RISK ASSESSMENT REPORT

FOR

CAPACITY EXPANSION OF LPG BOTTLING PLANT FROM 1063 MT TO 1963 MT AT UPSIDC INDUSTRIAL AREA, VILLAGE AND P.O. RATI KA NAGLA, TEHSIL: SIKANDRA RAU, DIST: HATHRAS, SALEMPUR, UP

By
Project Proponent:
M/s. BHARAT PETROLEUM CORPORATION LIMITED

Environment Consultant

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Abbreviations

MSIHC	Manufacture, Storage and Import of Hydro Carbons
OISD	Oil Industry Safety Directorate
PNGRB	Petroleum and Natural Gas Regulatory Board
NFPA	National Fire Protection Agency
RA	Risk Assessment
RRA	Rapid Risk Assessment
BPCL	Bharat Petroleum Corporation Limited
MOV	Motor Operated Valve
ROV	Remote operated Valve
NRV	Non Return Valve
SDV	Shut Down Valve
ESD	Emergency Shut Down
ESDV	Emergency Shut Down Valve
P&ID	Piping and Instrumentation Diagram
PFD	Process Flow Diagram
PHAST	Process Hazard Analysis Software Tool
OGP	Oil & Gas Producers
ALARP	As Low As Reasonably Practicable
HSE	Health, Safety & Environment
IR	Individual Risk
ISIR	Individual Specific Individual Risk
LSIR	Location Specific Individual Risk
SR	Societal Risk
HCRD	Hydro Carbon Release Database
ECC	Emergency Control Centre
LFL	Lower Flammable Limit
UFL	Upper Flammable Limit
DMP	Disaster Management Plan
MSDS	Material Safety Data Sheet
VCE	Vapour Cloud Explosion
BLEVE	Boiling Liquid Expanding Vapor Cloud Explosion
TLF	Truck Loading Facility
LPG	Liquified Petroleum Gas

1 : EXECUTIVE SUMMARY

1.1 EXECUTIVE SUMMARY

In order to assess the risk associated with the Transfer, Receipt and Storage of Liquified Petroleum Gas (LPG) by Bottling Plant, SalempurRisk Assessment (RA) study was carried out in the baseline Period from January to March 2018. The objectives of the study are to identify the vulnerable zones and estimate hazard distances for the scenarios generated due to accidental release of hazardous chemicals through Maximum Credible Accident (MCA) analysis. Risk mitigation measures are recommended based on the study. Disaster management plan is delineated covering onsite and offsite emergency scenarios.

The hazards associated with the LPG Bottling Plant, Salempur have been identified and categorized based on the computation of Fire and Explosion Indices. MCA analysis has been carried out to arrive at the hazard distances for Flammable release scenarios. The damage distances have been computed at an atmospheric stability class of "F" & 'D' with the wind velocity of 2, 3 & 5 m/s which is the most prevailing atmospheric condition around the proposed facility.

Accidental scenarios for Flammable release in case of Leak &piping rupture of LPG Bottling Plant, Salempur are documented. Damage distances have been tabulated by using PHAST & PHAST RISK software.

Table 1.1: Worst Case Consequence Analysis Result for 300 MT MSV at 5 D Wind Stability class

S. No.	Scenario Considered	Flash Fire At LFL concentration distance (m) for 5D wind stability Class	Jet Fire (m) for 5 D Wind Class at 37.5 kW/m^2	Fire ball(m) for Wind Class at 37.5 kW/m^2
1.	Proposed SRV of 300 MT MSV 5 MM Failure Leak	5.98081	9.91396	N/A
2.	Proposed 300 MT MSV 10 MM Leak	13.4482	18.9986	N/A
3.	Proposed 300 MT MSV 20 MM Leak	42.1192	35.6726	N/A

S. No.	Scenario Considered	Flash Fire At LFL concentration distance (m) for 5D wind stability Class	Jet Fire (m) for 5 D Wind Class at 37.5 kW/m^2	Fire ball(m) for Wind Class at 37.5 kW/m^2
4.	Proposed 300 MT MSV 50 MM Leak	153.088	81.1911	N/A
5.	Proposed 300 MT MSV Catastrophic Rupture	1177.54	9.91396	580.545
6.	Cylinder filling Shed Catastrophic Rupture in (200 no of 14.2 KG Cylinder)	118.781	N/A	N/A
7.	Cylinder filling Shed Catastrophic Rupture in (200 no of 19 KG Cylinder)	135.65	N/A	N/A

The maximum risk to persons working in the Station/terminal are within the ALARP Region and is 1E-04 per year.

It is observed that the ISO-risk contour of $1x10^{-6}$per year to $1x10^{-9}$per year is within the Station/terminal and the risk contour of $2.666x10^{-6}$ per year extended to the adjoining facilities.

This risk can very well be reduced by implementing adequate safety measures. As the terminal has already implemented auto shut off parameters controlled by control room taking in view of safety standards and compliances to various regulating authority. Regular monitoring and inspection schedule is in place.

Risk mitigation measures are recommended based on MCA analysis. Precautions to be taken for storage facility are listed.

1. Elimination of ground level ignition source
2. Nozzle for vapour cloud dispersion is to be put into operation
3. Provision for vapour dilution system

2 : INTRODUCTION

2.1 INTRODUCTION

Bharat Petroleum Corporation limited is a public sector undertaking company of government of India, deals in refining petroleum crude oil, distribution and marketing of the same in domestic and international market. It is considered a pioneer in marketing initiatives, and employs – "Best in Class" practices.

With a corporate vision to be 'The Energy of India' and to become 'A globally admired company,' Bharat Petroleum business interests straddle the entire hydrocarbon value-chain – from refining, pipeline transportation and marketing of petroleum products to exploration & production of crude oil & gas, marketing of natural gas.

The Liquefied Petroleum Gas (LPG) is transferred to Above Ground Bullets and MSV, LPG is then filled in to tanker and cylinders by operating LPG Pump.

The flow diagram of LPG Bottling process is given at the end of this section. LPG from bullets is transferred through a pipeline to filling manifolds of carousel and TLD with the help of centrifugal pumps.

The empty LPG cylinders brought into premises by Lorries are received and stored in the empty shed. They are fed to carousels / filling gun after due inspection through conveyor system in the filling shed. The filling is cut off as soon as the weight of LPG in the cylinder reaches 14.2 kg/19/47.5. After filling, these cylinders are counter checked for correct weight, tested for leaks from valves and body, capped and sealed before sending them to the filled cylinder shed. Any defective cylinder is emptied at evacuation unit and sent for cold repair in the "valve-changing" shed.

The material being handled, LPG is highly flammable. It is also stored in substantial quantity within the plant area. There is therefore, a substantial potential for damage and injury in the event of significant amount of LPG catching fire. Also being liquefied gas, there is some risk of formation of vapor cloud, which if ignited, could cause wide spread damage and injury. Therefore, there is a need to ensure that the site is separated from any concentration of people and building. The risk of storing and handling of high Inventories of flammable materials like LPG needs to be evaluated in order to plan suitable measures for reducing the risks and also to act quickly in case of emergency.

This report contains the Risk Analysis study for the LPG Bottling Plant, Salempur. The study is broadly divided into the following:

1. Identification of hazards
2. Effects and Consequence analysis
3. Risk analysis
4. Comparison against risk acceptance criteria
5. Recommendation for Risk Reduction`
6. Disastermanagement Plan

2.2 IMPORTANCE OF THE PROJECT

2.3 SCOPE OF STUDY

Vardan EnviroNet has been appointed for carrying out the Risk Analysis (RA). The objective of the Risk Analysis & HAZOP study is to identify vulnerable zones, major risk contributing events, understand the nature of risk posed to nearby areas and prepare a basis for the Emergency Response Disaster Management Plan (ERDMP). In addition, the Rapid Risk Analysis & HAZOP study is also necessary to ensure compliance to statutory rules and regulations. The project is involving Hazard Identification and Risk Analysis study of IOCL LPG Bottling plant as per IS-15656:2006. IOCL LPG bottling plant was started in 1997, all the existing facilities of Plant like firefighting, electrical system, Pump house, internal Piping etc. would comply with national, international standards and M.B. Lal committee recommendations.

Risk Analysis broadly comprises of the following steps:

- Project Description
- Identification of Hazards and Selection of Scenarios
- Effects and Consequence Calculations

- Risk Summation (Risk calculation)
- Risk assessment (using an acceptability criteria)
- Risk Mitigation Measures

2.4 EXECUTION METHODOLOGY

The methodology adopted for executing the assignment is briefly given below:

2.5 KICK-OFF MEETING WITH VARDAN

This was used to set the study basis, objectives and related matters and also identify in detail the facilities to be covered in the RA Report.

2.6 STUDY OF BPCL OPERATIONS

This was carried out for studying the Operation Philosophy for LPG Bottling plant, Salempur.

2.7 STUDY OF BPCL OPERATING PARAMETERS

This involved collection of pertinent project information on the operation process details such as P&ID's, process flow diagram and Plant Layout. Critical instruments their temperature and pressure and other details. The data so collected would ensure a more realistic picture for the risks subsequently identified and estimated.

3 : PROJECT DESCRIPTION

3.1 PROJECT DESCRIPTION

LPG is received at the plant in Tank Trucks by Road which are weighed in weighbridge and taken to the plant for decantation. LPG is unloaded from the Tank through pipeline and store in Existing 3 No of 150 MT Each of Above Ground Bullets and 1 no of 613 MT MSV storage.

LPG Tank Trucks is checked at main gate as per SOP. Exhaust is fitted with spark arrestor. Tank Trucks is properly earthed. LPG is filled in storage vessels (Bullets). LPG is utilized for filling of cylinders in the filling shed. For filling of cylinders, LPG pump is used. Filled cylinders are checked for weight correctness and leakage etc. The filled cylinders are stored in open shed, and dispatched.

The project is involving for Receipt, Storage and Distribution of Liquefied Petroleum Gas. All the facilities of Plant like firefighting, electrical system, Pump house, internal Piping etc. is complying with national, international standards and M.B. Lal committee recommendations. Project Proposal is as follows:

Table 3.1: Project Proposal

Sl. No.	Product	Types of storage unit	Quantity	Capacity (MT)
Existing (Capacity – 1063 MT):-				
1.	LPG	Bullets (Above ground)	3	150
2.	LPG	Mounded storage vessel (MSV)	1	613
Proposed (Capacity – 900 MT)				
1.	LPG	Mounded storage vessel	3	300

3.2 TYPE OF PROJECT

BPCL has LPG Bottling Plant Facilities at Rati Ka Nangla, Hathras, Salempurwhich include, Product storage vessels, TLD shed, product pump house, warehouse, security block, control room, MCC panel room, electrical substation, PMCC room, canteen, DG sets, parking, firefighting facilities such as fire pump house & fire water tanks as per OISD 116/117 norms, administration and amenities facilities and standard civil facilities. Safety and pollution control facilities have been provided as per statutory pollution control rules.

3.3 PROCESS DESCRIPTION

At present the Bulk LPG required for bottling is transported to the plant by road tankers of 12 to 18 MT Capacity which are specially fabricated for LPG transportation from Dahej, Pipavav and Jamnagar (Gujarat) through Vessel mounted trucks. LPG from road tankers is decanted to the LPG storage vessels (Bullets) by the pressure differential method using the LPG vapor compressors provided for the purpose.

LPG from the storage bullets will be pumped to the Existing 1 * 24-point electronic filling machines and Operational capacity of plant is also being increased by erection of 1 new 24 station carousel. The empty gas cylinders will be filled using the pneumatically operated filling guns. Each cylinder for domestic use will be filled with 5 kg, 14.2 kg of LPG, weight being automatically adjusted. The cylinders for industrial use will be filled with 19.0 Kg of LPG. After filling, the cylinders pass through various quality checks including the weight check, leak test etc., before sealing. The cylinders will be stored at the existing Filled Cylinder storage shed and loaded into trucks for dispatch. The Bottling Plant has following facilities as per OISD 214, 144 & M B lal committee recommendations.

A. Existing Plant Facilities

The plant functions primarily as LPG receipt, storage & bottling unit for filling into various size cylinders. The plant operations are categorized as, The LPG Bottling plant is for receipt, storage and distribution of petroleum products. Details of sections in the plant are as follows:

(a) Tank Lorry Filling Shed

An eight bay Tank Lorry Filling Shed (TLF) has been provided to transfer LPG from LPG bullet to tanker.

(b) LPG Bullets Storage's

Bottling Plant has Total 1063 MT of Existing storage at site. 3 no of 150 MT each Above Ground Storage Tank and 1 no of MSV of 613 MT each are installed. The bullets have been provided with all necessary fittings, for filling, emptying, vapor pressurization, draining facilities and measuring devices like pressure gauges thermometers and level indicators.

(c) LPG Pumps and Compressor House

2 no centrifugal pumps have been installed to pump liquid LPG from bullets to carousel. These pumps have been provided with pop-action valves on discharge lines and are coupled to flame proof motors.LPG P/L SIZE: 200 mm,150 mm,100 mm ,80 mm NB, 50 mm ,32 mm NB

Table 3.2: Details of LPG Pump

Particulars	Detail
Total number of LPG Pumps	2
Suction Pressure	7-8 kg/cm^2
Discharge pressure	16 kg/cm^2
Flow rate	27 m^3/hr
Diameter of Suction Line	6”
Diameter of Discharge Line	4”

3 no LPG compressors each coupled to a flame-proof motor have been installed for unloading of LPG tankers.

Table 3.3: Details of LPG Vapor Compressor

compressor	Pressure		Flow rate	Diameter	
	Suction Pressure	Discharge Pressure		Suction Line	Discharge Line
LPG Compressor	2 kg/cm^2	8 kg/cm^2	65CFM	4”	4”

Air Compressor screw type rotary	2 Kg/cm^2	8 kg/cm^2	250 CFM, 200 CFM and 35 CFM	4"	4"
Air Dryer			250 CFM and 200 CFM		

(d) Empty cum Filling Shed

2 no of 24 points carousels with semiautomatic filling operation and cylinder conveyor have been installed in this shed. Besides the above this shed also have electronic check scales for 100% weight checking filled cylinders, Automatic valve testing machines, test bath for checking any leakage from cylinder bung and body. Lastly cylinders are sealed before being dispatched. Total 56000 Cylinders will be filled In a day

Table 3.4: Details of Existing and Proposed Project

S.No.	Particulars	Existing	Proposed	Total
1	Operation Capacity	90 TMT	90 TMT	180 TMT
2	Land Area	39.5 Acres	-	39.5 Acres
3	Storage	1063 MT	900 MT	1963 MT

3.4 PROJECT FACILITIES

Table 3.5: Project: Existing Statutory Clearance of LPG Bottling Plant, Salempur

CCOE LICENCES :	**VALIDITY**
S/HO/UP/03/299 (S29182) - Bulk Storage	30.09.2019
S/HO/UP/03/514(S38700) - MSV	30.09.2019
G/HO/UP/05/282(G18494) - Filling	30.09.2018
G/HO/UP/06/254(G18494) - Cylinder Storage	30.09.2018
PCB:	
Hazardous Waste Management Approval 70/2/14	09.03.2023
Water Pollution No . 44/33/11	31.12.2019
Air Pollution 78/29/11	31.12.2019
FACTORY :	
ALI - 659	31.12.2018

Table 3.6: LPG Bottling Plant at Glance

S. No.	Feature	Details
1	Name of the Company	M/s Bharat Petroleum Corporation limited (A Govt. of India Undertaking).
2	Location	UPSIDC Industrial Area, village and P.O. Rati Ka Nagla, Salempur, Tehsil: Sikandra Rau, Dist: - Hathras, UP
4	Mode of receipt	Tankers
5	Total Terminal Area	39.5 Acre

Figure 3.1: Photographs of Existing Terminal

B) Proposed MSV Details

LPG Mounded storage is designed as per the following parameters

- DESIGN CODE: ASME SEC. VIII or BS – 5500 equivalents duly approved by CCOE.
- Design Pressure 14.5 kg/cm2 at 55 deg C
- Design Temperature -27 deg C to +55 deg C
- Corrosion allowance Min 1.5 mm
- Radiography Full
- Stress relieving 100 %
- Earthquake pressure As per IS 1893
- Hydro test pressure as per design code

Design Criteria

Mounded vessel is storage vessel sited above ground and completely covered by a mound of earth or similar inert material except for nozzles, manhole covers, inspection covers fitted on vessel (s). The mechanical design of storage vessel shall be based on following considers.

i. ASME SEC VIII or PD -5500 or equivalent duly approved by chief Controller of Explosives, A single code shall be adopted for design, fabrication, inspection and testing.

The specific consideration shall give to

a) Internal vapour and hydraulic pressure

b) External loadings on the vessel

c) Internal vacuum

ii. Material: Material of construction shall conform to above design code. ASTM A516 Gr. 70(IT) or SA 537 C II(IT) or PD: 5500 or equv. Material shall be used.

iii. Design Temperature: -27ºC to +55ºC

iv. Design Pressure: 14.5Kg/Cm2g (1.42Mpa) Vapour pressure of LPG at top of the vessel (as per IS: 4576 or IS: 14861) at 55ºC.

v. Cathodic Protection System: The design of the cathodic protection system shall be an integral part of the total vessel design. The structure to soil potential is used as a criterion for effective Cathodic protection. Each vessel shall be electrically isolated from other vessels, pipelines, structures and electrical and instrument earthing systems. Transformers/Rectifiers shall be of a special design for cathodic protection services.

vi. Other Considerations: Internal Corrosion Allowance: 1.5mm (minimum)

Radiography: Full

Stress Relieving: 100% irrespective of thickness

Earthquake pressure: as per IS: 1893

The recommended design pressure and temperature shall be treated as minimum requirement and other design consideration and statutory requirements shall also be considered.

Construction Methodology

i. Mounded vessels shall be placed on a firm foundation and installed so as to prevent movement or floatation. The sub-soil water, rain water or any other surface water should not be allowed to percolate into the mound. The foundation should be constructed such that in the longitudinal direction of a vessel slope of at least 1:200 is maintained to facilitate draining of the vessel.

ii. Site conditions and soil mechanics shall be deciding factors for selection of the type of foundation in a given situation. The preferred type of foundation is a continuous sand bed, supporting the vessel over its full length. The foundation shall have sufficient load bearing capacity and all the factors affecting the foundation shall be considered while designing the same.

iii. The sand bed beneath the vessel shall be adequate elevation not less than 760millimeter (mm) to facilitate drainage from liquid outlet pipe by gravity. Proper provision shall be made for encountering the consequences of the settlement of the vessel. The surrounding of the bottom connection should be filled with such material that can absorb such settlement.

iv. The mound shall protect the vessel from the effects of thermal radiation and shall be sufficiently robust to remain in place in the event of Jet flame impingement.

v. Mound shall be of earth, sand or other non-combustible, non-corrosive material such as Vermiculate or Perlite and shall provide at least 700mm minimum thickness of cover for the vessel.

vi. The mound surface shall be protected against erosion by rain or wind by providing a suitable cover or prefabricated stone, open concrete tiles etc

vii. Water ingress into the mound shall be minimized by providing impervious layer or suitable material. Proper drainage and slope on top of the mound shall also be provided.

viii. Longitudinal axis of vessels in a mound shall be parallel to each other with ends in line.

ix. The valve and appurtenances of mounded vessels shall be accessible for operation or repair, without disturbing the mound.

x. Provision shall be made to monitor the settlement of the mound/vessels by providing permanent reference points. A minimum of three reference points shall be provided to ascertain uniform/differential settlement and also identify possible vessel bending (one each near the vessel ends and one in the middle)

xi. Provision shall be made for inserting portable CuSO4 reference electrode on top of the mound for measurement of PSP at 12'O clock position of the vessel. This shall be protected to prevent water ingress in the mound

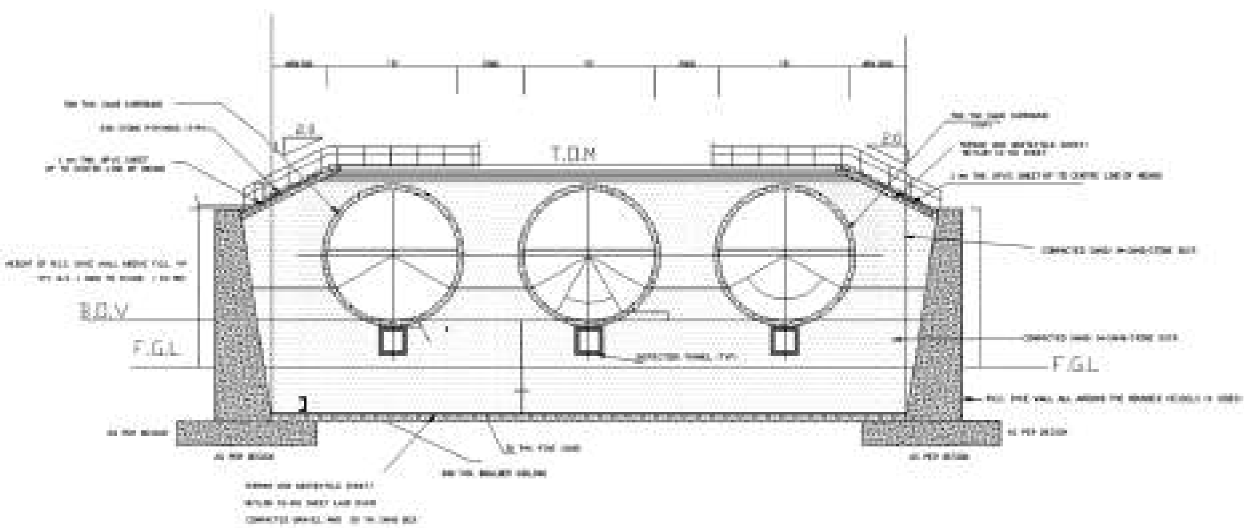


Figure 3.3:Transverse section of MSV

3.5 EXISTING FIRE FIGHTING FACILITY

Salempur LPG Plant is constructed on a total plot area of 39.5 acre. The proposed Additional Bulk Storage of the plant is 3 x 300 MT (Total – 900 MT) and the Existing Total Bulk Storage is 1063 MT. The Bulk LPG is received by TTs through Road.

We have 2carousels i.e. 24 Nos. of Electronic Filing machines each to fill 14.2 Kg cylinders and 19 Kg cylinders.

A. Firefighting facilities

The Plant is fully equipped with most modern / latest firefighting facilities. We shall be having automatic Fire Protection medium velocity sprinkler system. Details are as follows:

1. Tank Lorry Bay/Storage Vessels/Filling, Filled, LPG pump, PT shed are having Quartzite Bulb Detectors (QBDs) which will actuate the sprinkler system automatically in case of fire.
2. We have 3 Nos. (2 Main + 1 Standby) Diesel driven Fire Engine Pumps of 616 KL per hour with Auto Start Facility.The Fire Hydrant System is always kept pressurized at 7.0 Kg/cm^2 with a Maximum Flow rate of 10 KL/Hour by Electricity Operated Jockey Pumps.
3. We have Water Storage capacity of 2 nos. 2600 KL A/G Tank (Total Water Storage – 5200 KL) for fighting fire in case of most credible accident.
4. As per OISD 144, 116 & 117 (Guidelines on Fire Fighting Equipment and Appliances in Petroleum Industry) we are having 10 Kg and 75 Kg DCP Fire Extinguishers placed around the plant. Also, CO_2 Fire Extinguishers are placed wherever required as per standard.

THE FACILITIES PROVIDED ARE AS FOLLOWS:

a) Hydrants : 30 Nos.

b) Monitors : 24 Nos.

c) Deluge valves : 14 Nos.

d) MCP : 09 Nos.

e) ESD : 04 Nos.

Water replenishment is done through bore well.

Table 3.7: List of Fire Fighting Equipments

S. No.	Fire Fighting Equipments	Quantity
1.	Fire Water Tank	5100 KL
2.	Fire water pump capacity :	616 KL/HR (03 no's)
3.	Jockey Pump	2 (Capacity 10m^3/hr each)
4.	Cooling Water pump	5KL/HR
5.	Deluge valve	14 Nos.
6.	MCP	09 Nos.
7.	ESD	04 Nos.
8.	Fire hydrant monitors	30 Nos.
9.	Gas Monitoring System with 34 sensors	24 Nos.

Table 3.8: Existing Area detail of Plant (Storage, Bottling, Dispatch)

Item		Size	Area in Square Meter
1.	Admin. Building (D. Store yard)	15.0Mx20.0M	300
2.	Cycle, Car, Scooter Shed	20.0Mx5.0M	100
2A.	Cycle, Car, Scooter Shed	23.75Mx3.20M	76
3.	Security Block	3.5Mx3.5M	12.25
4.	Weigh Bridge Cabin	3.0Mx3.0M	9
5.	Fire Fighting Air Comp. Room	5.0Mx5.0M	25
6.	Fire Water Pump House	15.0MX8.00M	120
7.	FIRE WATER TANK (CAP=2x2600kl)	17Mx12.00M HT	204
8.	Transformer with Fence	7.25MX 7.25M	52.56
9.	Metering Room	3.0Mx3.0M	9
10.	H.T Panel Room	4.0Mx6.0M	24
11.	Elec. Sub-Station	20.0Mx6.0M	120
11 A.	Elec. Sub-Station	8.0Mx6.0M	48
12.	Dg Set Room	12.0Mx6.0M	72
12A.	Dg Set Shed	3.50Mx6.0M	21
13.	Air Comp.& C.W Pump House	16.0Mx6.0M	96
14.	Engg. Store	24.0Mx6.0M	1444
15.	Bulk Unloading Bays (4-Bays)	25.0Mx15.00M	375
1 5A.	Bulk Unloading Bays (4-Bays)	25.00Mx15.00M	375

16.	Time Office, Dress, Toilet	15.0Mx6.0M	90
17.	LPG Pump & Comp. House	15.0MX8.0M	120
17A.	LPG Pump & Comp. House	8.0Mx8.50M	68
18.	LPG STORAGE VESSEL (3x150 MT)	4.0M¢X 29.0M	116
19.	Toilet/ Rest Room	1O.OMX4.0M	40
20.	Empty/ Filling Shed	50.0MX37.5M 95.0MX37.5M	1875 3610
21.	Filled Cylinder Shed	30.0MX37.5M 45.0MX37.5M	1125 1687.5
22.	Pressure Testing Unit	21.0MX10.0M	210
23.	Inspection Platform	6.0MX1.0M	6
24.	Lorry Parking Area	85.0MX50.0M 85.0MX11 O.OM	4250
25.	Weigh Bridge	3.0Mx16.0M	48
26.	WATCH TOWER (5 Nos)	2.0MX2.0M	4
27.	Cooling Tower	7.50 M HIGH	7.5
28.	Bore Well (2nos)	4.0M X 3.0M	12
29.	Toilet/Drinking Water Fac.	4.0M X 4.0M	16
30	Cylinder Stacking	20.0M X 25.0M	500
31.	Vapor Extraction Blower with FLP Motor and Chimney		
32.	HSD Tank	7.50M X 1 0.50M	78.75
33.	Storage Yard	1 0.20M X 20.75M	211.65
34.	Air Comp. Room (35 Cfm)	3.65M X 5.50M	20.075
34A.	Air Comp. Shed	3.65M X 5.50M	20.075
35.	Cold Repair Machine		
36.	Water Pond 1	17.65M X 5.50M	97.075
37.	Water Pond 2	5.50M X 11.1 8M	61.05
38.	LPG MOUNDED VESSEL (1x600 MT)	6.00M X 48.50M	91
39.	Water Re-Cycling Tank	2.00M¢	2
40.	Store	7.60M X 5.50M	41.8
41.	Assembly Point		
42.	Emergency Control Room	5.00M X 4.00M	20
43.	Store	7.60M X 5.50M	41.8
44.	Effluent Treatment Plant	1 O.OM X 20.0M	200
45.	Go Switch	6.25M X 6.25M	39.06
46.	Proposed Plant Area	85 M X 40M	3400

3.6 OTHER SAFETY MEASURES

The basic philosophy of Fire Protection System design is centred on water as the main fire extinguishing medium. Our system is designed to give the adequate quantity of water at a specified minimum pressure and for an estimated minimum time required for fire-fighting. Sufficient quantity of water is always available and is pumped at pressure into a fire water piping network throughout the plant. Provision for other fire extinguishing medium such as foam, CO2, Dry chemical powder etc. have been made at various locations in the pipeline to control / fight the fire at the very initial stage. The Fire Terminal is connected with Fire alarm points located at various places in the pipeline. Siren at different places is also provided to alert the personnel about fire / disaster etc. Various Fire Fighting facilities provided in the plant are based on the accepted requirements stipulated in OISD-STD-117Terminal is having dedicated fire protection and HSE management system as per OISD and LPG Bottling Plant, Salempur SOP (Standard Operating Procedure). The Terminal is maintaining the fire protection equipments as per OISD. The enforcement same is being done through the dedicated HSE officer.The fire hydrant mains cover the entire Terminal. Fire Hydrant Layout attached as Annexure III

Table 3.9: PPE Details

Item	Quantity
Low Temp. Suit	2 No's
Fire Proximity Suit	2 No's
Water Jel Blankets	3 No's
Self-Contained Breathing Apparatus	1 plus 1 Extra No’s
Safety Belt	3 No's
Safety Helmets	8 No's
Hand Gloves for Electrical Handling	2 No's
VHF	10 plus 1 fixed No’s
Page phone	8 No's
Explosive meter	2 No's
Stretcher – Metallic	2 No's
Stretcher –folding	1 No's
Oxygen cylinder	2 No's

3.7 SITE LOCATION

Table 3.10: Latitude Longitude details of

Sl. No	Latitude	Longitude
1	27°39'47.58"N	78°15'2.78"E

3.7.1 Topography

The area exhibits more or less a flat topography with gentle undulation at places. The elevation of land surface varies from 172 to 180 m above mean sea level. The master slop is from NW to SE, with an average gradient of about 0.24 m/km. About 90% of district area, geomorphologically, occupies the extensive tract of older alluvial plain.

3.7.2 Population

The population, which may be exposed to risk of hazards present in the Terminal, is BPCL personnel working in and around the Terminal and the general population living in the immediate vicinity of the complex.

Location wise population data inside the Terminal, which has been considered for the study, is indicated in table 3.11given below:

Table 3.11: Population Detail

Existing	Proposed	Total (after expansion)
1.BPCL plant officers- 08no 2.General operators and clerical staffs- 16No 3.Contractual workers-96 no (including security guard)	Direct (in house)- 02 Indirect(contract)-54	176

3.8 METEOROLOGICAL CONDITION

Meteorological Data is given as:

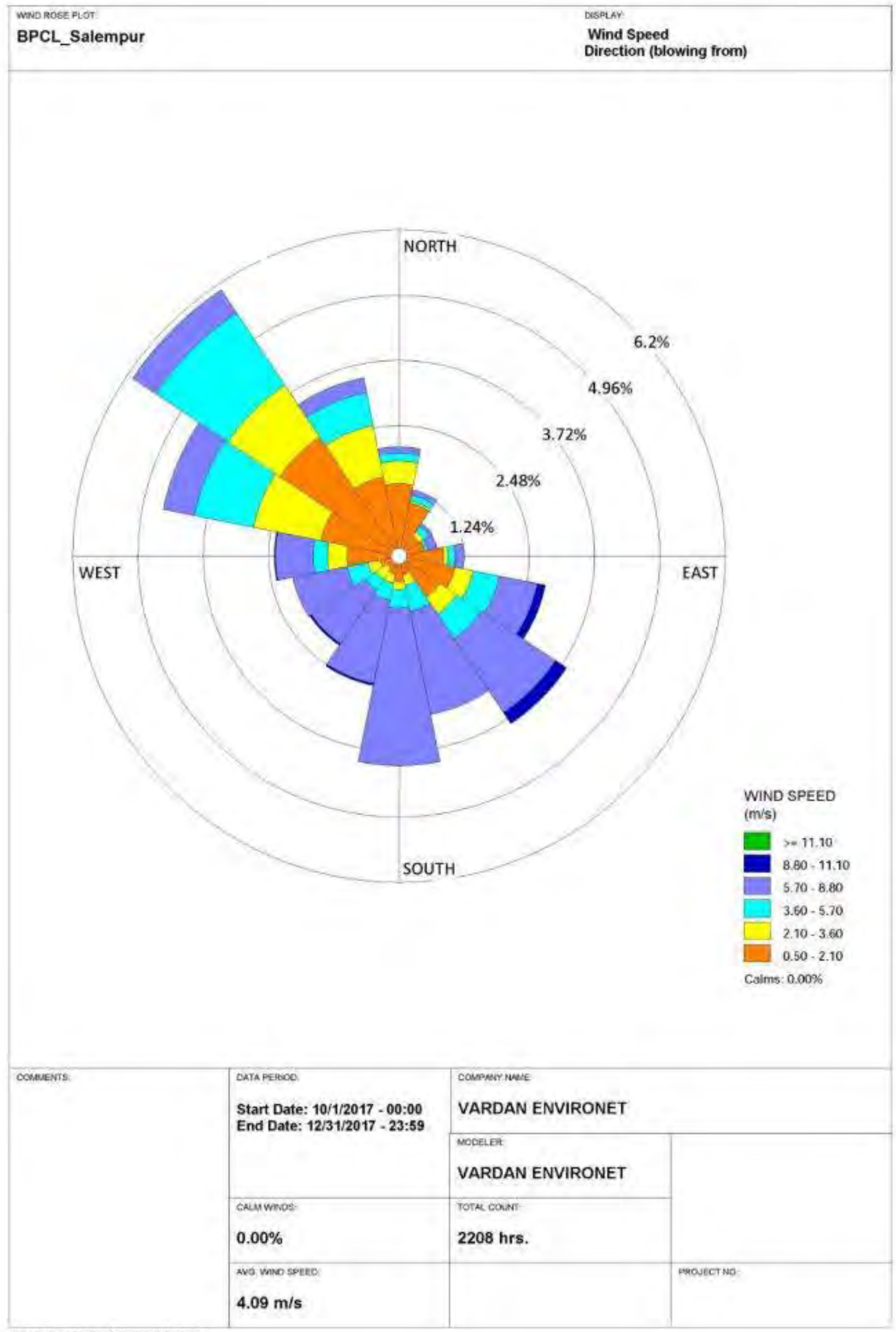


Figure 3.4:Windrose of the Salempur Area

3.9 PASQUILL STABILITY

One of the most important characteristics of atmosphere is its stability. Stability of atmosphere is its tendency to resist vertical motion or to suppress existing turbulence. This tendency directly influences the ability of atmosphere to disperse pollutants released from the facilities. In most dispersion scenarios, the relevant atmospheric layer is that nearest to the ground, varying in thickness from a few meters to a few thousand meters. Turbulence induced by buoyancy forces in the atmosphere is closely related to the vertical temperature gradient.

Temperature normally decreases with increasing height in the atmosphere. The rate at which the temperature of air decreases with height is called Environmental Lapse Rate (ELR). It varies from time to time and place to place. The atmosphere is considered to be stable, neutral or unstable according to ELR is less than, equal to or greater than Dry Adiabatic Lapse Rate (DALR), which is a constant value of 0.98°C/100 meters.

Pasquill stability parameter, based on Pasquill – Gifford categorization, is a meteorological parameter, which describes the stability of atmosphere, i.e., the degree of convective turbulence. Pasquill has defined six stability classes ranging from `A' (extremely unstable) to `F' (stable). Wind speeds, intensity of solar radiation (daytime insulation) and night time sky cover have been identified as prime factors defining these stability categories.

The following table indicates the Pasquill stability classes

Table 3.12: Pasquill stability classes

*** Class D & F are considered for modelling Worst case scenario*

Sr. No.	Stability Class	Weather Conditions
1.	A	Very unstable – sunny, light wind
2.	A/B	Unstable - as with A only less sunny or more windy
3.	B	Unstable - as with A/B only less sunny or more windy
4.	B/C	Moderately unstable – moderate sunny and moderate wind
5.	C	Moderately unstable – very windy / sunny or overcast / light wind
6.	C/D	Moderate unstable – moderate sun and high wind
7.	D	Neutral – little sun and high wind or overcast / windy night
8.	E	Moderately stable – less overcast and less windy night
9.	F	Stable – night with moderate clouds and light / moderate wind

10.	G	Very stable – possibly fog
Source:*Hanna , S. R. and Drivas, P. J. (1996) Guidelines for Use of Vapour Cloud Dispersion Models. AIChE, CCPS, New York*		

When the atmosphere is unstable and wind speed is moderate or high or gusty, rapid dispersion of pollutants will occur. Under these conditions, pollutant concentration in air will be moderate or lowand the material will be dispersed rapidly. When the atmosphere is stable and wind speed is low, dispersion of material will be limited and pollutant concentration in air will be high.

Stability category for this study is identified based on the cloud amount, day time solar radiation and wind speed.

Table 3.13: Weather parameters for consequence analysis

S. No.	Wind Speed(m/s)	Pasquill Stability
1.	2	F
2.	3	D
3.	5	D

4 : MAXIMUM CREDIBLE ACCIDENT SCENARIO

MCA stands for Maximum Credible Accident or in other words, an accident with maximum damage distance, which is believed to be probable. MCA analysis does not include quantification of the probability of occurrence of an accident. In practice the selection of accident scenarios for MCA analysis is carried out on the basis of engineering judgement and expertise in the field of risk analysis especially in accident analysis.

A classical definition of hazard states that hazard is in fact the characteristic of system/plant/process that presents potential for an accident. Hence, all the components of a system/plant/process need to be thoroughly examined in order to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

In Risk Analysis terminology a hazard is something with the potential to cause harm. Hence, the Hazard Identification step is an exercise that seeks to identify what can go wrong at the major hazard installation or process in such a way that people may be harmed. The output of this step is a list of events that need to be passed on to later steps for further analysis.

The potential hazards posed by the facility were identified based on the past accidents, lessons learnt and a checklist. This list includes the following elements. Catastrophic rupture of pressure vessel. "Guillotine-Breakage" of pipe-work Small hole, cracks or instrument tapping failure in piping and vessels. Flange leaks, Leaks from pump glands and similar seals.

Modes of Failure

There are various potential sources of large leakage, which may release hazardous chemicals and hydrocarbon materials into the atmosphere. These could be in form of gasket failure in flanged joints, bleeder valve left open inadvertently, an instrument tubing giving way, pump seal failure, guillotine failure of equipment/pipeline or any other source of leakage. Operating experience can identify lots of these sources and their modes of failure. A list of general equipment and pipeline failure mechanisms is as follows:

Material/Construction Defects

- Incorrect selection or supply of materials of construction

- Incorrect use of design codes
- Weld failures
- Failure of inadequate pipeline supports

Pre-Operational Failures

- Failure induced during delivery at site
- Failure induced during installation.
- Pressure and temperature effects
- Overpressure
- Temperature expansion/contraction (improper stress analysis and support design)
- Low temperature brittle fracture (if metallurgy is incorrect)
- Fatigue loading (cycling and mechanical vibration)

Corrosion Failures

- Internal corrosion (e.g. ingress of moisture)
- External corrosion
- Cladding/insulation failure (e.g. ingress of moisture)
- Cathodic protection failure, if provided

Failures due to Operational Errors

- Human error
- Failure to inspect regularly and identify any defects

External Impact Induced Failures

- Dropped objects
- Impact from transport such as construction traffic
- Vandalism
- Subsidence
- Strong winds

Failure due to Fire

- External fire impinging on pipeline or equipment
- Rapid vaporization of cold liquid in contact with hot surfaces

4.1 HAZARDS ASSOCIATED WITH LPG BOTTLING PLANT

The Plant handles hazardous material i.e. LPG – Liquefied Petroleum Gas which have a potential to cause fire and explosion hazards. This chapter describes in brief the hazards associated with this material.

Table 4.1:Associated Hazards

Sr. No.	Hazards	Factors responsible for the occurrence	Controls
1.	Explosion	Rapid oxidation or Rapid Burning.	
2.	Fire	By any external source.	Automated hydrant system extinguisher.
3.	BLEVE (Boiling Liquid expanding vapor explosion)	Occurs when LPG containers are accidentally surrounded by fire.	BLEVE can only be control by controlling the fire (initial startup of fire), sprinkler system, and automated hydrant system.
4.	Confined and Unconfined Vapour cloud explosion	Confined explosions are those, which occur within some sort of containment such as vessel or pipe-work. Explosions that occur in the open air are referred to as unconfined explosions.	For controlling unconfined vapor cloud explosion use proper ventilation, GMS for vapor and gas detection.
5.	Gas Leakage	Bursting of storage tank, or leakage of liquid LPG from bottom line, or rupture of any cylinder.	Gas monitoring system, frisking gate, proper handling of cylinders during filling and transportation.
6.	Carousel	Carousel failure during filling of cylinders.	Proper usage of carousel and continuous maintenance.

4.2 PAST ACCIDENT DATA FOR LPG INCIDENTS

A. HARYANA,1973 ROAD Accident

A truck carrying 300 LPG cylinders on National Highway 20 miles away from Delhi capsized and LPG cylinders tumbled down. Suspected cause of fire is friction between the cylinders which might have leaked due to rolling down. 1 person died & 3 others were injured

B. MADRAS,4.4.1981, Fire Accident at LPG filling Plant at Madras Refineries Limited

On the day of the fire no filling operation was planned. however, it was planned to do some housekeeping & clean-up operations & interacting of cylinders & stacking. a truck was also engaged to remove defective cylinders. prior to the removal of defective cylinders, reported that about 4500 cylinders were lying there. till the truck arrived the contract workmen were engaged in shifting cylinders by rolling to the new stacking location & they removed about 400 cylinders & had been stacking them. the truck also made one trip , of intercarting of 265 cylinders to the new location. , the truck made a second trip , picked up about 230cylinders & came to the stacking location & stood by , ready to unload the cylinders . at this time the fire broke out from the middle of the new stack of defective cylinders & spread fast to the entire stack of cylinders . in a matter of minutes cylinders had started to burst with a loud noise due to exposure to intense heat of fire & several cylinders gave way due to over pressuring . sudden bursting of cylinders led the splinters / metal pieces to fly off in all odd directions quite far away from the accident spot. due to bursting of cylinders & spreading of fire, the truck also caught fire & with its full load of cylinders was gulfed in fire & was totally destroyed. smoking is believed to be the cause of this accident

C. DELHI, 15.05.1983

A large fire occurred in LPG Bottling Plant filling 9000 cylinders per day , in two shift operation . LPG was supplied to the plant in tank wagons The fire originated from the cylinder repair area . Leaked LPG got ignited by the lighted beedi, which one of the workers, in the repair area ,was smoking while he was carrying decanting operations 4 persons died & 25 were injured. About 80665 cylinders were damaged.

D. MADRAS, 1985

Fire accident occurred in one of the restaurants when one of the untrained workers attempted to disconnect an empty cylinder from the pigtail connection for fixing a filled LPG cylinder. 7 people died & 10 others were injured.LPG gas leak was observed through the improperly closed gate valve near the top manhole, in a railway wagon. Due to timely action a big fire accident could be averted.

E. NELLORE 1988

Tanker carrying LPG cylinders burst into flames right under the Nellore railway bridge, melting the electric traction wire to a span of 45 m & completely twisting the track over the bridge. 1 person died & 2 others were injured

F. CHANDIGARH, 1989

An accident occurred in a LPG Plant , when some employees of LPG agency were trying to pilfer LPG from one cylinder to another when the leaking gas got ignited from the open fire nearby . Two people died & no one was reported injured.

G. RAJKOT.1989

Indian Oil Corporation LPG bottling Plant: A LPG leakage incident involving a LPG road tanker took place at the IOCL. The locking pin of the shut off valve of the liquid line of the tanker was broken. Since the valve after being opened, could not be closed, LPG started leaking . 2 people were injured.

H. RONALI, BARODA, 1989

Another LPG leakage incident involving a road tanker occurred because the gasket used in the liquid line of the tanker had worn out & gave way leading to leakage of LPG.

I. DHULE, MAHARASHTRA, 1990

Another LPG incident involving road tankers took place when the driver of the tanker lost control & the vehicle fell into a ditch leading to the shearing of excess flow check valve & safety valve of the tank resulting in the leakage of LPG. The cloud travelled a distance of 100 m away & met with a source of ignition resulting in flash fire. 12 people died in this accident.

J. HOWRAH, BRIDHE, CALCUTTA, 1990

A road tanker carrying 12.45 MT of LPG overturned on Howrah bridge & the roto gauge was damaged & the gas leak occurred. Due to prompt safety measures taken by the fire brigade, an explosion was averted. Two people were injured in this incident

K. BONTHAPALLY, AP,1990

There was a gas leak from a faulty valve. At the same time static charge accumulated on the tanker during unloading. Since the tanker was not "earthed" electrostatic arcing occurred & resulted in an explosion & the entire vehicle was burnt. Nobody was hurt.

L. GANAURSI, PUNJAB, 1990

Yet another LPG road tanker incident, a tanker overturned & the safety valve got damaged resulting in a gas leak which enveloped an entire village. The gas got ignited on coming in contact with some flame & resulted in a massive fire. 31 People died & 30 others were injured.

M. JAMSHEDPUR, 1991

Due to damage in the Teflon packing around the thermowell connecting the nozzle to the Horton sphere thermowell was displaced resulting in a leak. One person was injured O. PUNE, 1992 Since the liquid discharge valve was not closed properly after the unloading of LPG from the tanker, liquid LPG leaked out. The vapors from the leak, reached the workers quarters, & got ignited. The flames reached the tanker, which caught fire. One person died & two others were injured.

4.3 METHODOLOGY OF MCA ANALYSIS

The MCA analysis involves ordering and ranking of various sections in terms of potential vulnerability. The data requirements for MCA analysis are:

- Operating manual
- Flow diagram and P&I diagram
- Detailed design parameters
- Physical and chemical properties of all the chemicals
- Detailed plant layout
- Detailed area layout
- Past accident data

Following steps are involved in the MCA analysis:

- Identification of potential hazardous sections and representative failure cases

- Visualization of release scenarios considering type and the quantity of the hazardous material
- Damage distance computations for the released cases at different wind velocities and atmospheric stability classes for heat radiations and pressure waves
- Drawing of damage contours on plot plan to show the effect due to the accidental release of chemicals

4.4 HAZARDS ASSOCIATED WITH FLAMMABLE HYDROCARBONS

Ignition Source

The ignition sources within and outside the Terminal premise is a key factor in performing RA Study. The ignition sources, combined with their ignition probability, wind directional probability and presence of flammable hydrocarbon is a key factor in determining the delayed ignition probability of the cloud which further results in flash fire and overpressure scenarios.The various ignition sources considered in the study includes but not limited to heaters, Incinerators, smoking booth, canteen, traffic movement within the Terminal and movement of rail wagons for unloading purpose.

4.5 LIQUIFIED PETROLEUM GAS

Liquefied Petroleum Gas (LPG) is a colourless and odourless gas. It is highly flammable at normal temperature and pressure, therefore there should be no ignition sources in close proximity to areas where LPG is stored and handled. On release it may give rise to both fire and explosion hazards. LPG is a blend of Propane and Butane, readily liquefied under moderate pressure. LPG has a density of 1.5 to 2.0 and is heavier than air, therefore, difficult to disperse. It should never be used or stored below ground, as this could result in asphyxiation when released in a confined space. Since LPG has only a faint scent, a mercaptan odorant is added to help in detection of its leakage especially when used as a domestic fuel. In the event of a LPG leak, the vaporization of liquid cools the surrounding atmospheric air and condenses the water vapor contained in it to form a whitish fog, which is easy to observe. LPG in fairly large concentrations displaces oxygen leading to a nauseous or suffocating feeling.

LPG being highly flammable may cause fire and explosion. It, therefore, calls for special attention during its handling.

IDENTITY OF MATERIAL

Table 4.2: Material Safety Data Sheet of Liquefied Petroleum Gas (LPG)

PRODUCT NAME	Liquefied Petroleum Gas
TRADENAME	Liquefied Petroleum Gas
FORMULA	Mixture of C_3H_8& C_4H_{10}
CAS No.	68476-85-7
UN No.	1075
HAZCHEMCODE	2WE
CODES/LABEL	Flammable, Class 2

Table 4.3: Physical & Chemical Properties of LPG

PROPERTY	**LPG**
Physical state	Liquid
Odour	Odourless Gas
Colour	colourless
Vapor Pressure (kPa)	16.5kg/m^2@15°C
Vapor Density (air=1)	1.55
Specific Gravity (Liquid)	0.7321 at 68 °F
Boiling point (°c)	-42°C
Solubility in H_2O @ 30°C	Slightly at 30°C

Table 4.4: Fire and Explosive Data of LPG

Flammability	Yes
Flash Point	-104°C
LEL-Lower Explosive Limit (%)	1.8% by volume
UEL-upper explosive limit (%)	9.5% by Volume
Auto Ignition Temperature (°F)	466.1°C for Propane 405°C for Butane

Hazardous combustion Products	Carbon monoxide and carbon dioxide

4.6 SELECTED FAILURE CASES

A list of failure cases was prepared based on process knowledge, engineering judgment, experience, past incidents associated with such facilities and considering the general mechanisms for loss of containment. The cases have been identified for the consequence analysis is based on the following-

- Cases with high chance of occurrence but having low consequence:

Example of such failure cases includes two-bolt gasket leak for flanges, seal failure for pumps, sample connection failure, instrument tapping failure, drains, vents, etc. The consequence results will provide enough data for planning routine safety exercises. This will emphasize the area where operator's vigilance is essential.

- Cases with low chance of occurrence but having high consequence (The example includes catastrophic failure of lines, process pressure vessels, etc.)

This approach ensures at least one representative case of all possible types of accidental failure events, is considered for the consequence analysis. Moreover, the list below includes at least one accidental case comprising of release of different sorts of highly hazardous materials handled in the Terminal. Although the list does not give complete failure incidents considering all equipments, units, but the consequence of a similar incident considered in the list below could be used to foresee the consequence of that particular accident.

4.7 HAZARD IDENTIFICATION AS PER NFPA

Standard System for the Identification of the Hazards of Materials for Emergency Response" is a standard maintained by the U.S.-based National Fire Protection Association. "fire diamond" used by emergency personnel to quickly and easily identify the risks posed by hazardous materials. The four divisions are typically color-coded with red indicating flammability, blue indicating level of health hazard, yellow for chemical reactivity, and white containing codes for special hazards.

Each of health, flammability and reactivity is rated on a scale from 0 (no hazard) to 4 (severe risk).

The numeric values in the first column are designated in the standard by "Degree of Hazard" using numerals (0, 1, 2, 3, 4)

Table 4.5:NFPA Code

IMPACT	NFPA CODE	COLOUR
Flammability hazard	Nf	
Health hazard	Nh	
Reactivity hazard	Nr	
Special hazards	W	

Table 4.6: Explanation of NFPA classification

Classification	Definition
Health Hazard	
4	Materials, which on very short exposure could cause death or major residual injury even though prompt medical treatments were given.
3	Materials, which on short exposure could cause serious temporary or residual injury even though prompt medical treatments were given.
2	Materials, which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.
1	Materials, which on exposure would cause irritation but only minor residual injury even if no treatment is given.
0	Materials, which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.
Flammability	
4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.
3	Liquids and solids that can be ignited under almost all ambient temperature conditions.
2	Materials that must be moderately heated or exposed to relatively high

Classification	Definition
	ambient temperatures before ignition can occur.
1	Material that must be preheated before ignition can occur.
0	Materials that will not burn.
Reactivity	
4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperature and pressures.
3	Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.
2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.
1	Materials which in themselves are normally stable, but which can become unstable at elevated temperature and pressures or which may react with water with some release of energy but not violently.
0	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

The fire and health hazards for LPG Bottling Plant, Salempur based on NFPA (National Fire Protection Association) classifications, described in **Table** below.

Table 4.7: NFPA for LPG

S. No	PETROLEUM PRODUCT	N_h	N_f	N_r
1.	LPG	1	4	0

Evaluation of the hazard based on the F&E Index is done based on the following guidelines:

4.8 FIRE & EXPLOSION INDEX

Fire and Explosion Index (FEI) is useful in identification of areas in which the potential ris reaches a certain level. It estimates the global risk associated with a process unit and classifies the units according to their general level 1of risk. FEI covers aspects related to the intrinsic hazard of materials, the quantities handled and operating conditions. This factor gives index value for the area which could be affected by an accident, the damage to property within the area and the working days lost due to accidents. Preventive and protective control measures are recommended based on degree of hazard. Therefore, FEI indicates the efforts to be taken to reduce risks for a particular unit. Degree of hazards based on FEI is given in the following Tables 4.8

Table 4.8: Degree of Hazards Based on FEI

FEI Range	Degree of Hazard
0 – 60	Light
61-96	Moderate
97 – 127	Intermediate
128 - 158	Heavy
159 and Above	Severe

***Source:** Dow's Fire and Explosion Index Hazard Classification Guide, Seventh Edition, AIChE Technical Manual (1994)*

Failure Frequency computed for LPG Bottling Plant, Salempur to be handled in the proposed facilities are presented in Table 4.19

Table 4.9: Fire & Explosion Calculation

Sr. No.	Unit Name	FEI	Category
1	LPG Mounted Bullet	94.5	Moderate
2	Road tanker	61.42	Moderate
3	LPG pump Transfer	66.15	Moderate
4	LPG compressor	70.24	Moderate
5	LPG cylinder storage shed	53.70	Light
6	LPG Cylinder manifold	55.44	Light

4.9 CHARACTERIZING THE FAILURES

Accidental release of flammable or toxic vapors can result in severe consequences. Delayed ignition of flammable vapors can result in blast overpressures covering large areas. This may lead to extensive loss of life and property. Toxic clouds may cover yet larger distances due to the lower threshold values in relation to those in case of explosive clouds (the lower explosive limits). In contrast, fires have localized consequences. Fires can be put out or contained in most cases; there are few mitigating actions one can take once a vapor cloud is released.

In a petroleum marketing installation such as the plant in question, the main hazard arises due to the possibility of leakage of petroleum products during decanting (number of hose connections, tank lorry movement etc.), storage, filling and transportation. To formulate a structured approach to identification of hazards an understanding of contributory factors is essential.

4.10 OPERATING PARAMETERS

Inventory

Inventory Analysis is commonly used in understanding the relative hazards and short listing of release scenarios. Inventory plays an important role in regard to the potential hazard. Larger the inventory of a vessel or a system, larger the quantity of potential release. A practice commonly used to generate an incident list is to consider potential leaks and major releases from fractures of pipelines and vessels containing sizable inventories. Each section is then characterized by the following parameters required for consequence modelling:

- Mass of flammable material in the process/storage section
- Pressure, Temperature and composition of the material
- Leak size for release

4.11 LOSS OF CONTAINMENT

Plant inventory can get discharged to Environment due to Loss of Containment. Various causes and modes for such an eventuality have been described. Certain features of materials to be handled at the plant need to the clearly understood to firstly list out all significant release cases and then to short list release scenarios for a detailed examination.

4.12 LIQUID OUTFLOW FROM A VESSEL/LINE

Liquid release can be either instantaneous or continuous. Failure of a vessel leading to an instantaneous outflow assumes the sudden appearance of such a major crack that practically all of the contents above the crack shall be released in a very short time. The flow rate will depend on the size of the hole as well as on the pressure in front of the hole, prior to the accident. Such pressure is basically dependent on the pressure in the vessel.

4.13 VAPORIZATION

The vaporization of released liquid depends on the vapor pressure and weather conditions.

Such consideration and others have been kept in mind both during the initial listing as well as during the short-listing procedure. Initial listing of all significant inventories in the process plants was carried out. This ensured no emission through inadvertence.

Based on the methodology discussed above a set of appropriate scenarios was generated to carry out Risk Analysis calculations for Pool fire, fire ball, source strength, toxic threat zone, flammability threat zone, overpressure (blast force) from vapor cloud explosion.

4.14 CONSEQUENCE ANALYSIS MODELING

Based on MCA Analysis Possible causes of Damage at LPG Bottling Plant, Salempur are as follows

Table 4.10 Probable Consequences of Failure at Bottling Plant Salempur

Failure Scenario Considered	Type of Failure	Probable MCA Scenario	Probability
Proposed SRV of 300 MT MSV	5 MM Failure Leak	Flash Fire, Jet Fire, VCE	Credible
Proposed 300 MT MSV	10 MM Leak, 20 MM Leak, 50 MM Leak		Credible
Proposed 300 MT MSV	Catastrophic Rupture	VCE, Fire Ball,	Worst Case ** BLEVE not possible as it is Mounded vessel
Pump Discharge Line Failure	5 mm,10 mm, and 25 mm Leak Scenario	Flash Fire, Jet Fire, VCE	Credible
Pump Discharge	Line Rupture (4”)	Flash Fire, Jet Fire, VCE	Worst Case
LPG Compressor Line Failure	5 mm,10 mm, and 25 mm Leak Scenario	Flash Fire, Jet Fire	Credible
Carousal Failure	5 MM Leak, 10MM Leak, 25 MM Leak	Flash Fire, Jet Fire, VCE	Credible
Carousal Failure	Line Rupture of 2”	Flash Fire, Jet Fire, VCE	Worst Case
Cylinder filling Shed	Catastrophic Rupture in (200 no of 14.2 KG Cylinder)	Pool Fire, Flash Fire, VCE, BLEVE	Credible Case
Cylinder filling Shed	Catastrophic Rupture in (200 no of 19 KG Cylinder)	Pool Fire, lash Fire, VCE, BLEVE	Credible Case

4.15 DISCHARGE RATE

The initial rate of release through a leak depends mainly on the pressure inside the equipment, size of the hole and phase of the release. The release rate decreases with time as the equipment depressurizes. This reduction depends mainly on the inventory and the action taken to isolate the leak and blow-down the equipment.

4.16 DISPERSION

Releases of gas into the open-air form clouds whose dispersion is governed by the wind, by turbulence around the site, the density of the gas and initial momentum of the release. In case of flammable materials, the sizes of these gas clouds above their Lower Flammable Limit (LFL) are important in determining whether the release will ignite. In this study, the results of dispersion modelling for flammable materials are presented LFL quantity.

4.17 FLASH FIRE

A flash fire occurs when a cloud of vapors/gas burns without generating any significant overpressure. The cloud is typically ignited on its edge, remote from the leak source. The combustion zone moves through the cloud away from the ignition point. The duration of the flash fire is relatively short but it may stabilize as a continuous jet fire from the leak source. For flash fires, an approximate estimate for the extent of the total effect zone is the area over which the cloud is above the LFL.

4.18 JET FIRE

Jet fires are burning jets of gas or atomized liquid whose shape is dominated by the momentum of the release. The jet flame stabilizes on or close to the point of release and continues until the release is stopped. Jet fire can be realized, if the leakage is immediately ignited. The effect of jet flame impingement is severe as it may cut through equipment, pipeline or structure. The damage effect of thermal radiation is depended on both the level of thermal radiation and duration of exposure.

4.19 POOL FIRE

A cylindrical shape of the pool fire is presumed. Pool-fire calculations are then carried out as part of an accidental scenario, e.g. in case, a hydrocarbon liquid leak from a vessel leads to the formation of an ignitable liquid pool. First no ignition is assumed, and pool evaporation and dispersion calculations are being carried out. Subsequently, late pool fires (ignition following spreading of liquid pool) are considered. If the release is bounded, the diameter is given by the size of the bund. If there is no bund, then the diameter is that which corresponds with a minimum pool thickness, set by the type of surface on which the pool is spreading.

While modelling cases of lighter hydrocarbons in the range of naphtha and MS wherein the rainout fraction has been minimal (not leading to pool formation) due to the horizontal direction of release, downward impingement has been considered for studying the effects of pool fire for consequence analysis only.

Pool fires occur when spilled hydrocarbons burn in the form of large diffusion flames. Calculating the incident flux to an observer involves four steps, namely-

- Characterizing the flame geometry
- Estimation of the flame radiation properties
- Computation of the geometric view factors
- Estimation of flame attenuation coefficients and computation of geometric view factors between observer and flame.

The size of the flame will depend upon the spill surface and the thermo chemical properties of the spilled liquid. In particular, the diameter of the fire, the visible height of the flame, the tilt and drag of the flame etc. The radioactive output of the flame will depend upon the fire size, the extent of mixing with air and the flame temperature. Some fraction of the thermal radiation is absorbed by the carbon dioxide and water vapor in the intervening atmosphere. In addition, large hydrocarbon fires produce thick smoke which significantly obscure flame radiation.

The calculations for radiation damage distances start with estimation of the burning velocity-

$Y= 92.6\ e - 0.0043 T_b Mw 10^{-7}/(\square\ X\ 6)$

Where, Y= burning velocity in m/s

Mw= molecular weight in kg/kg mol

T_b= normal boiling point

The next step involves calculation of the equivalent diameter for the spreading pool- this depends upon the duration of the spill (continuous, instantaneous, finite duration etc.). This is calculated using expressions like-

$D_{eq.} =2(V/3.142Y)^{1/2}$

Where, D_{eq}.is the steady state diameter of the pool in m

V= liquid spill rate in m^3/s

Y= Liquid burning rate in m/s

In the absence of frictional resistance during spreading, the equilibrium diameter is reached over a time given by-

$T_{eq.}= 0.949\ D_{eq.}/(\Delta y \text{ X } D_{eq.})^{1/3}$

The visible flame height is given by-

$H_{flame}= 42D_p\ ((BvD/D_a(gD_p)1/2)^{0.61}$

Where, H_{flame} = flame height in m

D= density in kg/m^3

D_a= air density in kg/m^3

g = gravitational acceleration or 9.81 m/s^2

The emissive power of a large turbulent fire is a function of the black body emissive power and the flame emissivity. The black body emissive power can be computed by Planck's law of radiation. The general equation used for the calculation is:

$E_P= -0.313T_b+117$

Where E_p is the effective emissive power in kW/m^2

T_b= normal boiling point of the liquid in °F

Materials with a boiling point above 30 °F typically burn with sooty flames-the emissive power from the sooty section is about 20 kW $/m^2$. The incident flux at any given location is given by the equation-

$Q_{incident} = E_P * t * V_F$

Where $Q_{incident}$ = incident flux in kW/m^2

t= transmissitivity (a function of path length, relative humidity and flame temperature) often taken as 1 and the attenuation of thermal flux due to atmospheric absorption ignored.

V_F= geometric view factor

The view factor defines the fraction of the flame that is seen by a given observer.

$V_F= 1.143\ (R_p/X)\ 1.757$

Where, X= distance from the flame centre in m

R_p= pool radius in m

Based on the radiation received, the fatality levels are calculated from Probit equation, which for protected clothing is given by-

Pr.= -37.23 + 2.56 ln (t X $Q^{4/3}$)

Where, Pr. = Probit No.

t= time in seconds

Q heat radiation in W/m^2

4.20 BLAST OVERPRESSURES

Blast Overpressures depend upon the reactivity class of material and the amount of gas between two explosive limits. MS could give rise to a VCE due to their vapor pressures-however, as the results will indicate, the cloud flammable masses are quite small due to the high boiling point and low vapor pressures. In addition, unless there is sufficient extent of confinement, it is unlikely to result in any major explosion. Examples where flammable mixtures could be found are within storage tanks and road tankers. Open-air explosions are unlikely. As a result, damage would be limited.

Equations governing the formation of overpressures in an explosion are given later. Blast overpressures are calculated based on comparison of combustion energy per unit mass of a vapor cloud with that of TNT and taking into account that only a fraction of the energy will contribute to the explosion. Overpressure data compiled from measurements on TNT are used to relate overpressure data to distance from explosions. The equivalent mass of TNT is calculated using the equations-

M_{TNT}= (M_{cloud} X (ΔH_c.)/1155 X Y_f)

Where, M_{TNT} is the TNT equivalent mass (lb)

ΔH_c = Heat of combustion is in Kcals/kg

M_{cloud} is mass in cloud in lbs

Y_f is the yield factor

The distance to a given overpressure is calculated from the general equation-

X=M_{TNT} 1/3 exp (3.5031-0.7241 ln (O_p) + 0.0398 (ln O_p))^2

Where, X is the distance to a given overpressure in feet

O_p is the peak overpressure

4.21 TOXIC RELEASE

The aim of the toxic risk study is to determine whether the operators in the plant, people occupied buildings and the public are likely to be affected by toxic substances. Toxic gas cloud e.g. H_2S, chlorine, etc was undertaken to the Immediately Dangerous to Life and Health concentration (IDLH) limit to determine the extent of the toxic hazard created as the result of loss of containment of a toxic substance.

4.22 DAMAGE CRITERIA

In order to appreciate the damage effect produced by various scenarios, physiological/physical effects of the blast wave, thermal radiation or toxic vapor exposition are discussed.

4.23 LFL OR FLASH FIRE

Hydrocarbon vapor released accidentally will spread out in the direction of wind. If a source of ignition finds an ignition source before being dispersed below lower flammability limit (LFL), a flash fire is likely to occur and the flame will travel back to the source of leak. Any person caught in the flash fire is likely to suffer fatal burn injury. Therefore, in consequence analysis, the distance of LFL value is usually taken to indicate the area, which may be affected by the flash fire.

Flash fire (LFL) events are considered to cause direct harm to the population present within the flammability range of the cloud. Fire escalation from flash fire such that process or storage equipment or building may be affected is considered unlikely.

4.24 THERMAL HAZARD DUE TO POOL FIRE, JET FIRE

Thermal radiation due to pool fire, jet fire or fire ball may cause various degree of burn on human body and process equipment. The following table details the damage caused by various thermal radiation intensity.

Table 4.11:Effects due to incident radiation intensity

Incident Radiation (kW/m^2)	Type of Damage
0.7	Equivalent to Solar Radiation
1.6	No discomfort for long exposure
4.0	Sufficient to cause pain within 20 sec. Blistering of skin (first degree burns are likely)

Incident Radiation (kW/m^2)	Type of Damage
9.5	Pain threshold reached after 8 sec. Second degree burns after 20 sec.
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.
25	Minimum energy required to ignite wood at indefinitely long exposure.
37.5	Sufficient to cause damage to process equipment.

Source: Major Hazard Control, ILO

4.25 VAPOR CLOUD EXPLOSION

In the event of explosion taking place within the plant, the resultant blast wave will have damaging effects on equipment, structures, building and piping falling within the overpressure distances of the blast. Tanks, buildings, structures etc. can only tolerate low level of overpressure. Human body, by comparison, can withstand higher overpressure. But injury or fatality can be inflicted by collapse of building of structures. The following Table4.23illustrates the damage effect of blast overpressure.

Table 4.12: Damage due to Overpressures

Peak Overpressure	Damage Type
12.04 psi	Total Destruction
4.35 psi	Heavy Damage
1.45 psi	Moderate Damage
0.44 psi	Significant Damage
0.15 psi	Minor Damage

4.26 BLAST EFFECTS

Petroleum Vapors evaporated from a large pool of spillage would normally spread out in the direction of wind and if a source of ignition is found before the lower inflammable level is reached, a flash fire preceded by a vapour cloud explosion will result. The resultant blast over pressure of the explosion may have serious damaging effects on building, structural and equipment, which are summarized below.

Table 4.13:Blast Overpressure Effects

Over pressure bar/ psi	Mechanical damage to equipment	Damage to people

0.3/4.41	Heavy damage of plant and structure	Fatality probability = 1 for humans indoor as well as outdoor 50 eardrum damage > 50 serious wounds from flying objects.
0.1/ 1.47	Repairable damage	1 % death > 1% eardrum damage > 1 serious wounds from flying objects.
0.03/ 0.441	Major glass damage	Slight injury from flying objects
0.01/0.147	10 % glass damage	--

4.27 GENERIC FAILURE RATE DATA

Standard failure frequencies for LPG Failure scenarios are used for the frequency analysis reported in the **Table** below-

Table 4.14: Failure frequency for LPG storage

Leak size	Frequency
10	$1 X 10^{-5}$ /year
25	$8 X 10^{-6}$ / year
50	$4 X 10^{-6}$ /year
Catastrophic rupture	$5 X 10^{-7}$ /year

Ref: HSE Guide assessment on installation key assumption (after Pape and Nussey, 1985) (Courtesy of the institution of Chemical Engineers), Ref: "Purple book" guide Netherlands

Table 4.15:Failure frequency for pumps and compressor

Equipment	Failure Frequency
Compressor, centrifugal	$1.4 x 10^{-2}$ /year
Compressor, reciprocating	0.66 /year
Pump, centrifugal	$1.7 x 10^{-2}$ /year
Pump, reciprocating	0.31 /year

Ref: HSE specification, Petroleum Development Oman, Failure frequency for instantaneous release from the road tankers is $5 x 10^{-7}$ (Purple book guide Netherlands)

From the above failure frequencies, it is evident that the frequencies of occurring of small hole size are more than that of the catastrophic rupture. Thus, the scenarios of occurring leak are more credible than catastrophic rupture. These failure frequencies are used for evaluating the risk associated with the facility.

4.28 PLANT DATA

Risk Assessment study conducted is based on the data available from current engineering documents for the LPG Bottling plant, Salempur. These documents are indicated in **Table**4.26 given below-

Table 4.16: List of documents used in study

S. No	Documents/Drawing	Documents Drawing No.
1.	Plant Layout	D.4L.SLM9.01
2.	Hydrant Layout	D.4L.SLM9.01

4.29 CONSEQUENCE ANALYSIS FOR LPG BOTTLING PLANT, SALEMPUR

Scenarios

The scenarios for consequence analysis have been identified as listed in Table 4.17given below-

Table 4.17:Table Showing Consequence Distance computed in PHAST RISK

Scenario considered	Wind stability class	Flash fire At LFL concentration distance (m)	Jet Fire Damage Distance for Various Heat Loads(m)			Distance downwind to VCE (Over Pressure 1 (0.02068 bar) [m]	Distance downwind to VCE (Overpressure) 2 (0.1379 bar) [m]	Distance downwind to VCE (overpressure) 3 (0.2068 bar) [m]
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2			
Proposed SRV of 300 MT MSV 5 MM Failure Leak	2F	7.40831	17.9139	14.1278	11.7942	31.0933	14.0996	13.0737
	3D	6.74352	17.1305	13.2651	10.8973	29.1098	13.7141	12.7847
	5D	5.98081	16.3152	12.3332	9.91396	N/A	N/A	N/A
Proposed 300 MT MSV 10 MM Leak	2F	18.2256	33.9917	26.7656	22.4411	96.9149	59.1182	56.8365
	3D	15.7841	32.5708	25.1877	20.801	70.6598	37.9025	35.925
	5D	13.4482	31.1058	23.4909	18.9986	66.6559	37.1243	35.3415
Proposed 300 MT MSV 20 MM Leak	2F	48.9592	64.0919	50.1731	41.9322	230.985	141.571	136.173
	3D	43.6682	61.5428	47.3179	38.9465	197.926	119.033	114.27
	5D	42.1192	58.928	44.2518	35.6726	182.447	107.968	103.471
Proposed 300	2F	142.652	147.41	114.345	94.8907	654.185	401.064	385.783

Scenario considered	Wind stability class	Flash fire At LFL concentration distance (m)	Jet Fire Damage Distance for Various Heat Loads(m)			Distance downwind to VCE (Over Pressure 1 (0.02068 bar) [m]	Distance downwind to VCE (Overpressure) 2 (0.1379 bar) [m]	Distance downwind to VCE (overpressure) 3 (0.2068 bar) [m]
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2			
MT MSV 50 MM Leak	3D	141.792	141.928	108.135	88.3585	561.728	342.812	329.596
	5D	153.088	136.34	101.493	81.1911	510.495	292.573	279.417
Proposed 300 MT MSV Catastrophic Rupture	2F	974.682	17.9139	14.1278	11.7942	6020.17	1737.22	1655.24
	3D	790.679	17.1305	13.2651	10.8973	5982.84	1549.58	1472.62
	5D	1177.54	16.3152	12.3332	9.91396	6052.58	1930.9	1885.95
Pump Discharge Line 5 MM leak	2F	12.0737	15.6985	12.7282	10.395	22.64	14.4193	12.035
	3D	10.4441	14.897	11.9192	9.62916	21.6708	14.0804	11.879
	5D	8.66709	14.1009	11.0632	8.79688	N/A	N/A	N/A
Pump DISCHARGE LINE Failure 10	2F	33.744	29.5367	23.8597	19.5136	56.1383	39.1386	34.2082

Scenario considered	Wind stability class	Flash fire At LFL concentration distance (m)	Jet Fire Damage Distance for Various Heat Loads(m)			Distance downwind to VCE (Over Pressure 1 (0.02068 bar) [m]	Distance downwind to VCE (Overpressure) 2 (0.1379 bar) [m]	Distance downwind to VCE (overpressure) 3 (0.2068 bar) [m]
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2			
MM leak	3D	31.199	28.0548	22.3592	18.1079	53.6308	38.2619	33.8045
	5D	28.087	26.5909	20.7678	16.5266	53.9136	38.3608	33.85
Pump Discharge Line Failure 25 MM leak	2F	49.24	67.909	54.5603	44.6687	190.106	138.007	122.897
	3D	45.271	64.5718	51.1725	41.4028	182.863	135.475	121.731
	5D	43.715	61.3331	47.6323	37.8224	182.292	135.275	121.639
Pump Discharge Line Rupture(4")	2F	25.0744	177.515	141.73	115.75	343.436	209.691	172.092

Scenario considered	Wind stability class	Flash fire At LFL concentration distance (m)	Jet Fire Damage Distance for Various Heat Loads(m)			Distance downwind to VCE (Over Pressure 1 (0.02068 bar) [m]	Distance downwind to VCE (Overpressure) 2 (0.1379 bar) [m]	Distance downwind to VCE (overpressure) 3 (0.2068 bar) [m]
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2			
	3D	24.3142	168.997	133.108	107.378	342.888	223.258	205.1
	5D	23.5934	161.002	124.267	98.2986	348.935	242.195	225.745
LPG Compressor Line Failure 5 mm Leak Scenario	2F	2.53604	3.86485	2.81086	N/A	N/A	N/A	N/A
	3D	2.52682	3.64477	2.61774	N/A	N/A	N/A	N/A
	5D	2.31438	3.416	2.40856	N/A	N/A	N/A	N/A
LPG Compressor Line Failure 10 mm Leak Scenario	2F	4.92299	7.7225	6.18916	4.7235			
	3D	4.78287	7.28806	5.75891	4.49158			
	5D	4.29527	6.84734	5.29955	4.04949			
LPG Compressor	2F	13.7645	18.3486	14.9078	12.2763	23.5768	14.7468	12.1858

Scenario considered	Wind stability class	Flash fire At LFL concentration distance (m)	Jet Fire Damage Distance for Various Heat Loads(m)			Distance downwind to VCE (Over Pressure 1 (0.02068 bar) [m]	Distance downwind to VCE (Overpressure) 2 (0.1379 bar) [m]	Distance downwind to VCE (overpressure) 3 (0.2068 bar) [m]
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2			
Line Failure 25 mm Leak Scenario								
	3D	12.6586	17.3821	13.9547	11.389	22.7141	14.4452	12.0469
	5D	10.6721	16.4162	12.9336	10.3962	22.1719	14.2556	11.9596
Carousal Failure 5 mm Leak Scenario	2F	11.2721	15.0761	12.2262	9.99138	22.0963	14.2292	11.9475
	3D	9.77786	14.3059	11.4484	9.24627	N/A	N/A	N/A
	5D	8.22107	13.5406	10.6259	8.44657	N/A	N/A	N/A
Carousal Failure 10 mm Leak Scenario	2F	30.5955	28.3691	22.9214	18.7478	54.7664	38.6589	33.9873
	3D	23.4704	26.9451	21.4795	17.3936	42.5408	27.8808	23.629

Scenario considered	Wind stability class	Flash fire At LFL concentration distance (m)	Jet Fire Damage Distance for Various Heat Loads(m)			Distance downwind to VCE (Over Pressure 1 (0.02068 bar) [m]	Distance downwind to VCE (Overpressure) 2 (0.1379 bar) [m]	Distance downwind to VCE (overpressure) 3 (0.2068 bar) [m]
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2			
	5D	17.9403	25.5374	19.9528	15.8737	40.8908	27.3039	23.3634
Carousal Failure 25mm Leak Scenario	2F	107.642	65.2327	52.4215	42.9165	176.512	126.751	112.318
	3D	110.797	62.0255	49.164	39.7821	179.557	134.319	121.198
	5D	104.429	58.9091	45.7587	36.3351	167.157	123.48	110.812
Carousal Failure Line Rupture of 2”	2F	48.5543	68.1922	54.7772	44.8335	180.998	128.319	113.04
	3D	45.9437	64.847	51.3782	41.5545	183.773	135.793	121.877
	5D	44.3914	61.6006	47.8267	37.9609	181.438	134.976	121.501
Cylinder filling	2F	96.8688	N/A	N/A	N/A	372.475	210.608	171.085

Scenario considered	Wind stability class	Flash fire At LFL concentration distance (m)	Jet Fire Damage Distance for Various Heat Loads(m)			Distance downwind to VCE (Over Pressure 1 (0.02068 bar) [m]	Distance downwind to VCE (Overpressure) 2 (0.1379 bar) [m]	Distance downwind to VCE (overpressure) 3 (0.2068 bar) [m]
			4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2			
Shed Catastrophic Rupture in (200 no of 14.2 KG Cylinder)	3D	114.125	N/A	N/A	N/A	373.609	214.37	188.411
	5D	118.781	N/A	N/A	N/A	372.255	217.184	197.123
Cylinder filling Shed Catastrophic Rupture in (200 no of 19 KG Cylinder)	2F	112.658	N/A	N/A	N/A	424.207	241.718	196.23
	3D	130.387	N/A	N/A	N/A	422.219	243.091	208.944
	5D	135.65	N/A	N/A	N/A	422.279	244.333	220.415

Table 4.18: Table Showing Consequence Distance of Fire Ball computed in PHAST RISK

**** BLEVE is not possible in Proposed 300 MT MSV as it is Mounded Bullet

Scenario	Wind Stability Class	Fire Ball Damage distance for various heat loads (m)			Fire Ball Diameter(m)
		4 kW/m^2	12.5 kW/m^2	37.5 kW/m^2	
MSV Bullet Catastrophic Rupture	2F	2576.93	1410.84	580.545	237.411
	3D	2576.93	1410.84	580.545	237.411
	5D	2576.93	1410.84	580.545	237.411

4.30 DAMAGE DISTANCE GRAPHS FOR COMPUTED WORSE CASE SCENARIO

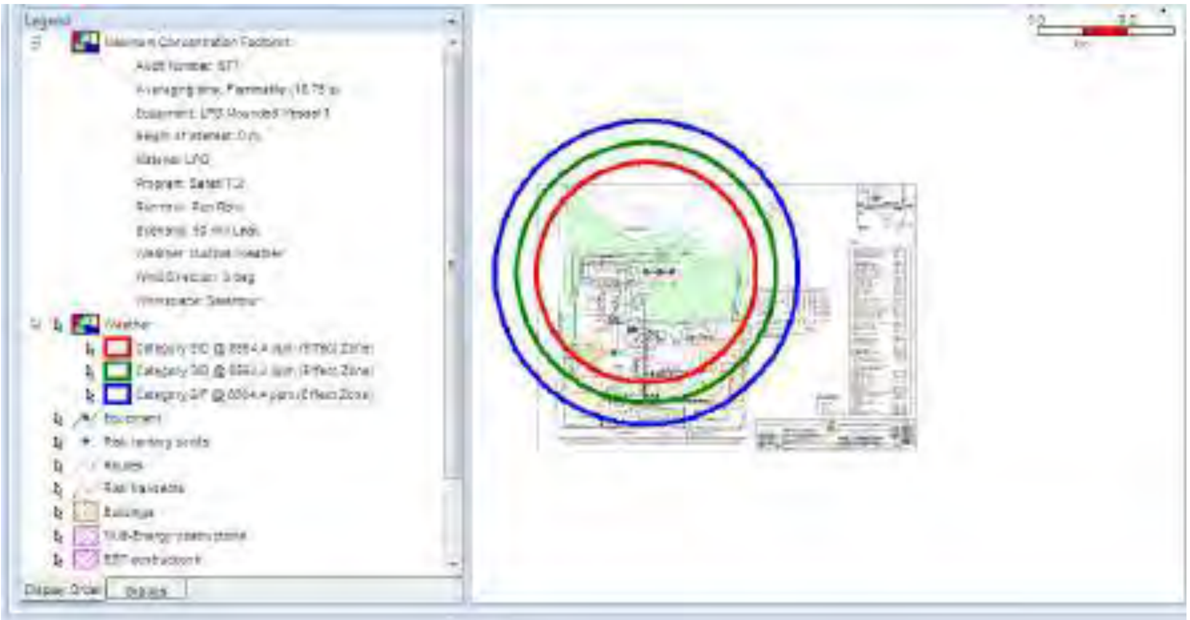


Figure 4.1: Maximum Concentration Graph for Worst case scenario of 50 mm Leak Scenario for LPG MSV 1

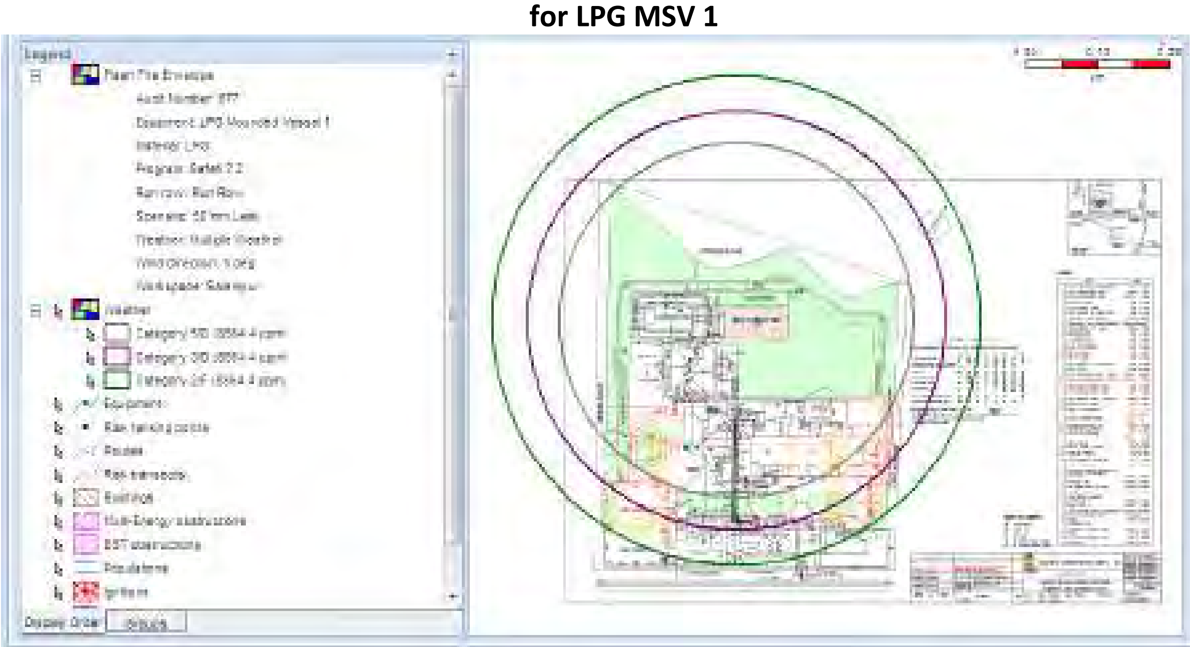


Figure 4.2: Flash Fire Graph for Worst case scenario of 50 mm Leak for LPG MSV 1

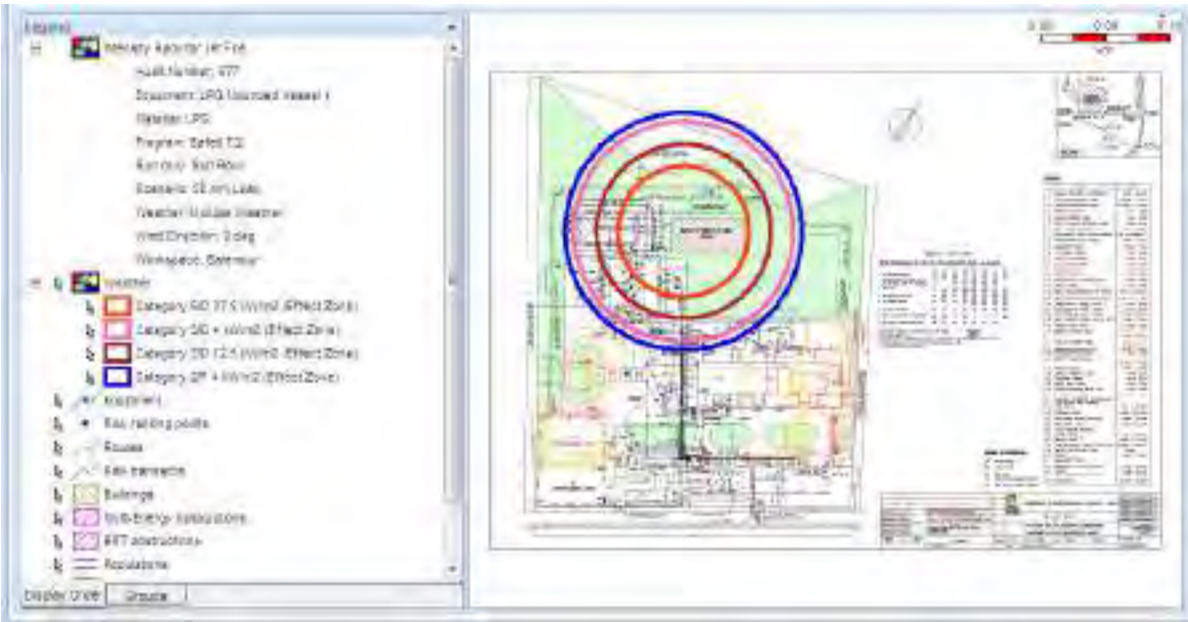


Figure 4.3: Intensity Radii for JetFire Graph for Worst case scenario of 50 MM LPG MSV 1

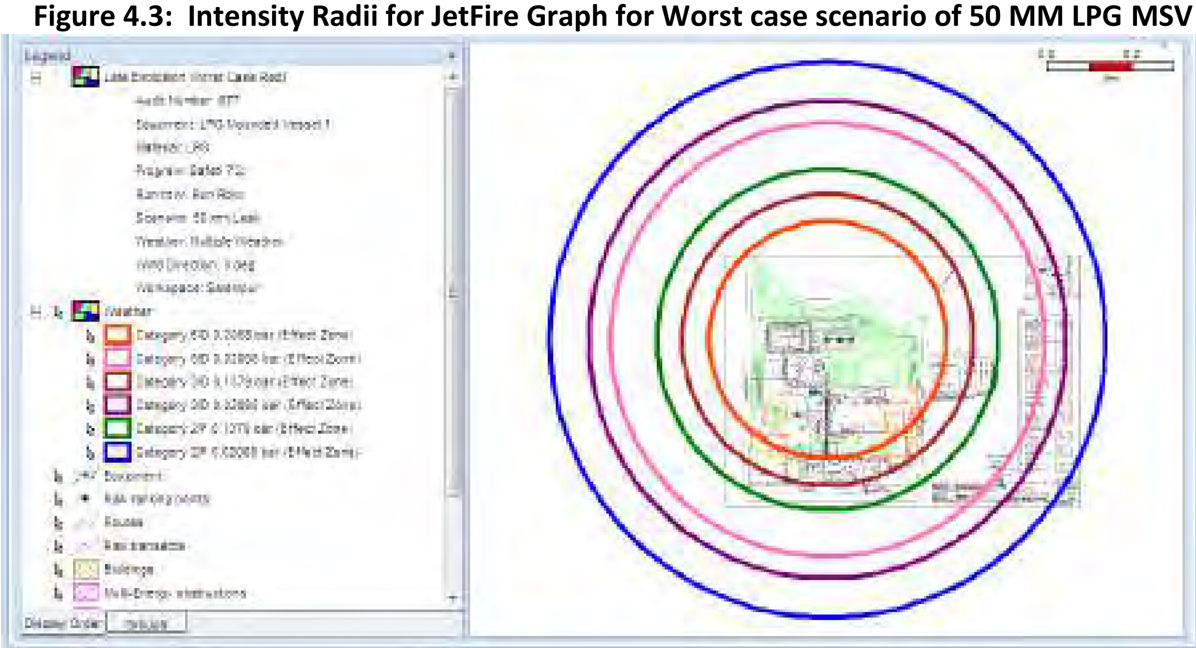


Figure 4.4: Late Explosion Worst Case Radii Graph for Worst case scenario of 50 MM LEAK in MSV 1

5 : RISK ANALYSIS

5.1 RISKS AND FAILURE PROBABILITY

The term Risk involves the quantitative evaluation of likelihood of any undesirable event as well as likelihood of harm or damage being caused to life, property and environment. This harm or damage may only occur due to sudden/accidental release of any hazardous material from the containment. This sudden/accidental release of hazardous material can occur due to failure of component systems. It is difficult to ascertain the failure probability of any system because it will depend on the components of the system. Even if failure occurs, the probability of fire/explosion and the extent of damage will depend on many factors like:

(a) Quantity and physical properties of material released.

(b) Source of ignition.

(c) Wind velocity, direction and atmospheric stability.

(d) Presence of population, properties etc. nearby.

Failure frequency of different components like pipes, valves, instruments, pressure vessels and other equipment manufactured in India are not available nor has any statutory authority tried to collect the information and form an acceptable data bank to be used under Indian condition.

Failure frequency data for some components accepted in *U.S.A* and *European Countries* are given in Table –5.1

Table 5.1: Failure Frequency Data

Sl. No.	**Item**	**Failure Frequency / 10^6 Years**
1]	Shell Failure (a) Process/pressure vessel (b) Pressurised Storage Vessel	 3 1
2]	Full Bore Vessel Connection Failure (Diameter mm) < 25 .... 40 .... 50 .... 80	 30 10 7.5 5

	100 .... >150	4 3
3]	Full Bore Process Pipeline Failure d <50 mm .... 50 <d <150 mm .... d >150 mm	 0.3 * 0.09 * 0.03 *
4]	Articulated Loading / unloading arm failure	$3x10^{-8}$**
5]	Gasket Failure	$0.5x10^{-6}$**
6]	Mechanical Seal failure	5

* Failure frequency expressed in (/m/10^6 years)

** Failure frequency expressed in (/hr of operation)

5.2 RISK ASSESSMENT

When hazardous material escapes to atmosphere, the formation of a vapour cloud may arise in the air. Direct cloud formation occurs when a gaseous or flashing liquid escapes to atmosphere. Indirect cloud formation occurs through evaporating pools of liquid on ground. For the assessment of 'Individual Risk' due to the LPG Bottling Plant at Hathras, following has been taken into consideration:

a) The individual risk has been calculated as cumulative effect of all the scenario mentioned for selected failure case as listed in **Table No. 5.2** for 2F, 3D and 5D where 2F, 3D & 5D are wind speed of 2 m/sec& stable stability class (F)& unstable stability class & wind speed of 3 m/sec and 5 m/sec. for neutral stability class atmospheric conditions (Class D) respectively.

b) Probability of wind directions has been taken from *IMD data and Baseline Monitoring results obtained from the EIA Study*.

c) No mitigation factors such as shelters, escape etc. are considered which will result in conservative risk estimation.

d) During risk assessment population data and source of ignition has been considered.

5.3 ACCEPTABILITY OF RISK

Risk evaluation is done in order to assess the impact the people being exposed both inside and outside the factory premises. The values is generally presented in terms of chances of death per million per year. Acceptability criteria for individual fatality risk are usually judged by comparing the values obtained in the risk analysis study to the statistical risk value of other normal human activities. Risk values of some of the familiar activities are given in Table - 5.2

The acceptability levels of risk for people employed within the organization are generally higher. This is because of the fact that those employed are well aware of the risk involved and have accepted voluntarily some amount of risk while accepting the job. This voluntary risk can be compared to the risk associated with other voluntary activities like rock climbing, motor vehicles accidents smoking etc.

Table 5.2: Individual Risk of Some Human Activities

Activities	Chance of Death/ Million/ Year
Voluntary Risk:	
Rock Climbing (UK)	40
Smoking (20 cigarettes/day)	5000
Accident at work (UK)	33
Playing Football (UK)	40
Involuntary Risk:	
Railway Accident (India)	15
Road Accident (India)- risk in urban is much more	50
Motor Vehicle Accident (UK)	106
Lighting (in UK)	0.1
Meteorite strikes	0.00006
Aircraft Crash (In UK)	0.02

Data source: Loss prevention in Process Industries – FP Lees

Risk of death 1 per million per year or 1x10-6 per year inside the factory premises are generally accepted without concern and this risk in often seen to be lower than voluntary and involuntary risk of death from human activities and other cases an individual is exposed to.In case of LPG

Bottling Plant, Salempur the acceptable risk of 1x10-4 to 1x10-6 per year remains confined within the factory boundary.

5.4 RISK CRITERIA

Individual risks are the key measure of risk acceptability for this type of study, where it is proposed that:

Risks to the public can be considered to be broadly acceptable (or negligible) if below 10^{-6} per year (one in 1 million years). Although risks of up to 10^{-4} per year (1 in 10,000 years) may be considered acceptable if shown to be As Low As Reasonably Practicable (ALARP), it is recommended that 10^{-5} per year (1 in 100,000 years) is adopted for this study as the maximum tolerable criteria, as per UK guideline.

Risks to workers can be considered to be broadly acceptable (or negligible) if below 10^{-5} per year and where risks of up to 10^{-3} per year (1 in 1000 years) may be considered acceptable if ALARP.

The Figure below presents the combined risk from all hazards modelled for the Bottling Plant. The risk is expressed as risk of fatality on average per year. The overall worst-case scenario for the LPG Bottling, Salempur is given in the figure below:

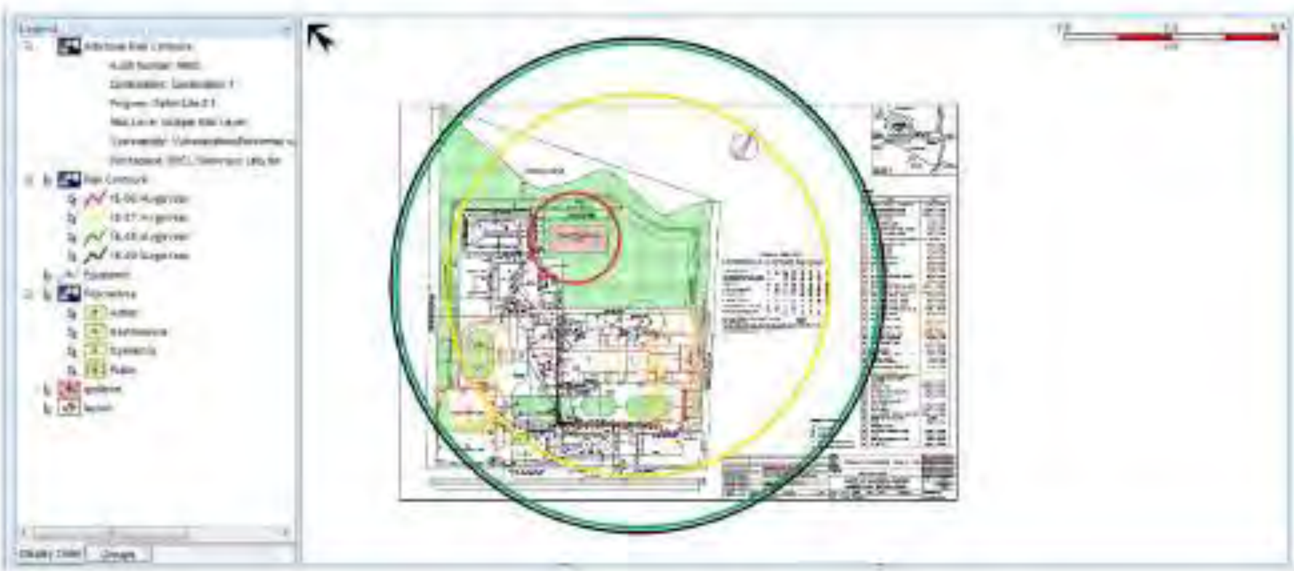


Figure 5.1: Overall Risk Contour of LPG Bottling plant, Salempur.

The maximum LSIR (Location Specific Individual Risk) of the BPCL, LPG Bottling Plant, Salempur is will be within the boundary and it is below the ALARP region.

Table 5.3: Maximum Location Specific Individual Risk at LPG Bottling plant, Salempur.

S. no.	Unit	Maximum LSIR
1.	LPG Bottling plant, Salempur.	1x10-5 / yr
Note: LSIR Value is as reported by PHAST RISK software		

5.5 INDIVIDUAL RISK (IR)

The Location specific individual risk (LSIR) is risk to a person who is standing at that point 365 days a year and 24 hours a day. Personnel in the Terminal are expected to work 8 hour shift as well as general shift. The actual risk to a person i.e. "Individual Specific Individual Risk (ISIR)" would be far less after accounting for the time fraction a person is expected to spend at a location.

ISIR Area = LSIR X (8/24) (8 hours shift) X (Time spent by and individual/8 hours)

ISIR Area = LSIR X (8/24) x (8 hours shift) X (Time spend by an individual/8 hours) =1x10-5 x (8/24) x (8) x (8/8) =0.266E-06 per year

The maximum ISIR in the units are listed in Table below:

Table 5.4: Maximum Individual Specific Individual Risk (ISIR) at LPG Bottling plant, Salempur.

S. no.	Unit	Maximum ISIR
1.	LPG Bottling plant, Salempur.	0.266E-06 per year
Note: ISIR Value is as reported by PHAST RISK software		

ALARP summary & comparison of Individual risk with acceptability criteria:

The objective of this RA study is to assess the risk levels at LPG Bottling Plant, Salempur with reference to the defined risk acceptability criteria and recommend measures to reduce the risk level to as low as reasonably practicable (ALARP).

The comparison of maximum individual risk with the risk acceptability criteria is shown in Figure below:-

The Figure below presents the combined risk from all hazards modelled for the terminal. The risk is expressed as risk of fatality on average per year. Risk levels of the order 1E-06, 1E-07 and 1E-08 per avg year only are observed in the location. The comparison of maximum Individual Risk with the Risk acceptability criterion is shown in the figure below:

Figure 5.2 Risk level at LPG Bottling plant, Salempur.

5.6 SOCIETAL RISK (SR)

Societal risk is defined as the relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realization of specified hazards. Societal risk evaluation is concerned with estimation of the chances of more than one individual being harmed simultaneously by an incident. The likelihood of the primary event (an accident at a major hazard plant) is still a factor, but the consequences are assessed in terms of level of harm and the numbers affected (severity), to provide an idea of the scale of an accident in terms of numbers killed or harmed. Societal risk is dependent on the risks from the substances and processes located on a major hazard installation. A key factor in estimating societal risk is the population around the site, in particular its location and density. For example, the more (occupied) buildings in any particular area, the more people could be harmed by toxic gas release passing through that area. For an installation with a population located in a specific compass direction, the chance of a toxic gas release would depend on the probability of drift in that direction. Criteria are also proposed, although these should be used as guidance only.

A criterion of 10^{-4} per year is recommended for determining design accidental loads for on-site buildings, i.e. buildings should be designed against the fire and explosion loads that occur with a frequency of 1 in 10,000 years.

Table 5.5: Societal Risk at LPG Bottling plant, Salempur.

S. no.	Unit	Maximum ISIR
1.	LPG Bottling plant, Salempur.	1 E-06 to 1 E-09 per year
Note: SR Value is as reported by PHAST RISK software		

The red and green lines show the intolerable and tolerable risk criteria as per the Standard Risk Criteria. The blue line shows the combined risk (both daytime and night time) of outside population. As seen above in the F-N curve, the societal risk falls in the ALARP region. The greatest number of fatalities from any event is 8, with a frequency of 1E-04 per average year

The result from the F-N curve shows that the societal risk due to LPG Bottling plant, Salempur and its surrounding are within the ALARP Region.

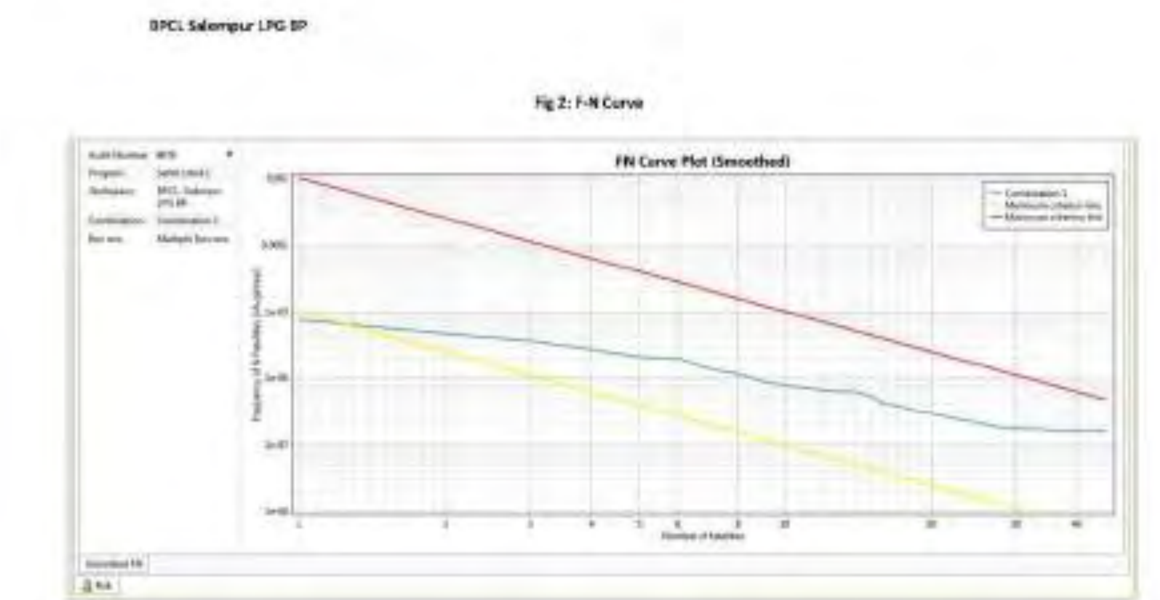


Figure 5.3: F-N Curve of LPG Bottling plant, Salempur.

6 : CONCLUSIONS & RECOMMENDATIONS

a) It is observed from the Iso-Risk Contour that the acceptable limit of individual risk of 1**x10^{-6}per year** to 1**x10^{-9}per year**remains mainly confined within factory premises.

b) Societal Risk (F/N Curve) developed for the plant remains mainly within the Acceptable limit.

c) The Hazard distances arrived from the consequence analysis reveals that in most of the cases hazard is confined within the plant premises.

d) Disaster Management Plan has been prepared for LPG Bottling Plant.

6.1 RECOMMENDATIONS

The recommendations as revealed from Risk analysis Study are as follows:

In order to reduce the failure frequency and consequent risk, codes, rules and standards framed e.g. OISD 117/118, SMPV rules (Unfired), gas cylinder rules etc. should be strictly followed.

2. Training in fire fighting, escape, operation of emergency switches etc. should be provided to the officials. The FIRE ORDERS drills, MOCK DRILLS etc. are the best ways of ensuring emergency preparedness.

3. Pump loading line failures. Hose failures etc. again have possibility of causing major damage. Great care is necessary, as the vicinity could have a lot of persons as possible victims. Supervision by staff, hoses maintenance and following strict procedures is essential for preventing escalation of such incidents of high frequency and low outcome.

4. TLD loading failures, again have possibility of causing major damage great care is necessary, as the vicinity could have many persons as possible victims. Supervision by staff, hoses maintenance and following strict procedures is essential for preventing escalation of such incidents of high frequency and low outcome.

5. The fire water pumps must be tested regularly for normal as well as emergency operation.

6. No need of fire proof coating in Horton sphere because radiation flux is generated due to Jet fire is in downwind direction. It is advisable that pipeline within 15 meters from the Bullets/sphere including LPG lines to be provided with Fire-proof Coating.

7 : DISASTER MANAGEMENT PLAN

The objective of any plant should be safe and trouble-free operation as well as smooth production. This is ensured by taking precautions right from design stage i.e. design of plant, equipment/pipeline as per standard codes, ensuring selection of proper material of construction, well designed codes/rules and instruments for safe operation of the plant. Safety should be ensured afterwards by operating the plant by trained manpower. Despite of all precautionary measures taken, accidents may happen due to human error or system malfunction. Any accident involving release of hazardous material may cause loss of human lives & property and damage to environment. Industrial installations are vulnerable to various natural as well as man-made disasters. Examples of natural disasters are flood, cyclone, earthquake, lightening etc. and manmade disasters are like major fire, explosion, sudden heavy leakage of toxic and poisonous gases & liquids, civil war, nuclear attacks, terrorist activities etc. The damage caused by any disaster is determined by the potential for losses surrounding the event. It is impossible to predict the time and nature of disaster, which might strike on undertaking. However, an effective disaster management plan i.e. pre-planned procedure involving proper utilisation of in-house as well as outside resources helps to minimise the loss to a minimum and resume the working condition as soon as possible.

7.1 STATUTORY REQUIREMENT

Disaster Management Plan is a statutory requirement for LPG Bottling Plant, Salempur at Hathras (UP). The applicable regulations are:

a) ***Factories Act, 1948*** and as amended

b) Manufacture, Storage and Import of hazardous ***Chemicals Rules, 1989***, notified under ***Environment Protection Act 1986andamended in 1994***.

c) ***Rules on Emergency Planning Preparedness and Response for Chemical Accidents, 1996***.

d) ***Stipulations of OISD-168***

e) **Public Liability Insurance Act, 1991.**

The Disaster Management Plan has been prepared based primarily on Schedule-11 of Manufacture, storage and Import of hazardousChemicals Rules, 1989 and amended in 1994 amended in 2000.

7.2 OBJECTIVE OF DISASTER MANAGEMENT PLAN

Disaster Management Plan is basically a containment, Control & mitigation Plan. The plan includes activities before disaster, during disaster and after disaster:

The objective of disaster management plan is to formulate and provide organizational set up and arrange proper facilities capable of taking part and effective action in any emergency situation in order to:

a) Brief the incident under control making full use of inside and outside resources

b) Protect the personnel inside the Terminal as well as public outside.

c) Safeguard the Terminal as well as outside property and environment.

d) Carry out rescue operation and treatment of casualties.

e) Preserve relevant records and evidences for subsequent enquiry

f) Ensure rapid return to normal operating conditions.

The above objectives can be achieved by –

i) Proper identification of possible hazards and evaluation of their hazard potential and identification of maximum credible hazard scenario.

ii) Arrange/augment facilities for firefighting, safety, medical (both equipment and manpower)

iii) Evolving proper action plan with proper organizational set-up and communication facilities as well as warning procedure.

7.3 DEFINITIONS

Disaster

Disaster is a general term, which implies a hazardous situation created by an accidental release or spill of hazardous materials, which poses threat to the safety of workers, residents in the neighbourhood, the environment or property.

Emergency

Emergency condition and Disaster Condition are synonymous.

ON-SITE Emergency/Disaster

In an On-Site Emergency the effect of any hazard (fire/explosion/release of toxic gases) are confined within the factory premises. An accident taking place inside the Terminal and its effects are confined within the boundary wall.

OFF-SITE Emergency/Disaster

In case of any hazard inside BPCL, LPG Bottling Plant, Salempur the effects that are also felt outside the boundary wall.

7.4 DESCRIPTION OF INDUSTRIAL ACTIVITY

Address of the person furnishing the information

Incharge LPG Bottling Plant,

Bharat PetroleumCorporation Ltd,

Rati Ka Nangla, Salempur, Hathras, U.P

c) Activities & Facilities

A brief description the activities in Hathras,POLTerminal are:

i) Receipt of the LPG through Tankers

ii) Storage of these products in storage tanks

iii) Tank Lorry Filling

Tank Lorries are filled in filling bays by pumping products from storage tank to filling bays 14 Nos. of bays are provided for this purpose. The discharge pipeline branches are connected to tank Lorries by loading arm through a flow control valve and flow meter. The tank Lorries are properly earthed before receiving the petroleum products.

7.5 SAFETY RELATED UTILITIES

i) Water

a) Fire water requirement is as per norms of OISD-117.

b) Water Storage Facilities: As per OISD-117

c) Facility available: Water Tanks 858 kl x 2 tanks, 1360 kl x 1 tank

d) Source of Water: Bore wells provided inside the Bottling Plant

e) Fire hydrants/monitors are provided in all the vulnerable areas of the plant.

ii) <u>Power</u>

The Existing and proposed Bottling Plant would require approximately 550 kVA of Electric power. This requirement shall be met from the nearest sub Station of Uttar Pradesh State Electricity Board (UPSEB). Unit has installed DG sets with capacity of 380 KVA (1 No.), 320 KVA (1 No.) and 125 KVA (1 No.).

7.6 DISASTER PLANNING

<u>Modern approach to disaster management plan involves</u>

a) Risk analysis Study

b) Action Plan

<u>Risk analysis study involves</u>

a) Risk Identification

b) Risk Evaluation

<u>Risk identification involves</u>

i) Identification of hazardous events in the installation, which can cause loss of capital equipment, loss of production, threaten health and safety of employees, threaten public health and damage to the environment.

ii) Identification of risk, important processes & areas to determine effective risk reduction measures

Risk evaluation involves calculation of damage potential of the identified hazards with damage distances (which is termed as consequence analysis) as well as estimation of frequencies of the events.

Hazardous areas with different hazard scenarios and their damage potential with respect to fire & explosion have already been mentioned in the chapter on Risk Analysis. However, failure rate of different hazard scenarios has been discussed broadly based on data available for similar incidents outside India.

Probability of any hazardous incident and the consequent damage also depends on –

a) Wind speed
b) Wind direction
c) Atmospheric stability
d) Source of ignition and
e) Presence of plant assets & population exposed in the direction of wind.

Action plan depends largely on results of risk analysis data and may include one or more of the following:

a) Plan for preventive as well as predictive maintenance.
b) Augment facilities for safety, firefighting, medical (both equipment and manpower) as per requirements of risk analysis.
c) Evolve emergency handling procedure both on-site and off-site.
d) Practice mock drill for ascertaining preparedness for tackling hazards/emergencies at any time- day or night.

7.7 IDENTIFICATION OF HAZARDS

7.8 GENERAL NATURE OF HAZARD

In LPG Bottling Plant, Salempur petroleum products to be handled are highly inflammable and also have explosive properties.

Any small fire in the installation, if not extinguished at early stage can cause large scale damage and may have a cascading effect. Hence the Terminal requires.

a) A quick responsive containment and control system requiring well planned safety and firefighting system.

b) Well organized trained manpower to handle the process equipment & systems safely.

c) Well trained personnel to handle safety and firefighting equipment to extinguish fire inside the installation promptly as well as tackle any type of emergency.

d) Well planned Disaster Management Plan.

7.9 HAZARD SCENARIOS AND EFFECTS.

- This has been discussed in detail in the Chapter on Risk Analysis. However, a brief outline is given in the following table:
- Flash fire due to spill of bund/tank
- Pipe flange leakage fire
- Fire at TT gantry
- Fire at TWD and TLF Pump house
- Fire at Exchange Pit/Manifold
- Electrical Fire at MCC room
- Electrical Fire at DG room/Fire Engine Room
- Fire in transformer Yard
- Fire in Lube Godown /Lube Storage Area

Table 7.1:Probability of Failure Scenarios at LPG Bottling Plant, Salempur

Sl.No.	Failure Scenarios	Likely Consequences	Credible/ Non Credible
1]	All Existing Above Ground bullets & MSV including proposed MSV(Catastrophic) on Fire with Domino effect.	Release of LPG	Partially Credible
2]	Vessel connection failure for tank outlet lines of all tanks	- do -	Partially Credible
Fire in Tank Wagon decantation Siding			
3]	TLF Pump Discharge Line Rupture	- do -	Non-Credible

4]	Gasket Failure in TLF Pump Discharge Line	- do -	Credible
5]	3 inches dia. loading arm failure for Road Tanker Loading	- do -	Partially Credible
6]	Pump Mechanical Seal Failure	- do -	Credible
7]	Hole in Pump Discharge Line (15mm)	- do -	Credible

All the scenarios are having damage potential to a different degree. However, maximum damage can happen due to storage tank pipeline connection failure or in case of tank fire.

In all the above cases fire/explosion can occur due to ignition of the vapor of petroleum products coming out from the containment. The sources of ignitions may be

(i) Hot work in the vicinity,

(ii) (ii) Smoking,

(iii) Lightning,

(iv) Generation of static electricity,

(v) Radiant heat from outside,

(vi) Deliberate ignition or sabotage,

(vii) By the ignition of dry grass in the dyke area.

7.10 EMERGENCY CONTROL CENTRE & SHELTER ROOM

The emergency control centre shall be situated in the office building. The office room of Terminal In-charge shall be designated as Emergency Control Centre. P&T telephones, Alarms, Emergency Control Manual and Safety and Personal Protective Appliances are to be arranged in sufficient numbers and kept in the room.

Emergency Shelter

The room has been proposed outside the licensed area for giving shelter to employees/ other personnel who are not involved in emergency control actions.

7.11 ALARM AND COMMUNICATION SYSTEM

A] Alarm System

i] One Electrical Siren and five Hand Sirens are provided in office building/Emergency Control Room for warning the public as well as employees inside.

ii] The sound of electrical siren shall be audible upto 3 KMs.

iii] For fire condition electrical siren will be wailing for minimum 2 minutes and for all clear signals it will be a straight run siren for 2 minutes.

iv] For disaster condition the wailing sound shall be repeated with a minimum 10 seconds gap.

B] Communication System

For communication with officers/employee's VHF system is provided. For external communication, Mobile, landline telephone, fax and email facilities are provided.

7.12 MUTUAL AID

It is not possible to combat large scale fire/disaster single handed effectively by any organization. Assistance of resources of firefighting and other services are of utmost importance during the hour of crisis. Following type of mutual aids are envisaged:

i] Assistance by firefighting teams & equipment.

ii] Medical and first aid assistance.

iii] Assistance of vehicles for any emergency requirement.

iv] Help in liaisoning with police, District Collect orate, Fire Brigade and Hospitals.

Mutual aid agreement should be done with nearby industries & facilities available in the area.

7.13 DISASTER CONTROL PLAN

The plan includes three major plans –

i] Equipment Plan

ii] Organization Plan

iii] Action Plan

Equipment Planning

Equipment plan i.e. arrangement of firefighting, safety, transport etc. has been discussed earlier. Assembly Points

I. Emergency Assembly Point in front of Administrative Office/Visitor gate area is pre-designated areas in safe zone as per quantitative risk assessment, where the personnel like workers, staff, contractor workers etc. not involved in emergency operations (as per ERDMP) shall assemble in case of an emergency.

II. Depending on the location of the emergency, the assembly point can vary. Accordingly for each potential hazardous zone, a specific assembly point is identified and clearly marked on the zones or maps as tabulated below.

Table 7.2:Table showing Potential Hazardous Zones in the plant

SL.No	Potential Hazard Zone	Assembly point Designated
1	Tank Farm 1	Assembly point-A
2	Tank Farm 2	Assembly point-A
3	Tank Farm 3	Assembly point-A
4	Admin Building	Assembly point-A
5	Security Gate -1	Assembly point-A
6	Canteen/Fire Station/Control Room/BPCL Hospitality /Project Office/MPSPL	Assembly Point-A
7	Tank Farm 4	Assembly Point-B

8	Tank Farm 5	Assembly Point-B
9	Security Gate -2	Assembly Point-B
10	TT Gantry Area/ETP Area	Assembly Point-B
11	MCC Room-1/DG Room Area	Assembly Point-B

7.14 ORGANIZATION PLAN

The disaster management organization and action plan is made in such a way that it is capable of quick response at any time to meet emergency situation. The plan gives a detailed chain of command, area of responsibility of each personnel involved, information flow pattern and coordination activity required to meet the emergency. A typical Disaster Management Organization Chart is given below:

Organization Chart of LPG Bottling Plant, Hathras for On-Site Disaster Control Plan

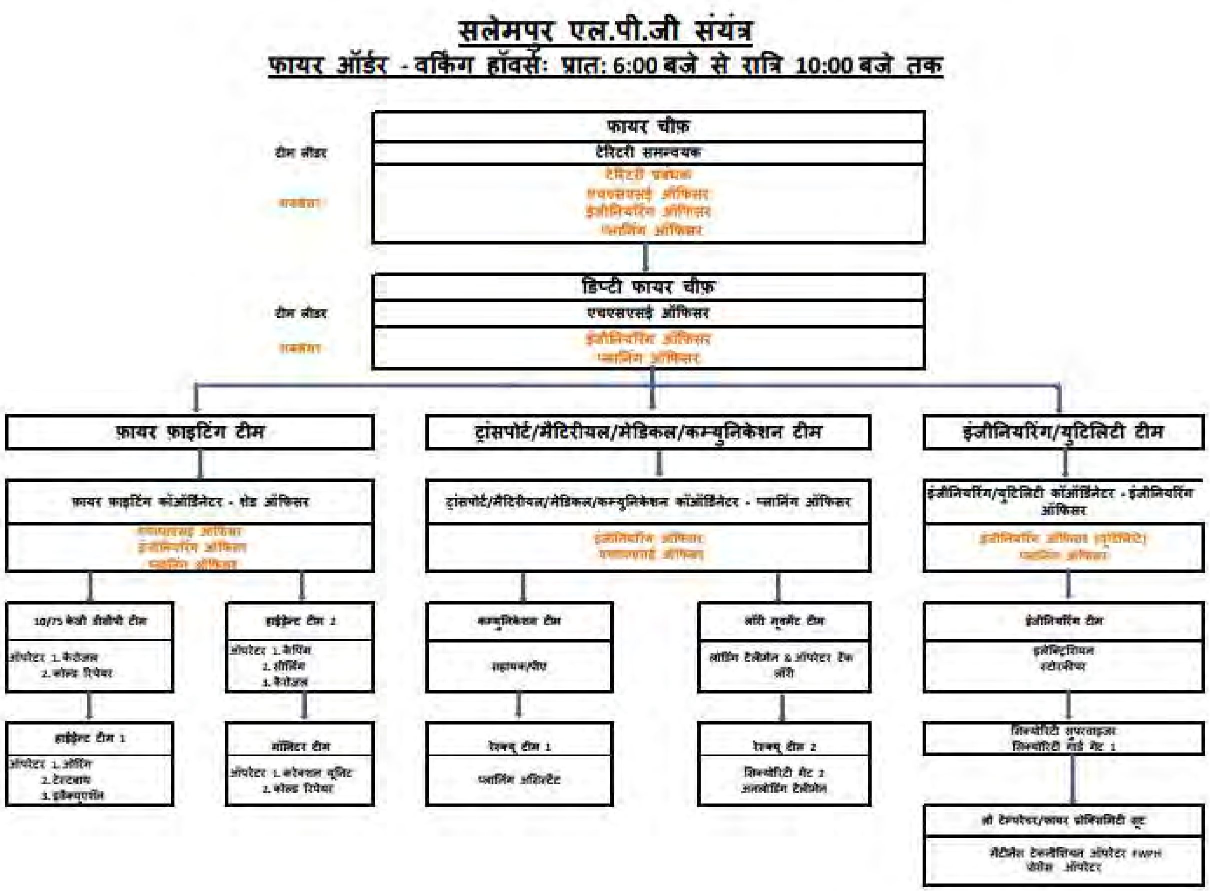


Figure 7.1:Organization Chart as per ERDMP

KEY PERSONNEL CHART

The senior officer in the Plant manager, who will be the Chief Emergency Controller. In pre-Emergency period he will delegate responsibility to other officers as other Coordinators as per suitability and the job to be done by them. During emergency, if Terminal Manager is not present at site, the senior most officers in the Terminal will assume the responsibility of Chief Emergency Controller and inform Terminal Manager to be present at site at shortest possible time.

The duties and responsibilities of Chief Controller and other Coordinator are as follows:

DUTIES & RESPONSIBILITIES OF KEY PERSONS & COORDINATORS

Chief Emergency Controller

For On-Site Emergency Preparedness Plan (EPP), the Location-in-Charge (Terminal Manager) shall be the Chief Emergency Controller to coordinate the execution of the plan during an emergency or a mock drill. He is responsible for preparation/updating of the plan, getting approval from the District authorities/Factory Inspectorate; and its implementation in the hour of need. His duties are -

a) Assess the magnitude of the situation and declare state of emergency. Activate EPP and ensure its implementation.
b) Mobilize the Coordinators/Key Personnel and exercise direct operational control of areas, other than those affected.
c) Declare danger zones and activate Emergency Control Centre.
d) Ensure calling in Mutual aid members and District emergency agencies like Fire Brigade, Police, and Medical authorities.
e) Maintain a speculative continuous review of possible developments and assess these to determine most probable course of events and appropriate response.
f) Inform Area Office, Head Quarters, Police, Statutory authorities, District authorities about the magnitude of the emergency casualties and rescue operations.
g) Ensure casualties are receiving required attention and their relatives are informed.

h) Ensure accounting of personnel.

i) Issue authorized statements to Press, Radio, TV etc., regarding the emergency and its possible impact on the surroundings.

j) Authorize procurement of emergency material.

k) Log important developments in chronological order and preserve material evidence for investigation. Direct isolation of power supply, plant shutdown, and evacuation of personnel inside the premises as deemed necessary.

l) Advise Police, District authorities regarding evacuation of public in the near vicinity/vulnerable zone. Ensure raising the siren in EMERGENCY mode till All Clear Signal.

m) When effects are likely to be felt outside, get in touch with District Authorities, who will take over the management and declare "Off-Site Emergency".

n) Control rehabilitation of affected areas on cessation of emergency.

Administration & Communication Coordinator

a) Liaise with Chief and other coordinators.

b) Inform and coordinate with External agencies and Mutual aid members for agreed assistance. Direct them on arrival to the respective coordinators.

c) In case communication means fail, send messengers to Mutual aid members/ Emergency departments. Coordinate with Police in controlling the traffic and mob outside the premises.

d) Activate the medical centre and mobilize medical team. Arrange ambulance and transfer casualties to hospitals. Also coordinate with police in case of fatalities.

e) Arrange for head count at the assembly points.

f) Arrange procurement of spares for firefighting and additional medical drugs/ appliances.

g) Mobilize Transport as and when required by various coordinators. Arrange to provide spark arrestors to emergency vehicles entering the premises.

h) Monitor entry/exit of personnel in the premises. Permit only authorized personnel/ vehicles inside the premises.

i) Control and disperse crowd from the emergency site. Regulate traffic inside the location.

j) Arrange food, beverages and drinking water for all those involved in execution of EPP in case the emergency prolongs.

k) Communicate with relatives of casualties.

l) Arrange evacuation of premises as directed by Chief Emergency controller.

m) Coordinate with civil authorities for evacuating public from the danger zone and arrange for refreshments at the evacuation centre.

Safety Coordinator

n) Ensure safe stoppage of the Operations, switching off main instruments, shut off valves on product lines, and isolation of affected area.

o) Demarcate Danger and Safe zones by putting RED and GREEN flags.

p) Mobilize the Firefighting crew and direct the Fire Fighting operation.

q) Effectively deploy manpower, both internal and external.

r) Direct & utilize the Fire Brigade personnel.

s) Arrange the replacement of various Fire Fighting Squads with the Mutual and External aid members on need basis.

t) Ensure/maintain sufficient pressure in the Hydrant mains.

u) Assess water level in the storage tank/reservoir and plan replenishment.

v) Monitor the requirements of Fire equipment and coordinate for procurement of spares.

w) Arrange for flood lighting of the affected areas and dewatering of the Firefighting area, if required.

x) Arrange to remove and park the tank Lorries (Bulk & Packed) to a safer place, as necessary.

y) In case of any leakage of petroleum products or fire any body witnessing the same should take immediate necessary action to stop leakage and extinguish fire with the help of fire extinguishers as well as inform Plant manager through VHF or through messenger or by shouting.

z) In case of any fire or explosion Terminal In-charge takes charge of the situation and controls it with a well-organized plan.

aa) If any accident e.g. fire occurs during night, shift/security personnel shall attend it and in case of emergency Terminal In-charge and others shall be informed / called from their residence.

7.15 ACTION PLAN

This gives guidelines to PREVENT, CONTROL AND TERMINATE AN EMERGENCY and consists of three parts.

a) Pre-emergency action

b) Action during emergency

c) Post emergency actions

a) <u>Pre-Emergency Actions</u>

These are essentially PRE-EMPTIVE AND PREVENTIVE measures and are extremely important. They include mock drills, checking of fire fighting facilities, keeping personal protective equipments in good condition in proper places, medical equipments, scheduled checking of safely devices, safety audits, preventive maintenance, good housekeeping, training of employees, education to the public and liaison with outside industries, State Fire Services, Police, district administration, hospitals, nursing homes etc.

<u>Public Awareness</u>

In case of major accidents like large fire, explosion, effect of which may spread outside the plant boundary, people of the adjoining area may be panicky due to ignorance and may aggravate the problems. To avoid panic, the Terminal management will make easily understandable pamphlets in local language about the properties of petroleum products and actions to be taken by them during an Off-site Emergency. Training and education will also be imparted to the local public by audio-visual system with the help of local authorities. This will be done through Local Crisis Group consisting of District Administration.

Mock Drills

This is periodic simulation of emergency condition, sometimes in consultation with District Crisis Group/Local Crisis Group. The sequence of operation undertaken by Disaster Management Team members and systems provided like alarm & communication system, information flow pattern etc. are carefully put into operation by competent officials and the deficiencies/problems are recorded. Based on this observation appropriate actions are taken to improve the efficiency of the plan.

Training of Employees

Regular training will be conducted to educate the employees about safely, fire fighting and Disaster Management. A selected number will be given intensive training in first aid, evacuation and rescue operation so that they can be utilized as a part of Disaster Control Team.

Liaison with Police, District Administration & State Fire Services & Neighbouring Industries

Help of Police and District Authorities are essential for off-site Emergency such as evacuation, transportation and treatment of individuals etc. In case of On-Site Emergency help of Police, District Administration, local hospitals and also fire services at Hathras district headquarter may be required depending on the severity of the situation.

PRE-EMERGENCY functions of Chief Emergency Controller are mainly

a) Ensure implementation of Emergency Planning
b) Ensure that all drafted for emergency are undergoing regular training.
c) Ensure all disciplines are fully prepared for tackling emergency.
d) Ensure that simulation of emergency condition is regularly arranged.
e) Ensure preventive and pre-emptive measures.
f) Keep liaison with outside agencies, police, district authorities, hospitals, nursing homes etc.

Pre-Emergency functions of other Emergency Controller and their team are

a) Keep all the team members ready for tackling emergency.

b) Ensure that all members understand their specific duties during emergency.

c) Ensure regular participation of their team in mock drills.

d) Ensure supply of adequate number of safety &fire fighting equipment in proper place and in good working condition.

b) Actions during Emergency

Actions to be taken by Chief Emergency Controller and other Incident Controllers have been discussed in the Organization Plan. In short the actions are:

a) Declare Emergency by electrical siren.

b) Instruct total/partial shutdown.

c) Arrange the team for tackling emergency.

d) Ask for outside help, if necessary.

e) Keep liaison with outside agencies and provide authoritative information to news media and others.

c) Post Emergency Actions

These are directed towards termination of emergency, restoration of normalcy and rehabilitation.

It also includes identification of victims, information to their next of kin, notification to various government authorities, appointment of enquiry committee for identification of causes and suggestions to ensure that similar accident does not occur.

7.16 IMPORTANT TELEPHONE NUMBERS:

Table 7.3: Important onsite telephone no

Important Telephone Numbers		
31		
32		

33		
34		
35		
36		

MEDICALFACILITIES

Hathras city has many well-known Hospitals. The range of medical facilities available here is very wide consisting of specialized treatment units for a wide variety of ailments and medical conditions.

Facilities available at first aid centre

First Aid Boxes: First aid boxes have been provided at various work stations to take care of first aid in case of any injury. The following medicines are available in the First Aid Boxes:

- Burnol
- Dispirin
- SterileGauze
- SurgicalDressing
- GauzeDressing
- PotassiumPermanganate
- IodineTincture
- Cotton
- Scissors
- Savlon

In addition, Snake antivenom is also available in the

Terminal Below are the first aid medical facilities present

at the Terminal.

Trained persons in first aid in the terminal

All emergency response personnel in the terminal are trained in first aid.

Facilities available at identified hospitals

- Emergency Department(ED)
- Accident & Emergency(A&E)
- Emergency Room(ER)

- Casualtydepartment
- Ambulance.

1.1.1 Industrial First Aid

GENERAL

First aid may be defined as skilled assistance to the victim in case of accident or sudden illness. The person who renders skilled assistance is called the First Aider.

First aid is primarily a temporary measure to arrest the worsening of the victim's condition till the arrival of a doctor. First Aider must have proper knowledge of all paramedical operations. This first aid is no substitute for treatment by a qualified doctor which must be sought at once.

INSTRUCTIONS TO FIRST AID PROVIDER

- Gather information as to how the accident or illness came about
- Look out for signs such as swelling, bleeding, immobility etc.
- Look out whether the victim feels thirst, nausea, cold, pain, numbness etc.
- Pay special attention to severe bleeding, failure of breathing and shock
- Arrange for speedy removal of the victim to proper medical care

DO'S AND DON'TS OF FIRST AID

- Do the first thing first quickly, quietly and calmly
- Stop severe bleeding, if any
- Administer artificial respiration if required and continue it till the doctor arrives
- Treat for shock
- Boost up the morale of the victim to lessen his anxiety
- Avoid crowding around the victim
- Unless required don't remove clothes
- Don't try to achieve too much
- Don't soak a victim to wake him up
- Unless victim complains of cold, don't wrap with blanket or coat

FIRST AID FOR SPECIFIC ACCIDENT OR ILLNESS

TREATMENT FOR SHOCK

- Keep patient warm.

- Keep head lower than feet
- Cover with blankets or coats
- Give hot coffee or hot tea

TREATMENT FOR SUNSTROKE

- Measure temperature with a clinical thermometer
- If the temperature is high put the victim into a tub of normal water or give full bath or apply wet sponge over his body
- If there is a rise in temperature, apply ice bag or clothes wrung in cold water

HEAT EXHAUSTION

SIGNS TO LOOK FOR: fatigue, irritability, headache, feeling of faintness, cold, clammy skin and a lot of perspiration

WHAT TO DO:

- Person should be made to lie down in a cool, shaded area or an air conditioned room. Raise feet
- Massage legs towards heart
- Give cold salt water, (1/2 teaspoon to ½ glass of water), or cool sweetened drinks, especially iced tea and coffee, every 15 minutes until person recovers
- DO NOT let person sit up, even after feeling recovered. Person should rest for a little longer

TREATMENT FOR FAINTING

- Place victim in lying down position with head lower than the rest of the body
- Loosen clothing around neck
- Ensure plenty of pure air
- Sprinkle face and chest with cold water
- Put smelling salt or ammonia to nose
- Rub limbs towards body
- Give stimulates which victim can swallow

TREATMENT FOR SPRAINS

- Ensure absolute rest for victim till the arrival of doctor
- The affected joint should not be used
- If possible elevate the affected joint
- Apply clothes wrung in cold water or shower the joint with cold water

TREATMENT FOR ORDINARY WOUNDS

- Prevent touching of the wound
- Don't apply ordinary water since it may contain infectious germs
- Don't use strong antiseptics like dichloride or mercury or carbolic acid
- Cover the wound with several layers of sterile gauze and bandage firmly but not tightly
- Call the doctor as early as possible

TREATMENT FOR BURNS AND SCALDS

- Place several layers of sterile gauze over the burn; saturate with 5 per cent tannic acid solution if available and apply bandage
- For serious burns on the body remove all clothing carefully
- If there are signs of collapse keep the victim warm and give sips of warm coffee or warm tea if not unconsciousness

TREATMENT FOR ACID AND ALKALI BURNS

- Wash off with copious amounts of clean water
- Do as given above in case of burns treatment

TREATMENT FOR GAS POISONING

- In all cases of gas poisoning, call the doctor at once
- Remove the victim to fresh air if possible
- Put the victim on a bed in a comfortable position and ensure that he is quiet and composed
- In the case of unconscious victim and difficulty in breathing, administer artificial respiration at once

FIRST AID FOR POISONS

- Administer four or more glasses of an emetic (salt and lukewarm water or soapy warm water)
- Induce vomiting by putting a finger down the victim's throat
- Administer the antidote, if you know it
- After emptying the stomach and cleaning it, give a soothing drink such as milk or flour and water

- In case the patient is weak and faints, he should lie down without pillow and should drink coffee or tea. He may use smelling salts

Follow the following instructions for an unconscious patient

- Don't feed anything into the mouth
- Don't cause vomiting
- Keep patient in lying position on left side and keep head low
- Remove false teeth, chewing gum, tobacco or other foreign objects in the mouth
- If patient is not breathing, place in prone position and apply artificial respiration
- Keep patient warm
- If breathing is shallow or skin, lips, ears, fingers, nail beds are blue give oxygen. Administer artificial respiration if necessary
- If the position is unknown give the universal antidote but only after the patient regains consciousness
- To prevent collapse or shock keep the victim warm, quiet and in lying position with head low. If there is consciousness, give strong tea or coffee. Give smelling salts or aromatic spirits of ammonia may be used
- If poison is inhaled through respiratory tract as vapor or gas, take the victim to fresh pure air, use artificial respiration to revive breathing
- If skin or eye is poisoned, wash off with large amounts of water and till the Doctor arrives don't wipe off water. Wash contaminated dress before re-use

ELECTRIC SHOCKS

GENERAL GUIDELINES

- Act at Once – Delay is Fatal
- Patient may become unconscious only due to interruption of breathing system due to severe shock. Therefore, life can be saved by immediate artificial respiration
- Send for, but never wait for, a Doctor

REMOVAL FROM ELECTRICAL CONTACT

- If the person who has received the shock is still in contact with the apparatus/circuit, immediate action should be taken to remove him
- Switch off the current immediately or send someone to do so
-

- Do not attempt to remove a person from contact with high voltage without using articles suitably insulated for the system voltage. When attempting to free a person from contact with low or medium voltage use rubber gloves, boots, mats, or insulated sticks

FIRST AID BOXES

First aid boxes to be kept in control room of all stations. The Fire and Safety Co-ordinator should inspect the contents of each first aid box at least once in every month and ensure that supplies of the necessary medicines in the first aid box are maintained. List of medicines kept in first aid box and their expiry date should also be maintained.

RESUSCITATION SET- Ambulance bag resuscitation set is available at all stations to render artificial respiration to the affected person.

MISCELLANEOUS TIPS

- In all cases of head injuries, always keep the victim's head above the level of his body by keeping someone supporting under his neck
- If the patient ceases to breath, as a result of an injury, electric shock, gas fumes etc. manual method of artificial respiration shall be started
- In an emergency like snake bite, immediately tie with a handkerchief above the level of bite and take the patient to hospital. Always keep the patient warm

ANNEXURE I

MSDS

MATERIAL SAFETY DATA SHEET

1. CHEMICAL IDENTITY		
CHEMICAL NAME : Liquefied petroleum gas		
CHEMICAL CLASSIFICATION: Mixture of butane and propane		
SYNONYMES :		
TRADE NAME: Liquefied petroleum gas		
FORMULA: Mixture of C_3H_8 & C_4H_{10}.	C.A.S. NO.	
U.N. NO: 1075	HAZCHEM CODE: 2WE	
REGULATED IDENTIFICATION : NA		
SHIPPING NAME CODES/ LABLE : Liquefied petroleum gas		
HAZARDOUS WASTE I.D. NO. : NA		
HAZARDOUS INGREDIENTS :	C.A.S. No. :	
1. Propane	106-97-8	
2. Butane	74-98-6	
3. Pentane	109-66-0	
2. PHYSICAL AND CHEMICAL DATA		
BOILING POINT (°C): >-40	PHYSICL STATE: Liquefied gas	APPEARANCE: Colorless
MELTING / FREEZING POINT(°C): N/A	VAPOUR PRESSURE @ 35 °C mm/Hg: 1311.56 mm hg @-20 Dg F	Odor: Odorless Gas.
VAPOUR DENSITY (AIR= 1): 1.5	SOLUBILITY IN H_2O @ 30 °C : Slight at 30 Deg. CG	
SPECIFIC GRAVITY (H2O=1): 0.51 to 0.58 at 50 Deg. CG	PH: NA	
3. FIRE AND EXPLOSION HAZARD DATA		
FLAMMABILITY : Yes	LEL : 1.8 %	UEL : 12.8 %
TDG FLAMMABILITY:	FLASH POINT (°C): -76	AUTO IGNITION

2.1	to -156 Deg. FH	TEMP(°C): 320 to 405 deg C
EXPLOSION SENSITIVITY TO IMPACT: NA	EXPLOSION SENSITIVITY TO STATIC ELECTRICITY: NA	HAZARDOUS COMBUSTION PRODUCTS : Carbon monoxide and carbon dioxide
HAZARDOUS POLIMERISATION : NA	EXPLOSIVE MATERIAL: NA	CORROSSIVE MATERIAL: NA
FLAMMABLE MATERIAL : NA	OXIDISER :NA	OTHERS :NA
PYROPHORIC : NA	ORGANIC PEROXIDE : NA	
4. REACTIVITY DATA		
CHEMICAL STABILITY : Stable		
INCOMPATABILITY WITH OTHER MATERIAL : With oxidizing materials		
REACTIVITY : Yes		
HAZARDOUS REACTION PRODUCTS : Carbon dioxide, Carbon monoxide		
5. HEALTH HAZARD DATA		
ROUTES OF ENTRY: Skin Absorption: NA. Skin Contact: Yes (liquid) Eye Contact: Yes Inhalation: Acute: Yes Chronic: NA. Ingestion: No		
EFFECTS OF EXPOSURE / SYMPTOMS: Inhalation can cause headache, disorientation, dizziness, drowsiness and possibly Unconsciousness at concentrations that cause oxygen deficiency and asphyxiation. Rapidly expanding gas or vaporized liquid may cause frostbite to skin and eyes		
EMERGENCY TREATMENT : Flush eyes and skin with plenty of water and get medical aid.		
TLV (ACGIH) : 100 PPM, 1800 mg/m3	STEL : PPM mg/m3	
PERMISSIBLE EXPOSURE LIMITS LD 50: PPM mg/m3	ODOUR THRESHOLD LD50 : 5000ppm to 20000 ppm	

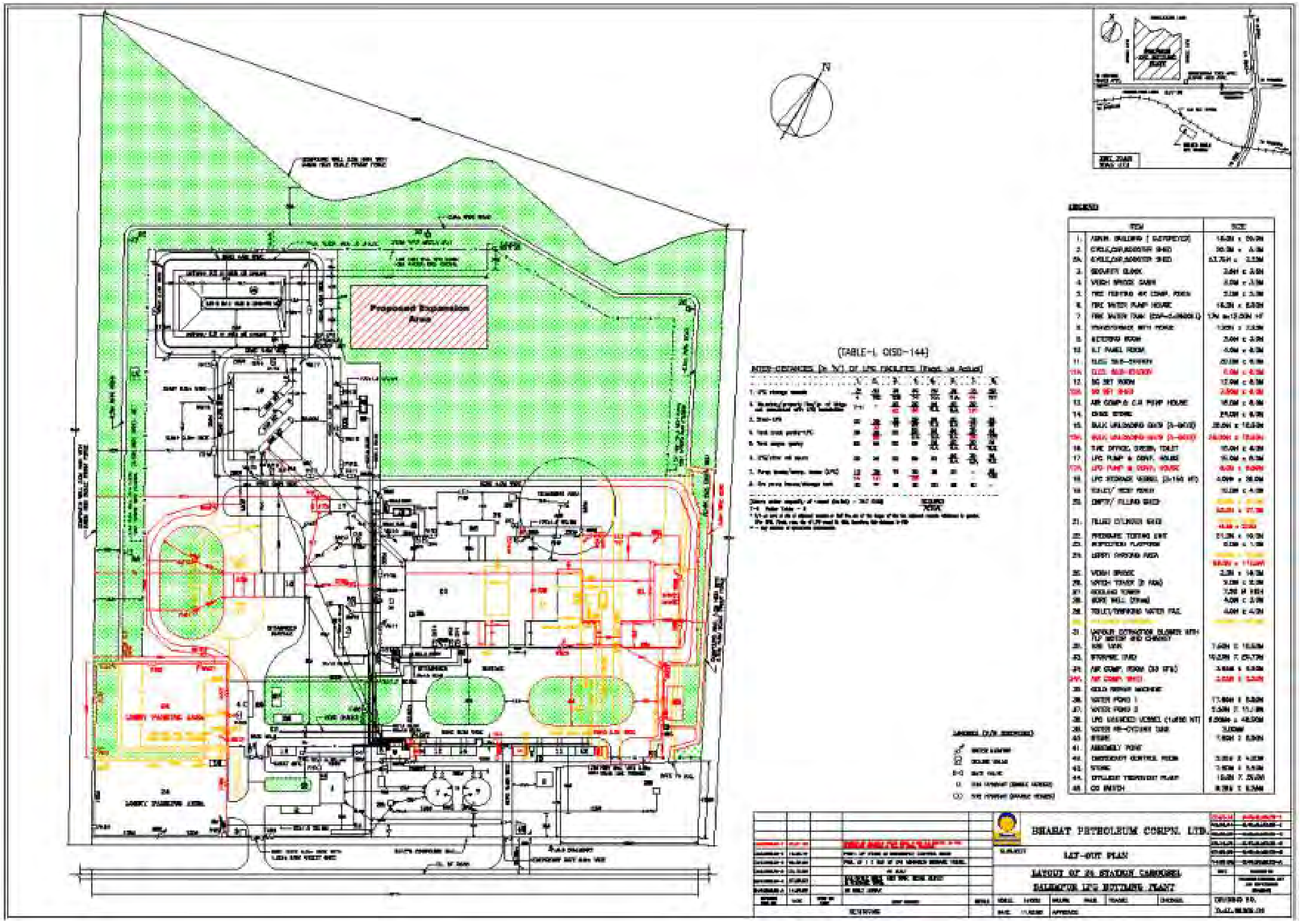
NFPA HAZARD	HELATH: NA	FLAMABILITY : Yes	STABILITY: Stable	SPECIAL: NA

RATING				
6. PREVENTIVE MEASURES				
PERSONAL PROTECTIVE EQUIPMENTS : Respiratory protective equipment required. **Eye & Face : Safety goggles.** **Hand & Arm : Hand gloves (PVC synthetic only)** **Other clothing and equipment : Gum boots, PVC apron.**				
HANDLING AND STORAGE PRECAUTION : Store the container in a cool, dry and well ventilated specified place, away from heat, spark and flame.				
7. EMERGENCY AND FIRST- AID MESURES				

FIRE	FIRE EXTINGUISHING MEDIA : Dry chemical powder, carbon dioxide and water spray.
	SPECIAL PROCEDURE : NA
	UNUSUAL HAZARDS : Air vapour mixture highly explosive.
EXPOSURE	FIRST AID MEASURES : **Skin**: If freeze burn occurs, gently bathe affected area in warm water (38 – 43) deg.C. Do not rub. Get medical attention. **Eye**: Immediately flush with large amounts of luke warm water for 15 minutes, lifting upper and lower lids at intervals. Seek medical attention if irritation persists. **Inhalation**: Remove to fresh air. Give oxygen, artificial respiration, or CPR if needed. Seek medical attention. **Ingestion**: Usually no effect by this route.
	ANTIDOTES / DOSAGES :NA
SPILLS	STEPS TO BE TAKEN : Do not enter in the gas area without protective wears. Get the area evacuated. Stop flow of gas if without risk. Spray water to keep the container cool
	WASTE DISPOSAL METHOD : Collect the spillage & wash the effected area with plenty of water. Allow gas to burn under control

ANNEXURE II

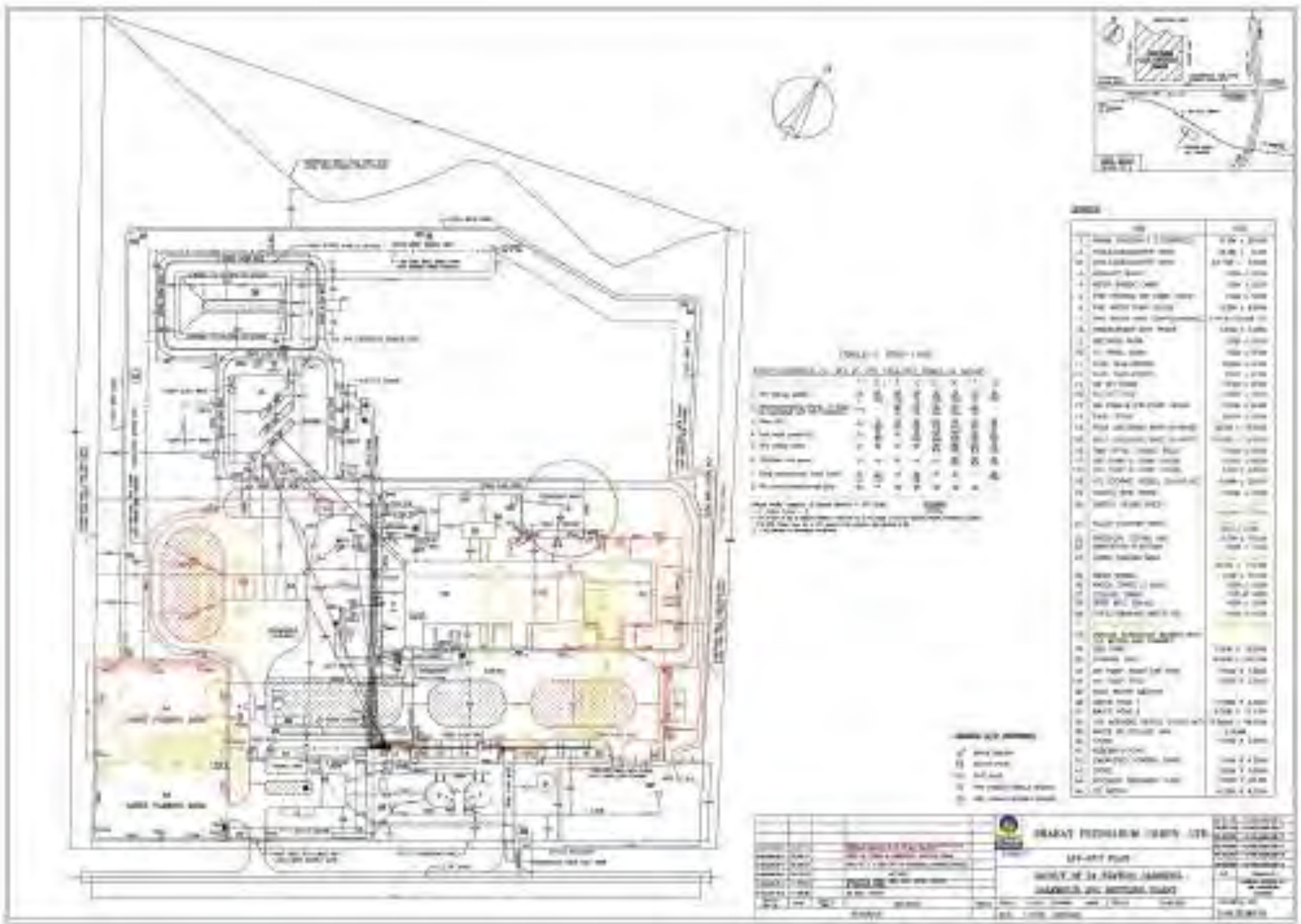
DETAILED LAYOUTS



Plant Layout

ANNEXURE III

HYDRANT LAYOUTS



Hydrant Layout