>
<td>5D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>72/572.299</td>
</tr>
<tr>
<td>7D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>88/696.07</td>
</tr>
<tr>
<td>Case-III 10 mm dia. Hole</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>31.49/94.6407</td>
</tr>
<tr>
<td>2F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>45/254.987</td>
</tr>
<tr>
<td>3D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>47.5/251.4</td>
</tr>
<tr>
<td>5D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>55.9/307.622</td>
</tr>
<tr>
<td>7D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>66/363.878</td>
</tr>
</tbody>
</table>

It is evident from the above table that hazard distance to IDLH value (300 ppm) will go up to a maximum distance of 121 m covering an area of 1424.82m<sup>2</sup> around the facility in case of formation of 25 mm dia. hole in Ammonia Converter outlet line.
### Table - 1.13

**HAZARD DISTANCES OF THERMAL RADIATION DUE TO JET FIRE & LFL**

<table>
<thead>
<tr>
<th>Thermal Radiation KW/M²</th>
<th>Hazard distances (m) for Wind speed (m/sec) and stability classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LFL 2F 2B 3D 5D 7D</td>
</tr>
<tr>
<td>Case-I 25 mm dia. hole (RR: 5.83 Kg/sec, Duration: 180 sec)</td>
<td></td>
</tr>
<tr>
<td>LFL</td>
<td>18 17 17 15 14</td>
</tr>
<tr>
<td>Thermal Radiation KW/M²</td>
<td>2F 2B 3D 5D 7D</td>
</tr>
<tr>
<td>37.5</td>
<td>NR NR NR NR NR</td>
</tr>
<tr>
<td>32.0</td>
<td>NR NR NR NR NR</td>
</tr>
<tr>
<td>12.5</td>
<td>28 28 28 30 32</td>
</tr>
<tr>
<td>8.0</td>
<td>30 30 31 33 35</td>
</tr>
<tr>
<td>4.5</td>
<td>35 35 36 37 38</td>
</tr>
<tr>
<td>Case-II 15 mm dia. hole (RR: 2.10 Kg/sec, Duration: 180 sec)</td>
<td></td>
</tr>
<tr>
<td>LFL</td>
<td>11 11 10 10 9</td>
</tr>
<tr>
<td>Thermal Radiation KW/M²</td>
<td>2F 2B 3D 5D 7D</td>
</tr>
<tr>
<td>37.5</td>
<td>NR NR NR NR NR</td>
</tr>
<tr>
<td>32.0</td>
<td>NR NR NR NR NR</td>
</tr>
<tr>
<td>12.5</td>
<td>15 14 15 16 17</td>
</tr>
<tr>
<td>8.0</td>
<td>18 18 18 19 20</td>
</tr>
<tr>
<td>4.5</td>
<td>21 21 21 22 22</td>
</tr>
<tr>
<td>Case-III 10 mm dia. hole (RR: 0.93 Kg/sec, Duration: 180 sec)</td>
<td></td>
</tr>
<tr>
<td>LFL</td>
<td>7 7 7 7 6</td>
</tr>
<tr>
<td>Thermal Radiation KW/M²</td>
<td>2F 2B 3D 5D 7D</td>
</tr>
<tr>
<td>37.5</td>
<td>NR NR NR NR NR</td>
</tr>
<tr>
<td>32.0</td>
<td>NR NR NR NR NR</td>
</tr>
<tr>
<td>12.5</td>
<td>NR NR NR NR NR</td>
</tr>
<tr>
<td>8.0</td>
<td>NR NR NR NR NR</td>
</tr>
<tr>
<td>4.5</td>
<td>13 13 13 13 14</td>
</tr>
</tbody>
</table>

RR: Release Rate; NR: Not Reached

It is evident from the above table that hazard distance to thermal radiation of 4.5 KW/m² (1\textsuperscript{st} degree burn) will go up to a maximum distance 38 meters in case of 25mm dia. hole in Ammonia Converter outlet line.
Table - 1.14
HAZARD DISTANCES TO OVERPRESSURE DUE TO UVCE

| Sl. No | Wind Speed (m/sec)/Stability Class | Hazard distances (m) |   |   |
|--------|-----------------------------------|----------------------|---|---|---|
|        |                                   | 0.3 Bar   | 0.1 Bar | 0.03 Bar |
|        |                                   | 35         | 39      | 52      |
|        |                                   | 34         | 39      | 51      |
|        |                                   | 34         | 39      | 51      |
|        |                                   | 34         | 38      | 50      |
|        |                                   | 24         | 28      | 39      |

Case-II 15 mm dia. hole

| Sl. No | Wind Speed (m/sec)/Stability Class | Hazard distances (m) |   |   |
|--------|-----------------------------------|----------------------|---|---|---|
|        |                                   | 23         | 26      | 33      |
|        |                                   | 13         | 15      | 22      |
|        |                                   | 13         | 15      | 22      |
|        |                                   | 12         | 15      | 21      |

Case-III 10 mm dia. hole

| Sl. No | Wind Speed (m/sec)/Stability Class | Hazard distances (m) |   |   |
|--------|-----------------------------------|----------------------|---|---|---|
|        |                                   | 12         | 14      | 19      |
|        |                                   | 12         | 14      | 18      |
|        |                                   | 12         | 14      | 18      |
|        |                                   | 12         | 13      | 18      |
|        |                                   | 12         | 13      | 18      |

It is evident from the above table that the hazard distance due to overpressure of 0.3 bar goes up to a maximum distance of 35 m by 25 mm dia. hole formation in the ammonia converter outlet line and can damage other equipments and pipelines in downwind direction.

1.7.4 Ammonia Recirculator Outlet Line Holes

<table>
<thead>
<tr>
<th>Line Size (&quot;)</th>
<th>Pressure (Kg/cm²g)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>150.5</td>
<td>34.5</td>
</tr>
</tbody>
</table>

Ammonia Recirculator outlet line is of 24" dia. size. The composition of the gas coming out of the recirculator shall be as follows:

**Components**  **Composition (%)**

Hydrogen       69.23  
Nitrogen       23.15  
Methane        0.03   
Argon          4.96   
Ammonia        2.63   

The gas exits from the ammonia recirculator outlet line at a temperature of 34°C and pressure of 150 Kg/cm²g. Full Bore failure of 24" dia. pipeline is an incredible phenomenon, hence the following cases have been considered for consequence analysis:
i) 25 mm dia. Hole,
ii) 15 mm dia. Hole
iii) 10 mm dia. Hole

In case of any holes as stated above in the Ammonia Recirculator outlet line, the gas shall come out as jet or may disperse in atmosphere which on getting any source of ignition may form jet fire and or UVCE. The hazard distances due to jet fire, LFL and overpressure distances are given in Table- 1.15 and 1.16.

<table>
<thead>
<tr>
<th>Thermal Radiation KW/M²</th>
<th>Hazard distances (m) for Wind speed (m/sec) and stability classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2F</td>
</tr>
<tr>
<td>LFL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>37.5</td>
</tr>
<tr>
<td></td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
</tr>
</tbody>
</table>

Case-II 15 mm dia. hole (RR: 2.88 Kg/sec, Duration: 180 sec)

<table>
<thead>
<tr>
<th>Thermal Radiation KW/M²</th>
<th>Hazard distances (m) for Wind speed (m/sec) and stability classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2F</td>
</tr>
<tr>
<td>LFL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>37.5</td>
</tr>
<tr>
<td></td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
</tr>
</tbody>
</table>

Case-III 10 mm dia. hole (RR: 1.28 Kg/sec, Duration: 180 sec)

<table>
<thead>
<tr>
<th>Thermal Radiation KW/M²</th>
<th>Hazard distances (m) for Wind speed (m/sec) and stability classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2F</td>
</tr>
<tr>
<td>LFL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>37.5</td>
</tr>
<tr>
<td></td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>12.5</td>
</tr>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
</tr>
</tbody>
</table>

NR: Not Reached
It is evident from the above table that hazard distance to thermal radiation of 4.5 KW/m² (1st degree burn) will go up to a maximum distance 45 meters in case of 25 mm dia. hole of Ammonia Recirculator outlet line.

### Table - 1.16

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Wind Speed (m/sec)/ Stability Class</th>
<th>Hazard distances (m)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.3 Bar</td>
<td>0.1 Bar</td>
</tr>
<tr>
<td>Case-I 25 mm dia. hole</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>67</td>
<td>75</td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>67</td>
<td>74</td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>67</td>
<td>74</td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>66</td>
<td>73</td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>56</td>
<td>62</td>
</tr>
<tr>
<td>Case-II 15 mm dia. hole</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>34</td>
<td>37</td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>23</td>
<td>27</td>
</tr>
<tr>
<td>Case-III 10 mm dia. hole</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>2F</td>
<td>23</td>
<td>26</td>
</tr>
<tr>
<td>2.</td>
<td>2B</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>3.</td>
<td>3D</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>5D</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>5.</td>
<td>7D</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

It is evident from the above table that the hazard distance to overpressure of 0.3 bar goes up to a maximum distance of 67m for 25 mm dia. hole of recirculator outlet line and can damage other equipments and pipelines downwind.

### 1.7.5 Liquid Ammonia Line Inlet to Liquid NH₃ Reservoir Holes

<table>
<thead>
<tr>
<th>Line Size (”)</th>
<th>Pressure (bar)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>26</td>
<td>5</td>
</tr>
</tbody>
</table>

Liquid Ammonia from Ammonia Plant goes to liquid NH₃ through an 8” dia. line at a temp. of 5°C and pressure of 2.6 Kg/Cm².

Full Bore failure of the line is an incredible phenomenon. Hence, consequence analysis has been done for the following cases.

i) 25mm dia. Hole  
ii) 15mm dia. Hole  
iii) 10mm dia. Hole
The liquid ammonia after coming out from the hole of the pipeline shall form gas and disperse in downwind direction. The distance and area upto which ammonia will disperse (GLC) are given in Table- 1.17.

<table>
<thead>
<tr>
<th>Wind speed (m/s)/ Stability Class</th>
<th>Downwind distances (m) for concentration of LC&lt;sub&gt;50&lt;/sub&gt; (12177 ppm)</th>
<th>LC&lt;sub&gt;20&lt;/sub&gt; (8001 ppm)</th>
<th>LC&lt;sub&gt;10&lt;/sub&gt; (6421 ppm)</th>
<th>IDLH (300 ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dis.(m)/Area(m&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>Dis.(m)/Area(m&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>Dis.(m)/Area(m&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>Dis.(m)/Area(m&lt;sup&gt;2&lt;/sup&gt;)</td>
</tr>
<tr>
<td>Case-I 25 mm dia. hole (RR:19.02 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>366/37473.8</td>
<td>427/72953.5</td>
<td>477/94398.3</td>
<td>1130/889200</td>
</tr>
<tr>
<td>2B</td>
<td>300/19844.7</td>
<td>350/35777.9</td>
<td>423/47946.2</td>
<td>898/491945</td>
</tr>
<tr>
<td>3D</td>
<td>298/15375.6</td>
<td>350/28065.4</td>
<td>377/36169.5</td>
<td>1300/552554</td>
</tr>
<tr>
<td>5D</td>
<td>240/7697.49</td>
<td>280/13606</td>
<td>310/17393.2</td>
<td>1125/294626</td>
</tr>
<tr>
<td>7D</td>
<td>205/4851.87</td>
<td>255/8681.72</td>
<td>276/11246.7</td>
<td>1015/197346</td>
</tr>
<tr>
<td>Case-II 15 mm dia. Hole (RR:6.85 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>226/10961.8</td>
<td>280/26021.9</td>
<td>320/35492.8</td>
<td>790/401853</td>
</tr>
<tr>
<td>2B</td>
<td>179/5117.8</td>
<td>220/10773.7</td>
<td>238/14130.4</td>
<td>579/147462</td>
</tr>
<tr>
<td>3D</td>
<td>170/3936.93</td>
<td>210/8168.91</td>
<td>230/10905.3</td>
<td>775/183929</td>
</tr>
<tr>
<td>5D</td>
<td>132/1893.02</td>
<td>168/3853.93</td>
<td>185/5161.88</td>
<td>670/98994.7</td>
</tr>
<tr>
<td>7D</td>
<td>119/1129.24</td>
<td>152/2490.62</td>
<td>168/3420.18</td>
<td>600/67890.3</td>
</tr>
<tr>
<td>Case-III 10 mm dia. Hole (RR:3.04 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>126/3029.71</td>
<td>170/8142.6</td>
<td>215/13448.5</td>
<td>227/256395</td>
</tr>
<tr>
<td>2B</td>
<td>109/1449.29</td>
<td>147/3810.36</td>
<td>160/5339.62</td>
<td>382/64268.4</td>
</tr>
<tr>
<td>3D</td>
<td>100/1057.87</td>
<td>139/2797.78</td>
<td>152/3982.49</td>
<td>515/77125.4</td>
</tr>
<tr>
<td>5D</td>
<td>78/407.84</td>
<td>108/1220.34</td>
<td>120/1779.7</td>
<td>441/41702.7</td>
</tr>
<tr>
<td>7D</td>
<td>46/85.9052</td>
<td>91/625.24</td>
<td>114/1055.59</td>
<td>395/28728.5</td>
</tr>
</tbody>
</table>

It is evident from the above table that the toxic hazard distance to IDLH of Ammonia goes up to a maximum distance of 1300 m downwind which covers an area of 552554m<sup>2</sup> around the facility due to 25mm dia. hole of the line. In other cases the distance and area is less. Hence, the pipeline should be checked periodically by Non-destructive testing.

### 1.7.6 Urea Plant

#### HP Liquid Ammonia Pump Outlet Line to Ejector Holes

<table>
<thead>
<tr>
<th>Line Size (&quot;)</th>
<th>Pressure (bar)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>221</td>
<td>94</td>
</tr>
</tbody>
</table>

HP liquid ammonia pump delivers liquid ammonia to ejector for carrying recycle carbamate to Urea reactor. The size of the line is 12". Full-Bore failure of this line is incredible. Hence, following cases have been considered:
RA & DMP study for proposed New Ammonia Urea Fertilizer project of M/s HURL at closed unit of FCIL Sindri

RISK ASSESSMENT

i) 25 mm dia. Hole
ii) 15 mm dia. Hole
iii) 10 mm dia. hole

In case of any of the above failures liquid, ammonia shall come out and vaporize. The vapour may disperse in atmosphere downwind. The dispersion distances for LC\textsubscript{50}, LC\textsubscript{20}, LC\textsubscript{10} & IDLH and area covered are given in table 1.18

<table>
<thead>
<tr>
<th>Wind speed (m/s)/Stability Class</th>
<th>Downwind distances (m) for concentration of</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LC\textsubscript{50} (12177 ppm)</td>
<td>LC\textsubscript{20} (8001 ppm)</td>
<td>LC\textsubscript{10} (6421 ppm)</td>
<td>IDLH (300 ppm)</td>
</tr>
<tr>
<td></td>
<td>Dis.(m)/Area(m\textsuperscript{2})</td>
<td>Dis.(m)/Area(m\textsuperscript{2})</td>
<td>Dis.(m)/Area(m\textsuperscript{2})</td>
<td>Dis.(m)/Area(m\textsuperscript{2})</td>
</tr>
<tr>
<td>Case-I 25 mm dia. Hole (RR:5.073 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>310/10121.2</td>
<td>560/24052.8</td>
<td>690/76899</td>
<td>2100/1.89x10\textsuperscript{6}</td>
</tr>
<tr>
<td>2B</td>
<td>340/11578.3</td>
<td>600/51746.2</td>
<td>680/88250</td>
<td>1615/1.91x10\textsuperscript{6}</td>
</tr>
<tr>
<td>3D</td>
<td>345/10344</td>
<td>550/36411.1</td>
<td>650/60805</td>
<td>1810/1.23x10\textsuperscript{6}</td>
</tr>
<tr>
<td>5D</td>
<td>355/9670.04</td>
<td>500/25756.9</td>
<td>560/37387</td>
<td>1975/800809</td>
</tr>
<tr>
<td>7D</td>
<td>320/7492.48</td>
<td>440/17496.3</td>
<td>590/24694</td>
<td>1800/539975</td>
</tr>
<tr>
<td>Case-II 15 mm dia. Hole (RR:18.264 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>170/2440.76</td>
<td>280/9375.36</td>
<td>420/14216.9</td>
<td>1410/839144</td>
</tr>
<tr>
<td>2B</td>
<td>175/2248.61</td>
<td>305/10492.8</td>
<td>380/20275.8</td>
<td>1100/508578</td>
</tr>
<tr>
<td>3D</td>
<td>160/2016.95</td>
<td>300/9121.74</td>
<td>375/16597.4</td>
<td>1345/483215</td>
</tr>
<tr>
<td>5D</td>
<td>170/1566.65</td>
<td>270/6141.42</td>
<td>315/9823.22</td>
<td>1160/264372</td>
</tr>
<tr>
<td>7D</td>
<td>150/1042.32</td>
<td>240/4230.99</td>
<td>280/6730.23</td>
<td>1048/181301</td>
</tr>
<tr>
<td>Case-III 10 mm dia. Hole (RR:8.117 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>100/509.654</td>
<td>175/2995.48</td>
<td>235/6339.75</td>
<td>1030/438296</td>
</tr>
<tr>
<td>2B</td>
<td>80/234.149</td>
<td>175/2698.63</td>
<td>240/6120.46</td>
<td>850/228673</td>
</tr>
<tr>
<td>3D</td>
<td>80/229.862</td>
<td>175/2298.31</td>
<td>230/5024.53</td>
<td>890/202535</td>
</tr>
<tr>
<td>5D</td>
<td>60/84.9961</td>
<td>150/1379.71</td>
<td>185/2847.16</td>
<td>770/111821</td>
</tr>
<tr>
<td>7D</td>
<td>50/33.5858</td>
<td>120/626.89</td>
<td>165/1623.05</td>
<td>680/76651.9</td>
</tr>
</tbody>
</table>

It is evident from the above table that for 25mm dia. hole, the distance to LC\textsubscript{50} covers a distance of 355 m covering an area of 9670.04 m\textsuperscript{2}. For IDLH, maximum distance covered is 2100 m covering an area of 1.89 x 10\textsuperscript{6} m\textsuperscript{2}. These distances goes outside the plant battery limit and \textit{people outside the factory premises may get affected}. Hence, awareness program for action taken during emergency in case of Ammonia leakage should be done periodically for the people residing outside.
1.7.7 Liquid NH₃ from Ammonia Reservoir to Liquid NH₃ Booster Pump Line Pressure Gauge Nozzle Failure

<table>
<thead>
<tr>
<th>Line Size (&quot;)</th>
<th>Pressure (bar)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4</td>
<td>18</td>
<td>35</td>
</tr>
</tbody>
</table>

Liquid Ammonia from Ammonia Reservoir transferred to Urea Plant via liquid Ammonia Booster Pump. The Pressure gauge nozzle in booster pump line is of ¾" dia. Hence, Full-Bore failure case has been considered.

In case of the above failure the liquid ammonia shall come out as jet which shall vaporize and disperse downwind. The dispersion distance for LC₅₀, LC₂₀, LC₁₀ & IDLH are given in Table 1.19.

<table>
<thead>
<tr>
<th>Wind speed (m/s)</th>
<th>Stability Class</th>
<th>Downwind distances (m) for concentration of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LC₅₀ (12177 ppm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dis.(m)/Area(m²)</td>
</tr>
<tr>
<td>Full-Bore Failure (RR:1.492 Kg/sec, Duration: 180 sec)</td>
<td>2F</td>
<td>55/168.155</td>
</tr>
<tr>
<td></td>
<td>2B</td>
<td>29/6.61633</td>
</tr>
<tr>
<td></td>
<td>3D</td>
<td>23/0.494303</td>
</tr>
<tr>
<td></td>
<td>5D</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>7D</td>
<td>-</td>
</tr>
</tbody>
</table>

It is evident from the above table that toxic hazard distance to LC₅₀ shall go up to a maximum distance of 55 m covering an area of 168.155m² around the facility. IDLH concentration shall go up to a maximum distance of 530 m covering an area of 121805 m².

1.7.8 Urea Reactor Outlet line To HP Stripper Holes

<table>
<thead>
<tr>
<th>Line Size (&quot;)</th>
<th>Pressure (bar)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>155</td>
<td>188</td>
</tr>
</tbody>
</table>

From Urea Plant Reactor, the liquid goes to HP Stripper for separation of Urea from unconverted Carbamate and Ammonia. In case of failure, Ammonia from the liquid shall vaporize and disperse downwind. The line size is 12".

Hence, following cases have been considered:

i) 25 mm dia. Hole  
ii) 15 mm dia. Hole  
iii) 10 mm dia. Hole
The dispersion analysis of Ammonia for LC_{50}, LC_{20}, LC_{10} & IDLH at different wind velocities and stability classes are given in Table 7.20. Since the gas contains ammonia, toxic effects on human beings may occur in downwind direction.

<table>
<thead>
<tr>
<th>Wind speed (m/s)/Stability Class</th>
<th>Downwind distances (m) for concentration of</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LC_{50} (12177 ppm)</td>
<td>LC_{20} (8001 ppm)</td>
<td>LC_{10} (6421 ppm)</td>
<td>IDLH (300 ppm)</td>
</tr>
<tr>
<td></td>
<td>Dis.(m)/Area(m²)</td>
<td>Dis.(m)/Area(m²)</td>
<td>Dis.(m)/Area(m²)</td>
<td>Dis.(m)/Area(m²)</td>
</tr>
<tr>
<td>Case-I 25mm dia. hole (RR:12.085 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>85/337.837</td>
<td>120/862.517</td>
<td>125/7822</td>
<td>559/21001.4</td>
</tr>
<tr>
<td>2B</td>
<td>75/263.498</td>
<td>110/793.046</td>
<td>130/1175.29</td>
<td>580/33190.6</td>
</tr>
<tr>
<td>3D</td>
<td>73/307.81</td>
<td>125/895.922</td>
<td>145/1312.89</td>
<td>695/32510</td>
</tr>
<tr>
<td>5D</td>
<td>80/236.782</td>
<td>128/807.796</td>
<td>152/1237.26</td>
<td>708/31304.7</td>
</tr>
<tr>
<td>7D</td>
<td>70/172.176</td>
<td>125/712.927</td>
<td>155/1145.44</td>
<td>740/31221.1</td>
</tr>
<tr>
<td>Case-II 15mm dia. hole (RR:4.350 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>-</td>
<td>65/162.273</td>
<td>82/326.4</td>
<td>412/10908.1</td>
</tr>
<tr>
<td>2B</td>
<td>-</td>
<td>55/109.91</td>
<td>71/268.467</td>
<td>410/15942.5</td>
</tr>
<tr>
<td>3D</td>
<td>-</td>
<td>61/121.623</td>
<td>80/297.814</td>
<td>502/16000.1</td>
</tr>
<tr>
<td>5D</td>
<td>-</td>
<td>50/55.347</td>
<td>72/208.16</td>
<td>500/15089.9</td>
</tr>
<tr>
<td>7D</td>
<td>-</td>
<td>35/5.78157</td>
<td>60/126.309</td>
<td>480/13905.2</td>
</tr>
<tr>
<td>Case-III 10mm dia. hole (RR:1.933 Kg/sec, Duration: 180 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>-</td>
<td>-</td>
<td>40/14.5448</td>
<td>312/6231.89</td>
</tr>
<tr>
<td>2B</td>
<td>-</td>
<td>-</td>
<td>38/8782.97</td>
<td></td>
</tr>
<tr>
<td>3D</td>
<td>-</td>
<td>-</td>
<td>383/8986.62</td>
<td></td>
</tr>
<tr>
<td>5D</td>
<td>-</td>
<td>-</td>
<td>350/7843.41</td>
<td></td>
</tr>
<tr>
<td>7D</td>
<td>-</td>
<td>-</td>
<td>303/6346.65</td>
<td></td>
</tr>
</tbody>
</table>

It is evident from the above table that toxic hazard distance to LC_{50} for 25mm dia. hole shall go up to 85m and cover an area of 337.837 m². IDLH value distance shall go up to 740m and cover an area of 31221.1 m². This may affect people outside factory premises and requires an awareness program to cope up with any such emergency.

1.7.9 CHLORINE STORAGE

Chlorine Tonner Nozzle Failure
Chlorine is used as biocide in Cooling Tower Circulating Water to prevent generation of algae & fungi. In case of use of chlorine tonner, the most foreseen accident scenario is the chlorine tonner outlet nozzle failure. Details used for the dispersion modelling are as follows:

Capacity of Chlorine Tonner : 900 Kg
Chlorine Tonner Outlet Nozzle Size : 10 mm
The result i.e. ground level chlorine concentrations for Chlorine Tonner Outlet nozzle failure are given in Table- 1.21.

<table>
<thead>
<tr>
<th>Wind speed (m/s)/Stability Class</th>
<th>Downwind distances (m) for concentration of</th>
<th>Dis.(m)/Area(m²)</th>
<th>Dis.(m)/Area(m²)</th>
<th>Dis.(m)/Area(m²)</th>
<th>Dis.(m)/Area(m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LC₅₀ (557 ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LC₂₀ (386 ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LC₁₀ (319 ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IDLH (10 ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR: 0.223 Kg/sec, Duration: 600 sec</td>
<td>Dis.(m)/Area(m²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F</td>
<td>80/2344</td>
<td>100/4056.93</td>
<td>130/5461.9</td>
<td>1790/256004</td>
<td></td>
</tr>
<tr>
<td>2B</td>
<td>60/762.109</td>
<td>64/991.356</td>
<td>68/1134.4</td>
<td>274/20042.9</td>
<td></td>
</tr>
<tr>
<td>3D</td>
<td>60/680.027</td>
<td>70/916.623</td>
<td>77/916.623</td>
<td>378/29783.9</td>
<td></td>
</tr>
<tr>
<td>5D</td>
<td>49/313.23</td>
<td>57/439.346</td>
<td>60/533.228</td>
<td>375/15830.1</td>
<td></td>
</tr>
<tr>
<td>7D</td>
<td>38/167.333</td>
<td>45/248.544</td>
<td>50/306.657</td>
<td>310/10025.1</td>
<td></td>
</tr>
</tbody>
</table>

From the above table, it may be concluded that the 319 ppm concentration of chlorine (i.e. LC₁₀) for the wind speed of 2 m/sec and atmospheric stability class of F may extend upto a distance of 130 m due to release of chlorine. The IDLH goes up to a maximum distance of 1790 m which is going outside the factory premises. In case of chlorine tonner outlet nozzle failure, arrangement shall be made to stop the leakage within shortest possible time and chlorine gas absorption system shall be run. The personnel should vacate the place immediately. However, chlorine detectors shall be provided in chlorine tonner rooms.

1.8 PRINCIPAL CONCLUSIONS & RECOMMENDATIONS

Conclusions:

a. It is evident from Iso-Risk contour (Drg. No. - A, Ann.-I) that acceptable individual risk level of 1.0 x 10⁻⁶/year due to plant facility shall be confined within the plant premises.

b. It may also be inferred from F-N curve (Drg. No.- B, Ann.-I) which remains within the acceptable region that plant shall be safe from environment risk point of view.
Recommendations:

1. The downwind distances to ground level concentration of ammonia and chlorine may extend beyond factory boundary. Hence, the population outside should be made aware of the properties of gases and what to do in case of any leakage.

2. In order to reduce the frequency of undesired incidents further and thus to reduce the level of individual risk, it is necessary to adopt due care in design, engineering, construction, inspection, operation and maintenance of the plant and equipment.

3. In order to reduce the frequency of failure of various items like pipelines, equipment & machinery, valves & fittings etc. Good operating and maintenance practices must be followed.

4. The Fertilizer Project of M/s HURL at Sindri shall be designed and engineered by internationally reputed process licensors, designers and engineers so that risk reduction and operability measures may be considered from very beginning stage.

5. Testing of plant safety system is to be carried out systematically at regular intervals and record should be maintained.

6. Safety audit and health monitoring of the pipeline and equipment are to be done at regular intervals and necessary corrective measures taken immediately.

7. Fire fighting facilities in the plant should be as per TAC guidelines. The facilities shall be provided for the proposed project and approval from competent authority shall be taken wherever necessary. People residing inside and outside the premises should be aware of emergencies that may arise in the plant.

8. Mock drills are to be conducted at regular intervals to cope up with any emergency.

9. Mutual Aid arrangement should be done with the neighbouring industries, fire stations, hospitals etc.

10. Both On-Site and Off-Site emergency plan should be prepared and practiced.

11. Minimization of Ammonia 25vapour cloud formation from the evaporation of liquid pools by covering it with foam whenever such leakage is observed. Such failure may be caused in the vicinity of ammonia.
12. Suitable no. of flammable gas detectors to be provided for early warning of a leak in potential sources of emissions such as pump seals, compressor seals, process drains, vents and other flammable materials containments.

13. To minimize the dispersion of NH$_3$ vapour cloud in the vicinity of leakage/rupture, arrangement for water curtains to be made to absorb the ammonia vapour formed especially in the area like vicinity of ammonia collector, Ammonia Storage Tank (AST) & associated facilities, intermediate liquid ammonia storage tank etc.

14. Facilities to provide sufficient ventilation, putting on personal protective equipment (PPE) before entering the contaminated area and remain in the upwind direction in case of leakage of NH$_3$ should be kept in mind and strictly followed. If the situation is more alarming, the vapour cloud may be minimized by spraying water so that necessary manual action can be taken to stop the dispersion of ammonia.

15. Water jet should not be applied over the pool of liquid NH$_3$ due to leakages, since the heat produced shall trigger a high evaporation rate.

16. Regular NDT of all the yard piping for ammonia/flammable/other toxic material transfer with high pressure should be carried out.

17. All the dykes should be made leak proof and their drain valves should be always kept in close position.

18. The control button of all Emergency Isolation Valves (EIVs) should be at safe and approachable distance from the maximum possible hazard source (such as leakage in mechanical pump seals, compressor seals etc.), so that it can be operated safely.

19. All EIVs should be tested at regular intervals. In case, they cannot be tested without upsetting the production, then must be tested fully during normal shutdown.

20. Valve closure may be initiated from a remote location and should be fire proof.

21. The size and frequency of (Gasket joints) leaks can be reduced by using spiral-wound gaskets in place of compressed asbestos fiber ones. Screwed joints should not be used.
22. In order to reduce the frequency of undesired incidents, further it is recommended to adopt standard codes & practices in inspection, operation and maintenance of the plant and equipment.

23. In order to reduce the frequency of failure of various items like pipelines, equipment & machinery, valves & fittings etc. Good operating and maintenance practices must be followed.

24. The Mock drills shall be conducted to cope up with any emergency and special attention must be given to the mock drills in Chlorine tonner/cylinder handling areas owing to severe toxic effects in case of leakage.

25. The concerned plant personnel of operation & maintenance department must give special attention towards emergency preparedness in case of toxic gas leakage. Maintenance & working of ammonia and Chlorine detectors should be checked regularly to ensure its immediate response.

26. Testing of plant safety system shall be done systematically at regular intervals.

27. Safety audit and health monitoring of the pipeline and equipment shall be done at regular intervals and necessary corrective measures shall be taken immediately.

28. Permanent sprinklers/ drench systems are very effective in controlling potentially large fires at an early stage and shall be installed on the storage tanks and vulnerable areas.

29. Ammonia gas sensors should be installed all around the periphery of HURL to detect/ prevent any off-site toxic hazards.
2.0 DISASTER MANAGEMENT PLAN

Disaster is an undesirable occurrence of events of such magnitude and nature that adversely affect production, cause loss of human lives and property as well as damage to the environment. Industrial installations are vulnerable to various kinds of natural and manmade disasters. Examples of natural disasters are flood, cyclone, earthquake, lightning etc. and manmade disasters are like major fire, explosion, sudden heavy leakage of toxic/ poisonous gases, civil war, nuclear attacks, terrorist activities etc. It is impossible to forecast the time and nature of disaster which might strike an undertaking. However, an effective disaster management plan helps to minimize the losses in terms of human lives, plant assets and environmental damage and then resumes working condition as soon as possible.

Risk analysis forms an integral part of disaster management plan and any realistic disaster management plan can only be made after proper risk analysis study of the activities and the facilities provided in the installation. Correct assessment and evaluation of the potential hazards, advance meticulous planning for prevention and control, training of personnel, mock drills and liaison with outside services available can minimize losses to the plant assets, rapidly contain the damage effects and effectively rehabilitate the damage areas.

2.1 NATURE OF HAZARD

In the proposed Sindri Fertilizer project, which includes ammonia & urea plants and associated units, hazardous materials shall also be handled. The basic raw material, Natural Gas (NG) shall be made available through 36" GAIL’s Jagdishpur-Phulpur-Haldia pipeline. The pipeline shall consist of 922 km mainline, and 1,128 km of spur lines and feeder lines of between 12" and 30" diameter. However, apart from NG, other process gases which are hazardous in nature are Carbon Monoxide, Hydrogen & Nitrogen which are toxic/ flammable or suffocating in nature and Carbon Dioxide is an asphyxiant. Liquid ammonia produced in ammonia plant is also highly toxic and contact of liquid ammonia with skin causes cold burn. Other hazards in ammonia plant and urea plant may be due to leakage of Chlorine from the
Chlorine Tonners which shall be used as biocide in cooling tower. Chlorine is a highly toxic gas.

In Urea plant, the main hazard is from liquid ammonia which is highly toxic and Carbon Dioxide which is an asphyxiant.

The credible hazard scenarios are -

(i) Flange gasket failure
(ii) Instrument Connection failure
(iii) Small bore pipe failure
(iv) Holes in pipeline

The rupture of pipelines and vessels due to explosion/ bursting or any other reasons cannot be ruled out, release of hazardous materials may pose threat to the people inside and outside the plants. The vulnerable area due to release and subsequent dispersion of ammonia and other toxic gases may extend beyond the plant premises, if release quantity is more and weather condition is favorable.

The failure and consequent hazard can be minimized by:

i) Regular physical check up.

ii) Regular monitoring of health of vessels & pipelines by non destructive testing followed by suitable action.

iii) A well organized trained manpower for operation of the plant safely

iv) Regular inspection and maintenance of moving machineries as per schedule

v) Regular check up of instrumentation, control & trip systems.

In addition to the above, following are necessary:

i) A quick responsive containment, control system requiring well planned safety and fire fighting arrangement.

ii) Well-trained personnel to handle safety and firefighting equipment as well as to operate the plant safely.

iii) A well formulated Disaster Management Plan both On-Site as well as Off-Site which covers well coordinated planning involving mutual aid between different organization, district administration, hospitals and moreover training/ awareness of the employees as well as the people living around the factory.
2.2 HAZARD ASSESSMENT

Hazard potential of the proposed project due to different scenarios has been discussed in Risk Assessment, Chapter 1.0.

2.3 PREVENTIVE AND PRE-EMPTIVE MEASURES

2.3.1 General

After identification and assessment of disaster potential, the next step in DMP is to formulate and practice the preventive and pre-emptive measures. Proper preventive and pre-emptive measures can reduce the disaster potential to a minimum.

Preventive and pre-emptive measures are taken from the design stage itself and shall be as follows:

i) Use of proper material of construction for equipment and piping as per relevant code/specification.

ii) Judicious layout of the equipment and pipelines with proper safety distances, operating space and proper supports for pipelines.

iii) Use of SRVs of proper size and capacity.

iv) Use of instrumentation for proper operation, safety with automatic alarm and shutdown system, if the operating parameters suddenly go out of control.

v) Installation of water sprays and fire fighting system e.g. fire hydrants, monitors, emergency power system for proper operation of fire fighting and for cooling as well as providing water curtain during emergency.

vi) Installation of gas detectors e.g. Ammonia, Chlorine, Carbon Monoxide & Nitrogen.

vii) Earthing of electrical, mechanical equipment/machineries etc.

Similar precautions shall be taken regarding procurement of materials, installation/erection of the equipment, piping and instruments. Precautions to be taken during procurement and installation can be categorized as follows:

a) Procurement of machineries, pipes, flanges, gaskets, valves, SRV's, instruments etc. as per proper code/specification.

b) Inspection of the materials by some reputed inspection agency.

c) Selection of experienced contractors specialized in erection job.

d) Supervision of work by experienced engineers.
Next step in pre-emptive measure shall be to formulate a detailed DMP (both ON-SITE as well as OFF-SITE) where actions to be taken before, during and post disaster period are clearly mentioned.

Authorities of HURL, Sindri shall provide the information about the possible hazards and their effects to the district administration which will help in preparation of OFF-SITE Disaster Management Plan.

2.3.2 Awareness
Creation of awareness amongst employees/public living in the vicinity of the factory and the role they have to play in case of any disaster occurring is very important. The employees of the factory shall be educated by various means as to what should be done by them to take care of themselves as well as to protect the properties in case of emergency. For public, awareness shall be created through film shows and distribution of leaflets in local language through village Panchayat periodically.

2.3.3 Mock Drill
Mock drill is very important to know the strength and weakness of the disaster control response plan. Efficient fire fighting arrangement shall be provided judiciously in the factory premises. Plants shall be surrounded by fire hydrants and monitors as well as cooling & water spray system. Mock drill for fire shall be conducted every month and mock drill for emergency shall be done every six months for fire as well as for toxic release.

2.3.4 Communication
In order to facilitate proper and timely communication to the members of the response team, which helps to minimize the effect of disaster through suitable and timely action, internal as well as external telephones shall be provided in sufficient numbers. In addition, public address system shall be also provided for communication in all the plants. In addition, manual call points shall be provided at different places for informing fire services department. Sirens of 5 Km range shall be provided to inform the employees as well as the public outside about emergency/disaster.
2.3.5 Entry of Personnel
Entry of personnel shall be restricted for preventing sabotage or any untoward incident due to inadvertence. This shall also eliminate any terrorist activity.

2.3.6 Mutual Aid Scheme
In many cases, facilities and arrangements available under control of the factory administration may be inadequate to combat the disaster. Under these circumstances, outside help may be necessary to contain and control the situation. For this, facilities in the nearby industries such as fire tenders with trained personnel, experts need to be called whenever such situation arises. Help from fire fighting station of State Govt. at Sindri shall be available. Medical help from state hospitals situated at Sindri and other primary health centers are to be made available.

2.4 DISASTER CONTROL PLAN

2.4.1 Objectives of the Plan
Disaster arrives unexpectedly and without any warning despite all precautions and preventive measures taken. However, an efficient control/response plan can minimize the losses in terms of property, human lives and damage to environment.

Main objective of the plan is to minimize the effect of the disaster. The plan shall be developed in such a way as to make best possible use of the resources at the command of the unit as well as resources available like State Fire Services, Police, Civil Administration, Hospitals etc. and the neighboring industries.

Advance and meticulous planning minimizes chaos and confusion, which normally occurs in such a situation, and reduces the response time of Disaster Management Organization.

The objectives of DMP are:

i) To contain and control the incident
ii) To rescue the victims and treat them suitably in quickest possible time
iii) To safeguard other personnel and evacuate them to safer places
iv) To identify persons affected or dead.
v) To give immediate warning signal to the employees as well as the people in the surrounding areas if such situation arises
vi) To inform relatives of the casualties
vii) To provide authoritative information to news media and others
viii) To preserve the affected area as well as the equipment as evidence for enquiry/investigation.
ix) To restore normal working condition at the earliest
x) To investigate the cause of the accident so that similar happenings do not occur

Both ON-SITE as well as OFF-SITE Disaster Management Response Plan can be sub-divided into Equipment Plan, Organizational Plan, and Action Plan. Outline of the plans are discussed below.

2.4.2 Equipment Plan
During an emergency easy access to the required equipment and facilities are of paramount importance. Equipment plan needs arrangement of sufficient and proper appliances to combat any disaster after careful study of requirements including alarm and communication system as well as provision of vehicles for communication and relief measures.

**On-Site Emergency**
Efficient and adequate measures shall be made available within premises of the proposed Ammonia-Urea fertilizer plant at Sindri to combat any “On-site Emergency”. An efficient fixed-fire-fighting arrangement as well as portable fire-fighting facilities, supported by safety appliances shall be made available within the premises to take care of emergency condition.

**Fire Fighting Equipment and Facilities**
Sindri fertilizer plant shall have fire tenders, fire water reservoir, fire water pumps, hydrants and monitors also other portable fire fighting appliances such as fire extinguishers of different types in sufficient numbers.

**Safety and Personal Protective Appliances**
Various types of safety and personal protective appliances in adequate numbers shall be made available in each plants, fire department as well as stores and emergency control centre.
Emergency Control Centre
An Emergency Control Centre shall be set-up at a safe place from where Chief Emergency Coordinator shall function for ON-SITE emergency. The Emergency Control Centre (ECC) shall be provided with adequate personal protective equipment, alarm and communication network (Siren, local as well as P&T Telephone, Public Address system), route map, fire hydrant and monitor layout, wind rose chart, copy of detailed DMP (where names, telephone numbers of the response team members and their responsibilities are clearly written as well as names and telephone numbers of key personnel from outside agencies in Mutual Aid Scheme and district authorities, Fire Stations, State Hospital and doctors are provided), first aid kit, material safety data sheets of chemicals etc. The Disaster Management Manual shall also contain map of the factory & surrounding areas, evacuation routes, fire hydrant network and other important information.

Assembly Point
Assembly points shall be set up near to the likely hazardous event sites where pre-designated persons from HURL plant shall assemble and meet the Site Incident Controller. This may be regarded as Site Incident Control Room where Incident Controllers shall receive instruction and furnish information to the Chief Emergency Coordinator. The site incident control room shall be provided with efficient communication system, adequate personal protective equipment, copy of Disaster Management Manual etc.

Emergency Shelter
Emergency shelter places shall be earmarked sufficiently away from expected hazard sites. Employees who are not in the emergency management team shall be asked to take shelter. The place is chosen such that the employees taking shelter are not affected by fire, explosion and release of toxic gases. More than one emergency shelter may be designated so that proper shelter point can be chosen depending on wind direction and other factors.

Wind Socks
Wind socks shall be provided on the top of tall structures/ towers & tall buildings e.g. Administrative Building to indicate the wind direction.
2.5 ORGANIZATIONAL PLAN

This part of DMP is a systematic list of persons in the emergency management team and their functions i.e. “Who will do what and How-Before, during and After Emergency”. The disaster management organization is capable of quick response at any time of the day or night to tackle the emergency situations arising from “On-site” as well as “Off-site”. The plan gives a detailed chain of command, area of responsibility of each personnel involved in the plan, the information flow pattern to be followed and co-ordination activities required to tackle the emergency. List of key personnel in On-site Emergency Plan of HURL, Sindri and their responsibilities are given in the following Table-2.1

<table>
<thead>
<tr>
<th>Key Personnel during Emergency</th>
<th>Designation</th>
<th>Major roles during Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Site Controller</td>
<td>Sr. General Manager (Unit Head)</td>
<td>Overall in-charge for Localization control &amp; mitigation of the emergency.</td>
</tr>
<tr>
<td>Incident controller (T)</td>
<td>General Manager alternate Plant I/C (Prodn.) of the affected Plant</td>
<td>Overall in-charge for the incident control including fire fighting and engineering activities</td>
</tr>
<tr>
<td>Incident controller (NT)</td>
<td>Advisor (P&amp;A) Alternate DGM (P&amp;A)</td>
<td>In charge of logistic activities like First-Aid &amp; Medical, Securities, Communication, Rescue, Evacuation, Transportation &amp; Roll Call.</td>
</tr>
<tr>
<td>Leader Fire Fighting &amp; Safety Team</td>
<td>DGM (F&amp;S) Alternate I/C (F&amp;S)</td>
<td>In charge of fire fighting &amp; Safety activities</td>
</tr>
<tr>
<td>Leader-Incident Controller Team</td>
<td>Plant in-charge (Prodn.) Alternate Dy. Plant I/C (Prodn.)</td>
<td>In-charge of combat activities</td>
</tr>
<tr>
<td>Leader Engineering Team</td>
<td>GM (Maint.) Alternate Sectional Head (Mech.) of Affected Plant</td>
<td>In charge of Emergency maintenance activities</td>
</tr>
<tr>
<td>Leader First–Aid &amp; Medical Team</td>
<td>Chief Medical officer Alternate Medical officer</td>
<td>In charge of treatment of affected persons</td>
</tr>
</tbody>
</table>
DISASTER MANAGEMENT PLAN

<table>
<thead>
<tr>
<th>Leader-Transport Team</th>
<th>Advisor (P&amp;A) Alternate DGM (P&amp;A)</th>
<th>All transportation arrangements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leader Roll Call Team</td>
<td>DGM (P&amp;A) Time Office Alternate Advisor (TPT)/ Manager (P&amp;A)</td>
<td>I/C of Assembly &amp; Roll Call Activities</td>
</tr>
<tr>
<td>Telephone Operation</td>
<td>Receptionist Alternate Staff of Time Office</td>
<td>Communication to different key persons</td>
</tr>
<tr>
<td>Store Keeper</td>
<td>Chief Manager (Materials) Alternate Sr. Manager (Materials)</td>
<td>Issue of materials for emergency activities</td>
</tr>
</tbody>
</table>

Main Site Controller shall take the charge of the whole situation and guides Incident Controllers and various leaders under his control to contain and control the incident.

It is a fact that first few minutes after start of the incident is most vital in prevention of its escalation. The personnel available in the plant round the clock basis play an important role. Important role shall be played by operators, shift in-charge, in-charge of fire & safety at the very initial period of the incident and when emergency is declared it should be guided by Main Site Controller.

2.5.1 ACTION/ RESPONSE PLAN

The action plans for tackling emergency include the following:

i) Actions to be taken in Pre-emergency Period.

ii) Action during Emergency/ Disaster.

iii) Actions to be taken in Post Disaster Period

Pre-emergency Actions

Some of the preventive and pre-emptive measures have already been discussed. Other pre-emergency measures in case of “On-site” emergency/ disaster can be listed as follows.

i) Ensure implementation of Disaster Planning.

ii) Ensure that all drafted for emergency undergo regular training.

iii) Ensure all team members in different disciplines to be prepared for tackling emergency/ disaster.

iv) Ensure simulated emergency condition to be regularly arranged and Mock Drills are performed to assess the strength and weaknesses of the response team/ plan.
v) Ensure awareness among employees through regular training.

vi) Ensure good liaison with all agencies and industries in the neighborhood for getting help, if situation arises.

**Action during Emergency**

The duties and responsibilities of some of the key personnel are defined below:

**Site Controller/ Chief Emergency Coordinator:**

Sr. General Manager (Unit head) i.e. the highest authority of the unit or his nominated personnel (Jt. General Manager), shall report at the Emergency Control Centre and shall assume the overall responsibility for the situation. His/ Her duties shall be:

i) To assess the magnitude of the disaster and decide a major emergency condition exists and declare emergency.

ii) Mobilize other members of his/ her team and exercise direct operational control of the areas for combating emergency.

iii) Activate Disaster Management Plan (DMP) and ensure implementation.

iv) Inform all statutory authorities, District Collectorate, Fire Brigade, Mutual Aid members on the magnitude of the disaster, help needed, casualties etc.

v) Review continuously the situation in consultation with Incident Controller (T) & Incident Controller (NT).

vi) Keep liaison with the senior official of police, Factory inspectorate and pass on the possible effects in the surrounding areas outside the factory premises.

vii) Assess whether evacuation of the employees and public are necessary and direct accordingly.

viii) Keep liaison with different service coordinators and check whether they are rendering their service properly.

ix) Ensure persons affected are getting proper care for relief and rehabilitation and next of kin are informed.

x) Release authoritative information to press, Radio, TV and advice about possible effect on surroundings.

xi) Conduct enquiry about the incident and bring normalcy as early as possible.
Incident Controller (T):  
Joint General Manager (Prod.)/ Sectional In-charge of the affected plant shall rush to the spot on hearing the alarm siren or getting the message through telephone and take charge of the situation. He/ She shall assess the situation and decide whether a major emergency exists or likely to develop. He/ She shall inform Chief Emergency Coordinator. Accordingly, His/ Her other duties shall be:

i) He/ She shall take overall charge of the situation for controlling all operations including fire fighting.

ii) Ensure proper Co-ordination and implementation of DCMP. Due priority shall be given to the safety of personnel, minimize damage to the plant properties and environment.

iii) Direct emergency shutdown of the plant and arrange evacuation of the area affected or likely shall be affected by the disaster in consultation with Incident Controller (NT).

iv) Arrange alternative power connection for lighting in case of normal failure of electricity if the disaster occurs at night.

v) Keep constant touch with Chief Emergency Coordinator and report the developments to him at intervals.

vi) Preserve the evidence in the affected area to facilitate investigation into the cause of the accident (arrange photographs etc.).

Incident Controller (NT):  
Advisor (P&A) shall act as Incident Controller (NT). He will also rush to emergency control room. He shall arrange for evacuation, First-Aid, Communications, assembly, roll call activities & transportation activities as per directive of Chief Emergency Coordinator.

Leader of respective activities will act as per direction of Incident Controllers. Their activities are as given in key personnel chart. Speedy implementation of response procedure under organized chain of command prevents escalation of emergency and helps to combat emergency in well organized manner.

Leader (Fire Fighting & Safety)  
i) Liaison with Incident Controller (T) and organize the team for fire fighting.
ii) Direct all operation within the affected areas with priorities for safety of personnel, operating facilities and environment.

iii) Keep the ring min. hydrant pressurized for uninterrupted supply of water for fire fighting.

iv) Assist Fire Brigade personnel in operating water monitor, water curtains to cool the affected area and isolate it as far as practicable.

**Leader (First Aid & Medical Team)**

Arrange first aid and remove the affected persons to Hospitals nearby Sindri, Dhanbad and other hospitals as per necessity and situation after giving first aid treatment. A record of persons sent to different hospitals should be maintained.

**Plant Personnel**

As stated earlier, persons present in the plant (especially operators, shift in-charges etc.) plays a crucial role. They should try to tackle the situation at the very onset. Their duties shall be:

i) Try to isolate the source

ii) Operate the manual call point information system and the public address system.

iii) Inform Fire & Safety Deptt.

iv) Inform Plant Manager

v) Inform Joint General Manager, Dy. GMs of the respective plant.

**Post Disaster Activities**

The post Disaster Activities mainly covers the followings:

i) Arrange for proper enquiry/investigation about the real cause and conditions of the accidents to prevent similar occurrences.

ii) Arrange for proper relief and rehabilitation of the affected employees.

iii) Payment of compensation to the next of kin of the causalities.

iv) Bring back normalcy as early as possible.

2.6 **SCENARIO SPECIFIC DISASTER MANAGEMENT PLAN**

It has been seen from Hazard Assessment that major emergency situation can arise mainly from release of ammonia & other toxic gases. For Ammonia & Chlorine leakage, operator on seeing the leakage should try to isolate the source of leakage by closing the isolation valve after wearing
proper PPE, then he should inform plant manager about this phenomena. Plant manager will then take proper precautions for the plant & plant personnel safety. The situation can be grave or minor depending on the scenario occurring causing the release of ammonia and other toxic gases. Care should be taken to tackle the minor incident. A list of emergency response functions that are identified for large-scale release of ammonia and other toxic gases is given as follows:

i) Alarm, warning and signaling

ii) Communication

iii) Operations

iv) Fire and Safety

v) Toxic Gas Spreading Protection

vi) Emergency Shelter

vii) Medical Services

viii) Transport Services for transportation of injured persons and evacuation.

ix) Welfare activities.

2.6.1 Resources Planning

Resource planning needs to be done so that the functions mentioned above can be operated smoothly. Regular Mock drill and training is essential for proper and timely response.

Since, the large scale leakage of ammonia, chlorine and other toxic gases can affect employees within HURL, Sindri complex as well as the public, creation of awareness is must. The employees and public shall also be taught the actions to be taken to save themselves.

2.6.2 Medical Services

The doctors in first aid post and the outside shall be trained for treatment of personnel by gas leakage. Necessary apparatus and drugs should also be available in first aid post inside the factory and other hospitals nearby.

Advisor (P&A) & Doctor in First Aid Post shall have good liaison with the authorities of nearby hospitals, nursing homes and primary health centers as well as doctors outside so that help may be available when required.
2.6.3 Transport and Communication
Ambulance Van should be available under the command of Advisor (P&A) inside the factory. However, in case of disaster all the vehicles in transport department will be used. In case of necessity vehicles will be requisitioned from outside.

2.6.4 Safety Appliances
Gas masks, BA set and respirators shall be made available in plants. They shall be checked and kept in good working order. Ammonia suits shall be procured and distributed in Main Ammonia plant, Ammonia storage, Urea Plant, Cooling Towers etc.

2.6.5 Operational Functions
Specific actions with respect to operational functions shall be as follows.

i) Detection of leakage and isolation from the source to prevent the leakage is the most important activity in the beginning. ROV’s shall be provided at different places in Ammonia storage & production and in the incoming ammonia line to Urea Plant to stop leakage of ammonia from the incoming ammonia line. It may also be necessary to isolate the line or equipment by closing the isolation valves. The functional requirement may be one or more operators to close the isolation valves manually in the area with high toxic concentration and possibility of liquid ammonia splashes on the body. The personnel should wear the ammonia suit with self-contained breathing apparatus. The operating personnel should be fully drilled in proper and safe use of the safety appliances.

ii) Plant or section of the plant shall be shut down.

iii) On release of liquid ammonia from the pipeline or equipment due to any reason 20% of the liquid ammonia flashes immediately and the balance 80% shall form a liquid pool.

Attempt shall be made to contain this quantity by immediate dyking etc. Otherwise, it will make its way to storm water drain. This may lead to spreading all around, rapid evaporation and acute pollution problem also.

iv) Sand bags & other devices shall be made available and some employees shall be engaged for the job wearing sufficient personal protective appliances.
v) Operator/ Shift-In-Charge shall inform immediately to Fire & Safety Deptt. as well as Concerned Chief Manager of the Plant, who in turn shall communicate Chief Emergency Coordinator.

vi) Emergency is to be declared and other actions are to be taken by them.

vii) Since ammonia is readily soluble in water, a water curtain may be prepared at downwind direction by the fire services to decrease the concentration of ammonia vapour in air and its dispersion.

viii) Rescue of the personnel affected and evacuation of other employees to emergency shelter room may be needed. Emergency shelter shall be located at a safe place at up wind direction.

ix) Medical help may be necessary to the affected personnel. Leader-First Aid and Medical Team and Leader-Transport Team to take proper care under guidance of Incident Controller (NT).

OFF-SITE EMERGENCY PLAN
An integral part of the DMP is the Off-Site Emergency Plan. In case of off-site emergency, the effect of the disaster shall be felt outside the factory premises for that District Collectorate shall act as chief emergency controller. He will direct plant personnel modality for control of emergency. He may take assistance of nearby industries and other organization. The plan is mainly dependent upon a very close co-ordination and assistance from the Local Administration like Police, Fire Brigade, Medical Services (hospitals) etc.

OFF-SITE ACTION
The Chief Controller shall inform about the incident like Fire, Explosions and toxic gases to –

(i) Police and District Collector
(ii) Fire Brigade
(iii) Medical Services
(iv) Technical Agencies
(v) Rehabilitation Agencies
(vi) Electricity Board

RESPONSIBILITIES OF THE SERVICES
1] Police
1 To control traffic & mob by cordonning off the area.
2) **Fire Brigade**
   1. Fighting fire & preventing its spread.
   2. Rescue & salvage operation.

3) **Medical/Ambulance**
   1. Providing First Aid to the injured persons.
   2. Shifting critically injured personnel to the hospitals.
   3. Providing medical treatment to other injured persons.

4) **Technical/ Statutory Bodies**
   (Constitutes Factory Inspectorate, Pollution Control Board, Technical Experts from Industries)
   1. Provide all technical information to the emergency services, as required.
   2. Investigate the cause of the disaster.

5) **Rehabilitation**
   1. Arrange for evacuation of persons to nominated rescue centre and arrange for their food, medical and hygienic requirements.
   2. Coordinating with the Insurance Companies for prompt disbursement of compensation to the affected persons.
   3. Maintain communication channels of the affected industry like telephone, mobile, internet etc. in perfect working condition.

6) **Electricity Board**
   To put off the power supply to the plant, if specifically asked for by HURL, Sindri.

7) **PERSONAL PROTECTIVE EQUIPMENT**
   The following of personal protective equipment should be available during an emergency.
(i) Fire proximity suit  
(ii) Self Contained Breathing Apparatus with one spare cylinder (30 mints)  
(iii) Water jel blankets.  
(iv) Safety helmets  
(v) Rubber hand gloves for use in electrical jobs  
(vi) Low temp. rubber hand gloves for LPG emergency  
(vii) Low temp. Suit for LPG emergency  
(viii) Resuscitator  
(ix) Ear Plugs  
(x) Air Mask  
(xi) Eye Goggles

8] IMPORTANT TELEPHONE NOS.

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## LIST OF PRIVATE NURSING HOMES IN DHANBAD DISTRICT

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<th>Cont. No.</th>
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## DISASTER MANAGEMENT PLAN

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Projects & Development India Limited, Sindri
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## DISASTER MANAGEMENT PLAN

### Prasad Nursing Home
- Location: Suraj Chawk, nizam, Doctor’s Colony, nizam, Dharwad,
- Contact: 9430953555
- Contact Person: Dr. Jagendra Prasad
- Collecting Point: X-ray
- Specialty: General

### Susanna Memorial Nursing Home
- Location: High school, Nira, Dharwad
- Contact: 09345299305
- Contact Person: Dr. Avinash Kumar
- Collecting Point: Pathology
- Specialty: General

### Mam-Shrir Sona Sunder
- Location: Upper Beach, Dharwad
- Contact: 09345299305
- Contact Person: Prabhakar Kumar
- Collecting Point: Sonography
- Specialty: General

### Lions Club
- Location: Check point, new bharat, Dharwad
- Contact: 09345299305
- Contact Person: Dr. Sanjeev Kumar
- Collecting Point: Pathology
- Specialty: General

### Maga Hydrodine
- Location: Bhilai, NTPC, Dharwad
- Contact: 9534027968
- Contact Person: Ram Pradeep Kumar
- Collecting Point: X-ray / Sonography
- Specialty: General

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**Projects & Development India Limited, Sindri**

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## RA & DMP study for proposed New Ammonia Urea Fertilizer project of M/s HURL at closed unit of FCIL Sindri

### DISASTER MANAGEMENT PLAN

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**Projects & Development India Limited, Sindri**

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| RA & DMP study for proposed New Ammonia Urea Fertilizer project of M/s HURL at closed unit of FCIL Sindri |

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**RA & DMP study for proposed New Ammonia Urea Fertilizer project of M/s HURL at closed unit of FCIL Sindri**

**DISASTER MANAGEMENT PLAN**

RA & DMP study for proposed New Ammonia Urea Fertilizer project of M/s HURL at closed unit of FCIL Sindri
### Disaster Management Plan

#### Projects & Development India Limited, Sindri

**RA & DMP study for proposed New Ammonia Urea Fertilizer project of M/s HURL at closed unit of FCIL Sindri**

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**Projects & Development India Limited, Sindri**

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Figure-2.1

Proposed Organogram for Disaster Management at Sindri Fertilizer Plant

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**Figure-2.1**

Proposed Organogram for Disaster Management at Sindri Fertilizer Plant