Risk Assessment Studies

1 Safety Management Plan

During construction, erection, testing, commissioning, operation and maintenance, the manpower, materials and machines are the basic inputs. The proposed development of Jakkasandra industrial area generally has problems related to occupational health and safety. Hence management proposes to take steps to minimize the impacts from the proposed development of industrial area to ensure appropriate occupational health, safety including fire plans by adapting Occupational Health &Safety measures as per Standard Procedures &Local Guidelines. All these activities again may be classified based on activities which needs attention during construction, erection, operation and maintenance phases.

Over-exertion, ergonomic injuries and illnesses caused due to repetitive motion and manual handling are among the most common during construction. The proper steps for their prevention and control include

- Training to be given to the workers regarding the lifting of materials & handling, placement of weight limits, planning of work, selection of tools and implementation of administrative controls in the site for the development.
- Implementation of good house-keeping practices, such as the sorting and placing loose construction materials or demolition debris in identified areas away from foot paths.
- A fall protection plan will be implemented for the persons who will work in heights and also depending on the nature and aspects of the fall hazard.
- Appropriate techniques and measures will be taken for the prevention and control of hazards caused by the objects and moving machinery in proposed site during constructional phase.
- Suitable dust suppression techniques will be implemented like water spraying to minimize dust from vehicle movements and also proper Personal Protective Equipment (PPE) used at excessive levels.

a) Policy

The employees safety policy includes the following

- Contact their immediate supervisors according to individual department policies. What happened will be sorted out through the accident reporting and investigation process.
- The supervisor or employee should see the following to be completed
  - Obtain the names, addresses, and phone numbers (work and home) of any witnesses. Interview the witnesses and prepare a report including statements from the witnesses. The report should include any suggestions to prevent a similar accident or incident from occurring in the future.

- Take photographs of the property damage or defect. A sufficient number of photos should be taken to fully describe the damage to a person who has not been at the scene.
- Prepare a report of the incident with all necessary information. The reports should be prepared to reflect the seriousness of the incident.
- Fill appropriate forms for future use.
- If individual department procedures include all of the information required by this policy, that document can be utilized to fulfill these requirements.
- This policy is in addition to a workers' compensation reporting requirements.

Appropriate risk management strategies will be implemented to protect the community from physical, chemical, or other hazards associated with sites through a combination of Institutional and administrative controls by adopting the community Health and Safety measures as per Standard procedures & local guidelines provided for community health and safety.

To control communicable and vector-borne diseases attributable in the proposed site are not potentially serious health threat to project personnel and residents of local communities. The investigation facilities are available to monitor all the employees for the occupational health diseases expected due the production activities in the industrial area premises and also maintaining periodical check-up of our all workers from certified industrial & occupational health physician. The industrial area will maintain the first aid box with sufficient medicines to face any emergency in the industrial premises.

The problem of occupational health in the operation and maintenance phase of member industries is due to noise hearing losses. The personal protective equipments are given to all the workers.

The working personnel are given the following personnel protective equipments as appropriate to their working environment.

- Industrial safety helmet
- Face shield with replacement acrylic vision
- Zero power plain goggles with cut type filters on both ends
- Welders equipment for eye and face protection
- Ear muffs
- Canister gas mask
- Self-contained breathing apparatus
- Leather apron
- Full body Safety harness
- Leather hand gloves
- Acid/Alkali proof rubberized hand gloves

- Electrically tested electrical resistance hand gloves and
- Industrial safety shoes.

Emergency medical facilities are available round the clock for attending emergency arising out of accidents, if any. All working personnel are medically examined at least once in every year and at the end of his term of employment.

b) Safety Plan

Safety of both men and materials during construction and operational phases is of concern. The preparedness in the proposed site for the occurrence of possible disasters is known as emergency plan. The disaster in the proposed site may be possible due to leakage of hazardous fuels like HSD, collapse of structures and fire/explosion etc.

Keeping in view the safety requirement during construction, operation and maintenance phases, developer/common facilitator propose to formulate the safety policy and the same will be further strengthening after establishment of the proposed industrial area

The safety policy is based on the following regulations

- To allocate sufficient resources to maintain safe and healthy conditions of work
- To take steps to ensure that all known safety factors are taken into account in the design, construction, operation and maintenance of member industries, machinery and equipment
- To ensure that adequate safety instructions are given to all employees
- To provide wherever necessary protective equipment, safety appliances and clothing and to ensure their proper use
- To inform employees about materials, equipment or processes used in their work which are known to be potentially hazardous to health or safety
- To keep all operations and methods of work under regular review for making necessary changes from the point of view of safety in the light of experience and upto date knowledge
- To provide appropriate facilities for first aid and prompt treatment of injuries and illness at work
- To provide appropriate instruction, training, retraining and supervision to employees in health and safety, first aid and to ensure that adequate publicity is given to these matters
- To ensure proper implementation of fire prevention methods and an appropriate firefighting service together with training facilities for personnel involved in this service
- To organize collection, analysis and presentation of data on accident, sickness and incident involving people injury or injury to health with a view to taking corrective, remedial and preventive action

- To promote through the established machinery, joint consultation in health and safety matters to ensure effective participation by all employees
- To publish/notify regulations, instructions and notices in the common language of employees
- To prepare separate safety rules for each type of occupation/processes involved in a proposed industrial area and to ensure regular safety inspection by a competent person at suitable intervals of all buildings, equipments, work places and operations in all member industries.

2 Safety Organization

- **Construction and Erection Phase**

A qualified and experienced safety officer shall be appointed by the member industries and for the entire industrial area. The responsibilities of the safety officers include identification of the hazardous conditions and unsafe acts of workers and advice on corrective actions, conduct safety audit, organize training programs and provide professional expert advice on various issues related to occupational safety and health. He is also responsible to ensure compliance of Safety Rules/ Statutory Provisions. In addition to employment of safety officer by industry every contractor, who employs more than 250 workers, in the proposed site for the development of industrial area/member industry shall also employ one safety officer to ensure safety of the worker, in accordance with the conditions of contract.

- **Operation and Maintenance Phase**

When the construction is completed the posting of safety officers shall be in accordance with the requirement of Factories Act and their duties and responsibilities shall be as defined thereof.

A training center shall be set up at the proposed industrial area. Safety training shall be provided by the Safety Officer with the assistance of External faculty members called from Professional Safety Institutions and Universities. In addition to regular employees, contract labors shall also be provided safety training. To create safety awareness safety films shall be shown to workers and leaflets etc.

3 Risk Assessment Plan

Risk involves the potential occurrence of some accident consisting of an event or sequence of events. Risk (R) can be mathematically expressed as R = fD where R is the risk (individual or societal), f is the frequency of occurrence of an undesired event and D is the expected damage distance due to likely occurrence of that unfortunate event. The main objectives of the study are as follows

i. Identification of hazard prone area and estimation of damage distance for the Maximum Credible Accident (MCA) scenarios visualized for storages.

ii. Computation of frequency of occurrence of hazards and evaluation of risk.

iii. Based on the studies, suggest risk mitigation measures and arrive at guidelines for Disaster Management and Emergency Preparedness Plan (DMP and EPP).

4 Inventory at Site

The inventory at the project site is given in the **Table 1.**

Table 1

Storage Capacity in project site

S.No	Name of Hazardous Materials & Location	Nature of Hazard	No. of Storage Units	Capacity of storage (Liters)
1	HSD (High Speed Diesel) Stored at Utilities Department	Fire & Explosion	1 No	1000

5 Hazard Identification and Preliminary Hazard Analysis

5.1 Introduction to Hazard Identification

Identification of hazards in proposed site is of primary significance in the analysis, quantification and cost effective control of accidents involving chemicals and process. 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 to assess their potential for initiating or propagating an unplanned event/sequence of events, which can be termed as an accident.

5.2 Identification of Major Hazardous Units

Hazardous substances may be combustible/flammable in nature. The HSD characteristics proposed to be stored at the project site are given in **Table 2.**

Table 2

HSD Characteristics

Chemical	Codes/ Label	TLV	FBP	MP	FP	LEL	UEL
						%	
HSD (High Speed Diesel)	Flammable	800 ppm	215- 376^0 C	NA	32^0 C	0.6	6.0

TLV : Threshold Limit Value FBP : Final Boiling Point
MP : Melting Point FP : Flash Point
UEL : Upper Explosive Limit LEL : Lower Explosive Limit

5.3 Classification Based On Inventory Rating

In order to ensure a steady supply of raw materials, process chemicals and fuels, adequate inventory of all these materials is maintained at the project site. The quantities stored and the degrees of hazard in terms of NFPA ratings are given below. The National Fire Protection Agency, USA (NFPA), on scale 0 to 4 (least to worst), hazard rating is used as a tool to assess the preliminary hazard potential of a material shown in the **Table 7.3.**

Table 3

Properties of Fuel employed

S.No	Raw Material	N_h	N_f	N_r
1	HSD (High Speed Diesel)	1	2	0

From the above table it can be inferred that HSD falls under the category of "moderate" category of flammability index with Nf being 2.

5.4 Identification of Major Hazard Installations Based on Manufacture, Storage, and Import of Hazardous Chemicals (MSIHC) Rules 1989 and the Amended Rules in October 1994 and January 2000

Over the past few decades a specific legislation covering a major hazard activity has been enforced by Govt. of India in 1989 in conjunction with Environment Protection Act, 1986. This is referred here as MSIHC Rules 1989. For the purpose of identifying major hazard installations the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals.

- Besides a list of hazardous substances with their threshold quantities are provided in Part II of Schedule I of the rules
- Schedule II of the rules sets out the threshold quantities for isolated storage units
- Schedule III gives a list of hazardous chemicals with their threshold quantities. In this schedule different chemicals are classified into distinct groups viz. Group 1 - Toxic substances, Group 2 -Toxic substances, Group 3 -Highly reactive substances, Group 4 -Explosive substances and Group 5-Flammable substances.
- Schedule IV of the rules indicate various operations which are hazardous during production, processing or treatment of organic and inorganic chemicals.

Indicative Criteria for Identification of Toxic, Flammable and Explosive Chemicals (MSIHC Rules 1989) is given in **Table 4.**

Table 4
Indicative Criteria for Identification of Toxic, Flammable and Explosive Chemicals (MSIHC Rules 1989)

a. Toxic Chemicals				
Chemicals having the following values of acute toxicity and which, owing to their physical and chemical properties, are capable of producing major accident hazards				
S. No.	Degree of Toxicity	Medium lethal dose by the oral route (oral toxicity) LD 50 (mg/Kg body weight of test animals)	Medium lethal dose by the dermal route (dermal toxicity) LD 50(mg/Kg body weight of test animals)	Medium lethal concentration by inhalation route (four hours) LC50 (mg/L inhalation in test animals)
1.	Extremely toxic	1-50	1-200	0.1-0.5
2.	Highly toxic	51-500	201-2000	0.5-2.0
b. Flammable Chemicals				
i.	Flammable gases: Chemicals which in the gaseous state at normal pressure and when mixed with air become flammable and the boiling point of which at normal pressure is 20°C or below			
ii.	Highly flammable liquids: Chemicals, which have a flash point, lower than 23°C and the boiling point of which at normal pressure is above 20°C.			
iii.	Flammable liquids: Chemicals which have a flash point lower than 65°C and which remain liquids under pressure, where particular processing conditions, such as high pressure and high temperature, may create major accident hazards			
c. Explosives				
Chemicals which may explode under the effect of flame, heat or photo-chemical conditions or which are more sensitive to shocks or friction than dinitrobenzene.				

Based on the indicative criteria inventory (liquids/fuels) stored in proposed site has been analyzed for applicability of MSIHC Rules 1989 and the results are summarized in **Table 5**.

Table 5
Applicability of MSIHC Rules to Storages

S. No.	Chemical/ Fuel	Listed in Schedule	*Actual Expected Quantity	Threshold Quantity	
				for Application of Rules 5,7 – 9 and 13 - 15	for Application of Rules 10 - 12
1	HSD	3 (2(e)(iii),5 and 6(1)(a) /)	1 T	2500 T	20,000 T

*Expected quantity to be stored for a week

From the above table it can be inferred that HSD tanks does not (with capacity less than 1 T) attract rules 2(e)(iii), 5 and 6(1)(a) and 7-15, as the stored quantities are less than that of the stipulated threshold quantities

6 Short Listed Hazards

Based on the preliminary hazard analysis, the following scenarios are short-listed for consequence analysis to quantify the risks involved. The nature of Hazards that could occur in proposed site is presented in the **Table 6** along with the sources.

Table 6

Short listed Hazards

Nature Of Hazards	Sources & Location
Fire Hazards	HSD Storage area. Storage & handling of HSD in DG power house
Explosion Hazard	HSD
Fire / explosions due to leakage	Spillage / transfer of HSD cause explosion due to leakage
Accidents due to material handling equipment	Connected with all material handling activities and equipment
Dust hazard	Storage and handling of product concentrate at production block as well in storage yard
High voltage electrical hazard	DG power house, switch yard, HT Motors/ lines
Fall from height	Civil construction works, welding and other hot jobs done at height.

7 Maximum Credible Accident Analysis

Hazardous substances may be released as a result of failures or catastrophes, causing possible damage to the surrounding area. This chapter deals with the question of how the consequences of the release of such substances and the damage to the surrounding area can be determined by means of models.

A disastrous situation is generally due to outcome of fire, explosion or toxic hazards in addition to other natural causes, which eventually lead to loss of life, property and ecological imbalance.

Major hazards posed by hazardous chemical storages can be identified taking recourse to MCA Analysis. MCA analysis encompasses certain techniques to identify the hazards and calculate the consequent effects in terms of damage distances of heat radiation, toxic releases, vapor cloud explosion, etc. A host of probable or potential accidents of the major units in the complex arising due to use, storage and handling of the hazardous materials are examined to establish their credibility. Depending upon the effective hazardous attributes and their impact on the event, the maximum effect on the surrounding environment and the respective damage caused can be assessed.

Various models for calculating the physical effects of the incidental release of hazardous substances are detailed subsequently. First, attention is paid to the factors, which are decisive for the selection of the models to be used in a particular situation, after which the various effect models are discussed.

8 Injuries Resulting From Flammable Liquids

In the case of flammable liquids such as HSD for immediate ignition of a pool fire will occur. The injuries in this case are mainly caused by heat radiation. Serious injuries as the result of the shock wave generally do not occur outside the fire ball zone. Fragmentation of the storage system can cause damage up to distance of over 50m depending on the capacity of the affected storage tank. If the gas is not ignited immediately, it will disperse into the atmosphere. If the gas cloud ignites it is assumed that everyone present within the gas cloud will die as a result of burns or asphyxiation. Outside the gas cloud the duration of the thermal load will be too brief to cause any injuries. In the event of very rapid combustion of the gas cloud the shock wave may cause damage outside the limits of the cloud. Explosive combustion will only occur if the cloud is enclosed to some extent between buildings and obstacles. The Mathematical models and analytical models for Hazard Analysis of the flammable liquids in the proposed site are as shown in **Table 7.**Damage criteria in **Table 8.**Radiation exposure and lethality in **Table 9**.

Table 7

Mathematical models and analytical models for Hazard Analysis

S. No	Explosions	
1	Pool fire	Fire ball

Table 8

Damage criteria

Heat Radiation		Explosions		Toxic Gas Dispersion
Incident Flux KW/m^2	**Damage**	**Peak overpressure (bar)**	**Damage**	
37.5	100% lethality, Heavy damage to equipment	0.3	Heavy - 90%	The extent of damage depends upon the concentration of the toxic compound in the atmosphere. The relation between percent of injuries and the toxic load is normally given in the form of probity function.
25.0	50% lethality, non piloted ignition	0.03	Damage of glass	
12.5	1% lethality, piloted ignition	0.01	Crack of windows	
4.5	Not lethal, 1st degree burns			
1.6	No discomfort even after long exposure			

Table 9

Radiation exposure and lethality

Radiation Intensity (KW/m^2)	Exposure Time (seconds)	Lethality (%)	Degree of Burns
1.6	--	0	No Discomfort even after long exposure
4.5	20	0	1st
4.5	50	0	1st
8.0	20	0	1st
8.0	50	<1	3rd
8.0	60	<1	3rd
12.0	20	<1	2nd
12.0	50	8	3rd
12.5	--	1	--
25.0	--	50	--
37.5	--	100	--

9 Pool Fire Analysis of HSD Tanks

The detailed computations of FEI (Fire and Explosion Index) for HSD (High Speed Diesel) at proposed site are given in **Table 10**

The Health (N_h), Flammability (N_f), Reactivity (Nr), and MF (Material Factor) for the HSD fuel under consideration was derived from NFPA (National Fire Protection Association) codes. The GPH (General Process Hazard Factor) and SPH (Specific Process Hazard Factor) was calculated accordingly. Based on F&EI (Fire and Explosion Index), the HSD fall under light degree of hazard category and nil toxicity.Thus Risk Assessment and Hazard analysis has been carried out due to fire hazard for HSD storage tanks by carrying out MCA (Maximum Credible Accident) analysis.

Table 10

F&EI of fuels used for the proposed industrial area

Chemical/Fuel	NFPA Classification				GPH	SPH	*F&EI	F&E Category
	N_h	N_f	N_r	MF				
HSD	1	2	0	10	1.8	2.83	50.89	Light

FEI = MF *(1+GPH) * (1+SPH)

The F&EI values are ranked into following categories

Table 11

F&E Category

S.No	F&EI	F&E Category
1	1-60	Low
2	60-90	Medium
3	90 and above	Severe

9.1 Damage distance computations for MCA (Maximum Credible Accident) analysis

The major hazard scenarios identified for the possibility of occurrence are mainly concerned with HSD storage tanks for both phases.

The Maximum capacity of the storage of HSD will be 1×1000 L. The most credible failure is the rupture of the largest pipe connecting to the storage tank.

A perusal of the above table clearly indicates that 37.5 KW/sq.m (100%) lethality occurs within the radius of the pool which is computed at <10 m tank on pool fire. This vulnerable zone will damage all fuel storage equipment falling within the pool radius.

Similarly the threshold limit for first degree burns is 1.6 KW/sq.m, this vulnerable zone in which the thermal fluxes above the threshold limit for first degree is restricted to 19m in case fuel storage area catches pool fire.

The risk contours are sown in below **Figure 1** and ALOHA source point on the layout is shown in **Figure 2.**

9.2 Pool Fire of HSD Storage Tanks

A storage tank of HSD with a capacity of 1000 liters is considered for the proposed industrial area. Tank fire would occur if the radiation intensity is high on the peripheral surface of tanks leading to increase in internal tank pressure. Pool fire would occur when fuel oil collected in the dyke due to leakage gets ignited. As the tanks are provided within the dyke the fire will be confined within the dyke wall.

Site Data

Location: Kolar, India
Building Air Exchanges per Hour: 0.50 (sheltered single storied)
Time: September 08, 2015 1248 hours ST (using computer's clock)

Chemical Data

Chemical Name: High Speed Diesel Molecular Weight: 114.23 g/mol
PAC-1: 300 ppm PAC-2: 385 ppm PAC-3: 5000 ppm
IDLH: 1000 ppm LEL: 9600 ppm UEL: 65000 ppm
Ambient Boiling Point: 121.7° C
Vapor Pressure at Ambient Temperature: 0.032 atm
Ambient Saturation Concentration: 35,445 ppm or 3.54%

Atmospheric Data (Manual Input of Data)

Wind: 1.75 meters/second from E at 10 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 35° C
Stability Class: D (user override)
No Inversion Height Relative Humidity: 83%

Source Strength

Leak from hole in vertical cylindrical tank
Flammable chemical is burning as it escapes from tank
Tank Diameter: 0.8 meters Tank Length: 2.1 meters
Tank Volume: 1,056 liters
Tank contains liquid Internal Temperature: 35° C
Chemical Mass in Tank: 696 kilograms
Tank is 95% full
Circular Opening Diameter: 1.5 inches
Opening is 0.42 meters from tank bottom
Max Flame Length: 11 meters Burn Duration: 12 minutes
Max Burn Rate: 49.5 kilograms/min
Total Amount Burned: 552 kilograms
Note: The chemical escaped as a liquid and formed a burning puddle.
The puddle spread to a diameter of 3.4 meters.

Threat Zone

Threat Modeled: Thermal radiation from pool fire
Red : less than 10 meters - (12.5 kW/ (sq m))
Orange: 11 meters - (4.5 kW/ (sq m))
Yellow: 21 meters - (1.6 kW/ (sq m))

Figure 1

Thermal Radiation Threat Zone

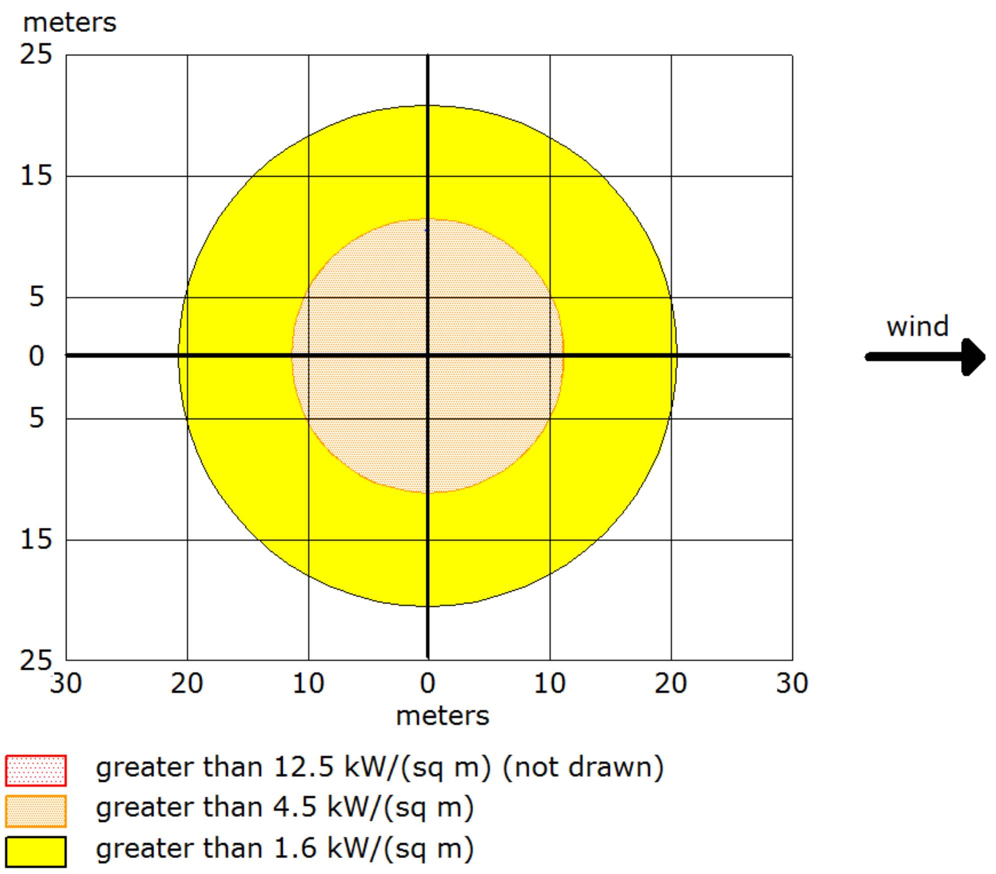
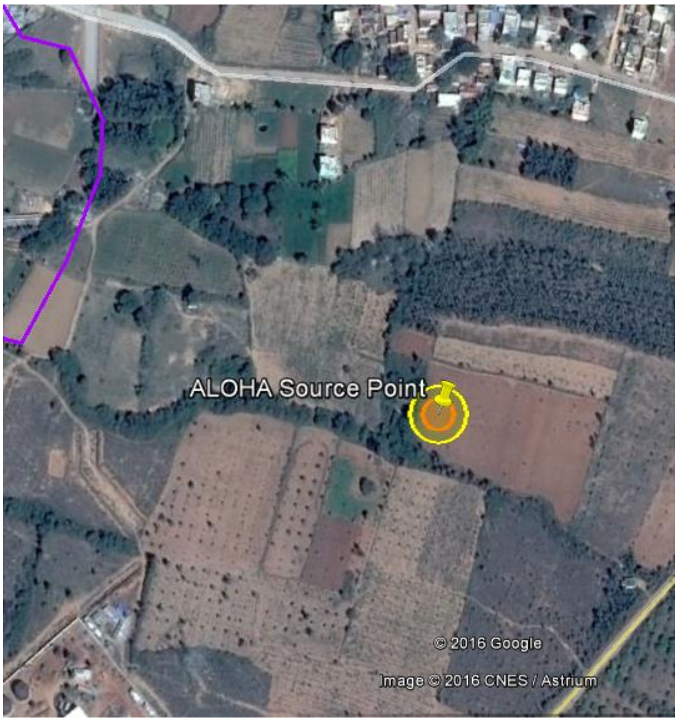


Figure 2

ALOHA Source point on the layout



ALOHA Source Point

Time: September 8, 2015 1355 hours ST
Chemical Name: High Speed Diesel
Wind: 1.75 meters/second from E at 10 meters

THREAT ZONE:
Red : less than 10 meters(10.9 yards) --- (12.5 kW/(sq m))
Orange: 11 meters --- (4.5 kW/(sq m))
Yellow: 21 meters --- (1.6 kW/(sq m))

Model: ALOHA Thermal radiation from pool fire

10 Risk Assessment for LPG storage

10.1 Overview

Risk Analysis is proven valuable as a management tool in assessing the overall safety performance of the chemical process industry and hazardous substance handling operations at a specific location. Although management systems such as engineering codes, checklists and reviews by experienced engineers have provided substantial safety assurances, major incidents involving numerous casualties, injuries and significant damage can occur – as illustrated by recent world-scale catastrophes. Risk Analysis techniques provide advanced quantitative means to supplement other hazard identification, analysis, assessment, control and management methods to identify the potential for such incidents and to evaluate control strategies.

10.2 Hazard Identification

The following two methods for hazard identification have been employed in the study

- Identification of major hazardous units based on manufacture, storage and import of hazardous chemicals rules, 1989 of Government of India (GOI rules, 1989) and
- Identification of hazardous units and segments of plants and storage units based on relative ranking technique, viz. fire-explosion and toxicity index (FE&TI).

Hazardous substances may be classified into three main classes namely flammable substances, unstable substances and toxic substances. The ratings for a large number of chemicals based on flammability, reactivity and toxicity have been given in NFPA Codes 49 and 345 M. The major hazardous materials to be stored, handled and utilized within the facility have been summarized and the fuel storage details and properties are given in in the **Table 12**.

Table 12

Details of LPG

<table>
<tr><th colspan="8">Category Wise Schedule Of Storage Tanks</th></tr>
<tr><td>LPG</td><td colspan="7">UN 1972. Dangerous Goods Class 3 – Flammable Gas</td></tr>
<tr><td colspan="8"></td></tr>
<tr><th colspan="8">Hazardous Materials Stored, Transported And Handled</th></tr>
<tr><td>S. No</td><td>Material</td><td colspan="2">No. of Tanks</td><td colspan="4">Capacity</td></tr>
<tr><td>1</td><td>LPG</td><td colspan="2">2</td><td colspan="4">75 T (Liquid & Pressurized)</td></tr>
<tr><td colspan="8"></td></tr>
<tr><th colspan="8">Properties</th></tr>
<tr><td>Chemical</td><td>Label</td><td>TLV</td><td>Boiling Point</td><td>Melting Point</td><td>Flash point</td><td>Upper Flammable Limit</td><td>Lower Flammable Limit</td></tr>
<tr><td rowspan="2">LPG</td><td rowspan="2">Flammable</td><td rowspan="2">1000 ppm</td><td colspan="3">°C</td><td colspan="2">%</td></tr>
<tr><td>>-40</td><td>NA</td><td>NA</td><td>9.5</td><td>1.9</td></tr>
</table>

10.3 Physico-Chemical Properties of Hazardous Chemicals Stored/Used

10.3.1 Liquefied Petroleum Gas (LPG)

LPG is a big fire and explosion hazard. Primarily, LPG is associated with the severe fire and explosion hazards, i.e., boiling liquid expanding vapour explosion (BLEVE) under sustained ignition and also vapour cloud explosion (VCE). BLEVE can be caused by an external fire near the storage vessel causing heating of the contents and pressure build-up. While tanks are often designed to withstand great pressure, constant heating can cause the metal to weaken and eventually fail. The most recognized hazard with LPG storage vessels is BLEVE (Boiling liquid expanding vapor explosions). BLEVE is possible when the vessel is involved in fire it may over heat and rupture violently giving an intensely hot fireball and may project pieces of the vessel travel over considerable distance. Such situations occur when there could be fire accident in nearby areas and storage vessel meets with sever heat radiation. Usually BLEVE eliminated by providing

Mounded type bullets (75 T). Worst case scenario can be consider when LPG tanker of 18 T capacity, during refilling of the 75 T LPG bullet in the storage yard.

An unconfined (i.e., in open space) vapour cloud explosion (VCE) is possible only when a large amount comes from a rupture of line/leak from large hole and accumulates in the open space as a cloud while moving along the wind. If the mixture of cloud and air is in the flammability range and some ignition source is available on its way, it ignites and subsequently releases the energy on the point of ignition in the form of a blast wave. It is called vapour cloud explosion (VCE). The human injury and loss of property in case of VCE depends upon the mass involved in the explosion and the location of the center of explosion. A flammable release of gas that does not ignite at the leak source, or has a delayed ignition, can produce a large vapour cloud, which covers a significant area. In the absence of significant confinement or obstruction, ignition of the cloud results in a low velocity flame front with minimal over pressure effects, known as a flash fire and typically results (initially) only in impacts within the flammable cloud.

10.4 Identification of Major Hazard Installations Based on GOI Rules, 1989

Over a few decades, a specific legislation covering major hazard activities has been enforced by Govt. of India in 1989 in conjunction with Environment Protection Act, 1986. This is referred here as GOI Rules 1989. For the purpose of identifying major hazard installations, the rules employ certain criteria based on toxic, flammable and explosive properties of chemicals.

A systematic analysis of the fuels/chemicals and their quantities of storage has been carried out, to determine threshold quantities as notified by GOI Rules, 1989 and the applicable rules are identified. Applicability of storage rules are summarized in **Table 13**

Table 13
Applicability of MSIHC Rules to Storages

S.No	Material	Listed in schedule	Total Quantity	Threshold Quantity (T) for Application of Rules	
LPG	Flammable	3(1)	2x75 T	5,7-9,13-15	10-12
				15	200

10.5 Fire Explosion and Toxicity Index (FE&TI) Approach

Fire, explosion and toxicity indexing (FE & TI) is a rapid ranking method for identifying the degree of hazard. The application of FE & TI would help to make a quick assessment of the nature and quantification of the hazard in these areas. However, this does not provide precise information. The degree of hazard potential is identified based on the numerical value of F&EI and TI. The details are given in **Table 14** and **Table 15.**

Table 14

F&EI of fuels used for the proposed industrial area

Category	Fire and Explosion Index (F&EI)	Toxicity Index (TI)	Degree of Hazard
I	F&EI < 65	TI < 6	Light
II	65 < or = F&EI < 95	6 < or = TI < 10	Moderate
III	F&EI > or = 95	TI > or = 10	Heavy

Table 15

Results of FE and TI for Storage/Process Units

S.No	Material	Capacity	F& EI	Category	TI	Category
1	LPG	2x75 T	101.90	III	5.43	I

10.6 Consequence Analysis

Consequence analysis deals with the study of physical effects of potential dangers associated with hazardous chemicals, their storage and operation etc. for flammable and explosive chemicals like LPG, consequence on humans/animals and structures are studied in terms of heat radiations and over pressures. For toxic chemicals like carbon monoxide, consequences on human/animals are studied in terms of concentration and dose-response relationships. The physical impact of heat radiation, over pressure and toxic concentration are given in **Table 16.**

The consequence modeling for different release scenarios for proposed scenarios has been carried out using the model ALOHA - "Area Locations of Hazardous Atmospheres" developed by NOHAA and USEPA. Aloha predicates the rate at which chemical vapors may escape into the atmospheres from the leaking/ruptured tank

Table 16

Damage to Heat Radiation Intensity

Incident Radiation Intensity (kW/m^2)	Type Of Damage
37.5	Sufficient to cause damage to process equipment
25	Minimum energy required to ignite nearby wood at infinitely long exposure (non-piloted)
12.5	Minimum energy required for piloted ignition of wood, melting plastic tubing etc.
4.5	Sufficient to cause pain to personnel if unable to reach cover within 20 seconds. However blistering of skin (1^{st} degree burns) is likely.
1.6	Will cause no discomfort to long exposure

10.6.1 Consequences of Over Pressure

The effects of the shock wave vary depending on the characteristics of the material, the quantity involved and the degree of confinement of the vapor cloud. The peak pressures in an explosion therefore vary between a slight over-pressure and a few hundred kilopascals (kPa). Direct injury to people occurs at pressures of 5-10 kPa (with loss of life generally occurring at a greater over-pressure), whereas dwellings are demolished and windows and doors broken at pressures of as low as 3-10 kPa. The pressure of the shock wave decreases rapidly with the increase in distance from the source of the explosion. Details are given in **Table 17**.

Table 17

Over Pressure Damage

Over Pressure, Bar	Damage
0.3	Heavy damage
0.1	Moderate damage
0.03	Significant damage

10.6.2 Discussion and evaluation of results on Consequence Analysis

Since the worst-case release scenario of LPG release are Boiling Liquid Expanding Vapor Explosion (BLEVE) and unconfined Vapor Cloud Explosion (VCE), the impact factors considered are radiation intensity and explosion overpressure. The heat radiation levels of 37.5 kW/m^2, 25 kW/m^2, 12.5 kW/m^2, 4.5 kW/m^2 and 1.6 kW/m^2 and three explosion overpressure levels of 0.3 Bar, 0.1 Bar and 0.03 Bar corresponding to severe moderate and low damage levels have been considered respectively. Maximum affected downwind distances (in m) due to heat radiation and explosion over pressure level of LPG are given in **Table 18** and **Table 19**. Thermal radiation threat zones are shown in **Figure 3** and **Figure 4** and the same on the layout is shown in **Figure 5**. Pressure levels are shown in **Figure 6** and the same on the layout is shown in **Figure 7.**

Table 18

BLEVE due to catastrophic failure of a LPG Bullet

S. No	Thermal Radiation in KW/m^2	Distance in m
1	37.5	192
2	25	245
3	12.5	356
4	4.5	593
5	1.6	976

Table 19

Vapor cloud explosion due to catastrophic rupture of LPG bullet

S. No	Explosion Overpressure Level in Bar	Distance in m
1	0.3	145
2	0.1	230
3	0.03	437

Site Data:
Location: Kolar, India, India
Building Air Exchanges per Hour: 0.39 (sheltered single storied)
Time: September 08, 2015 1248 hours ST (using computer's clock)

Chemical Data:
Chemical Name: LPG
CAS Number: 74-98-6 Molecular Weight: 44.10 g/mol
AEGL-1 (60 min): 5500 ppm AEGL-2 (60 min): 17000 ppm
AEGL-3 (60 min): 33000 ppm IDLH: 2100 ppm
LEL: 21000 ppm UEL: 95000 ppm
Ambient Boiling Point: -44.6° C
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

Atmospheric Data: (Manual Input of Data)
Wind: 1.75 meters/second from E at 10 meters
Ground Roughness: open country Cloud Cover: 5 tenths
Air Temperature: 30° C
Stability Class: D (user override)
No Inversion Height Relative Humidity: 85%

Source Strength:
BLEVE of flammable liquid in horizontal cylindrical tank
Tank Diameter: 4.5 meters Tank Length: 10 meters
Tank Volume: 159 cubic meters
Tank contains liquid
Internal Storage Temperature: 30° C
Chemical Mass in Tank: 32,898 kilograms
Tank is 40% full
Percentage of Tank Mass in Fireball: 100%
Fireball Diameter: 186 meters Burn Duration: 12 seconds

Threat Zone:
Threat Modeled: Thermal radiation from fireball
Red : 192 meters --- (37.5 kW/ (sq m))
Orange: 245 meters --- (25 kW/ (sq m))
Yellow: 356 meters --- (12.5 kW/ (sq m))
Orange: 593 meters --- (4.5 kW/ (sq m))
Yellow: 976 meters --- (1.6 kW/ (sq m))

Source Strength:
Leak from hole in horizontal cylindrical tank
Flammable chemical escaping from tank (not burning)
Tank Diameter: 4.5 meters Tank Length: 10 meters
Tank Volume: 159 cubic meters
Tank contains liquid Internal Temperature: 30° C
Chemical Mass in Tank: 32,898 kilograms
Tank is 40% full

Circular Opening Diameter: 5 centimeters
Opening is 4.05 meters from tank bottom
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 1,260 kilograms/min (averaged over a minute or more)
Total Amount Released: 26,810 kilograms
Note: The chemical escaped as a mixture of gas and aerosol (two phase flow).

Threat Zone:
Threat Modeled: Overpressure (blast force) from vapor cloud explosion
Type of Ignition: ignited by spark or flame
Level of Congestion: Congested
Model Run: Heavy Gas
Red : 145 meters --- (4.35 psi)
Orange: 230 meters --- (1.45 psi)
Yellow: 437 meters --- (0.5 psi)

Figure 3
Thermal Radiation Threat Zone - 1

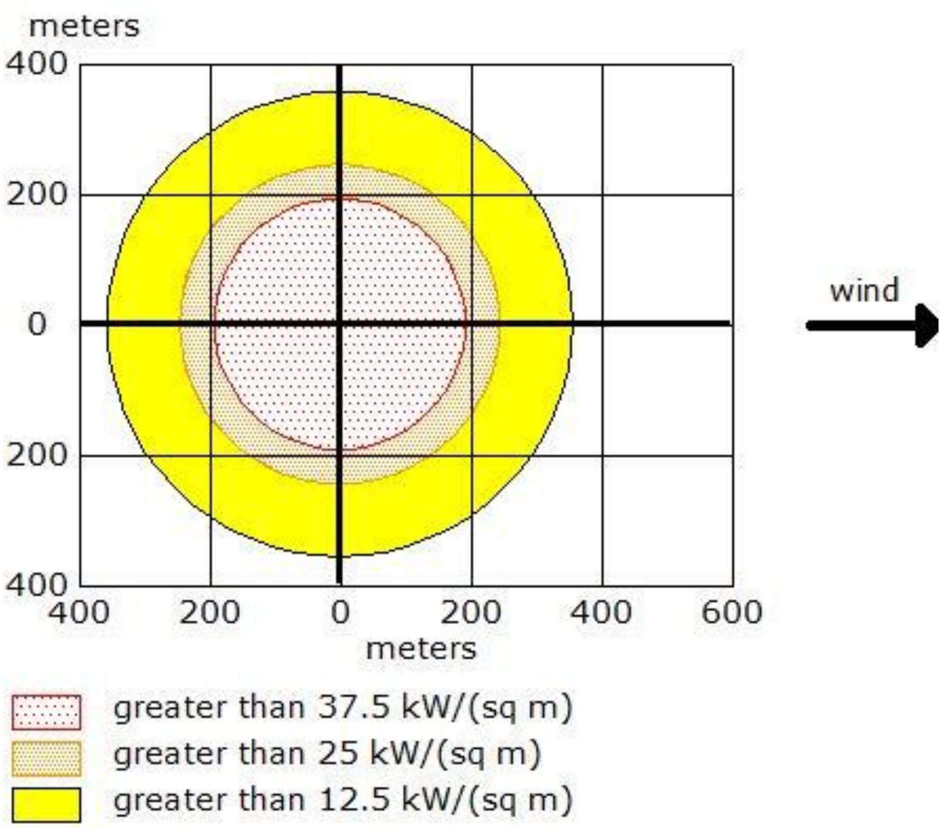


Figure 4

Thermal Radiation Threat Zone - 2

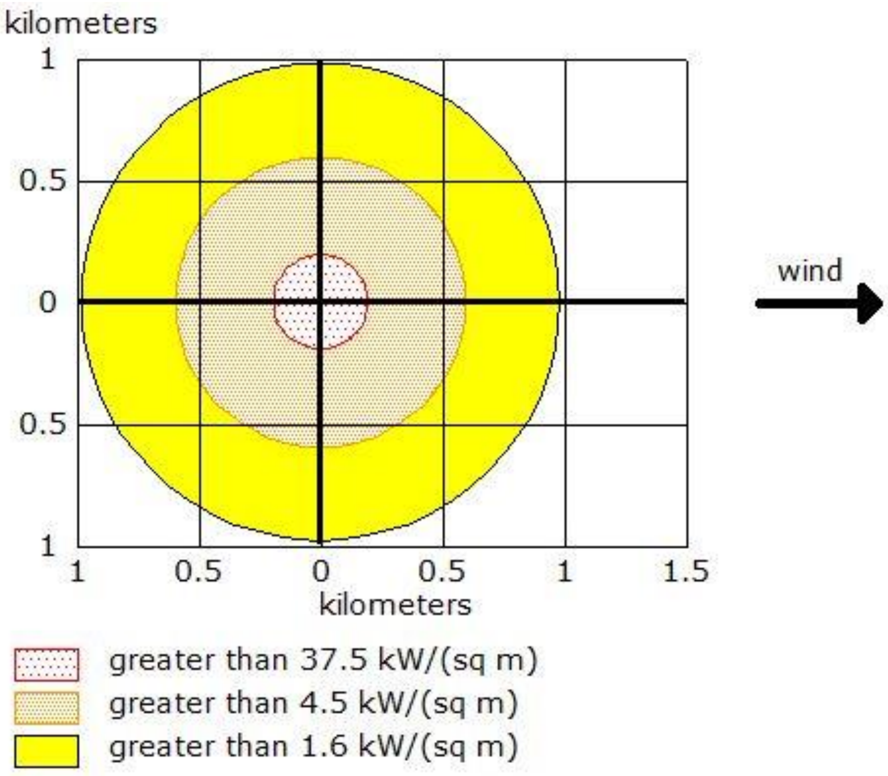


Figure 5

Thermal Radiation Levels

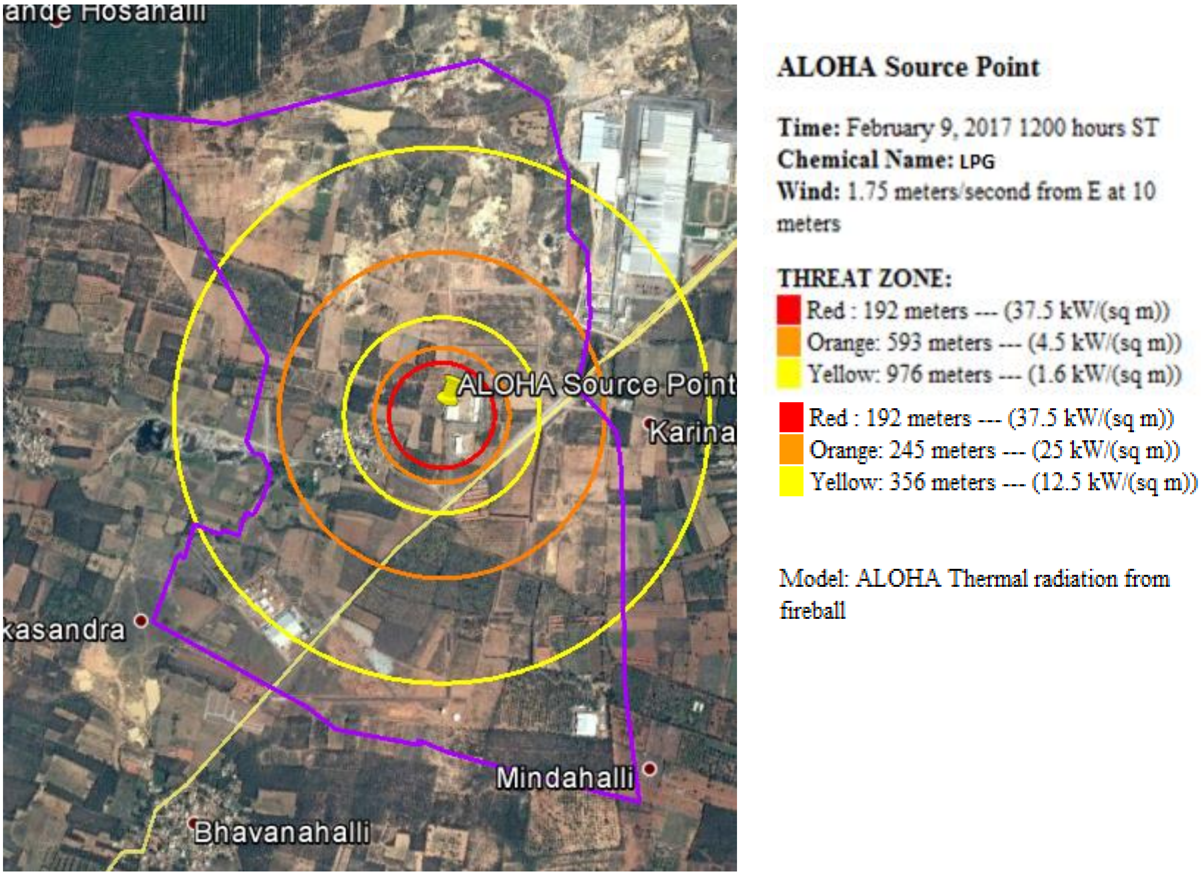


Figure 6

Explosive over Pressure

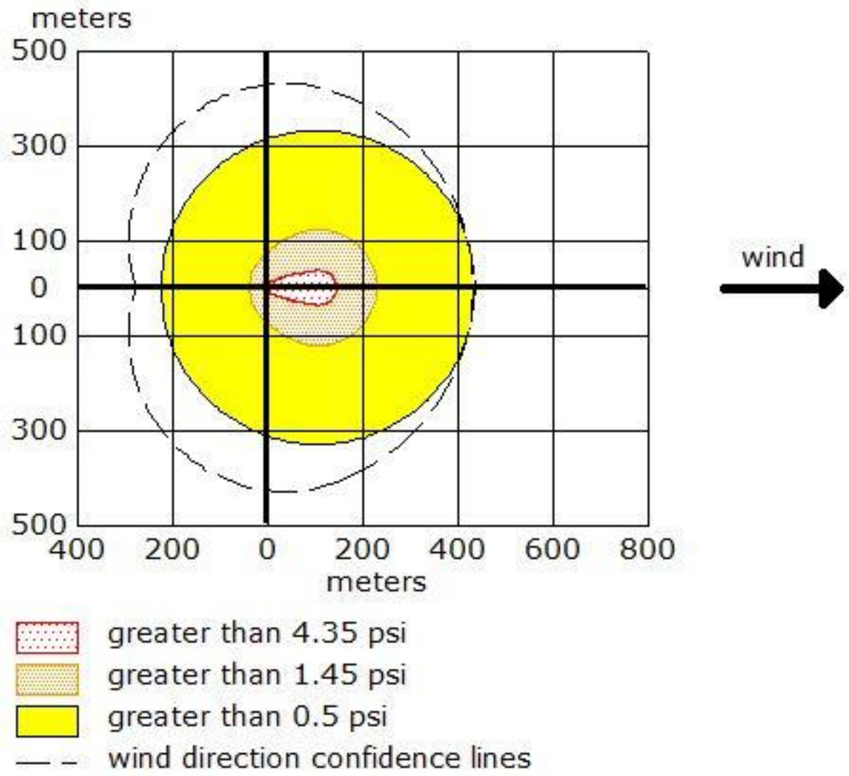
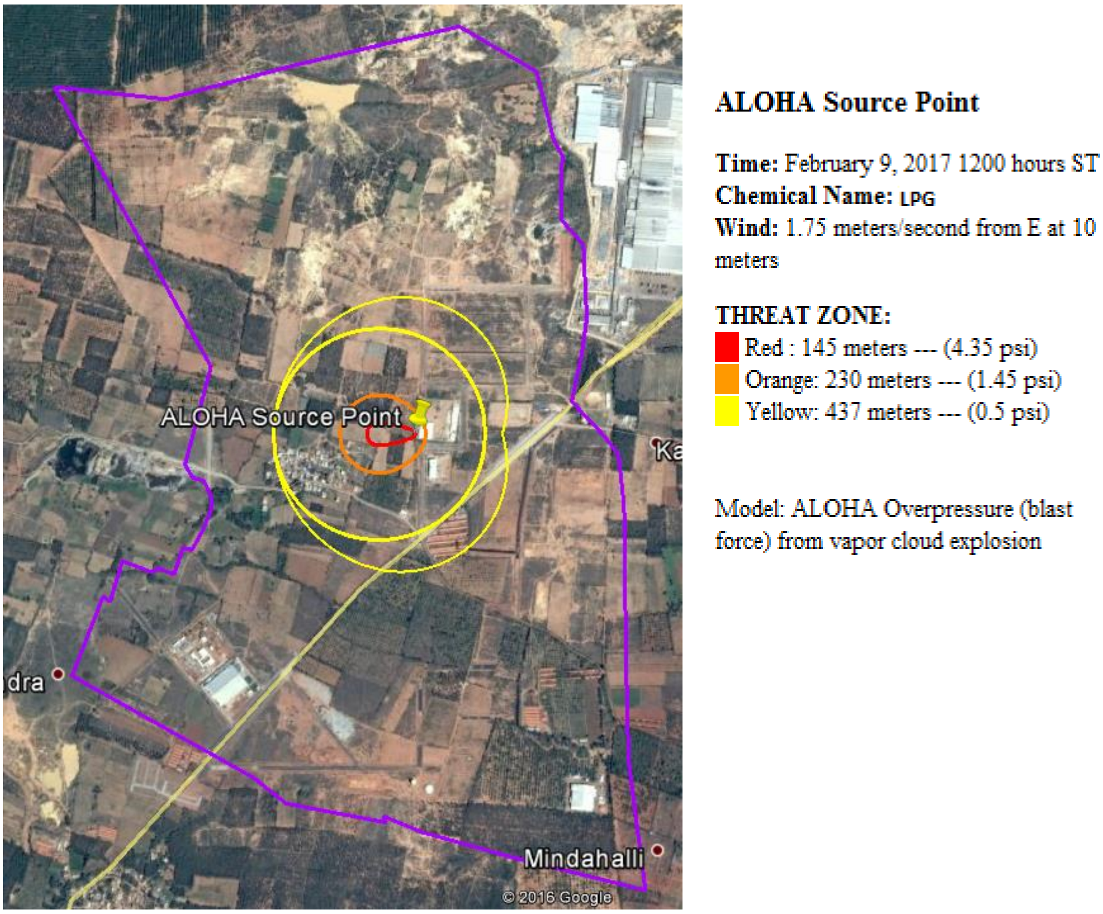


Figure 7

Explosive over Pressure Levels



10.7 Safety Measures of LPG Storage

In the majority of cases the tank will be owned by the company that supplies the gas, but if you are unsure then you should check this with your own supplier. In general, the supplier will look after the tank and its fittings (their integrity and maintenance) but again check this with your supplier if you are unsure, as legally it needs to be maintained in a safe condition. The user of the LPG (i.e. the person operating the site) does have responsibilities in relation to the tank including

- Siting of the tank
- Ventilation and conditions around the tank
- Tanker access
- Security
- Impact protection
- Emergency arrangements

Siting of the tank

There should be a minimum distance (called the separation distance) between the tank and any building, boundary line or fixed source of ignition. This should have been checked when the tank was first installed and the supplier will know what the distance should be if you are unsure.

Modifications to the area may have been made since the tank was installed. These could include altering walls, building sheds or fences, installing electrical equipment near the tank or planting trees or shrubs nearby. These should not be any closer to the tank than this minimum distance and, if they are, then arrangements need to be made to move them.

There should not be any drains or gullies near to the tank unless a water trap is provided to prevent gas entering the drains. This is because LPG is heavier than air and if a leak were to develop from the tank or its controls or pipework or when it is being filled then the vapour could accumulate in an untrapped drain or gully. Ignition of these vapours could then lead to fire/explosion.

The tank should also not be painted in any colour other than originally supplied as this may increase the amount of heat it absorbs from the sun.

Ventilation and conditions around the tank

In case of leaks there should be plenty of room around the tanks to ensure good air flow so that pockets of heavier-than-air LPG vapours cannot build up around them.

It is also very important to keep the area around the tank free of rubbish, particularly if it is combustible or could reduce the levels of ventilation. For similar reasons keep weeds and grass cut down around the tank. If you choose to use a weed killer then you should not use something that is chlorate-based (as this can make the dead plants easier to ignite).

Tanker access

There should be a dedicated flat parking area for the tanker delivering LPG. This parking area should be clear on a delivery day and people should be kept away from the tank and tanker while the transfer of LPG is taking place. The supplier of the LPG will need to make sure that the tanker cannot drive away with the supply hose still connected, that there is no risk of an electrical spark being generated from static electricity or by other means. The LPG suppliers should ensure that their drivers are suitably trained and have the correct procedures to follow.

Security

People not involved with the installation, for example workers with no responsibility for the LPG or visitors to the site, should be kept well away from it. No one should smoke use electrical equipment or park vehicles near the tank. 'No smoking' and other signs should be clearly displayed and maintained. Ignition sources, e.g. bonfires and barbecues, should not be allowed near the tank. Temporary use of grass-cutting equipment within the vicinity of the tank is permitted.

The tank should be protected from unauthorised access to reduce the chance of intentional or accidental interference. For larger tanks (i.e. four tonnes or higher LPG capacity) a security fence is required to keep it secure. This fence should allow natural air flow (e.g. made from wire mesh) and should be kept in good condition. Any gates should be kept locked unless access to the tank is required. For tanks below four tonnes LPG capacity, there may be certain circumstances where a fence may not be necessary. This can only be justified where the risk of interference is low and there is no uncontrolled public access - for example due to tank location or other accessibility factors. Tank valve covers should be kept locked whether or not the tank is fenced.

Impact protection

If possible, the tank (and its associated piping) should not be located in areas where there is motor traffic. However, where this is not possible, then protection from a motor vehicle hitting the tank is required such as crash barriers or bollards. A security fence and/or road markings (e.g. 'no-parking' notices, double yellow lines) are unlikely to provide this protection.

Emergency arrangements

The LPG tank will have printed on it the supplier's emergency number that should be called if there is a leak. If a fire breaks out then the user should have in place an emergency plan which includes evacuating people from the premises. In general, leave tackling any fire near the tank to the fire brigade unless it is judged that it can be put out without endangering anyone. In the event of an emergency and where it is safe to do so, the shut-off valve on the top of the tank and the emergency control valve (ECV) should be closed.

Service pipework of LPG storage

Looking after your service pipes

The pipe that carries the LPG vapour from the bulk storage tank to the different work stations is called the service pipe works. This is most likely to be owned by whoever owns the premises using the LPG. It is normally not owned by the LPG supplier, even though it may have been installed by them.

The main concern with service pipework is that if it is damaged it is likely to release the LPG it is carrying. If the escaping LPG vapours were to ignite, the LPG could then cause a fire or explosion. Damage to the pipework could be caused by physical impact or through chemical means, for example corrosion of a metal service pipe.

Owners of service pipework therefore have some important responsibilities and should consider the following

- Installation route
- Materials of construction
- Pressure
- Inspection and maintenance
- Replacement
- Entry into the premises

The legal framework provides more information on the background to these responsibilities.

Installation route

Ideally, LPG service pipework should be run above ground using a route that minimizes the possibility of physical damage, for example from vehicles and away from excessive heat or cold. Where damage can be foreseen, protective barriers, bollards etc. should be provided. If it is not possible to run the pipework above ground, then it can be buried underground and in such cases, it is important to know its route and to mark it so that others are aware of it. Where traffic or other heavy loads pass over the pipe, protection should be provided, such as load-bearing slabs or covers.

For the majority of premises, it is likely that service pipework will already be installed. If this is the case then for buried pipework it is important to ensure that its route is known, recorded and where possible, clearly marked. If the pipework is to be replaced, then think about replacing it with pipework that runs above ground if at all possible. If not then it should be replaced with non-corroding pipework made of material such as polyethylene (PE).

Materials of construction

The material pipework is made from is very important, particularly if it is buried. In general, steel or copper can be used for pipework that runs above ground. Where pipework needs to be buried then it should be made of material, such as polyethylene, that is non-corroding. This is important because corrosion of buried metallic pipework can result in leaking of LPG and this could lead to a fire or explosion if it accumulates and is ignited.

Buried pipework installed within the last 15 years is likely to be made of non-corroding material, such as polyethylene. Older installations, though, may have buried metallic pipework. In these cases, the pipework is likely (but not always) to have some form of corrosion protection provided (for example it may have been wrapped in a special protective tape). This protection will not last indefinitely and the pipes will corrode over time. This may also happen more quickly in certain types of soil, for example waterlogged clay soil. If buried pipework is metallic then it will need to be replaced. This should be done as part of a pipework replacement programme.

Pressure

The LPG in the service pipework will be under pressure to drive the gas through the system. Generally, the pressure may be low (less than 75 millibar) or medium (between 75 millibar and 2 bar gauge). Pipework at medium pressure is of greater concern if leaks should develop as the amount of LPG that could be released is likely to be greater than at low pressure. The pressure of the LPG in the pipework may be influenced by the rating of appliances in the premises that it is supplying. For example, factories using LPG in manufacturing processes may need a higher volume of LPG to run their appliances and so may require medium pressure to meet this need. In contrast, commercial premises, such as pubs, hotels and care homes may only be using the LPG to provide heating and cooking appliances and this can be met by low pressure.

You can tell if your pipework is under low or medium pressure by the type of regulators that are attached to the pipework. If the pipework has only a single regulator on the tank and one near where it enters the building then it is probably under medium pressure. If a second stage regulator is located at the tank then this indicates that the pipework is under low pressure. If you are not sure about the pressure in your pipework then you should consult someone who can help such as your supplier or an independent expert.

Inspection and maintenance

It is very important that service pipework is regularly inspected and maintained whether it is above or below ground. It is the responsibility of the owner of the pipework to ensure it is regularly inspected and maintained. This is likely to be the owner of the site, not the LPG supplier, even though it may have been installed by a supplier originally (check your supply contract).

A competent person should review the state of the pipework and establish the length of time for which it can be used safely before its next inspection, taking into account the time since it was last checked and any action taken at that time. For buried pipework, the only really effective inspection method currently available is to excavate the pipe for examination, particularly if it is metallic. Care should be taken when excavating pipe to prevent damage to the pipe or its corrosion protection. For metallic buried pipework that is likely to corrode, a specialised expert in corrosion of metal pipework would be required to assess its state on excavation.

Other tests are available for investigating the state of the pipework at the time of the test but these cannot give any assurances about its condition in the longer term.

Replacement

It is known that buried metallic pipework, even if it was protected when it was first installed, will corrode over time. Corrosion can result in LPG leaking from the pipe and can lead to a fire or explosion if ignited. Buried metallic pipework will therefore need to be replaced with pipe made from non-corroding material such as polyethylene. The suppliers of LPG have developed a prioritised replacement programme for buried metallic pipes. If you are contacted by your supplier about replacing buried metallic pipework then you should discuss this with them and make the necessary arrangements to have the pipework replaced.

Entry into premises

Pipework should enter a building above ground and it should be contained in a sleeve sealed to the structure. This will protect the pipe and help to stop any passage of LPG vapour into the building should the pipe develop a leak. Within the building, any pipework should ideally not travel through any unventilated void (e.g. under floor space, cellar or basement). Where it passes through a cavity wall it should be sleeved to prevent gas entering the cavity should it leak.

Where buried pipework leaves the ground to feed into the building (the so-called ‘riser’), if it is made of polyethylene (the preferred material that is being used to replace underground metallic pipework) it should be protected with a glass-reinforced plastic sleeve. This protects the pipe from physical damage and from UV light which will make it brittle over time. Entry into the building from the riser should be above ground. This should be checked in case at some point in the past it was covered by other building work (for example raising the level of a yard or garden). If the buried pipe is made from polyethylene, then before it enters the building there should be a transition to steel or copper piping which then enters the building.

Valves

All bulk LPG installations providing LPG must be provided with

- a regulator to maintain the gas supply pressure within the range at which the appliance has been designed to operate safely
- where an installation is subject to the Gas Safety Installation over-pressure shut-off and under-pressure shut-off valves which provide back-up protection should the regulator fail or the gas supply pressure falls to a dangerously low level, for example if the bulk tank becomes empty for some reason.

OPSO (over-pressure shut-off valve) – This device must be re-set only by the gas supplier if it trips out and shuts off the gas supply when over-pressure conditions exist. UPSO (under-pressure shut-off valve) – This device may be re-set by the gas user if it trips out and shuts off the gas supply when the gas pressure drops below its set pressure value.
A pressure relief valve (PRV) is a valve fitted to the top of a bulk tank to relieve internal pressure within the tank if this were to increase due to external influences, such as thermal radiation impact from a fire

Emergency control valve (ECV)
An ECV is intended to allow the gas user to shut off the supply of gas in the event of an escape. Where an installation is in the scope of gas safety installations, the ECV must be within reach and situated as near as reasonably practicable to the point where the pipe supplying gas enters the premises. ECVs are required under gas safety installations but we recommend that these are fitted also at factory premises.

11 Disaster Management Plan (DMP)

A Disaster is called when following one or the other or more incidents occur

i) Risk of loss of human lives-ten or more in one single situation
ii) A situation which goes beyond the control of available resource of the plant
iii) Loss of property as a consequence of the incident and/or bears a potential to the above
iv) A situation apparently may not have much loss but its long-term severity can affect loss of life, production and property.

Disasters occur due to
i). Emergencies on account of
- Fire
- Explosion
- Spillage of toxic chemicals
- Electrocution

ii) Natural calamity on account of
- Flood
- Earth quake / Cyclone / Storm / Cloud burst / Lightning

iii). External factor on account of
- Food poisoning

- Sabotage

The objective of the study is to assess the likely hazards and risk associated with the fuel storage activity and preparation of preliminary Disaster Management Plan (DMP).These guidelines would be in addition to the guidelines issued by the NDMA (National Disaster Management Authority) which are available at http://ndma.gov.in/ndma/guidelines.html . The main objectives of DMP are

- To control and contain the incident/accident and if possible, eliminate it
- To minimize the effects of the incident on persons, property and environment

On-site Disaster

If an accident/incident takes place within the industrial area and its effects are confined to the premises, involving only the persons working in the industrial area and the property inside the industrial area, it is called as on-site disaster.

Off-site Disaster

If the accident is such that its affects inside the industrial area are uncontrollable and it may spread outside the premises, it is called as off-site disaster.

11.1 On-Site Disaster Management Plan

Main elements of On-site Emergency plans

- Leadership and administration
- Role and responsibilities of key personnel
- Emergency action
- Light and power
- Source of energy control
- Protective and rescue equipment
- Communication
- Medical care
- Public relation
- Protection of vital records
- Training
- Periodical revision of plan

Action Plan for On-Site Disaster Management Plan

- Designated control centre/room
- Key personnel

Control Centre

This is the main center from where the operations to handle the emergency are directed and coordinated. Facilities to be made available in the control centre are

i. Internal and external communication

ii. Computer and other essential records

iii. Daily attendance of workers employed

iv. Storage of hazardous material records and manufacturing records

v. Pollution records

vi. Walky-talky

vii. Plan of the plant showing

a. Storage area of hazardous materials

b. Storage of safety equipments

c. Fire-fighting system and additional source of water

d. Site entrance, roadway and emergency exist

e. Assembly points

f. Truck parking area

g. Surrounding location

viii. Note book, pad and pencil

ix. List of key personnel with addresses, telephone number etc.

Assembly Points

A safe place should be pre-determined as assembly point where in case of emergency personnel evacuated from the affected areas are to be assembled. The workers, contract workers and visitors should assemble in assembly point in case of emergency and the time office clerk should take their attendance so as to assess the missing persons during emergency.

The Key Personnel for onsite emergency

1. Works Main Controller
2. Works Incident Controller
3. Other Key Officers
    a. Communication officer
    b. Security and fire officer
    c. Telephone operators
    d. Medical officer
    e. Personnel/administrative officer
    f. Essential work team leaders

1. Works Main Controller

The General Manager of the site should act as main controller. His duties are to

i. Assess the magnitude of the situation and decide whether the evacuation of staff from the plant is needed.

ii. Exercise and direct operational control over areas other than those affected.

iii. Maintain a continuous review of possible development and assess in consultation with work incident controller and other key personnel.

iv. Liaison with police, fire service, medical services, factory inspectorate and other govt. agencies.

v. Direct and control rehabilitation of affected area after emergency.

vi. Intimate off-site emergency controller if the emergency spreads beyond the factory premises and likely to affect the surrounding area.

vii. Ensure that evidence is preserved for enquiries to be conducted by statutory authorities.

The works main controller will declare the emergency and he will instruct gate office to operate the emergency siren after assessing the gravity of the situation.

Work Incident Controller (WIC)

He is the next responsible officer after the works main controller. Generally the supervisor is designated as work incident controller. In case of emergency he will rush to the place of occurrence and take overall charge and report to the works main controller by personnel communication system like cell phones or walky-talky and inform about the magnitude of emergency. He will assess the situation and considering the magnitude of emergency he will take decision and inform communication officer to communicate the news of emergency to different agencies. He will give direction to stop all operations within the affected area. He will take the charge of main controller till the main controller arrives. He will order for shutdown and evacuation of workers and staffs from affected area. He will inform all key personnel and all outside agency for help. He will inform security and fire officers and state fire services. He will ensure that all non-essential workers/staff are evacuated to assembly point and areas searched for casualties. He will report all significant development to communication officer. Moreover he will advise to preserve evidence of emergency into the cause of emergency.

Other Key Personnel and their duties

a. Communication Officer. On hearing the emergency siren/alarm he will proceed to the control center and communicate to work incident controller. He will collect information from the emergency affected area and send correct message to work main controller for declaration of emergency. He will maintain a log book of incident. He will contact all essential departments. He will take stock of the meteorological condition from local meteorological Department. He will communicate all information as directed by works main controller.

b. Security and Fire Officer. The security or fire officer will be responsible for the fire-fighting. On hearing the emergency alarm/siren, he will reach the incident area with fire and security staff. Immediately after arrival to the emergency area, he will inform through telephone or walky-talky to the communication officer. He will inform to the work incident controller about the situation and requirement of outside help like state fire service and other members. At the site, the entire fire squad member will respond to the advice and information given by the works incident controller. The security will control the visitors and the vehicle entry.

***c. Telephone Operator*.** In case of fire is discovered but no emergency siren is operated, he shall ensure the information about the location of the fire/emergency incident from the persons discovered/notices the above and communicate to different Key Personnel immediately with clear message.

d. Medical Officer. Medical officer with his team will report to the works incident controller on hearing the fire/emergency siren immediately. The ambulance will be parked nearest to the site of incident. Name of injured and other casualties carried to the Hospital will be recoded and handed over to works incident controller. The ambulance will carry the injured to the nearest hospital for treatment.

e. Personnel/Administrative Officer. He should work as a liaison officer liaisoning with works main controller and other essential departments such as Police, Press and Statutory authorities. His responsibilities shall include

- To ensure that casualties receive adequate attention to arrange additional help if required and inform relatives.
- To control traffic movement into the factory and ensure that alternative transport is available when needed.
- When emergency is prolonged, arrange for the relief of personnel and organize refreshment and catering facilities.
- Arrange for finance for the expenditure to handle the emergency.

Alarm System

Alarm system varies and will depend on the size of the works area - simple fire bell, hand operated siren – break open type, fire alarm etc. Automatic alarm may be needed for highly hazardous nature of industries in the industrial area.

Communication System

Communication is a key component to control an emergency. The following communication system may be provided in the industrial area

- Walky-Talky.
- Telephone (internal & external).
- Cell phone.
- Intercom/paging.
- Runners (verbal or written messages).

Siren for Emergency

Siren for emergency should be different from the normal siren. The emergency siren should be audible to a distance of 5 km radius. The emergency siren should be used only in case of emergency.

Escape Route

The escape route from each and every plant should be clearly marked. The escape route is the shortest route to reach out of the plant area to open area, which leads to assembly point. This route should be indicated on the layout plan attached to the on-site management plan.

Evacuation

All non-essential staff should be evacuated from the emergency site. As soon as the emergency siren rings the workers have to shut down the industrial area and move to the assembly point. The shutdown procedure in case of emergency should be prepared and kept ready and responsible persons should be nominated for the purpose.

Counting of Personnel

All personnel working in the industrial area should be counted. Time office persons should collect the details of personnel arriving at the assembly point. These should be checked with the attendances of regular workers, contract workers present in the site on the day of emergency. The accident control should be informed and arrangement should be made for searching missing persons in the emergency affected area. The employees' address, contact number of next to kin should be maintained in the time office so that during emergency relatives of those affected due to emergency may be informed accordingly. Information in respect of emergency should be given to the media and other agency.

All Clear Signal

After control of emergency the work incident controller will communicate to the works main controller about the cessation of emergency. The main controller can declare all clear by instructing the time office to sound "All Clear Sirens".

Emergency facilities

The following facilities should be provided to tackle any emergency at any time.

- Fire protection and fire-fighting facilities
- Emergency lighting and standby power
- Emergency equipment and rescue equipment
- Breathing apparatus with compressed air cylinder
- Fire proximity suit
- Resuscitator
- Water gel Blanket
- Low temperature suit

- First aid kit
- Stretchers
- Torches
- Ladders
- Safety Equipment
  a. Respirators
  b. Gum boots
  c. Safety helmets
  d. Asbestos rubber hand gloves
  e. Goggles and face shield
  f. Toxic gas measuring instruments
  g. Explosive meter
  h. Oxygen measuring instruments
  i. Toxic gas measuring instrument
  j. Wind direction indicator

On-site Emergency Plan should contain

1. Site plan and topographic plan
2. Plan showing the fire-fighting facilities
3. Plan showing hazardous material storage area
4. Material safety data sheets for hazardous chemicals
5. Facilities available in main control center
6. List of emergency equipment
7. List of Safety Equipment
8. List of important telephone numbers and addresses
   i. Nearest hospitals and ambulance service center
   ii. Nearest fire station
   iii. Govt. officials
   iv. Transport provider
9. Names and address & contact telephone number of key personnel

The on-site emergency plan so prepared shall be documented in a printed form in sufficient copies to give all concerned for knowledge, study and easy follow up. The emergency plan shall be rehearsed and practiced at regular intervals to test efficiency of personnel, equipment coordinated efforts and to increase confidence and experience to operate such plan. The plan so prepared should be updated annually and uploaded in the factory website for easy reference.

11.2 Off-site Disaster Management Plan

The main objectives of the off-site emergency plan are

   i. To save lives and injuries

ii. To prevent or reduce property losses and

iv. To provide for quick resumption of normal situation or operation.

Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 prescribes for the constitution of the state crisis group as apex body at the state level to deal with major chemical accidents and to provide expert guidance for handling major chemical accidents. Schedule 7 and Schedule 8 of the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 prescribes for the constitution of District and Local Crisis Groups.

The composition of the district crisis group has been prescribed under the chairpersonship of district collector and local crisis group under the chairpersonship of sub-divisional magistrate. The district crisis group shall meet every forty five days and send a report to the state crisis group. The local crisis group shall meet every month and forward a copy of the proceedings to the district crisis group.

A. Functions of the State Crisis Group

i) Review all district off-site emergency plans in the state with a view to examine its adequacy in accordance with the MSIHC Rules and forward a report to the central crisis group once in three months

ii) Assist the state government in managing chemical accidents at a site

iii) Assist the state government in the planning, preparedness and mitigation of major chemical accidents at a site in the state

iv) Continuously monitor the post-accident situation arising out of a major chemical accident in the State and forward a report to the central crisis group

v) Review the progress report submitted by the district crisis groups

vi) Respond to queries addressed to it by the district crisis groups

vii) Publish a list of experts and officials in the state who are concerned with the management of chemical accidents.

B. Functions of the District Crisis Group

i. Assist the preparation of the district off-site emergency plan

ii. Review all the on-site emergency plans prepared by the occupier of major accident hazard’s installation for the preparation of the district off-site emergency plan

iii. Assist the district administration in the management of chemical accidents at a site lying within the district

iv. Continuously monitor every chemical accident

v. Ensure continuous information flow from the district to the centre and state crisis group regarding accident situation and mitigation efforts

vi. Forward a report of the chemical accident within fifteen days to the state crisis group

v. Conduct at least one full scale mock-drill of a chemical accident at a site each year and forward a report of the strength and the weakness of the plan to the state crisis group.

C) Functions of the Local Crisis Group

a) Prepare local emergency plan for the industrial pocket

b) Ensure dovetailing of local emergency plan with the district off-site emergency plan

c) Train personnel involved in chemical accident management

d) Educate the population likely to be affected in a chemical accident about the remedies and existing preparedness in the area

e) Conduct at least one full scale mock-drill of a chemical accident at a site every six months and forward a report to the district crisis group and

f) Respond to all public inquiries on the subject.

Central Control Committee

As the offsite plan is to be prepared by the government, a central control committee shall be formed under the chairmanship of the district collector. Other officers from police, fire service, factory inspectorate, medical department shall be incorporated as members of the central control committee. Under the central control committee the following committees shall be constituted under the control of the district collector.

i. Incident and environment control committee
ii. Fire control committee
iii. Traffic control, law and order, evacuation and rehabilitation committee
iv. Medical help, ambulance and hospital committee
v. Welfare, restoration and resumption committee
vi. Utility and engineering services committee
vii. Press, publicity and public relations committee

The off-site emergency plan shall be prepared by the district magistrate in consultation with the factory management and govt. agencies. The plan contains up-to-date details of outside emergency services and resources such as fire services, hospitals, police etc. with telephone number. The district authorities are to be included in the plan area.

a. Police department
b. Revenue department
c. Fire brigade
d. Medical department
e. Municipality
f. Gram panchayat
g. Railway department
h. Telephone department

i. Factory department

j. Electricity department

k. Pollution control department

l. Explosive department

m. Press and media

Mock exercises on off-site plan should be carried out at least once in a year to train the employees, up to date the plan, observe and rectify deficiencies. Each industrial unit or group of units should prepare separate emergency preparedness and DMP which will be in sync with the main DMP of industrial area incorporating details of action to be taken in case of any major accident/disaster occurring within the unit. The plan should cover all types of major accident/occurrences and identify the risk involved in the industry. Mock drills on the plan should be carried out periodically to make the plan foolproof and persons are made fully prepared to fight against any incident in the industry. The plan will vary according to the type of industry and emergency.