7.2 Quantitative Risk Assessment

7.3 Objective

Objective of this study is to carry out a Comprehensive Quantitative Risk Assessment (QRA), considering all scenarios including the Worst Consequence Scenario (say catastrophic rupture of Ammonia Tank), clearly showing individual Risk Contours and Societal Risk associated.

7.4 Study Methodology

Risk is the combination of severity of consequence and the likelihood of occurrence. Some failure events may have potential for consequences of high severity but the likelihood of occurrence would be very low. On the other hand some failure events with low severity consequence might occur very frequently.

Risk = (Severity of Consequence) × (Likelihood of Occurrence)

Quantitative risk assessment (QRA) provides measure of risk in numerical value for specified time period, which is normally one year.

The five normal components of a Quantitative Risk Analysis (QRA) study are:

2. Hazard, (or Failure Case) Identification
3. Risk Assessment / Consequence Analysis (using appropriate risk acceptability criteria)
4. Consequence Calculations
5. Failure Frequency Estimation
6. Risk Calculation (Risk Summation)

The relationship of each step and the additional external data requirements are presented in ***Figure 7-1***.

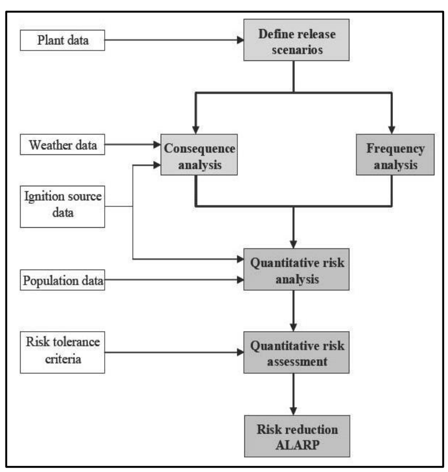


Figure 7-1: Approach to QRA

This QRA study has been conducted using the internationally renowned DNV software package, Phast Risk Micro Version 6.6.

From ***Figure 7-1***, it is clear that the total data requirement can be broadly classified into five major categories that are as follows:

7.4.1 Plant Data

The plant data are derived from the engineering documentation for the facilities including process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs), lay out plans etc.

7.4.2 Generic Failure Rate Data

Generic leak frequency data used in this study are based on the following publications:

- International Association of Oil & Gas Producers (OGP) Risk data directory (March 2010), Risk Assessment Data Directory – Storage Incident Frequencies (Report No. 434-3 dated March 2010) published by International Association of Oil & Gas Producers.

Guideline for Quantitative Risk Assessment 'Purple Book' (Document No. CPR 18E) *The Approach to Calculate Failure Frequency*.

7.4.3 Population Data

This QRA study covers the fatality risk to people by exposure to flammable and toxic hazards. Data on distribution of onsite population in the plant & township area and offsite population in surrounding area collected from are tabulated in ***Table 7-4***.

Table 7-4: Population Data

S. No.	Area	Average number of Persons	
		Day Time	Night Time
1	GNFC Plant Area	2,000	500
2	GIDC Area	100	20
3	GNFC Township	2,000	3,000
4	Bharuch Town Area	1,70,000	1,70,000
5	Area North of GNFC including Vadadla village	700	1,553
6	Area West of GNFC including Factory Area	500	1,000
7	Chavaj Village	2,000	2,540
8	Bholav Village	20,000	25,275
9	Nadelav	11,250	14,062

7.4.4 Meteorological Data

Atmospheric stability plays an important role in the dispersion of chemicals. "Stability means, its ability to suppress existing turbulence or to resist vertical motion".

The Weather categories selected for consequence analysis are presented in ***Table 7-5***.

Table 7-5: Weather Condition Selected

Time	Remarks	Weather Condition		
		Temperature in °C	Wind speed m/s	Stability Class
Day Time	Prevalent during the day, most times of the year	30	1.2	B
Night Time	Prevalent during the night, most times of the year	20	1	E

Monsoon Period	Prevalent during the monsoon months	30	4	D

7.4.5 Ignition Source Data

Following are the ignition sources:

- Transformers yard and MCC,
- Boilers/Fire Heaters,
- Roads outside the plant area i.e. NH-8E, and SH-6,
- Railway Line

7.5 Hazard (or Failure Case) Identification

The first stage in any QRA is to identify the potential accidents that could result in the release of the hazardous material from its normal containment. This is achieved by a systematic review of the facilities together with an effective screening process. The project description, and other project related data provided by the client have been comprehensively reviewed to identify the hazardous operations. Also the information on the hazardous properties (MSDS) of all the chemicals handled at the site has been reviewed to identify the hazards associated with the same

In this study, toxic & flammable hazards are relevant. There is a possibility of failure associated with each mechanical component of the plant (vessels, pipes, pumps or compressors). These are generic failures and can be caused by such mechanisms as corrosion, vibration or external impact (mechanical or overpressure). A small event (such as a leak) may escalate to a bigger event, by itself causing a larger failure.

The range of possible releases for a given component covers a wide spectrum, from a pinhole leak up to a catastrophic rupture (of a vessel) or full bore rupture (of a pipe). For the purpose of QRA in an objective manner, representative failure cases are generated covering both the range of possible releases and their total frequency. On the basis of this the important hazardous events that can lead to accidents are presented in ***Table 7-6***.

Table 7-6: Event Classification

Type of Event	Explanation
BLEVE	Boiling Liquid Evaporating Vapor Explosion; may happen due to catastrophic failure of refrigerated or pressurized gases or liquids stored above their boiling points, followed by early ignition of the same, typically leading to a fire ball
Deflagration	Is the same as detonation but with reaction occurring at less than sonic velocity and initiation of the reaction at lower energy levels
Detonation	A propagating chemical reaction of a substance in which the reaction front advances in the unreacted substance at or greater than sonic velocity in the unreacted material
Explosion	A release of large amount of energy that form a blast wave
Fire	Fire
Fireball	The burning of a flammable gas cloud on being immediately ignited at the edge before forming a flammable/explosive mixture.
Flash Fire	A flammable gas release gets ignited at the farthest edge resulting in flash-back fire

Type of Event	Explanation
Jet Fire	A jet fire occur when flammable gas releases from the pipeline (or hole) and the released gas ignites immediately. Damage distance depends on the operating pressure and the diameter of the hole or opening flow rate.
Pool Fire	Pool fire is a turbulent diffusion fire burning above a horizontal pool of vaporizing hydrocarbon fuel where the fuel has zero or low initial momentum
Spill Release	'Loss of containment'. Release of fluid or gas to the surroundings from unit's own equipment / tanks causing (potential) pollution and / or risk of explosion and / or fire
Structural Damage	Breakage or fatigue failures (mostly failures caused by weather but not necessarily) of structural support and direct structural failures
Vapor Cloud Explosion	Explosion resulting from vapor clouds formed from flashing liquids or non-flashing liquids and gases

7.5.1 Hazard and Damage Assessment

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

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

Consequences of Toxic Release

The effect of exposure to toxic substance depends upon the duration of exposure and the concentration of the toxic substance. Short-term exposures to high concentration give Acute Effects while long term exposures to low concentrations result in Chronic Effects.

Only acute effects are considered under hazard analysis as they are likely credible scenarios. These effects are:

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

Immediately Dangerous to Life and Health (IDLH)

Airborne concentration from which a worker could escape without injury or irreversible health effects from an IDLH exposure in the event of the failure of respiratory protection equipment. IDLH values are based on effects that might occur as a consequence of a 30-minute exposure.

Emergency Response Planning Guideline (ERPG) Values

The Emergency Response Planning Guideline (ERPG) values are published by American Industrial Hygiene Association. They are intended to provide estimates of concentration ranges where one reasonably might anticipate observing adverse effects as described in the definitions for ERPG-1, ERPG-2, and ERPG-3 as a consequence of exposure to the specific substance.

- The ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.

- The ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

The ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing life-threatening health effects.

Consequences of Fire/Heat Wave

The effect of thermal radiation on people is mainly a function of intensity of radiation and exposure time. The effect is expressed in term of the probability of death and different degree of burn. The consequence effects studied to assess the impact of the events on the receptors are presented in ***Table 7-7***.

Table 7-7: Damage due to Radiation Intensity

Radiation (kW/m^2)	Damage to Equipment	Damage to People
1.2	Solar heat at noon	-
1.6	-	Minimum level of pain threshold
2.0	PVC insulated cable damage	-
4.0	-	Causes pain if duration is longer than 20 sec. But blistering is unlikely.
6.4	-	Pain threshold reached after 8 sec. Second degree burns after 20 sec.
12.5	Minimum energy to ignite wood with a flame; melts plastic tubing.	1% lethality in one minute. First degree burns in 10 sec.
16.0	-	Severe burns after 5 sec.
25.0	Minimum energy to ignite wood at identifying long exposure without a flame.	100% lethality in 1 min. Significant injury in 10 sec.
37.5	Severe damage to plant	100% lethality in 1 min. 50% lethality in 20 sec. 1% lethality in 10 sec.

Consequences of Overpressure

The effects of the shock wave vary depending on the characteristics of the material, the quantity involved and the degree of confinement of the vapor cloud. The peak pressures in an explosion therefore vary between a slight over-pressure and a few hundred kilopascals (kPa). Whereas dwelling are demolished and windows and doors broken at overpressures as low as 0.03- 0.1 bar. Direct injury to people occur at greater pressures. The pressure of the shock wave decreases rapidly with the increase in distance from the source of the explosion. The overpressure damage is shown in ***Table 7-8***.

Table 7-8: Overpressure Damage

Overpressure(bar)	Damage
0.001	Annoying noise (137 dB if of low frequency 10-15 Hz)
0.002	Loud noise (143 dB, sonic boom glass failure)

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

Source: CCPS Consequence analysis of chemical release

7.6 Risk Assessment / Consequence Analysis

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

- Modeling of discharge rates when holes develop in process equipment/pipe work/pipeline;
- Modeling of the size and shape of flammable and toxic gas clouds from releases in the atmosphere;

- Modeling of the flame and radiation field of the releases that are ignited and burn as jet fire, pool fire, flash fire and BLEVE/Fire ball;
- Modeling of the explosion fields of releases, which are ignited away from the point of release.

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

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

7.6.1 Selection of Material

Following points are considered while selecting the release scenarios:

- Flash point and boiling for flammable chemicals
- IDLH of Toxic chemicals
- Operating Temperature and Pressure of the material
- Total inventory of the material
- Bund dimensions

The chemical properties along with their storage capacity and bund dimensions are presented in ***Table 7-9***.

Table 7-9: Chemicals with Storage Capacity, Storage Condition and Bund Dimension

S. No.	Full name of the Raw Material	Hazard involved	Flash Point °C	IDLH in ppm	No. of container & Size at Site	Consequence analysis done for	Storage Parameters		Bund Details
							Pressure Kg/cm²	Temp. °C	
1	Ammonia	Flammable & Toxic	-	300	2 tanks 10,000 MT	√	Atmospheric	-33	Dyke Volume: 20,317 m^3
2	Aniline	Flammable & Toxic	-1	-17	3 tanks- 1,000m^3 each	√	Atmospheric	Ambient	Dyke Volume : 1429.5 m^3
					2 tanks- 500 m^3 each				
					2 tanks- 80 m^3 each				
3	Benzene	Flammable	-11.1	500	2 tanks - 750 m^3 each	√	Atmospheric	Ambient	Dyke Volume : 1,038.47 m^3
4	Chlorine	Toxic	-	10	4 tanks - 300 MT in Bullet & 180 in toners	√	11-12	30	Dyke Volume : 423.65 m^3
5	Methanol	Flammable	11	6,000	3 tanks 3,078 m^3 (each)	√	Atmospheric	Ambient	Dyke Volume : 3,425 m^3
					2 tanks 3,078 m^3 (each)				Dyke Volume : 3,425 m^3
					2 tanks 150 m^3 (each)				Dyke Volume : 1,439.73 m^3
					1 tanks 150 m^3 (each)				Dyke Volume : 262.44 m^3
					1 tanks 937 m^3 (each)				Dyke Volume. : 2,822.4 m^3
					1 tanks 937 m^3 (each)				Dyke Volume : 101.1 m^3
6	Nitrobenzene	Flammable	87.78	200	3 tanks – 100 m^3 each		Atmospheric	Ambient	Dyke Volume : 340.7 m^3
					1 tank – 135 m^3	√			
7	TDI	Poisonous	121	-	4 Tanks of 250 m^3, 3 Receiver of 35 m^3, 02 Bland tank of 35 m^3, 01 Mixing tank of 15 m^3	√	Atmospheric	Ambient	Dyke Volume : 523.9 m^3
8	Toluene	Flammable	4.4	500	3 tanks, 500 m^3 (each)	√	Atmospheric	Ambient	Dyke Volume : 1,038.47 m^3

7.6.2 Scenarios Considered for Risk Analysis

Following categories of failure scenarios are considered for this bulk chemical liquid storage and handling installations.

Worst Case Scenario: Catastrophic Rupture of Tank

The worst case scenario is the release of entire contain of a tank filled to its maximum capacity. In this case the whole dyke area will be filled. The potential consequences are

- Dispersion of vapor;
- Dyke fire (pool fire), if the vapors get ignited early;
- Vapor cloud explosion, if the vapors get ignited late at a far distance.

As per available information from technical survey a few catastrophic failures of single wall atmospheric tanks have occurred. The main causes of such failures are

- Internal explosion in the tanks containing flammable material due to hot work (welding etc.) on or near the tank top;
- Damage of the bottom plate of the tank containing crude oil due to heavy corrosion by the water accumulation.

There are two atmospheric storage tanks for liquid ammonia in GNFC. Each tank has 10,000 MT capacity. One tank constructed initially is a single wall tank. The second tank constructed later is double-wall-double integrity type, also known as cup-in-tank. Both the inner tank and outer tank are made of low temperature steel suitable for liquid ammonia at -33 °C. The ammonia tanks at GNFC have been designed and constructed according to relevant codes and standards incorporating all necessary safety features. The ammonia storage system has been in successful service for many years.

It is proposed to convert the earlier tank also to double-wall-double-integrity type as part of this project. There has been no case history of catastrophic failure of double wall tank. In view of the above factors, it is observed that catastrophic failure of atmospheric ammonia tank is not a credible scenario. It is however considered as the worst case scenario for risk assessment as required by the ToR.

Catastrophic failure of the following chemical tanks is also considered in worst case scenarios:

- Ammonia tank;
- Aniline tank;
- Benzene tank;
- Methanol tank;
- Nitrobenzene tank;
- Toluene tank.

Maximum Credible Accident Scenario

The following base scenarios are likely to occur under some abnormal condition:

- Heavy leakage from the pipe flange due to failure of gasket;
- Malfunction of drain valve due to damage of internal plug/disc;
- Over flow from the tank due to malfunction of level instruments/ control.

The cases of gasket failure and drain valve failure are estimated to correspond to leak through a hole, if 50 mm diameter (approximate cross sectional area of 2,000 mm^2). The duration of release is considered as 1 hour on a conservative basis.

In case of tank overflow due to level instrument malfunction, the tank filling will be stopped immediately by the operating personnel present at site and the quantity spilled is expensed to be small. Overfilling of ammonia tank is not a credible scenario as the filling rate from ammonia plant is not high and the tank inventory is strictly monitored with highly reliable level instruments.

7.6.3 Consequence Analysis

Ammonia Tank

The radiation level and effect distances due to release of ammonia tank are presented in ***Table 7-10***, whereas the overpressure effect distance and the effect distance to the toxic dose is presented in ***Table 7-11*** and ***Table 7-12***.

Table 7-10: Radiation Level and Effect Distance due to release of Ammonia

Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2
Ammonia Tank Liquid Outlet 50mm leak	Jet fire	1.0/E	173	NR	NR
		1.2/B	174	NR	NR
		4.0/D	147	122	NR
	Late Pool Fire	1.0/E	116	80	59
		1.2/B	116	80	60
		4.0/D	118	87	61
Ammonia Tank Fixed duration Release	Jet fire	1.0/E	111	35	NR
		1.2/B	119	36	NR
		4.0/D	242	93	29
	Late Pool Fire	1.0/E	109	74	52
		1.2/B	108	73	52
		4.0/D	111	80	54

Table 7-11: Overpressure Effect Distance due to the Release of Ammonia

Failure Scenarios	Consequence	Met Data	Overpressure Distances in Meters		
			0.02 bar	0.13 bar	0.20 bar
Ammonia Tank Liquid Outlet	Late Ignition	1.0/E	115	52	47
		1.2/B	114	52	47
		4.0/D	116	52	47
Ammonia Tank Fixed duration Release	Late Ignition	1.0/E	253	88	75
		1.2/B	287	111	97
		4.0/D	347	164	150

Table 7-12: Effect Distance for Toxic Dose Due to Release of Ammonia

<table>
<tr><th colspan="4" rowspan="2">Failure Scenarios</th><th rowspan="2">Met. Data</th><th colspan="4">Effect Distance in Meters to Toxic Dose (in ppm)</th></tr>
<tr><th>IDLH (300)</th><th>ERPG 1 (30)</th><th>ERPG 2 (160)</th><th>ERPG 3 (1,100)</th></tr>
<tr><td colspan="4" rowspan="3">Ammonia Tank Liquid Outlet 50 mm leak</td><td>1.0/E</td><td>1699</td><td>7642</td><td>2135</td><td>375</td></tr>
<tr><td>1.2/B</td><td>744</td><td>2458</td><td>889</td><td>248</td></tr>
<tr><td>4.0/D</td><td>100</td><td>3352</td><td>1193</td><td>338</td></tr>
<tr><td rowspan="3">Ammonia Tank Fixed duration Release</td><td>1.0/E</td><td>15658</td><td>48527</td><td colspan="2">19423</td><td colspan="3">4420</td></tr>
<tr><td>1.2/B</td><td>3604</td><td>13442</td><td colspan="2">4331</td><td colspan="3">1197</td></tr>
<tr><td>4.0/D</td><td>5376</td><td>19672</td><td colspan="2">6526</td><td colspan="3">1742</td></tr>
</table>

The effect contour generated due to the 50 mm leak and catastrophic rupture of ammonia tank are presented in ***Figure 7-2*** and ***Figure 7-3***.

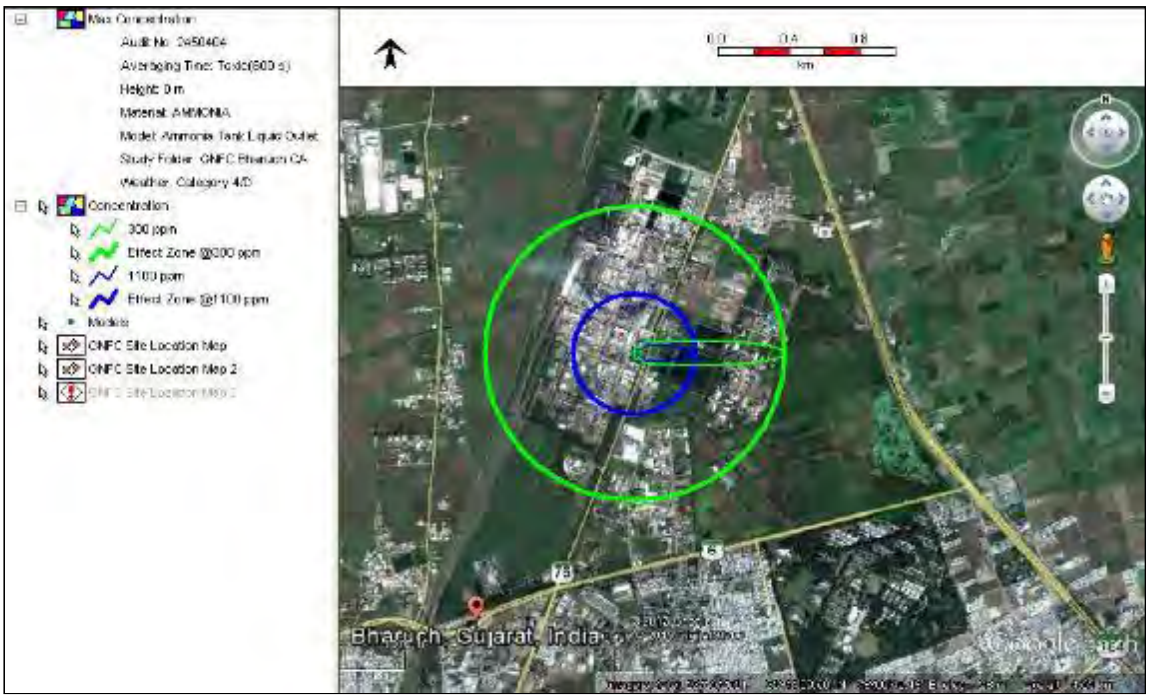


Figure 7-2: Late pool fire risk contour due to 50 mm Leak in Ammonia tank at weather 4.0/D

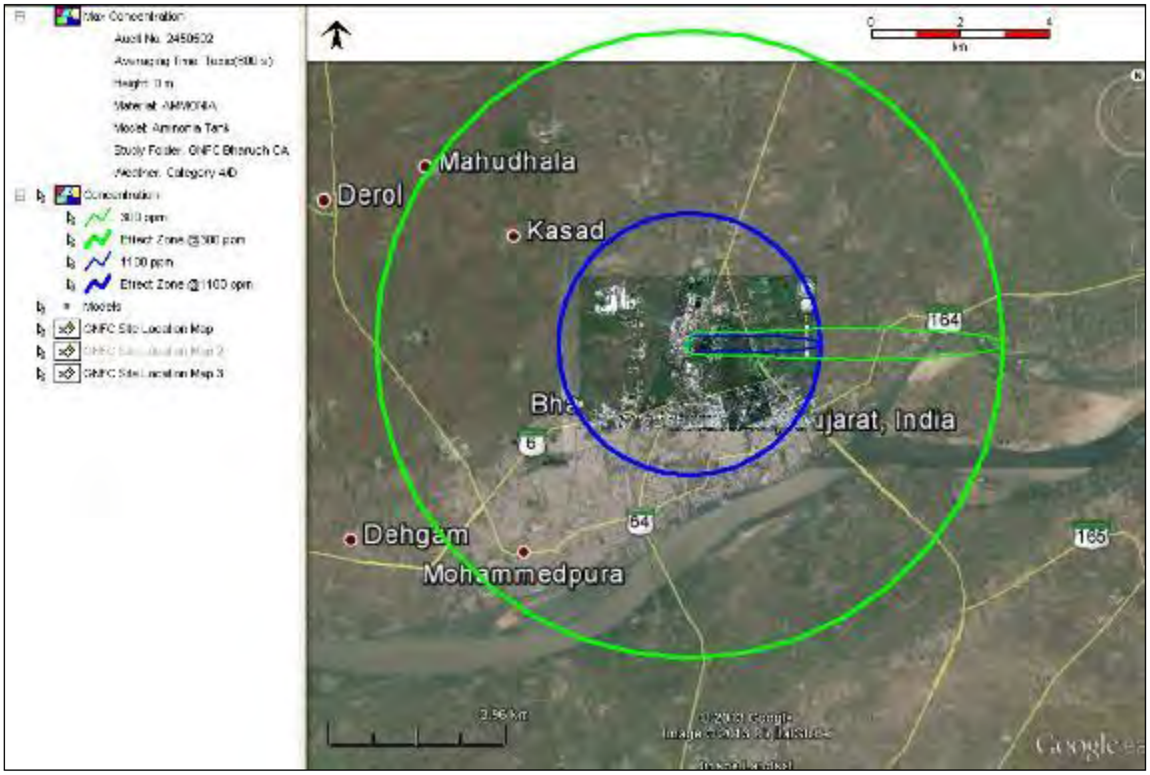


Figure 7-3: Concentration risk contour - Catastrophic Rupture of Ammonia Tank at 4.0/D

Aniline Tank

The radiation level and effect distance due to the catastrophic rupture of aniline tanks are presented in ***Table 7-13***, whereas the overpressure effect distance due to the release of the same is presented in ***Table 7-14***.

Table 7-13: Radiation Level and Effect Distance Due to Release of Aniline

Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2
Aniline Tank	Late Pool Fire	1.0/E	41	22	NR
		1.2/B	42	22	NR
		4.0/D	48	26	NR

Table 7-14: Overpressure Effect Distance Due to Release of Aniline

Failure Scenarios	Consequence	Met Data	Overpressure Distances in Meters		
			0.02 bar	0.13 bar	0.20 bar
Aniline Tank	Late Ignition	1.0/E	13	11	11
		1.2/B	14	11	11
		4.0/D	13	11	11

Pool fire effect distance due to the catastrophic rupture of aniline is presented in ***Figure 7-4***, whereas overpressure effect distance contour is presented in ***Figure 7-5***.

Figure 7-4: Late pool fire risk contour - Catastrophic Rupture in Aniline tank at 4.0/D

Figure 7-5: Late Explosion overpressure risk contour catastrophic rupture of Aniline tank at 4.0/D

Benzene Tank

The radiation level and effect distances due to release of benzene are presented in ***Table 7-15***, whereas the overpressure effect distance and the effect distance to the toxic dose is presented in ***Table 7-16*** and ***Table 7-17***.

Table 7-15: Radiation Level and Effect Distance Due to Release of Benzene

Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2
Benzene Tank	Late Pool Fire	1.0/E	60	30	NR
		1.2/B	60	30	NR
		4.0/D	76	33	NR

Table 7-16: Overpressure Effect Distance Due to Release of Benzene

Failure Scenarios	Consequence	Met Data	Overpressure Distances in Meters		
			0.02 bar	0.13 bar	0.20 bar
Benzene Tank	Late Ignition	1.0/E	267	152	145
		1.2/B	207	122	117
		4.0/D	124	74	71

Table 7-17: Effect Distance for Toxic Dose Due to Release of Benzene

Failure Scenarios	Met. Data	Effect Distance in Meters to Toxic Dose (in ppm)			
		IDLH (500)	ERPG 1 (50)	ERPG 2 (150)	ERPG 3 (1,000)
Benzene Tank	1.0/E	305	1168	519	213
	1.2/B	182	562	279	115
	4.0/D	155	796	345	56

The effect distance contour due to the catastrophic rupture of benzene tank at 4.0/D weather condition is presented in ***Figure 7-6***.

Figure 7-6: Late pool fire risk contour - Catastrophic Rupture in Benzene tank at 4.0/D

Overpressure effect distance and concentration risk contour due to catastrophic rupture of benzene tank are presented in ***Figure 7-7*** and ***Figure 7-8***.

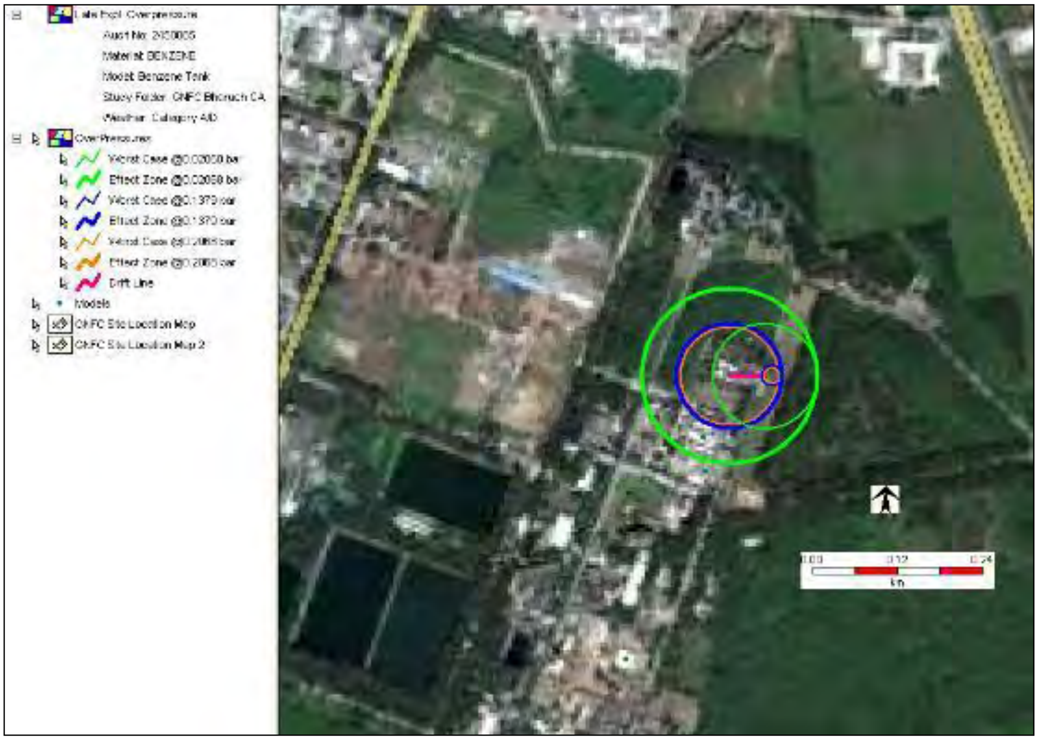


Figure 7-7: Late Explosion overpressure risk contour - catastrophic rupture of Benzene tank at 4.0/D

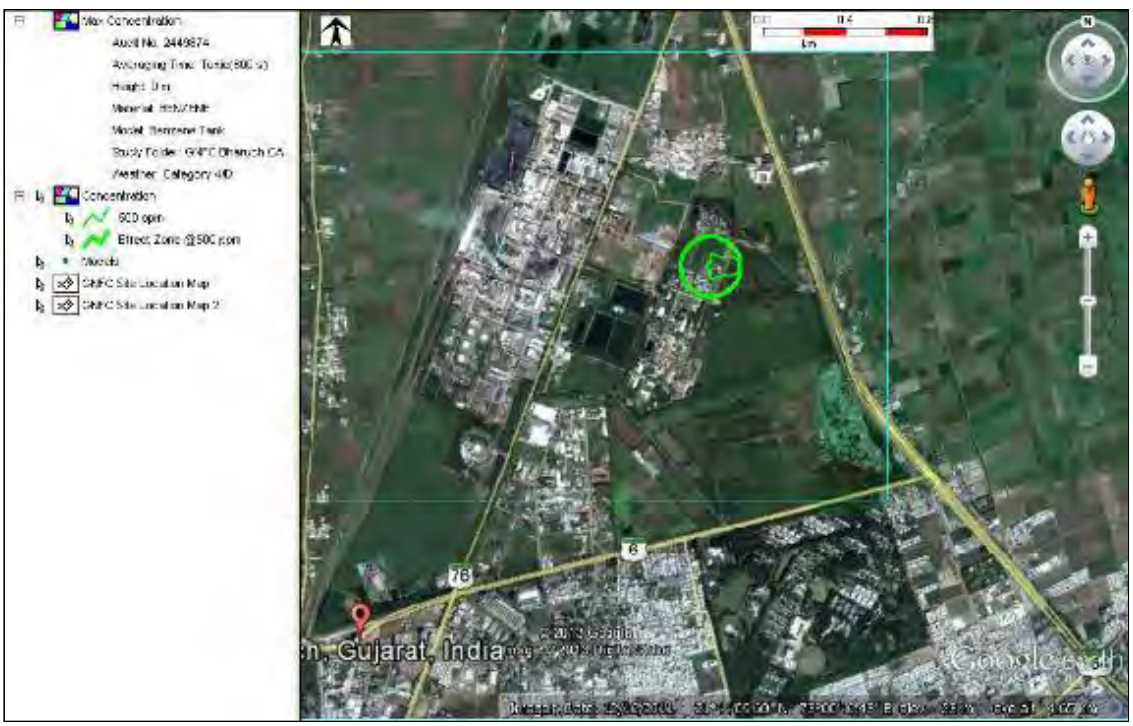


Figure 7-8: Concentration risk contour - Catastrophic Rupture of Benzene tank at 4.0/D

Methanol Tank

The radiation level and effect distances due to release of methanol tank are presented in ***Table 7-18***, whereas the overpressure effect distance and the effect distance to the toxic dose is presented in ***Table 7-19*** and ***Table 7-20.***

Table 7-18: Radiation Level and Effect Distance Due to Release of Methanol

Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2
Methanol Tank	Late Pool Fire	1.0/E	66	43	27
		1.2/B	66	43	27
		4.0/D	68	48	30

Table 7-19: Overpressure Effect Distance Due to Release of Methanol

Failure Scenarios	Consequence	Met Data	Overpressure Distances in Meters		
			0.02 bar	0.13 bar	0.20 bar
Methanol Tank	Late Ignition	1.0/E	135	85	82
		1.2/B	51	28	26
		4.0/D	50	28	26

Table 7-20: Effect Distance for Toxic Dose Due to Release of Methanol

Failure Scenarios	Met. Data	Effect Distance in Meters to Toxic Dose (in ppm)			
		IDLH (6,000)	ERPG 1 (200)	ERPG 2 (1,000)	ERPG 3 (5,000)
Methanol Tank	1.0/E	186	1791	534	100
	1.2/B	46	427	130	23
	4.0/D	19	520	109	0

The effect distance contour due to the catastrophic rupture of methanol tank at 4.0/D weather condition is presented in ***Figure 7-9***, where as the overpressure effect distance due to the catastrophic rupture is presented in ***Figure 7-10***.

Figure 7-9: Late pool fire risk contour - Catastrophic Rupture in Methanol tank at 4.0/D

Figure 7-10: Late Explosion overpressure risk contour - Catastrophic rupture of Methanol tank at 4.0/D

Nitrobenzene

The radiation level and effect distance due to the catastrophic rupture of nitrobenzene tanks are presented in ***Table 7-21***, whereas the overpressure effect distance due to the release of the same is presented in ***Table 7-22***.

Table 7-21: Radiation Level and Effect Distance Due to Release of Nitrobenzene

Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
			4 kW/m²	12.5 kW/m²	37.5 kW/m²
Nitrobenzene Tank	Late Pool Fire	1.0/E	30	18	NR
		1.2/B	31	19	NR
		4.0/D	33	23	NR

Table 7-22: Overpressure Effect Distance Due to Release of Nitrobenzene

Failure Scenarios	Consequence	Met Data	Overpressure Distances in Meters		
			0.02 bar	0.13 bar	0.20 bar
Nitrobenzene Tank	Late Ignition	1.0/E	NH	NH	NH
		1.2/B	NH	NH	NH
		4.0/D	NH	NH	NH

Pool fire effect distance due to the catastrophic rupture of nitrobenzene tank is presented in ***Figure 7-11***, whereas the overpressure effect distance contour level is shown in ***Figure 7-12***.

Figure 7-11: Late pool fire risk contour - Catastrophic Rupture in Nitrobenzene tank at 4.0/D

Figure 7-12: Late Explosion overpressure risk contour - Catastrophic rupture of Nitrobenzene tank at 4.0/D

Toluene

The radiation level and effect distance due to the catastrophic rupture of toluene tanks are presented in ***Table 7-23***, whereas the overpressure effect distance due to the release of the same is presented in ***Table 7-24***.

Table 7-23: Radiation Level and Effect Distance Due to Release of Toluene

Failure Scenario	Consequence	Met Data	Effective Distance in meter to Radiation Level		
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2
Toluene Tank	Late Pool Fire	1.0/E	60	30	NR
		1.2/B	60	30	NR
		4.0/D	75	33	NR

Table 7-24: Overpressure Effect Distance Due to Release of Toluene

Failure Scenarios	Consequence	Met Data	Overpressure Distances in Meters		
			0.02 bar	0.13 bar	0.20 bar
Toluene Tank	Late Ignition	1.0/E	131	73	70
		1.2/B	104	61	58
		4.0/D	55	36	35

The effect distance contour due to the catastrophic rupture of toluene tank at 4.0/D weather condition is presented in ***Figure 7-13***.

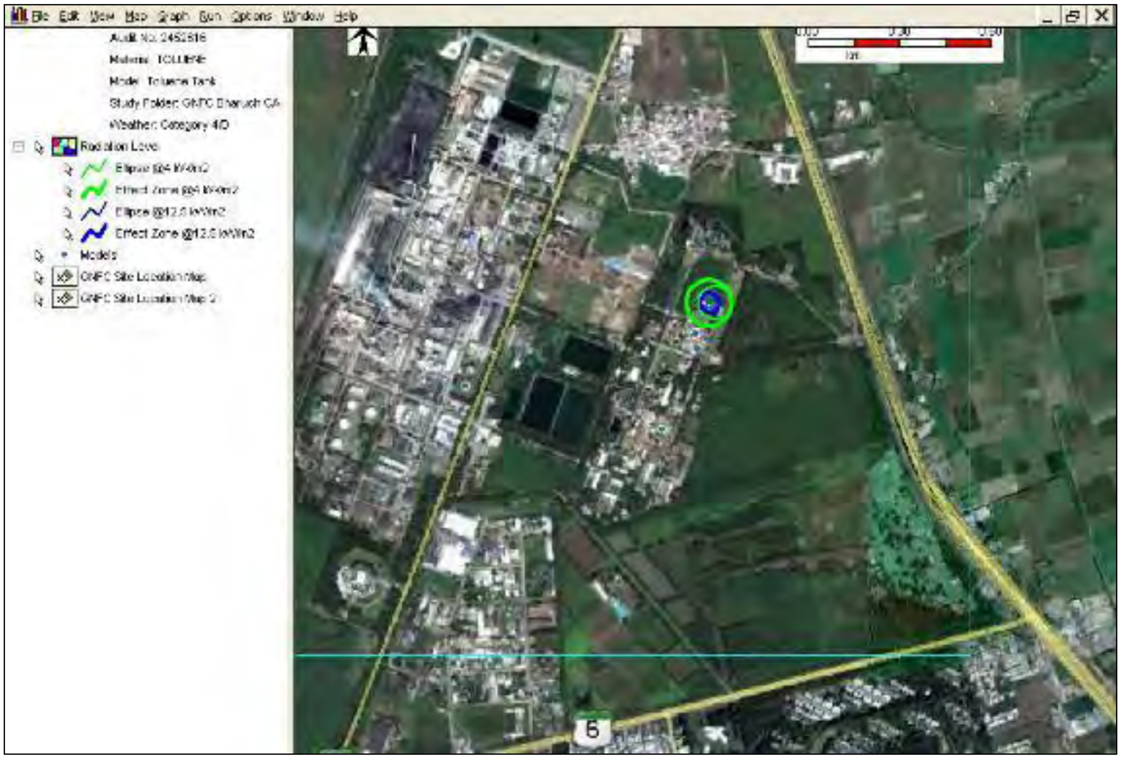


Figure 7-13: Late pool fire risk contour - Catastrophic Rupture in Toluene tank at 4.0/D

The contour level showing the overpressure effect distance and concentration effect distance are presented in ***Figure 7-14*** and ***Figure 7-15*** respectively.

Figure 7-14: Late Explosion overpressure risk contour - catastrophic rupture of Toluene tank at 4.0/D

Figure 7-15: Concentration risk contour - Catastrophic Rupture of Toluene tank at 4.0/D

TDI

Effect distance for toxic dose due to the release of TDI is presented in ***Table 7-25***.

Table 7-25: Effect Distance for Toxic Dose Due to Release of TDI

Failure Scenarios	Met. Data	Effect Distance in Meters to Toxic Dose (in ppm)			
		IDLH (2.5)	ERPG 1 (0.02)	ERPG 2 (0.083)	ERPG 3 (0.51)
TDI Tank	1.0/E	9	87	35	16
	1.2/B	9	37	24	16
	4.0/D	9	58	28	16

The concentration risk contour due to the catastrpohic rupture is shown in ***Figure 7-16***.

Figure 7-16: Concentration risk contour - Catastrophic Rupture of TDI tank at 4.0/D

7.6.4 Conclusion

From the above consequence analysis, following conclusion can be made and are presented in ***Table 7-26*** and are elaborated below it.

Table 7-26: Conclusion

Chemical/ Scenario	Effect Distance in Meters at Weather condition 4.0/D			
	At Radiation Level 4 kW/m^2	At Overpressure 0.02 bar	IDLH Concentration	ERPG-3 Concentration
Ammonia Tank Catastrophic Failure (Worst Case Scenario)	111	347	5376	1742
Ammonia Tank Outlet Pipe (50 mm leak)	118	116	100	338
Aniline Tank	48	13	-	-
Benzene Tank	76	124	155	56
Methanol Tank	64	50	19	0
Nitrobenzene Tank	33	NH	-	-
TDI Tank	-	-	9	16
Toluene Tank	75	55	62	19

- The effect of pool (dyke) fire and toxic dispersion due to failure of tanks for benzene, nitrobenzene, aniline, toluene, TDI and methanol do not extend beyond the plant boundary.

- In case of maximum credible scenario of leak in ammonia tank outlet line (leak size equivalent to 50 mm diameter hole) unmitigated effect distance for toxic dispersion upto IDLH concentration extends to a downwind distance of about 100 m which extends beyond the plant boundary. However, necessary mitigation measure in the form of dyke and water spray system to absorb the ammonia vapor is available to deal with such emergency.
- The possibility of cascade effect of tank fire is reduced to an extent by providing bund to each tank.

7.7 Consequence Calculations

Using the failure case data developed, the consequence program of the PHAST software package, undertakes consequence calculations for each identified failure. Initially the dispersion of the released material is analyzed using the Unified Dispersion Model.

For flammable materials, the effect zones for the various possible outcomes of such a release are determined. A release can ignite as the result of the event, which causes it, or can ignite close to the source before the flammable cloud has travelled away from the release source. If a release does not ignite in this way, and it is still flammable, it can be ignited at a number of points downwind if its path is such that it goes across (for example) a road, an area where people are present or other ignition sources.

The program undertakes these calculations for the selected representative meteorological conditions, which are derived from the annual meteorological conditions in the study area.

Consequence models are used to predict the physical behavior of hazardous incidents. Some models only calculate the effect of a limited number of physical processes, like discharge or radiation effects. More complex models interlink the various steps in consequence modeling into one package.

7.8 Risk Calculations

The final estimation of risk is undertaken within the MPACT program of the SAFETI package. Each failure case is analyzed to determine its impact (in terms of fatalities). Effect zone information is combined with meteorological, ignition source and population data. Event tree conditional probabilities leading to a particular outcome and frequency information, extracted from the original failure case description, are used to determine the level of risk for the specific failure case under analysis.

The modeling of flammable impacts can be quite involved. This is because there are many possible final outcomes from a single release and ignition may occur at several locations.

MPACT generates the required standard forms of risk measure. It calculates both individual risk at grid points and the societal group risk of each incident outcome.

To calculate group or societal risk, the total number of fatalities for each release case, event tree outcome, weather type and wind direction must be calculated. The frequencies of all those combinations contributing to the same number of fatalities must be summed. The SAFETI package allows these results to be presented in the form of an FN group risk curve. An FN curve is a graph, which plots the frequency of N or more fatalities per year (F) against the number of fatalities (N). It is conventional that this information is presented on a log-log plot.

7.8.1 Risk Presentation

The risk levels associated with the facilities are presented in the following standard forms:

- Individual risk contours which show the geographical distribution of risk to an individual.
- Group risk (FN) curves which show the cumulative frequency (F) distribution of accidents causing different numbers (N) of fatalities. The FN curve therefore indicates whether the societal risk to the facility is dominated by relatively frequent accidents causing small numbers of fatalities or low frequency accidents causing many fatalities.

7.8.2 Risk Assessment

The final, and most significant, step in the process is the assessment of what the calculated risk levels portray. Risk assessment is a process by which the results of a risk analysis are used to make judgments, either through relative risk ranking of risk reduction strategies or through comparison with risk targets (criteria). Where risk criteria have been issued by the regulatory authority, it is possible for interested parties to assess the calculated risk levels against these criteria. The risk assessment stage determines whether the risks are 'Tolerable' or if risk mitigation measures are required to reduce the risk to a level, which can be considered to be 'As Low As Reasonably Practicable (ALARP)'.

7.8.3 Risk Tolerability Criteria

A risk analysis provides measures of the risk resulting from a particular facility or activity. However, the assessment of the tolerability that risk is by relating it to well defined risk criteria for individual risk and societal risk.

7.8.4 Individual Risk Criteria

The risk acceptability criteria published by UK Health & Safety Executive (UK-HSE) is proposed to be applied for judging the tolerability of risk to people due to the DAP production facilities of PPL. It broadly indicates as follows:

1. Individual risk to any worker above 10^{-3} per annum shall be considered intolerable and fundamental risk reduction improvements are required.
2. Individual risk below 10^{-3} for but above 10^{-6} per annum for any worker shall be considered tolerable if it can be demonstrated that the risks are as low as reasonably practicable.
3. Individual risk below 10^{-6} per annum for any worker shall be considered as broadly acceptable and no further improvements are considered necessary provided documented control measures are in place and maintained.
4. Individual risk to any member of the general public as a result of SRAAC Businesses activities shall be considered as intolerable if greater than 10^{-4} per annum, broadly acceptable if less than 10^{-6} per annum and shall be reduced to as low as reasonably practicable between these limits.

The upper limit of tolerable risk to public, 1 x 10^{-4} per year is in the range of risk due to transport accidents.

The upper limit of broadly acceptable risk, 1 x 10^{-6} per year, is in the range of risk due to natural hazard such as lightning.

The Graphical representation of the same is indicated in ***Figure 7-17***.

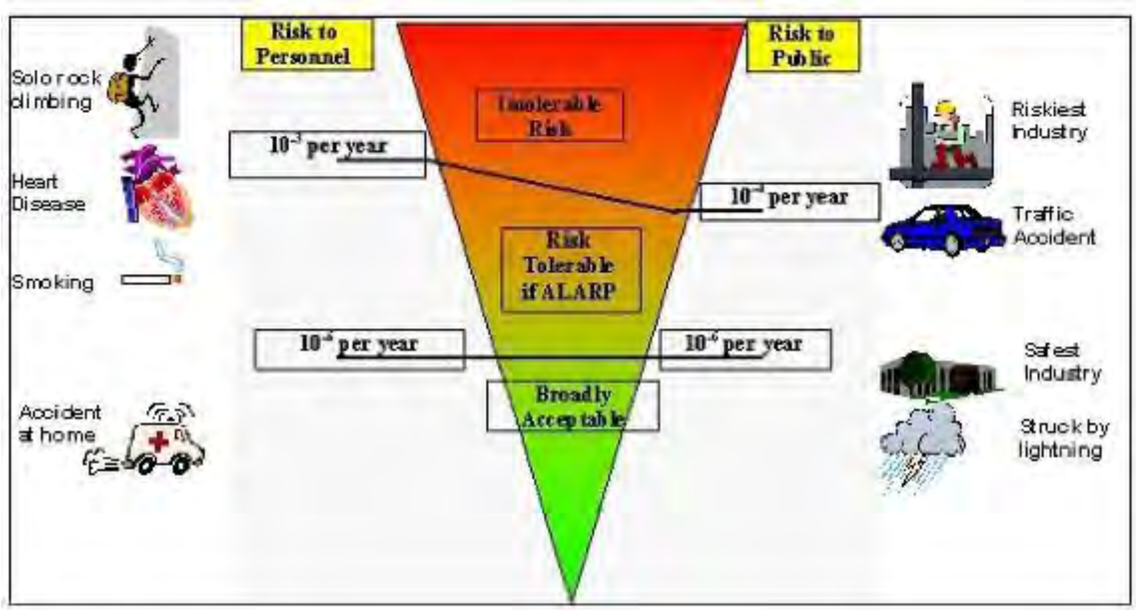


Figure 7-17: Criteria for Individual Risk

7.8.5 Group Risk Criteria – FN Curves

When considering the risks associated with a major hazard facility, the risk to an individual is not always an adequate measure of total risks; the number of individuals at risk is also important. Catastrophic incidents with potential multiple fatalities have little influence on the level of individual risk but have a disproportionate effect on the response of society and impact on company reputation.

Group risk is the relationship between frequency of an event and the number of people affected. Societal risk from a major hazard facility can thus be expressed as the relationship between the number of potential fatalities N following a major accident and the frequency F at which N fatalities are predicted to occur. Minimum criteria for societal risk based on F-N curves are presented in ***Figure 7-18***.

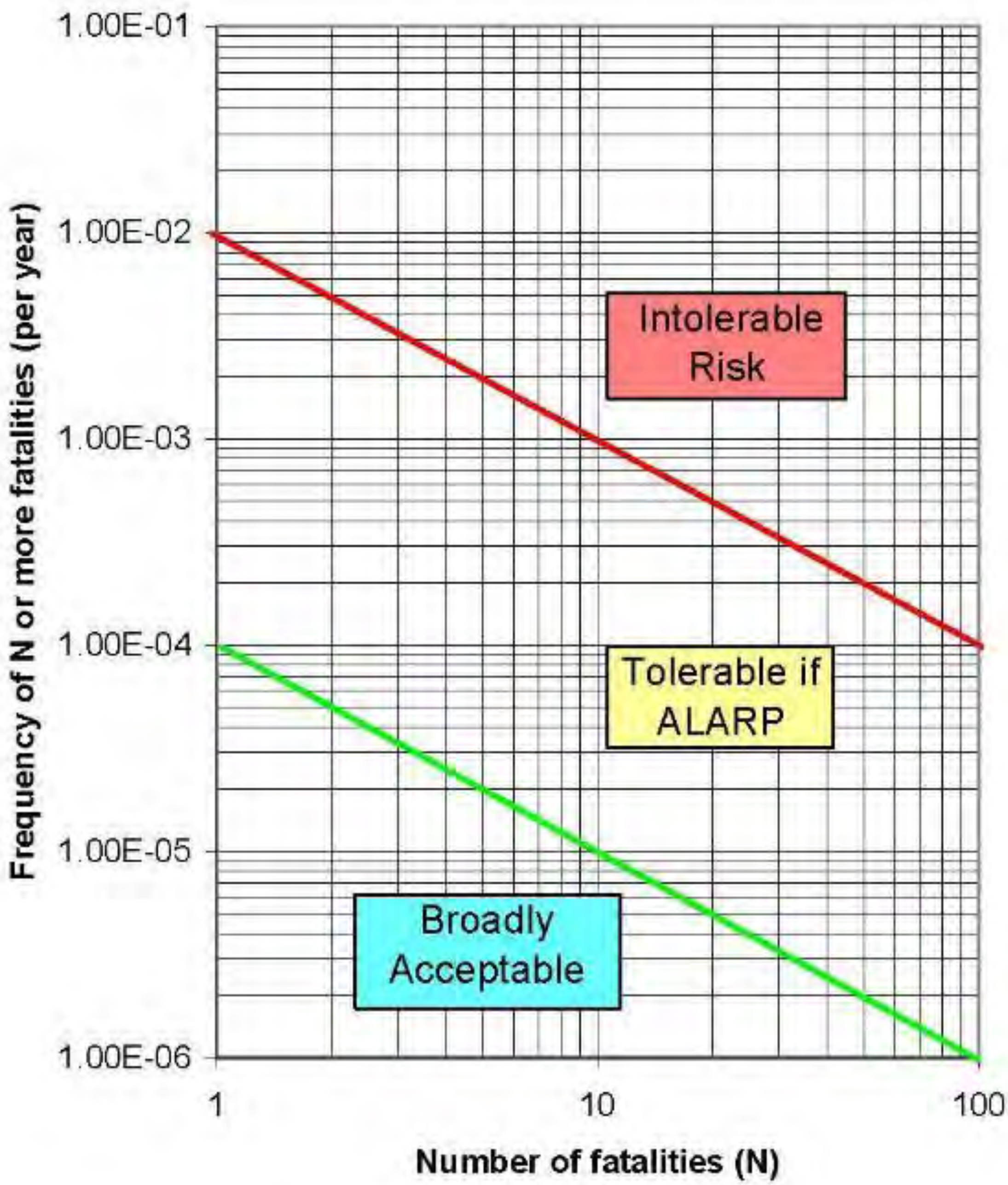


Figure 7-18: Criteria for Group Risk

7.9 The Approach to Calculate Failure Frequency

- For each case, record the number of each type of items.
- Insert the failure frequencies for each type of item.
- Multiply by the number of items to obtain the frequency for each item type and leak size.
- Sum the frequencies for each leak size over all the items to give the case frequencies.

The details of these failure cases with frequency are indicated in ***Table 7-27***.

Table 7-27: Failure Cases Input to PHAST Risk

S No.	Description	Leak Size	Material & Phase	Temp. (°C)	Pressure (kg/cm^2g)	Leak Frequency (per year)
	Ammonia Storage Tanks (D-1003A, D-1003B)					
1	Ammonia Tank (each tank)	Catastrophic Failure	Liquid Ammonia	(-)33	0.1	2.5E-08
2	Outlet pipe (each tank)	Rupture	Liquid Ammonia	(-)33	0.1 + liquid head	1.0E-05
	Ammonia Receiver					
3	Medium Leak	25 mm	Liquid Ammonia	40	14.5	2.5E-04
4	Major Leak	100 mm	Liquid Ammonia	40	14.5	5.1E-05
	Chemical Tanks					
5	Benzene	Spillage outside Tank	Liquid Benzene	30	Atm	2.8E-03
6	Benzene	Catastrophic rupture	Liquid Benzene	30	Atm	3.0E-06
7	Toluene	Spillage outside Tank	Liquid Toluene	30	Atm	2.8E-03
8	Toluene	Catastrophic rupture	Liquid Toluene	30	Atm	3.0E-06
9	Aniline	Spillage outside Tank	Liquid Aniline	30	Atm	2.8E-03
10	Aniline	Catastrophic rupture	Liquid Aniline	30	Atm	3.0E-06
11	Nitrobenzene	Spillage outside Tank	Liquid Nitrobenzene	30	Atm	2.8E-03
12	Nitrobenzene	Catastrophic rupture	Liquid Nitrobenzene	30	Atm	3.0E-06
13	Methanol (MFB-503 A/B/C)	Spillage outside Tank	Liquid Methanol	30	Atm	2.8E-03
14	Methanol (MFB-503 A/B/C)	Catastrophic rupture	Liquid Methanol	30	Atm	3.0E-06
15	Methanol (MFE-503 D/E)	Spillage outside Tank	Liquid Methanol	30	Atm	2.8E-03
16	Methanol (MFB-503 D/E)	Catastrophic rupture	Liquid Methanol	30	Atm	3.0E-06
17	Fuel Oil Tank (D-2101 A)	Spillage outside Tank	Fuel Oil	30	Atm	2.8E-03
18	Fuel Oil Tank (D-2101 A)	Catastrophic rupture	Fuel Oil	30	Atm	3.0E-06
19	Fuel Oil Tank (D-2101 B)	Spillage outside Tank	Fuel Oil	30	Atm	2.8E-03
20	Fuel Oil Tank (D-2101 B)	Catastrophic rupture	Fuel Oil	30	Atm	3.0E-06
21	Fuel Oil Tank (D-2102 A)	Spillage outside Tank	Fuel Oil	30	Atm	2.8E-03
22	Fuel Oil Tank (D-2102 A)	Catastrophic rupture	Fuel Oil	30	Atm	3.0E-06
23	Fuel Oil Tank (D-2102 B)	Spillage outside Tank	Fuel Oil	30	Atm	2.8E-03
24	Fuel Oil Tank (D-2102 B)	Catastrophic rupture	Fuel Oil	30	Atm	3.0E-06

S No.	Description	Leak Size	Material & Phase	Temp. (°C)	Pressure (kg/cm^2g)	Leak Frequency (per year)
25	Ethanol	Spillage outside Tank	Liquid ethanol	30	Atm	2.8E-03
26	Ethanol	Catastrophic rupture	Liquid ethanol	30	Atm	3.0E-06
27	Ethyl Acetate	Spillage outside Tank	Ethyl Acetate	30	Atm	2.8E-03
28	Ethyl Acetate	Catastrophic rupture	Ethyl Acetate	30	Atm	3.0E-06
29	Chlorine Bullet (each bullet)	10 mm Leak	Chlorine	30	8	1.0E-05
30	Chlorine Bullet (each bullet)	Catastrophic Rupture	Chlorine	30	8	5.0E-07
31	Chlorine Bullet (each bullet)	Entire contents released in 10 minutes	Chlorine	30	8	5.0E-07

7.10 Results Analysis Results

7.10.1 Individual Risk

The iso–risk contours representing Location Specific Individual Risk (LSIR) in the main plant area are presented in ***Figure 7-19*** along with the enlarged view presented as ***Figure 7-20***.

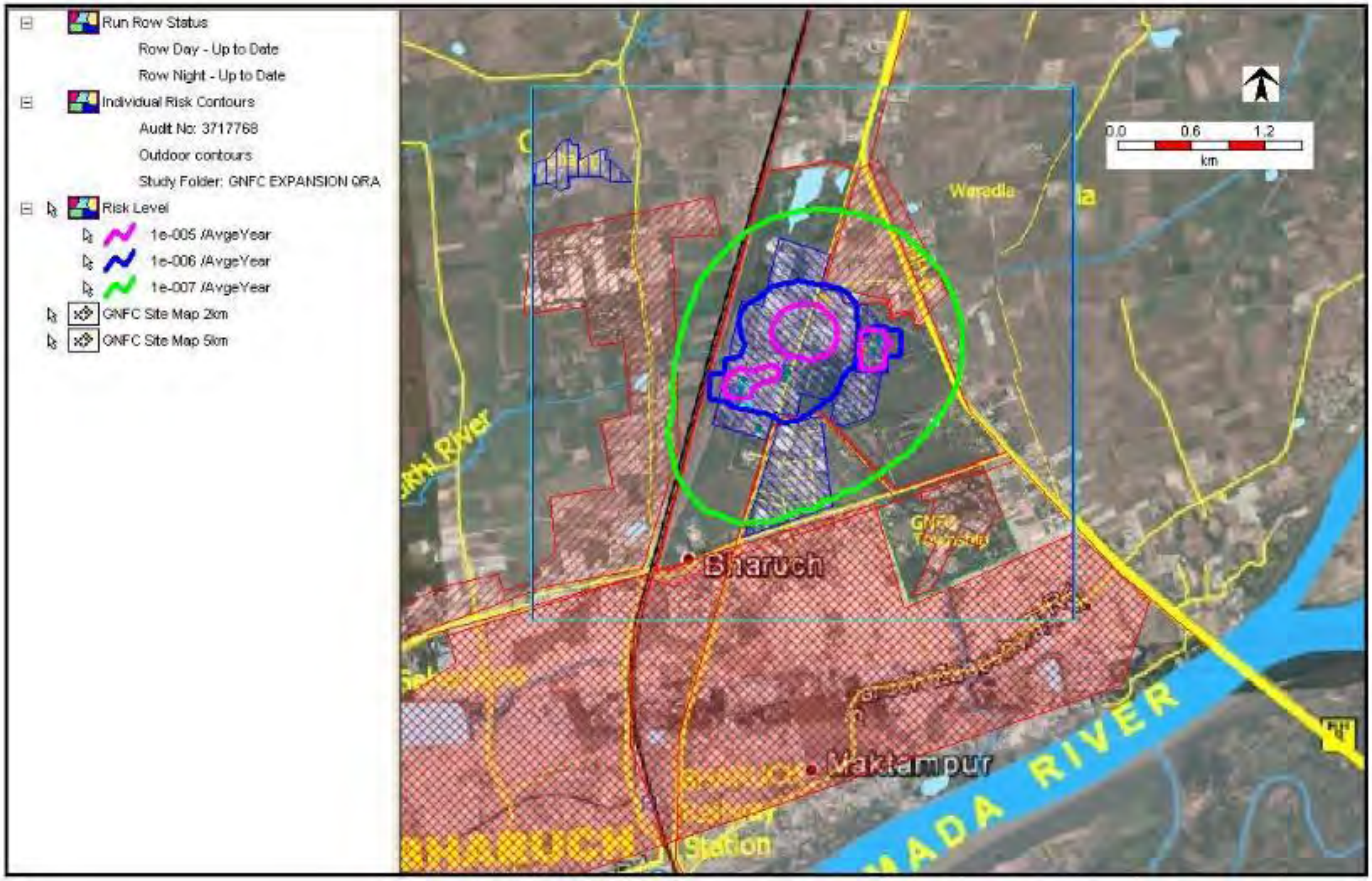


Figure 7-19: Iso-risk Contours-Overall Plant Area

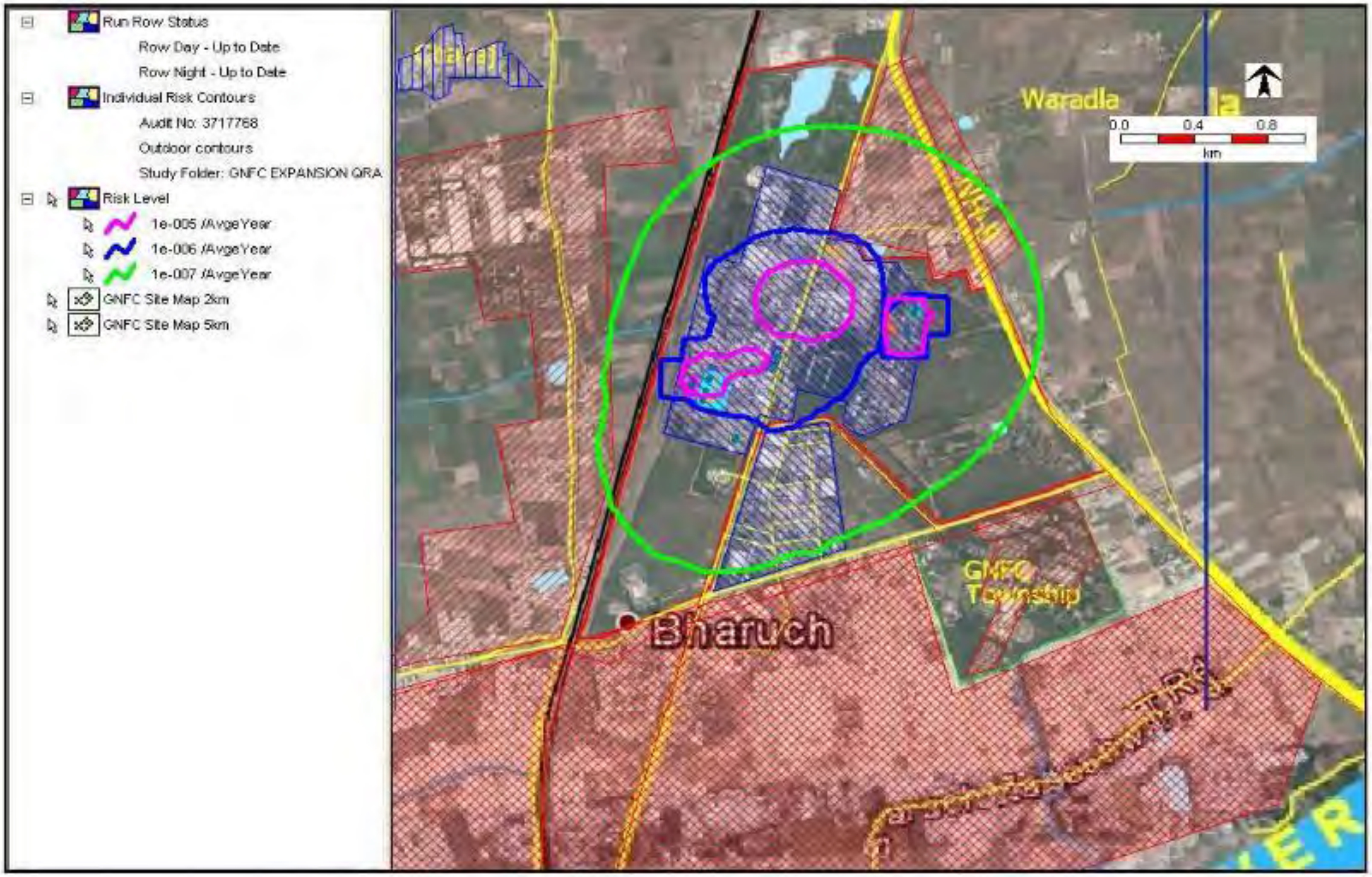


Figure 7-20: Iso-Risk Contour Enlarged View

It is observed that the Iso-Risk Contour of 1×10^{-6} per year crosses the plant boundary only on southern and northern part of the plant.

The maximum individual risk on the southern boundary of the plant is 1.4×10^{-6} per year, whereas at the northern boundary it is 1.8×10^{-6}. Along the east and west boundaries of the plant the individual risk is less than 1.0×10^{-6} per year.

Based on the above it is seen that the maximum individual risk to members of the public is 1.8×10^{-6} per year. This is in the lower part of ALARP region close to Broadly Acceptable level.

Maximum Location-Specific Individual Risk (LSIR) to plant personnel is found to be 6.0×10^{-5} per year. This is the individual risk to a person present at the site all the time in a year. As a person working in the plant is present at the site for maximum 8 hours in a day (average during a year), the maximum risk specific to an individual person is estimated as

$$6.0 \times 10^{-5} \text{ per year} \times (8/24) = 2.0 \times 10^{-5} \text{ per year.}$$

Thus, it is observed that the maximum individual risk to personnel working in the plant site is in the middle of ALARP region. The maximum individual risk to members of the public and person working in the plant in comparison with the specified risk tolerance criteria are shown in ***Figure 7-21***.

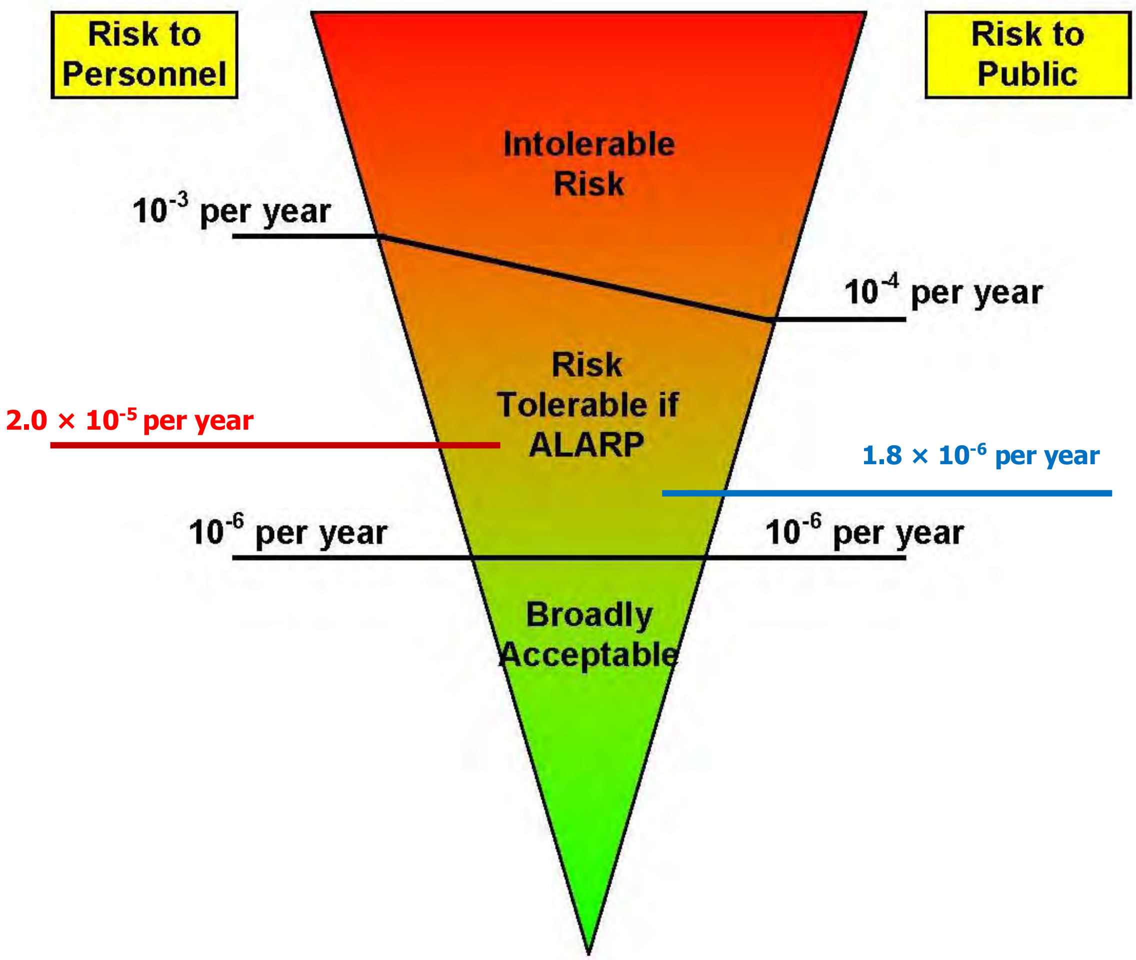


Figure 7-21: Individual Risk

7.10.1.1 Group Risk-FN Curve

The Group risk for on-site population is shown in ***Figure 7-22***, in the form of an FN curve. The criteria used here is the Group Risk Criteria for FN curve. From the curve it is observed that, the societal risk for events resulting in less than three fatalities is in the lower part of ALARP region. For events resulting in three and more fatalities is in Broadly Acceptable region.

Similarly the risk for off-site population is shown in ***Figure 7-23***, from which it is observed that, the societal risk for off-site population is in Broadly Acceptable region.

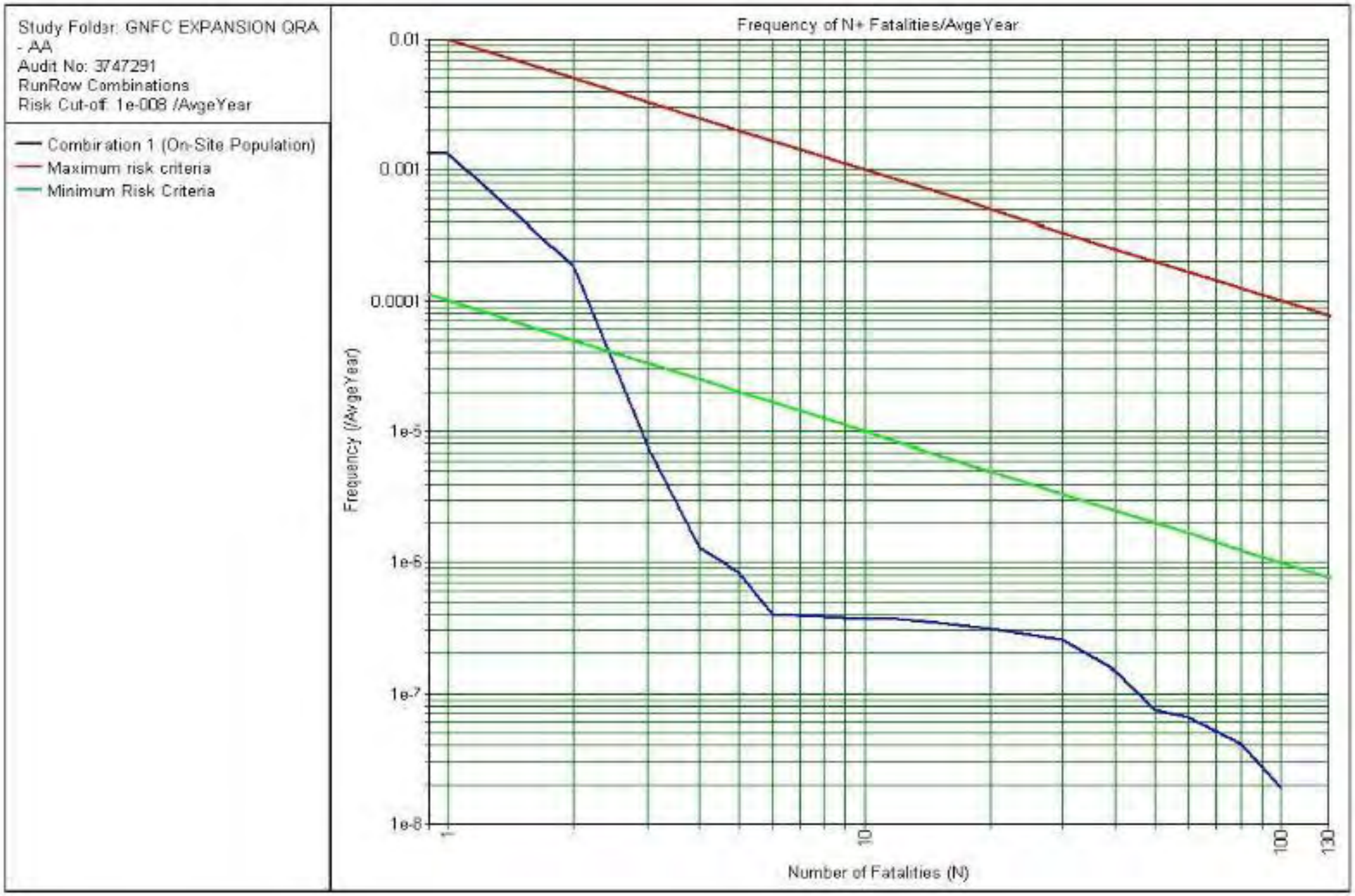


Figure 7-22: FN Curve of Group Risk (on-site)

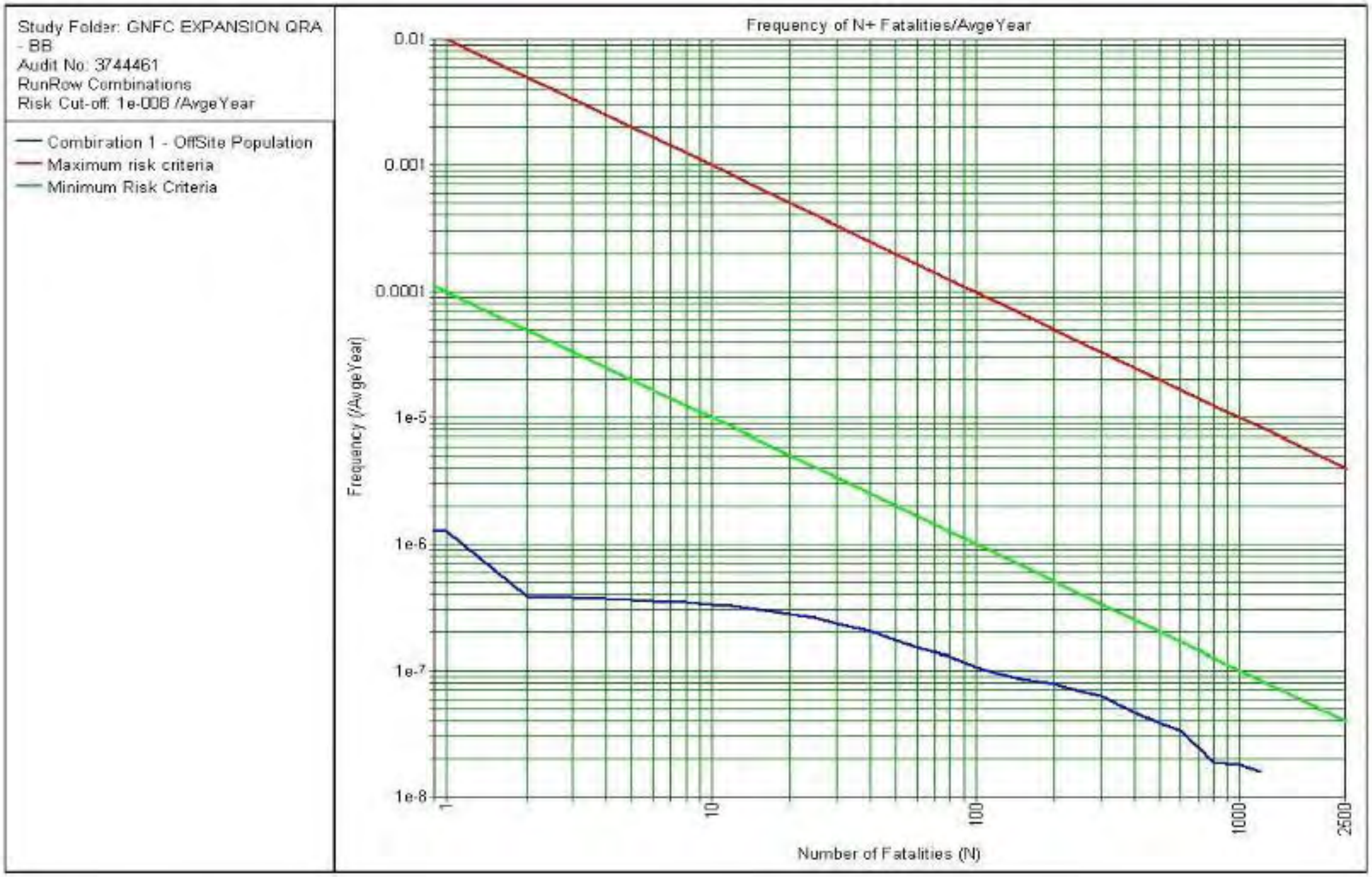


Figure 7-23: FN curve of Group Risk (off-site)

7.10.2 Risk Contribution

The list of major societal risk contributors provided by PHAST risk is presented in ***Table 7-28***.

Table 7-28: Major Risk Contributors

S. No.	Description	Risk Contribution (%)
1.	Methanol tanks	33
2.	Ammonia tanks and ammonia receiver	21
3.	Aniline tank	18
4.	Chlorine bullets	10
5.	Toluene tank	8
6.	Benzene tank	6
7.	Nitrobenzene tank	4
Total		**100**

7.11 Conclusions

The comprehensive quantitative risk assessment of the GNFC Expansion Project considering all scenarios including the worst consequence scenarios such as catastrophic rupture of ammonia tank leads to the following conclusions.

1. There are two atmospheric ammonia storage tanks each 10,000 MT capacity. One is a single wall tank and the other is double wall double integrity type. As part of the Expansion Project, the single wall tank will be converted to a double wall double integrity tank of the same capacity and there will no increase in storage capacity. The ammonia tanks are provided with dyke containment. Hence the risk due to ammonia storage will be less after implementation of the Expansion Project.
2. The liquid chlorine storage system consists of four bullets out of which one is always kept empty for emergency. One bullet will be under inspection and testing. The Expansion Project will not involve any increase in liquid chlorine storage. High capacity chlorine leak absorption system having chlorine detectors and elephant trunk hoods is always kept in operation. The system reliability is ensured by the provision of standby pump and blower, and emergency power supply.
3. Based on the operation experience with the system over many years, it is seen that the chlorine storage system has adequate leak prevention and mitigation measures. It is to be noted that the Expansion Project does not involve any increase in chlorine bullets storage system.

The results of QRA of GNFC Expansion Project indicate the following:

- The maximum individual risk to members of the public from the significant hazardous chemical storage systems after the Expansion Project is 1.8×10^{-6} per year on the north side boundary. This is in the lower part of ALARP region close to Broadly Acceptable level.
- The maximum individual risk personnel working in the plant is 2.0×10^{-5} per year which is in the middle part of ALARP region.
- The FN curve representing societal risk to on-site population is the lower part of ALARP region for incidents which could result in less than 3 fatalities and in Broadly Acceptable region for incidents with potential for more number of fatalities.
- The FN curve representing societal risk to offsite population is in Broadly Acceptable region.

- The hazardous chemicals storage systems at GNFC Bharuch after the Expansion Project meet the risk tolerance criteria satisfactorily.

7.12 Mitigations

The following recommendations are made for improving the safety systems at GNFC Bharuch.

1. Ammonia Storage System
   a) It is to be ensured that the liquid outlet pipe from the bottom of ammonia tank is made of welded construction (with no flange joint) upto the remote-operated emergency isolation valve.
   b) Liquid ammonia entering the storage tank from the new ammonia plant should have a minimum water content of 0.2 % to prevent stress corrosion.
   c) Water monitors are provided outside the dyke area around the ammonia tanks. Provision of suitable water curtain system outside the dyke with remote-operated valve is to be considered. This will help in mitigation of ammonia vapor dispersion in case of large ammonia leak.
   d) Special foam system having high stability may be considered for application on large liquid ammonia spills to minimize vapor generation.
   e) Ammonia leak detectors are provided in the ammonia tank area. In addition, installation of CCTV system with infra-red (IR) capability may be considered. This will help in timely detection of ammonia leaks.
2. Chlorine Storage System
   a) Emergency chlorine leak absorption system with high reliability is already provided. It is necessary to minimize the chlorine vapor generation in case of large liquid release. For this purpose the following arrangement is to be considered:
      i. Provision of dyke around the chlorine bullet to contain the liquid.
      ii. Provision of flooring with steep slope (1:5) around the bullets leading to a sump/ pit to collect the liquid.
      iii. Arrangement for transferring the liquid collected in the sump/ pit to the absorption system by means of ejector or pump.
      iv. Provision of vapor suction hood over the liquid collection sump/ pit to transfer the chlorine vapor to the absorption system.
   b) Remote-operated emergency isolation valve is to be provided in the liquid line from chlorine bullet.
   c) Water spray system around the liquid chlorine bullet area may be considered. Though the solubility of chlorine in water is low, the water spray system will provide a physical barrier and help in dispersion of chlorine vapor.

References:

- *Safety Advice for Bulk Chlorine Installations, UK HSE Publication HSG-28 (1999)*
- *Handbook of Chlorination and Alternative Disinfectants by Geo. Clifford White - Chapter 9: Chlorine Facilities Design.*

7.13 Onsite Emergency Plan

7.13.1 Emergency Categorized

7.13.1.1 Emergency controllable within the plant / area

Small leakage of hazardous material from equipment or piping which may result,

- Small jet fire or pool fire
- Toxic dispersion

7.13.1.2 Emergency confinable within the Factory premises

Emergency may be due to:

- Big fire in factory premises
- Medium scale explosion
- Heavy leakage of toxic gas for short duration

7.13.1.3 Likelihood of vapor cloud with formation of toxic / flammable gases drifting and affecting the general public (i.e. outside of plant premises)

Emergency may be due to:

- Release of large quantity of toxic liquid/ vapour from storage high pressure equipment resulting in toxic dispersion well beyond the plant boundary
- Release of large quantity of flammable liquid/ vapour from storage high pressure equipment resulting in vapour cloud explosion with serious overpressure effect beyond the plant boundary.

7.13.2 On Site Emergency Plan for GNFC, Bharuch

GNFC have a detailed On Site Emergency Plan in place covering all the plants for more than 15 years. The Plan is supported by the following:

- Organogram of key persons for emergency management
- Well-defined roles and responsibilities for the emergency team members and factory management
- Provision of necessary resources such as emergency control centers, emergency equipment and PPE, communication system
- Training of personnel and mock drills

The On Site Emergency Plan will also cover the proposed new plants when they become operational. In this connection the following points are noteworthy.

- The proposed new plants are similar to the existing plants and located at adjoining site.
- No additional storage for liquid ammonia is proposed. There are two existing ammonia tanks, one single wall tank and the other double wall double integrity tank. The single wall tanks will also be converted to double wall double integrity type.

The new plants will be provided with all necessary state-of-the art safety measures as per the best industry practice. This includes fire and gas detection systems, fire alarm system and remote-operated emergency isolation system.

Fire protection system for the new plants will meet the approval of Chief Control of Explosives, Petroleum and Explosives Safety Organization (PESO). Any additional mobile firefighting equipment such as fire tenders, foam & CO_2 tenders etc. found necessary to meet the emergency requirements when the new plants become operational will also be provided.

The existing arrangements for emergency response are briefly described below to provide a general indication of the type and extent of the systems involved.

7.13.2.1 Mutual Aid Scheme

GNFC have a "Mutual Aid Scheme" with Bharuch Nagarpalika Fire Brigade, ONGC – Ankleshwar, KRIBHCO – Hazira, IPCL - Vadodara and Dahej units and GSFC - Vadodara. Helps from such organizations also will be coordinated in case of emergency. Details of various facilities available with them are also available. Help for Heavy equipment also can be obtained from these organizations.

The mutual aid scheme with ONGC is in operation & well tested.

7.13.2.2 Information on the Preliminary Hazard Analysis

Type of accidents

The types of accident, where "Onsite Emergency Plan" is to be involved, during the course of manufacturing Fertilizers, & chemicals with the help of raw material such as considered as listed below:

1. Fire
2. Explosion
3. Release of Toxic material
4. A combination of more than one

However, types of personnel injuries may include: Burn injury, cut, / blunt injuries, or fracture injuries during the course of industrial activity.

System elements or events that can lead to a major accident

Unplanned event, resulting from uncontrolled developments during an industrial activity, which causes, or has the potential to cause:

- Serious adverse effect immediate or delayed (death, injuries, poisoning or hospitalization) to a number of people inside the installation and / or to person outside the establishment.
- Significant Damage to crops, plants or animals, or significant contamination of land, water, and air.
- An Emergency Intervention out-side the establishment (e.g. evacuation of local population, stopping of local traffic)
- Significant changes in the process operating condition, such as stoppage or suspension of normal work in the concerned plant for a significant period of time.
- Release of huge quantity of gases
- Major fire or Explosion in pipeline/ tank
- System failure
- Destruction during war or cyclone
- Occurrence of severe natural catastrophes or Earthquake beyond design considerations
- Any combination of above effects.

Hazards

Manufacturing process involves many type hazardous chemicals.

Handling and storage of these hazardous chemicals and their use in the process may lead to a hazardous situation.

A brief on types of accidents may happen are as follows:-

- Injury due to inhalation of toxic gases.
- Burn injury accident due to attending electrical faults, handling of acid and steam etc.
- Hit / cut type accidents due to various maintenance jobs.
- Falling from height.

Safety relevant components

Design stage is much more important in any installation. It is the stage where inbuilt safety can be considered, which will be more effective and as a result, failure of equipment's or an accident can be eliminated. Selection of material of construction, planning proper layout, providing inter locks arrangements, safety valves and other sophisticated instrument control for measurements of various parameters for safe operations are the factors which were considered for the fail safe arrangement in our plant.

Some Safety relevant components are mentioned below;

- Automatic, Remote, NRV, Vent, or Safety valve provided for more safety.
- In all tanks vent valve with interlock.
- Electronic tank pressure indicator and recorder.
- Safety relief valves on tanks, pipeline, and heat exchangers.
- Electronic level indicator and controller for the annular space.
- Multi temperature recorder.
- Tank level high / low level alarm and shut off interlock.
- Common flare stacks for storage tanks.
- Wind indicators.
- Lighting arrestors.
- Earthing of the tanks.
- Refrigeration system for maintaining tank pressure and temperature with various interlock for safety of Tanks and compressor.
- Control Room equipped with DCS system.
- Adequate annular space between the control room and the tank.
- Insulation of the tanks and piping with fire retarding properties.
- Pressure controller at transfer line to plant, etc.

7.13.2.3 Details about the Site

Location of Dangerous Substances

This indicate boundary walls, all entry and exit gates, situation of various departments, hazardous storage and process areas, effluent treatment plant, fire station , first aid centers, ambulance room, shelters, lunch room, canteen, assembly points, emergency control center, parking plots, approach roads, telephone center, safety office, main office building and place of fire fighting and personal protective equipment.

Seat of key personnel

All key personnel as per the role of Onsite emergency plan are sitting in plant area.

Emergency Control Room

- Presently F & S control room is designated as emergency control room looking to communication network available & other facilities.
- Second emergency control room has been earmarked as Local Crisis Control room situated at Training center. All communication facilities i.e. Internal as well as external, is installed in LCG control room. We will put all efforts to make it live and opera table all the time.
- Personal Protective Equipment is kept in all control rooms, at F & S dept. and Central stores. We have kept PPEs at LCG control room also.

7.13.2.4 Hazards in Various Plants

Ammonia Plant

CO Shift Conversion Section:

- Hazardous materials: Gas containing CO, CO_2 and Hydrogen at operating pressure 82 bar (g) and temperature upto 485 °C.

Ammonia Synthesis Section:

- Hazardous materials: Gas containing Hydrogen, Nitrogen and Ammonia; liquid ammonia. Operating pressure upto 180 bar (g) and temperature upto 300 °C.

Ammonia Storage System and Ammonia Refrigeration System:

- Hazardous materials: Liquid ammonia

Process safety measures provided are mentioned below:

- Process control with alarms and shut-down interlocks for high pressure, low pressure, high temperature, high/ low flow of critical components, high/ low level.
- Selection of material of construction or specific equipment and piping
- Nitrogen purging arrangement to prevent fire/ explosion hazard
- Safety relief valves venting to flare system for safe disposal of process gas

Urea Plant

In this plant, major hazard is of ammonia processing at high pressure in pumps and pressure vessels. Suitable material of constructions has been utilized in whole plant with SS-316 lining in the Urea Reactor.

Leak detection system is provided for urea reactor which is multi-layer vessels. This is to ensure timely warning for leak in the liner and prevent corrosion damage of the shell.

Remote-operated isolation valves are provided for ammonia received to prevent large release of liquid ammonia in case of any leakage in high pressure feed pump area.

Ammonia leak detectors and water spray arrangement are provided around pump house to mitigate ammonia leaks.

Aniline Plant

Nitrobenzene is produced by reaction of benzene and mixture of sulphuric acid and nitric acid. Nitrobenzene is then reacted with hydrogen to produce aniline.

Process safety measures provided are mentioned below:

- Selection of material of construction for nitrobenzene reactor.
- Process conditions maintained to avoid side reactions which may form dinitrobenzene etc.
- Temperature control and shutdown system for exothermic hydrogenation reactor
- Nitrogen purging system to prevent ingress of air hitch may form flammable mixture
- Water sprinkler system around hydrogenation
- Totally enclosed system for thickener and spent catalyst filter.
- System to prevent occupational exposure to benzene, nitrobenzene and aniline.
- Chiller is provided in tank vents to minimize vapour emission.
- Loading arms with flange joints are used to prevent exposure during tanker loading.
- Use of PPE is strictly enforced.

TDI Plant

Fire hazard is moderate.

TDI fume is toxic. Under fire condition thermal decomposition may produce carbon monoxide.

Process safety measures provided

- There is no storage for the intermediate product phosgene, which is highly toxic. It is consumed in the reactor itself, thus making the process inherently safe. Online analyzer provided for loop phosgene in TDI.
- Emergency scrubber has been installed to mitigate any emergency arising out of release of phosgene from plant, reactor separator, degasser, HCL stripper, degasser compressor, phosgene absorber column, and other distillation section of TDI.
- Vent scrubber has been installed to scrub process vent gases from TDI plant &HCL absorption system, TDI tank farm and drumming area. Vent scrubber is equipped with Elephant Trunk system for instant handling of any leakage.
- Product TDI drumming is carried out on automated system.
- Use of PPE is strictly enforced.

7.13.2.5 Details Regarding Warning, Alarm, and Safety and Security Systems

Warning

Fire Station receives reports of all emergencies in the plant areas through Fire Alarm, 100 Phone, or 2300 Phone.

Appropriate response personnel are alerted by:

- Telephones
- Intercoms
- PAX connection
- Plant PA systems
- Runners with vehicles

- Runners

Site Main Controller (SMC), Deputy SMC or Incident Controller (IC) or Deputy IC will decide & issue general warning depending on the emergency type.

- Factory wide alarm through sirens.
- Plant intercoms.
- Telephones.
- Using plant PA systems / Hot lines with other plants.
- Through Public announcing by vehicles.
- Runners in remote areas.

All systems will be maintained in perfect working conditions depending on areas of responsibilities. Periodic tests will be carried out at least every two months.

Notification procedures will answer the following seven questions:

- What Happened?
- Where did it happen?
- Who did it happen to?
- When did it happen?
- How did it happen?
- To what Extent?
- What help is needed?

Visitors / Contract lob ours / Contractors will be informed by the Officers / Employees under whom they are working. New visitor's entry at the gate will not be allowed by both Security Gates (i. e. North & South).

Alarm

Alarm and hazard control plans in line with disaster control and hazard control planning, ensuring the necessary technical and organizational precautions;

Besides Fire Alarm System, we have a special "5333" intercom telephone No. connected at Company's Fire Station.

We have an internal telephone system network with Company's own telephone exchange having about 911 telephone lines in various Plants / Depts. / Emergency Services etc.

Ambulance Services / First-Aid Services are connected by Internal Telephones / Pax telephones.

There are **Hot Lines** between all control rooms i.e. Ammonia, Urea, Boilers, Captive Power Plant, Methanol, Formic acid etc. To pass on critical messages & normal operation, problems etc. by concerned operators /Shift engineers.

Fire Water pump House is also connected by intercom.

Township Hospital is connected by internal telephone with Company & by a hot line with Fire Station telephones. Anybody on observing any emergency like Fire/ Gas Leakage can inform regarding the incident / place etc. via intercom.

Atmospheric Storage Tanks

The atmospheric storage tank has been provided with numbers of safety devices and instruments are as below;

- Tank pressure indicator (Direct) Tank vapor pressure.
- Tank pressure indicator (Pneumatic / Electronic) Panel mounted for tank vapor pressure.
- Tank pressure recorder (Pneumatic / Electronic) to record vapor pressure of the tank.
- Level indicator (Pneumatic /Electronic) to measure liquid level of tank in % of volume.
- Level indicator (Digital) to measure liquid level of Tank in mm.
- Level indicator (Pneumatic /Electronic) to measure level of the liquid in the annular space between two tanks.
- Pressure switches (Receiver) Interlocks and annunciation.
- Pressure switches (Direct) back up for pressure switch for interlock and annunciation.
- Safety Valves (Pilot Operated) to blow off at excess pressure.
- Safety Valve (Pneumatic operated) to blow of excess vapor manually in emergency.
- Continuous tank temperature recorder to check tank liquid condition at all times.

Safety valves are provided in all the ammonia lines and equipment's.

A number of interlocks from operation and safety point of view are provided throughout the installation. Some of them are mentioned below

- Jetty control valve will stop with pressure and high level of Atmospheric storage tank and thus preventing the tanks with high level & high pressure during unloading.
- All the six compressors of old and new compressor house of atmospheric storage tank are interlocked with tank pressure at various settings of pressure so that required compressors will start / stop automatically to maintain desired pressure.
- Level control valve of saturator and flash vessel and solenoid valve in vapor line condenser to saturator are interlocked with compressor. These valves will close /open with compressor stop / start to avoid any operational problem and hence safety also.
- Ammonia transfer pumps and control valves in suction line of these pumps, both will stop at low level of tank.
- All the six compressors are provided with self-interlocked for high discharge pressure, temp. and low oil pressure to ensure safe operation of equipment and personal safety.
- All important parameters are controlled and monitored by DCS. Data acquisition and report generation is done by DCS system. Control of all main parameters has been centralized in control room on a computer monitor. This system is having following control operation either manually or automatically to avoid any damage to the plant and ensure safety.

Control Provided

- Level indicator / controllers (Auto) for saturator and flash vessel.
- Level indicator in percentage and in mm. for main tank.
- Level indicator in percentage of outer tank (interspaces).
- Pressure indicator, controllers and recorder for main tank.
- Emergency stop of all Jetty control Valve and suction valve to pumps.
- Stop switch for all motors compressors and pumps.
- Emergency stop of all motors by one lock switch.
- Emergency stop of Unloading compressor to trip breaker from MRSS

- Audio / visual annunciators have been provided for all important process parameters and equipment's.

Besides this, the atmospheric storage tank is of double integrity type also known as

"CUP IN TANK" type which has the following advantages -

- Double containment for liquid; even in case one container leaks, the other will provide safe containment.
- Large vapor space which is additional buffer to take care of pressure change
- The annular vapor space acts as insulation to reduce heat transfer from ambient air to liquid ammonia inside
- In case of power failure and other interruption there is enough time for initiating action.

Precautions in designing of the foundation and load bearing parts of the building

All the structures, foundations of equipment, pedestals, frames, etc. are designed and erected as per relevant standards and codes of practices. Most of the foundations are erected on piling and all the Storage Tanks constructed on piling foundations.

Continuous surveillance of operations

Plant control panel are equipped with DCS (Distributed control system), where computers are installed for continuous surveillance and monitoring of all parameters required to be controlled for smooth operation of a plant.

Audio alarms with trip system are provided to stop any segment of plant to bring under control at any point of time. On line data recorder are provide to monitor the parameters of the process plants. The operators and supervisor are continuously taking round s of the plant and monitoring the processes parameters through local monitoring instruments provided in the field.

Ammonia sensors also provided in ammonia storage area with audio alarm system in DCS system at Control Room.

Maintenance and repair work according to the generally recognized rules of good engineering practices

Periodical Inspection

Third Party Safety Audit and Testing / Inspection, from Government Authorities like Factory Inspector& other various statutory bodies & the periodical inspection by committee of company's official are being carried out. Inspection / Testing of tanks, equipment's, pipe lines, valve etc. is carried out periodically at regular intervals. The inspection of Ammonia storage tanks is carried out at regular interval as per international standard. The Ammonia storage tanks are being inspected by following test.

1. Magnafux Crack detection test.
2. Ultrasonic thickness measurements.
3. Dye Penetration test.
4. Vacuum Box test.
5. Hydrostatic test.
6. Hardness test & other required testing etc.

Periodical & regular maintenance of all safety equipment's, pump etc. are being carried out.

Electrical earthing resistance measurement and continuity is checked.

Electrical earth resistance measurement and continuity test for storage tank is carried out quarterly.

Details of communication facilities available during emergency and those required for an off-site emergency.

- We have an internal telephone network with about 800 lines with a fully-fledged telecommunication staff / engineers. This also covers Township.
- A separate '100' telephone no. is provided at fire station so that anybody on observing incident will make telephone at "100" informing fire people.
- Internal telephone exchange & external telephone exchange (P&T) at Company's premises are manned round the clock.
- Telephone systems are well maintained by well experienced staff.
- We have EPBAX system also connected with P & T internal communication is also possible..
- There are direct hot lines installed between all important / critical control rooms like Ammonia - Boiler, Ammonia - Urea, Ammonia - Methanol-I, & II, Ammonia - Formic acid. This enables quick transfer of message / instructions for normal operations as well as emergency.
- There is a Public Address system well-maintained by our instrument department in all plants. This system is utilized for normal operations / communication as well as emergency communications. It is two ways i.e. any person can talk to plant control room field & vice versa.
- We have one 5.0 kms range siren installed on F & S control room. This is hooted continuously for two minutes for testing purposes.
- It will be hooted continuously (rising & lowering sound) for five minutes twice at an interval of two minutes in case of major emergency.
- Though our telephone network is quite reliable & effective, we shall have to constantly review & check for improvements. All new facilities will be connected with the network immediately.

- We have installed six (06) wind indicators at following locations :

  a) Ammonia storage tank.
  b) Formic acid plant
  c) Nitro phosphate plant building.
  d) Acetic acid plant.
  e) Section: 400 top of Ammonia plant.
  f) Methanol tank

These wind indicators are well maintained by our fire & safety department.

We have installed one wind speed indicator with to indicate wind velocity, wind direction. It is able to give average of specified time

Details of fire fighting and other facilities available and those required for an offsite emergency.

- We have fire water network system & well organized F&S Dept. A ready lists of all fire hydrants, hose boxes, fire extinguishers, fire pumps, water monitors, foam chambers, automatic fire alarms, smoke detectors, sprinkler system, landing valves, risers, sluice valves, isolation valves, fire buckets etc. are maintained as record & also all equipment have been given serial numbers &

all fire extinguishers are provided with a card on which testing / use records are maintained. Similarly history cards of all equipment are kept.

- All above mentioned facilities are maintained in up to date conditions. Fire alarm system is checked fortnightly. Call points are tested periodically. Fire extinguishers are checked for any defect monthly & they are hydro tested periodically & also painted frequently.
  - There is a well-planned testing schedule for all equipment & it is being done systematically.
  - Fire pumps capacities, delivery pressures, water level in reservoirs etc. are checked regularly.
  - Auto start / stop of fire water pumps is tested periodically by F&S Dept. & Risk Analysis Group. In fact due to draw of water, many-times regular startups are observed.
  - Stand by electrical & Diesel pumps are also run periodically.
  - Fire engines are road tasted every day and engines are tasted every shift.
  - All inbuilt features of fire engines like pumps, hose reels, DCP systems, foam systems etc.,
  - Protective appliances kept with fire brigade are also checked in every shift.

Details of First aid and Hospital services available and its adequacy

a) We have a well-equipped / well organized Hospital in our town ship 1.5 Kms. away from the plant. This is equipped with 32 beds, Operation Theater, X- ray facilities, Intensive care unit, Burns ward & all general facilities, Medicines etc.

b) Blood Group Records & Medical History of all Employees & their Family Members are kept in our Hospital by the Addl. General Manager (Medical services). Also Blood Group have been mentioned on Employees Identity cards. They are also available with Personnel Dept. All new coming Employees' records will be updated.

c) Our Addl. General Manager (Medical services) is a well experienced professional in this regard. All other Doctors are also being trained for handling emergency situations / causalities. This will be continued. They attend seminars, workshops etc. organized at our Company & outside State Level / National Level. More efforts will be put in these regards.

d) Addl. General Manager (Medical services) keep liaison with City Hospitals& other Hospitals / Doctors in this area. Also we had organized a seminar in which all Doctors from surrounding hospitals- Bharuch, Ankleshwar, Baroda, participated. In this seminar, detailed information regarding our operations, various chemicals handled, health hazards, treatment methods facilities etc. were discussed. We also have given a Booklet containing properties of chemical handled by us. This practice will be continued for continuous liaison & information exchange.

e) Our Narmadanagar Hospital maintains a list of Blood donors in Company & in the Township. This will be updated. Their addresses, Telephones nos. etc. will be kept ready.

Details of Blood Banks in Bharuch, Surat, Baroda & other places will be made ready with their addresses, Telephone numbers etc. to contact them in case of emergency.

7.13.2.6 Rescue Tools

The rescue tools available at the site are shown in ***Photograph 7-3***.

Ram Jack- used to create gap of ~575 cm stroke

Cutter- Used for cutting up to 30 mm round steel diameter

Spreader- To create gap up to 720 mm distance

Lifting Bag- To lift 68 ton load up to 52 cm height

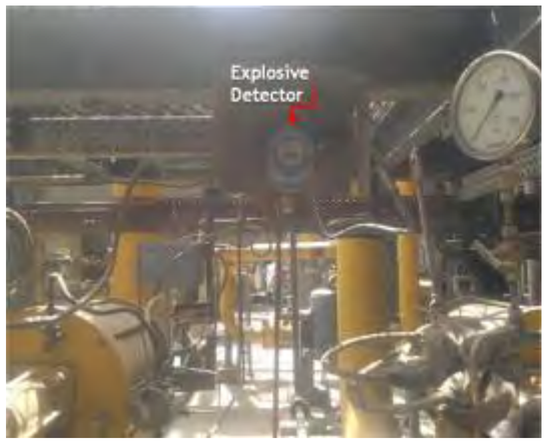
Photograph 7-3: Rescue Tools Available

7.13.2.7 Detectors

Leak detection systems are provided in the plant and leak survey is also carried out at regular bases on plant as shown in ***Photograph 7-4***.

Carbon Monoxide Detector

Ammonia Detector



Explosive Detector

Photograph 7-4: Leak Detectors installed at Site

7.13.2.8 Inventory for Fire Protection

Hydrant network is set up as per the requirement and approved from Traffic Advisory Committee & it is recertified by Loss Prevention Association. Fire protection facilities details at site is given in ***Table 7-29***.

Table 7-29: Fire Protection Facility at Site

S. No.	Description	Area	Quantity
1	Foam Tenders	Fertilizer Complex	4 Nos.
		Aniline/ TDI Complex	2 Nos.
2	Fire Water Reservoirs	Ammonia/ Urea Complex	11000 m^3
		NPP	1000 m^3
		IP Filling	1941 m^3
		Aniline/ TDI Complex	4973 m^3
3	Fire Water Pump	Ammonia/ Urea Complex	2- Electric Pumps 4- Diesel Pumps 2- Jockey Pumps
		NPP	1- Diesel Pumps
		IP Filling	2- Diesel Pumps

S. No.	Description	Area	Quantity
			1- Jockey Pumps
		Aniline/ TDI Complex	2- Electric Pumps 1- Diesel Pumps 1- Jockey Pumps
4	Fire Extinguisher	Fertilizer Complex	1016 Nos.
		Aniline/ TDI Complex	584 Nos.
5	Fire Hydrants	Ammonia/ Urea Complex	512 Nos.
		NPP	100 Nos.
		IP Filling	49 Nos.
		Aniline/ TDI Complex	211 Nos.

7.13.2.9 Occupational Health of the Contract and Sub contract Workers

Action Plan for the Implementation of OHS standards as per OSHAS/USEPA

GNFC has already procured OSHAS 18001:2007 certificate for Existing units as attached as ***Annexure 5***. For the proposed project, Action plan for the implementation of OHS Standards as per OSHAS/USEPA is as shown below:

- Display of Occupational Health & Safety Policy;
- To comply with statutory legal compliance related to the OHC dept.;
- Develop Onsite and Offsite emergency plan as Emergency Procedures to respond to Potential Emergencies;
- Schedule Regular Emergency Evacuation Drills by active participation and evaluation as and when drill planned by safety department;
- Six monthly periodic medical examinations of all workers working with the hazardous process;
- Reporting of all incidence and accidents by Accident & Incidence Reporting System;
- Investigation of all incidence and accidents by Investigation Report System;
- MSDS of all chemicals of company;
- Review of first aid facility;
- Preparing first aider & its information at work place;
- Identifying training needs of all the departments;
- Awareness of Occupational Hazards & General health promotional in workers by conducting lectures for occupational health hazards in annual planner at training center;
- Upkeepment of ambulance & OHC by maintaining records.

Health Checkup Plan

Regular (6 monthly) periodic medical checkup of contract and subcontract workers working at hazardous processes is done as per clause 68 T of Factory's Act.

Action Plan in Case of Emergency

- Same procedure and facilities are availed of for emergencies related to contract and subcontract workers, as in cases of regular employees.
- There is a well-equipped OHC available in the Plant and 32 beds Hospital in Township, very near to the Plant premises. Full time Doctor and Round the clock male nurses available at OHC. Facilities for full time specialist services, major operation theatre, pathology laboratory, digital X

ray, ECG, Doppler, Ultrasonography, Physiotherapy, In house registered pharmacy etc. are available at the main hospital.

- Total 5 ambulances with drivers also available round the clock at OHC and main Hospital for referring patients elsewhere, if need arises.
- Oxygen cylinders, antidotes like methylene blue, IV fluids, wide range of medicines and injections are available at both IMC, main hospital and even in ambulances.
- There is cashless hospitalization tie up with 32 hospitals in Gujarat and process of post pay reimbursement at all other hospitals to facilitate indoor treatment.
- There are periodic mock drills, regular first aid classes, fire audit, audit by OHSAS 18001 group and TUV Ltd.
- Onsite & Offsite emergency plans are available.

Fund Allocated

As all periodic medical checkups, data maintenance, and first aid classes are done by in house doctors and Para medicals, no separate budgetary provisions are made in any year's budget. Budgetary provision for medical reimbursement was INR 700 Lacs last year, and is INR 770 Lacs for the coming year. Medicines and laboratory reagents were budgeted at INR 100 Lacs last year and at INR 110 Lacs for next year. For conferences and trainings, including disaster management trainings, INR 3 lakhs were made available last year and 3.3 lakhs for next year.

Accident Details

Details of Injury to the contract workers in the Year 2012 are presented in ***Annexure 27***.

Health Checkup of the Workers

Unit has well planned system for health checkup for every employee including contract workers. Based on the exposures medical checkup has been carried out at pre decided interval of 6 monthly. Details of checkup are presented in ***Table 7-30***.

Table 7-30: Details of Checkup based on Exposure

Department	Exposure to Hazards	Test being Done	Age groups	Preventive actions
Acetic Acid	Acetic Acid, CO, H_2SO_4, Cl_2 GAS	Complete Blood Count, HB, PFT	42 TO 53 Yrs. / Male	Routine Counseling + Awareness Lectures Of Health Hazards
Ammonia FC	Ammonia, N_2, CO, H_2SO_4, Cl_2, Noise	Complete Blood Count, HB, PFT, Audiometry	26 TO 53 Yrs. / Male	
Ammonia Maintenance	Ammonia, N_2, CO, H_2SO_4, Cl_2, Noise	Complete Blood Count, HB, PFT, Audiometry	26 TO 59 Yrs. / Male	
Ammonia Production	Ammonia, N_2, CO, H_2SO_4, Cl_2, Noise	Complete Blood Count, HB, PFT, Audiometry	26 TO 57 Yrs. / Male	
Bagging Plant	Dust	PFT	42 TO 54 Yrs. / Male	
Boiler Maintenance	Noise, Dust	PFT, Audiometry	47 TO 54 Yrs. / Male	
Boiler production	Noise, Dust	PFT, Audiometry	40 TO 58 Yrs. / Male	

Department	Exposure to Hazards	Test being Done	Age groups	Preventive actions
Comp. Maintenance group	Noise, Dust, N_2, NH_3, H_2, CO, CO_2	Complete Blood Count, HB, PFT, Audiometry	42 TO 54 Yrs. / Male	
CPSU operation	Noise, H_2SO_4, Chlorine	Complete Blood Count, HB, PFT, Audiometry	23 TO 50 Yrs. / Male	
D/m. Maintenance	Acid Fumes	PFT	52 TO 58 Yrs. / Male	
E. acetate (process)	E. Acetate, Acetic Acid, Ethanol, H_2SO_4, Chlorine, Noise	Complete Blood Count, HB, PFT, Audiometry	23 TO 54 Yrs. / Male	
ETP	H_2SO_4, Dust	PFT	40 TO 58 Yrs. / Male	
Electrical	Noise, Dust	PFT, Audiometry	26 TO 58 Yrs. / Male	
ETP ANI-TDI	H_2SO_4, Dust	PFT	34 TO 56 Yrs. / Male	
Formic acid	Formic Acid, CO, H_2SO_4, Chlorine	Complete Blood Count, HB, PFT, Vision	42 TO 53 Yrs. / Male	Transferred to Other Plant
Hazardous chem.	Methanol, NH_3	Complete Blood Count, HB, PFT, SGPT	44 TO 57 Yrs. / Male	
IP filling station	Methanol, Acetic Acid, Formic Acid, Ethyl Acetate	Complete Blood Count, HB, PFT, SGPT	39 TO 53 Yrs. / Male	
Laboratory	Chemicals, Acids, Heat, Fumes	Complete Blood Count, HB, PFT, SGPT	28 TO 59 Yrs. / Male	
Methanol-II	Methanol, H_2, CO, Cl_2, H_2SO_4, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	24 TO 50 Yrs. / Male	
Methanol-II (M)	Methanol, H_2, CO, Cl_2, H_2SO_4, Noise	Complete Blood Count, HB, S. CRATININE, SGPT, PFT, Audiometry	25 TO 57 Yrs. / Male	
Nit. Phos (CNA-III)	NO_X, Dust, Nitric Acid, NH_3, Noise	Complete Blood Count, HB,, S. Cratinine, SGPT, PFT, Audiometry	27 TO 51 Yrs. / Male	
Nit. Phos (WNA-II)	NO_X, Dust, Nitric Acid, NH_3, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	22 TO 54 Yrs. / Male	
Nit. Phos (ANP)	NO_X, Dust, Nitric Acid, NH_3, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	23 TO 59 Yrs. / Male	
Nit. Phos (CAN)	NO_X, Dust, Nitric Acid, NH_3, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	40 TO 54 Yrs. / Male	

Department	Exposure to Hazards	Test being Done	Age groups	Preventive actions
Nit. Phos (CNA)	NO_X, Dust, Nitric Acid, NH_3, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	25 TO 48 Yrs. / Male	
Nit. Phos (WNA)	NO_X, Dust, Nitric Acid, NH_3, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	25 TO 54 Yrs. / Male	
Nit. Phos Maintenance	NO_X, Dust, Nitric Acid, NH_3, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	24 TO 56 Yrs. / Male	
Product Handling	Dust	PFT	48 TO 59 Yrs. / Male	
SGGU	Methanol, CO, H_2, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	39 TO 50 Yrs. / Male	
Urea Maintenance	Urea Dust, NH_3, CO_2, H_2SO_4, Cl_2, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	24 TO 57 Yrs. / Male	
Urea production	Urea Dust, NH_3, CO_2, H_2SO_4, Cl_2, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	32 TO 56 Yrs. / Male	
Utility (DM)	HCl, HNO_3, H_2SO_4, Noise, Dust	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	38 TO 57 Yrs. / Male	
Inspection	Chemicals, Acids, Dust, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	25 TO 54 Yrs. / Male	
Instrument	Chemicals, Acids, Dust, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	25 TO 57 Yrs. / Male	
Contract workers	Chemicals, Acids, Dust, Noise	Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	24 TO 54 Yrs. / Male	
Aniline	Aniline, CO, H_2SO_4	G 6 PD, Metheamoglobin, Urine Phenol, Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	31 TO 55 Yrs. / Male	OHH Awareness
Benzene, Nitrobenzene	Benzene, Nitrobenzene	G 6 PD, Metheamoglobin, Urine Phenol, Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry	34 TO 40 Yrs. / Male	
TDI	TDI, Toluene, ODCB, Noise	G 6 PD, Metheamoglobin, Urine Hippuric Acid, Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry, Urine R & M	25 TO 45 Yrs. / Male	Transferred to Other Plant

Department	Exposure to Hazards	Test being Done	Age groups	Preventive actions
Phosgene	Phosgene, Cl_2, CO	PFT, Complete Blood Count, Hb, S. Cratinine, Sgpt,, Audiometry	26 TO 45 Yrs. / Male	-
Mech. Maintenance. ANI-TDI	Aniline, CO, H_2SO_4, Noise, TDI, Toluene, ODCB, Phosgene	G 6 PD, Metheamoglobin, Urine Phenol, Urine Hippuric Acid, Complete Blood Count, HB, S. Cratinine, SGPT, PFT, Audiometry, Urine R & M,	28 TO 53 Yrs. / Male	OHH Awareness

Other tests being done are near &distant vision test, colour vision test, ECG, clinical examination.

7.13.2.10 Antidote and First Aid Box

Methylene Blue injection is used as antidote for exposure of Aniline which leading to Metheamoglobinemia (Cynosis). It is stored at room temperature. Its availability at site has to maintain by the OHC. At plant ~ 101 first aid boxes are available at different location. In ANI- TDI unit ~ 11 first aid boxes are available rest is found in Unit- I.

Photographs of occupational health center and checkup are given in ***Photograph 7-5***.

Photograph 7-5: Photographs of Occupational Health Centre and Check up

Reporting Mechanism

GNFC have a system of reporting of non compliance / violations of environmental norms to the board of Directors of the company. Meetings are conducted to review the status of non compliances as mentioned below:

- Daily: General meeting, department wise with DPM.
- Once in 2 months: Board meeting.
- Yearly: ISO 14001 review meeting.

7.14 Precautions Taken During Storage and Transportation of Hazardous Chemicals

Benzene

- Tank design and installed as per CCE (Chief Controller of Explosive) approval with Emergency vent provided to avoid pressurization of tank and Flame Arrester provided to avoid backfire.
- Foam chamber & water curtain system installed in Benzene / Toluene storage tanks/ tanker area as per CCE.

- Sniffer provided for early detection of any leakage.
- To avoid static electricity while unloading of materials, Earthling interlock provided with unloading pump and jumpers provided for the continuity of earthing. The system earthing is checked at regular interval.
- Dyke wall is provided for containing any leakage.
- Special brass tools are used to avoid spark generation while connecting tankers.
- Shut off Control Valves provided for remote isolation of tanks in case of any leakage.

Toluene

- We have installed 2 main storage tanks of Toluene each of 400 m^3. Total storage capacity is 800 m^3.
- Tank design and installed as per CCE (Chief Controller of Explosive) approval.
- FLA provided to avoid backfire.
- Foam chamber & water curtain system installed in Benzene / Toluene storage tanks/ Tanker area as per CCE.
- To avoid static current while unloading of materials, earthling interlock provided with unloading pump and jumpers provided for the continuity of earthling. The system earthing is checked at regular interval as per defined schedule.
- Special brass tools are used to avoid spark generation while connecting tankers.
- HS provided for remote isolation.

Nitro Benzene (NB)

- Requisite PPE is used to avoid NB exposure.
- Safest pump reactor technology has been given by Chematur Engineering.
- Water Sprinkler system provided at reactor/distillation section to mitigate any emergency during run away reaction.
- Dyke wall provided for catchments of leakage.
- Sniffers installed at NB plant & Benzene storage tank for early detection of leakage.
- Rupture disc followed by Safety valve installed at various equipment handling hazardous chemicals.
- Emergency draining system is installed in NB plant.
- Scrubbing system installed for scrubbing of organic & acidic fumes from equipments / intermediate & Product tanks.
- Multiple interlocking system to cutoff feed automatically on any abnormal process deviation e.g. Temperature / pressure / flow etc.

Phosgene Plant

- No storage of phosgene.
- Installation of minimum flange joints (Tongue & groove type) & high schedule pipe rating helped in preventing leakages.
- Online CO/Cl_2 analyzer in phosgene synthesis to monitor the parameters.
- Stand by phosgene synthesis reactors.
- Rupture disc followed by PSV have been installed.
- Phosgene synthesis cooling circuit pump is emergency power backed.
- Multiple interlocking system to cut off feed automatically on any process deviation e.g.Temperature / Pressure /Flow etc.

- Sniffer for detecting CO, Cl_2, Phosgene are installed at various location to identify leakage at the earliest.
- Plant can be stopped from C/R & field immediately.
- Caustic scrubber system to evacuate hold up volume of Cl_2/Phosgene with emergency power backed pumps & blowers.
- Elephant Trunk system for instant handling of any leakage.
- Water sprinkler system installed surrounding phosgene plant to contain leakage.

Hydrogen (H_2)

- No storage of hydrogen in aniline plant area.
- The Hydrogen flow can be isolated from remote control room with the help of Digital Control System (DCS).
- H_2 vent line has flame arrester and also with steam purging to avoid any fire in the system.

Aniline

- Water sprinkler system installed surrounding Aniline Reactor & all organic handling area to mitigate any fire hazards.
- Rupture disc followed by Safety valve installed at various equipment handling hazardous chemicals.
- Multiple interlocking system to cutoff feed automatically on any process deviation e.g. Temperature / pressure / flow etc.
- Required Antidotes (Methylene Blue) kept at medical center for any exposure to Aniline.
- Proper training in handling is given to any new employee (Contractual as well as our own employee).
- Periodical medical check up carried out to identify exposure of Aniline / benzene.
- Dyke wall provided for catchments of leakage.
- Pressure Control Valve & breather valves provided to avoid pressurization & vacuum.
- Airline masks with Breathing Air System is provided at different locations in the plant.

MTD

- Multiple interlocking system to cut off feed automatically on any process deviation e.g. Temperature / Pressure / Flow etc.
- Rupture Disc followed by PSVs have been installed.
- Reactor vent H2 gas passes through Catch Tank & Emergency Flare pot system before being discharged into atmosphere.
- Water sprinkler system surrounding MTD reactor & its bottom circulation pump.
- Dyke wall is provided for containing any leakage from storage tanks.
- Storage tanks are provided with N2 purging-cum-blanketing system.
- Vent gases from MTD storage tanks are subjected to Wet Scrubber before discharging into atmosphere.
- Magnetic driven pumps (sealless pumps) have been installed.
- MTD is highly hazardous in nature. Required PPEs are used. Periodical medical check-up being carried out.
- Proper training is imparted to any new employee (contractual as well as company employee).

TDI Plant/TDI Storage/HCl/HCl Storage:

- TDI is kept stored in barrels also.
- 11number of HCl storage tanks have been installed. Total HCl storage capacity is 1350MT.
- Online analyser of loop Phosgene / HCl in TDI synthesis.
- Multiple interlocking system to cut off feed automatically on any process deviation e.g.Temperature / Pressure / Flow etc.
- Emergency power back-up is available to critical motors.
- Emergency scrubber has been installed to mitigate any emergency arising out of release of Phosgene from Phosgene plant, reactor separator, degasser, HCl stripper, degasser compressor, phosgene absorption column & other various distillation sections of TDI plant. Emergency scrubber system has been installed with emergency power back-up pumps & blowers.
- Vent scrubber has been installed to scrub process vent gases from TDI plant & HCl absorption system, TDI tank farm & drumming area.Vent scrubber is equipped with Elephant Trunk system for instant handling of any leakage. Vent scrubber system has been installed with emergency power back-up pumps & blowers.
- Venturi scrubber system has been installed for handling of HCl gases arising out of HCl storage tanks, while filling HCl into tankers.
- Product TDI drumming is carried out on automated system.
- ODCB is used as a solvent, which is recycled to the system. Required PPEs are used to handle it.

AN Melt Storage Safety

- Only saturated steam usage in evaporation by steam saturator.
- Steam letdown to special level < 8 bar g so as to restrict high temperature to 175 °C.
- Falling film type evaporators provided - no stagnant portion subject to overheating.
- Pumps: Casing Temp. Sensing switch with trip setting~155 °C.
- In synthesis reactor, circulation flow of 200 m^3/hr is maintained so as to get uniform temp, pH and local overheating is avoided.
- NH_3dosing line provided to control its pH.
- Heating of piping by LP sat. Steam of 4.5 bar to avoid AN crystallization and prevent overheating.
- Before feeding 60% AN to evaporators, automatic pH controllers are provided.
- Storage in alkaline condition so that there is no scope of unneutralised acid.
- Storage in atm. tank under slight vacuum by exhaust blower.
- Pumps with discharge flow measurement and low flow switch.
- Pumps with circulation line back to suction to prevent pump running with blocked discharge.
- Motors of AN pump with current low trips to prevent overheating of stagnant fluid in the casing in the event of pump decoupling.
- Evaporation unit separators level measurement by radioactive sensors which are highly reliable and not affected by foaming or encrustation. Accurate levels in separator helps in preventing built up of level.
- Only DM water is used in nitric acid production hence high chlorides through nitric acid is ruled out.
- Water tank provided at fifth floor for emergency water feed in the tank.
- Outlet HS valves provided which opens at 150 °C.
- Level indicator provided on control panel.
- High level & Low level alarm provided in control room.
- Collection pit provided.

- Drain provided at lowest point of tank leading to effluent.
- Earthing and bonding done.
- Tank is insulated.
- Fire monitors and fire hydrants system around the tank.
- Fire water addition for dilution and cooling in case of emergency in all tanks.

Ammonium Nitrate (NH_4NO_3) - Loading operation Safety

- Dedicated tankers for AN melt and inspection and washing of AN melt tankers before loading.
- Pumps provided with trips on high casing temperature, low flow and low current.
- Storage tanks provided with water dumping on high temperature.
- PH control system for storage tanks.
- Steam cut off to storage tanks on high temperature.
- Blast proof wall in AN melt tanker filling area. The blast wall is in C shape protecting tanks, control room and all plant areas.
- Temperature monitoring in AN melt tankers during filling and water injecting / dumping in event of high temperature in tankers. This operation is on auto.
- Auto cut off valves are there for filling and when set pre determine quantity is filled up filling valve gets closed. Mass flow meter is there.
- Operations are controlled automatically and remote operated valves are there. Filling stops and water is started into road tanker in case of temperature rise.
- Check list for operator available.
- Inspection and certification of tankers fitness by third party.
- Tanker washing facility available.

DNT Storage Safety

- Storage as per CCE approval.
- Bunker provided for the handling of DNT. DNT is stored in emulsion form with 40:60 ratio in water.
- Safest technology for nitration system.
- Fire monitors and fire hydrants system around the tank.
- Temp transmitter with high alarm and plant tripping system to avoid TNT formation.
- Installation of 1 number of jacketed/limpet tank having capacity of $40m^3$ for storage of DNT.
- DNT is stored in the form of water/DNT emulsion.
- Tank is kept in circulation on round the clock basis having emergency power back-up.
- Pump nitration technology having very low inventory of raw material at a particular moment.
- Dyke wall is provided for containing any leakage of stored DNT.
- Emergency draining system is installed in DNT plant.
- Vent condensers are installed for condensing vapors prior to sending the NO_x gases to plinked NO_x unit.
- Multi-layer interlocking system to cut off feed automatically on any process deviation, e.g. Temperature/pressure/flow etc.
- Pumping of pure DNT is about 45m radially away from main plant, as per approval from CCE.
- Pure DNT handling pump is installed in a bunker surrounding 1m thick concrete wall.
- All the lines of DNT plant are traced with hot water to avoid excessive heating.

Concentrated Nitric Acid (CNA)

- Tanks are made of pure aluminum and tanks are designed with dip seal system to avoid pressurization and vacuum while loading / unloading.
- Dyke wall is provided for containing any leakage.
- Requisite Personal Protection Equipment (PPE) is used to avoid CNA exposure during any operation.

Sulfuric Acid (SA)

- Dyke wall is provided for containing any leakage.
- Requisite PPE is used to avoid exposure.

Caustic Soda

- Dyke wall is provided for containing any leakage.
- Requisite PPE is used to avoid Caustic Soda exposure.

Cl_2 Handling/Storage System

- Cl_2 from tonners is transferred to Cl_2 bullets using Nitrogen.
- CCE approved Cl_2 tonner shed to keep 200 tonners at a time.
- 3 no. of Cl_2 storage bullets, each having $100m^3$ capacity, have been installed, keeping 1 bullet in empty condition all the time to mitigate any exigency.
- Installation of all the Cl_2 bullets are as per approval from CCE.
- Various Chlorine sniffers have been installed at different location for detection of any leakage.
- Separate Cl_2 scrubber (two in numbers) has been installed circulating Caustic Solution having emergency power back up for its pumps & blowers.
- Scheme for strengthening existing Cl_2 scrubber is under way.
- Elephant Trunk (ET) system for instant handling of any leakage.
- Installation of Tongue & Groove type flanges with bellow seal type isolation valves at various locations with minimum flange joints & high schedule pipe rating.

Annexure 5: ISO 14001:2004 and OSHAS 18001:2007 Certificates

CERTIFICATE

TÜV NORD

Management system as per
ISO 14001 : 2004

In accordance with TÜV NORD CERT procedures, it is hereby certified that

GUJARAT NARMADA VALLEY FERTILIZERS & CHEMICALS LTD.
P.O. Narmadanagar,
Bharuch - 392 015, Gujarat,
India

applies a management system in line with the above standard for the following scope

Manufacture of Fertilizers, Chemicals, Petrochemicals and Supporting Facilities

Certificate Registration No. **44 104 020515**
Audit Report No. **2.5-0286/2003**

Valid until **03.09.2016**
Initial certification **08.01.2002**

Certification Body
at TÜV NORD CERT GmbH

Issue **10.09.2013**
Place : **Mumbai**

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH | Langemarckstrasse 20 | 45141 Essen | www.tuev-nord-cert.com

TGA-ZM-07-06-60

ISO 14001:2004 Certificate for Existing Unit

CERTIFICATE

TÜV NORD

Management system as per
BS OHSAS 18001 : 2007

In accordance with TÜV NORD CERT procedures, it is hereby certified that

GUJARAT NARMADA VALLEY FERTILIZERS & CHEMICALS LTD.
P.O. Narmadanagar,
Bharuch - 392 015, Gujarat,
India

applies a management system in line with the above standard for the following scope

Manufacture of Fertilizers, Chemicals, Petrochemicals and Supporting Facilities

Certificate Registration No. **44 116 071368**
Audit Report No. **2.5-0286/2003**

Valid until **03.09.2016**
Initial certification **04.09.2010**

Certification Body
at TÜV NORD CERT GmbH

Issue **10.09.2013**
Place : **Mumbai**

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH Langemarckstrasse 20 45141 Essen www.tuev-nord-cert.com

TGA-ZM-07-06-64

OSHAS 18001:2007 Certificate for Existing Unit

Annexure 27: Details of Injury to the Contract Workers in the Year 2012

S. No.	Date	Arrival at OHC	Name	Type of Injury/Exposure	Place of incidence	Ref. To Hospital	Place of Treatment	Fit/ Unfit
1	03/01/2012	11.00 AM	Imran A khan	Cut On Forehead by Iron Road	Nitro Bagging (D&C worker)	No	OHC	Fit
2	20/01/2012	4.30 pm	Shaikhali Shaiyed	Crush Injury over Rt.Index Finger	Meth - II	No	OHC	Fit
3	25/01/2012	1.10 PM	Chaturbhai Parmar	Head Injury	Hazardous (Sanitory Worker)	No	OHC	Fit
4	29/01/2012	9.00 pm	Yunushbhai	Liq. TDI Exposure in Lt. EYE	TDI tank farm (LAB samplers)	No	OHC	Fit
5	09-02-2012	10.05 am	Hiren Patel	Weldinf Flash in Both Eyes	Ammonia Tank	No	OHC	Fit
6	12-03-2012	7.10 PM	Mohmed Sahid Ali	CO exposure	AMM. Plant -Safety Valve - T201B	No	OHC	Fit
7	21/03/2012	9.50 am	Shanabhai B. Solanki	Inury over Rt. Forearm	Amm.Plant (Mech)	No	OHC	Unfit
8	27/03/2012	9.10 am	Vikram Vankar	lt. Shoulder,Chest Injury, Slip of Foot	CPSU -PO4 dosing tank	No	OHC	Fit
9	30/03/2012	7.15 PM	Buddhipal	# Lt. tibia lower third	Boiler Ash	Yes	Dr. Sheth	Unfit
10	04-11-2012	7.00 PM	Shreedharan S.	Aniline Exposure	Aniline Tank Farm	No	OHC	Fit
11	02-05-2012	12.45 pm	Dinesh Gohil	Phosgene Exposure	Phosgene Plant	Yes	Hospital	Unfit
12	02-05-2012	12.45 pm	Jay Hind	Phosgene Exposure	Phosgene Plant	Yes	Hospital	Fit
13	02-05-2012	12.45 pm	Suresh Gohil	Phosgene Exposure	Phosgene Plant	Yes	Hospital	Fit
14	02-05-2012	8.35 pm	Maganbhai C Vasava	Crush Injury over Lt. Nostril & Lip	Ammonia Plant	No	OHC	Fit
15	03-05-2012	6.10 pm	Javed A Divan	Ammonia Exposure	Ammonia Plant	No	OHC	Fit
16	04-05-2012	4.00 pm	Dharamchan K Nagar	Honey Bee Bite(Multiple)	LPG Haz. Plant	No	OHC	Fit
17	09-05-2012	1.50 am	Dinesh Gohil	Chlorine Gas Exposure	Chlorine Tonner	No	OHC	Fit
18	21-05-2012	12.50 pm	Dinesh B. Dintali	CLW on Rt. Hand Palm	Acetic Acid	No	OHC	Fit
19	22-05-2012	12.25 pm	Ramesh S Yadav	Clw on Rt. Index Finger	SGGU Plant	No	OHC	Fit
20	23-05-2012		Tausif Ahmed Patel	Crush Injury Rt. 4th, 5th Fingers	Meth - II	No	OHC	Unfit
21	24-05-2012	4.00 pm	Kapil Dev Mahato	Injury on Lt. Little Finger	NB plant	No	OHC	Fit

S. No.	Date	Arrival at OHC	Name	Type of Injury/Exposure	Place of incidence	Ref. To Hospital	Place of Treatment	Fit/ Unfit
22	27-05-2012	6.00 am	Tirath sinh	Cut Injury on Lt. hand palm	LPG area	Yes	Hospital	Unfit
23	31-05-2012	7.05 pm	Manoj C. Doherawala	Hydrazine in Both Eyes	CPSU	No	OHC	Fit
24	03-06-2012	3.00 am	Amarjit Singh	Phosgene Exposure	TDI Plant- 2nd Floor	No	OHC	Fit
25	03-06-2012	3.00 am	Kalvindear Singh	Phosgene Exposure	TDI Plant- 2nd Floor	No	OHC	Fit
26	04-06-2012	1.00 am	Bhagirath	TDI Exposure	TDI Plant	No	OHC	Fit
27	05-06-2012	1.00 am	Kapil Dev Mahato	TDI Exposure	TDI Plant	No	OHC	Fit
28	07-06-2012	11.00 am	Thakor C Vasava	Aniline Exposure	Aniline Tank Farm	No	OHC	Fit
29	13-06-2012	6.15 pm	Manoj Sing	Bitumen Exposure	Acetic Acid	Yes	Hospital	Unfit
30	29-06-2012	1.25 pm	Takebahadur F.Thapa	Cut Injury on face (Cheek)	Disel section(Forklift crans)	No	OHC	Fit
31	07-07-2012	10:15am	Dhaval D Suthar	Multiple Brise on Rt. Elbow, Knee and Gluteal region	Ethyle Acetate project site (2nd floor)	No	OHC	Fit
32	21-08-2012	05.15 am	Arjun D. Parmar	Cut injury over Left leg (shin)	Haz. Chem Plant	No	OHC	Fit
33	05-09-2012	8:50am	Gumanbhai Nathuram Dhurasta	Crush injury over Rt. Middle & Ring finger	D M Maintanance workshop	Yes	Hospital	
34	17-09-2012	5:25 PM	Parbatbhai R Parmar	Liq. Acetic in Lt. eye	IP filling plant	Yes	OHC	
35	21-09-2012	11:45 PM	Pravin K Vasava	Liq Methanol in both eyes	Haz. Chem Plant	No	OHC	
36	28-09-2012	19:20 PM	Ranjit Vakad Vasava	Hot water burns on Lt. leg	Ethyle Acetate plant	No	OHC	Fit
37	01-10-2012	10:00 AM	Sanjay J Thakore	Steam Burns on lT. forearm	NPP (ANP plant)	No	OHC	Unfit

Appendix 2 & 3 – MSDS for existing chemicals (Pg. 878 – 1211)

shall be submitted in CD due to limitation of file size for uploading.