1 RISK ASSESSMENT & DISASTER MANAGEMENT PLAN

This section on Risk Assessment (RA) aims to provide a systematic analysis of the major risks that may arise as a result of the proposed expansion of the natural gas based power plant of OTPC in Tripura. The RA process outlines rational evaluations of the identified risks based on their significance and provides the outline for appropriate preventive and risk mitigation measures. The output of the RA will contribute towards strengthening of the Emergency Response Plan (ERP) in order to prevent damage to personnel, infrastructure and receptors in the immediate vicinity of the plant. Additionally, the results of the RA can also provide valuable inputs for keeping risk at As Low As Reasonably Practicable (ALARP) and arriving at decisions for mitigation of high risk events.

The following section describes the objectives, methodology of the risk assessment study and assessment for each of the potential risk separately. This includes identification of major hazards, hazard screening and ranking, frequency and consequence analysis for major hazards. The hazards have been quantitatively evaluated through a criteria based risk evaluation matrix. Risk mitigation measures to reduce significant risks to acceptable levels have also been recommended as a part of the risk assessment study.

1.1.1 RA Study Objective

The overall objective of this RA with respect to the proposed expansion project involves identification and evaluation of major risks, prioritizing risks identified based on their hazard consequences and using the outcome to guide and strengthen both onsite and offsite ERP. Hence in order to ensure effective management of any emergency situations that may arise from failure of natural gas supply pipelines, the following specific objectives need to be achieved.

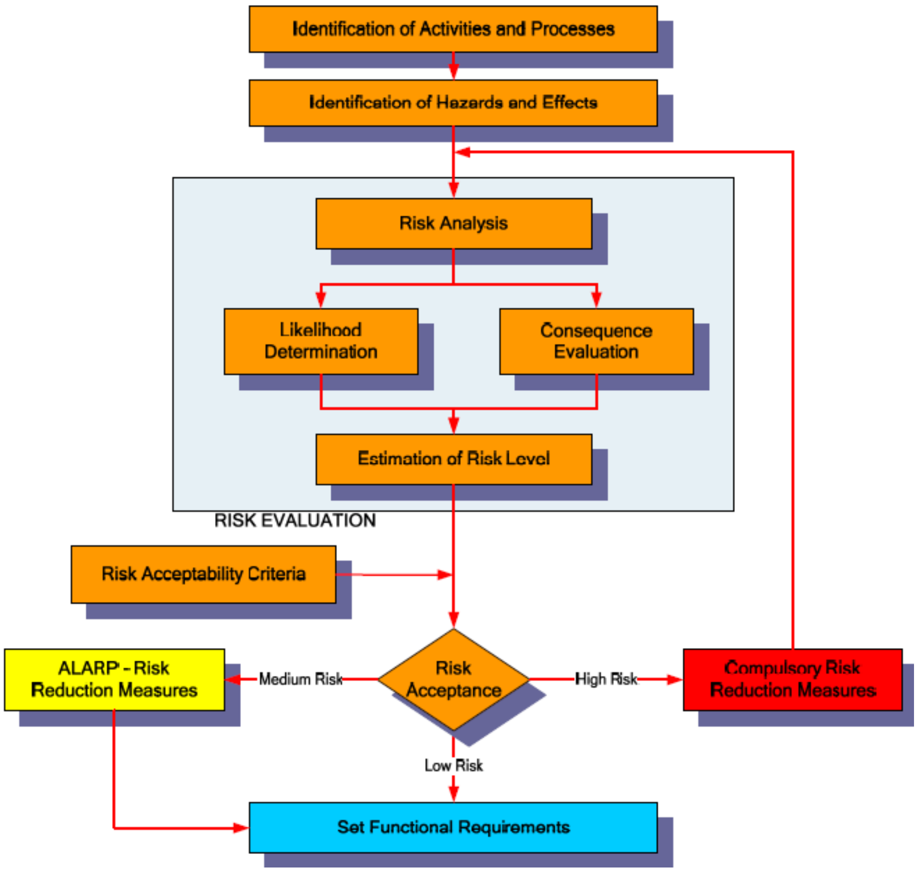
- Identify potential risk scenarios that may arise from supply of natural gas via pipelines;
- Review existing information and historical databases to arrive at possible likelihood of such risk scenarios;
- Predict the consequences of such potential risk scenarios and if consequences are observed to be high, establish the same through application of quantitative simulations; and
- Recommend feasible preventive and risk mitigation measures as well as provide inputs for strengthening of the project Emergency Response Plan (ERP).

1.1.2 RA Methodology

The risk assessment process is primarily based on likelihood of occurrence of the risks identified and their possible hazard consequences particularly being evaluated through hypothetical accident scenarios. With respect to the proposed expansion project, major risks viz. leaks and rupture of pipelines been assessed and evaluated through a risk matrix generated to combine the risk severity and likelihood factor. Risk associated with the proposed expansion of the OTPC gas based power project have been determined semiquantitatively as the product of likelihood/probability and severity/consequence by using order of magnitude data (*risk ranking = severity/consequence factor X likelihood/probability factor*). Significance of such project related risks have been then established through their classification as high, medium, low, very low depending upon risk ranking.

The risk matrix is widely accepted as standardized method of risk assessment and is preferred over purely quantitative methods, given that it's inherent limitations to define a risk event is certain. Application of this tool has resulted in the prioritization of the potential risks events for the existing operations and proposed expansion thus providing the basis for drawing up risk mitigation measures and leading to formulation of plans for risk and emergency management. The overall approach is summarized below in ***Figure 1.1.***

Figure 1.1 Risk Assessment Methodology



1.1.3 Safety Controls Proposed for Natural Gas Supply Pipeline

Adequate number of gas leak detection and fire detection system as per stipulated norms will be provided for the pipeline supply of natural gas. Gas flow measurement system with integrator and local/remote indication will also be installed.

Preventive Measures for Handling of Natural Gas

- Leak detection sensors to be located at areas prone to fire risk/ leakages;
- All safety and firefighting requirements as per OISD norms to be put in place;

- High temperature and high pressure alarm with auto-activation of water sprinklers as well as safety relief valve to be provided;
- Flame proof electrical fittings to be provided for the installation;
- Periodical training/awareness to be given to work force at the project site to handle any emergency situation;
- Periodic mock drills to be conducted so as to check the alertness and efficiency and corresponding records to be maintained;
- Signboards including emergency phone numbers and 'no smoking' signs should be installed at all appropriate locations;
- Plant should have adequate communication system;
- Pipeline route/equipment should be provided with smoke / fire detection and alarm system. Fire alarm and firefighting facility commensurate with the storage should be provided at the unloading point;
- 'No smoking zone' should be declared at all fire prone areas. Non sparking tools should be used for any maintenance; and
- Wind socks should be installed to check the wind direction at the time of accident and accordingly persons may be diverted in opposite direction of wind.

1.1.4 Hazard Identification

The first stage in any risk assessment is to identify the potential incidents that could lead to the release of a hazardous material from its normal containment and result in a major accident. This is achieved by a systematic review of the facilities to determine where a release of a hazardous material could occur from various parts of the installation.

The major hazards are generally one of three types: flammable, reactive and/or toxic. In this study, only flammable hazards are relevant involving loss of containment of diesel and leakage from natural gas pipeline. Flammable hazards may manifest as high thermal radiation from fires and over pressures following explosions that may cause direct damage, building collapse, etc. Flammable hazards are present throughout the facility and associated pipelines. Fires may occur if flammable materials are released to the atmosphere and ignition takes place.

Based on the result of this exercise, potential hazards that may arise due to proposed expansion project were identified and a qualitative understanding of their probability and significance were obtained. Taking into account the applicability of different risk aspects the following hazards have been identified with respect to the proposed expansion project which has been dealt in detail in the subsequent sections.

- Accidental release of natural gas from pipelines leading to jet fire, flash fire or vapour cloud explosion (VCE).

Hazards from Flammable Liquid Storages and Gas Pipelines

There are a number of hazards that are present at the proposed expansion project site that may result in injury to people or a fatality in more serious cases. This study is only concerned with 'major hazards', which are as follows:

- Jet fires associated with pipework failures;
- Vapour cloud explosions; and
- Flash fires.

Each of these hazards has been described below.

Jet Fire

Jet fires result from ignited releases of pressurized flammable gas or superheated/pressurized liquid. The momentum of the release carries the material forward in a long plume entraining air to give a flammable mixture. Jet fires only occur where the natural gas is being handled under pressure or when handled in gas phase and the releases are unobstructed.

Flash Fire

Vapour clouds can be formed from the release of vapour of pressurized flammable material as well as from non-flashing liquid releases where vapour clouds can be formed from the evaporation of liquid pools or leakage/rupture of pressurized pipelines transporting flammable gas.

Where ignition of a release does not occur immediately, a vapour cloud is formed and moves away from the point of origin under the action of the wind.
This drifting cloud may undergo delayed ignition if an ignition source is reached, resulting in a flash fire if the cloud ignites in an unconfined area or vapour cloud explosion (VCE) if within confined area.

Vapour Cloud Explosion

If the generation of heat in a fire involving a vapour-air mixture is accompanied by the generation of pressure then the resulting effect is avapour cloud explosion (VCE). The amount of overpressure produced in a VCE is determined by the reactivity of the gas, the strength of the ignition source, the degree of confinement of the vapour cloud, the number of obstacles in and around the cloud and the location of the point of ignition with respect to the escape path of the expanding gases.

1.1.5 Frequency Analysis

The frequency analysis of the hazards identified with respect to the proposed expansion project was undertaken to estimate the likelihood of their occurrences during the project life cycle. Hazard frequencies in relation to the proposed expansion project were estimated based on the analysis of historical accident frequency data and professional judgment. Based on the range of probabilities arrived at for different potential hazards that may be encountered with respect to the supply of natural gas the following frequency categories and criteria have been defined (Refer***Table 1.1***).

Table 1.1 Frequency Categories and Criteria

Likelihood Ranking	Criteria Ranking (cases/year)	Frequency Class
5	Likely to occur often in the life of the project, with a probability greater than 10^{-1}	Frequent
4	Will occur several times in the life of project, with a probability of occurrence less than 10^{-1}, but greater than 10^{-2}	Probable
3	Likely to occur sometime in the life of a project, with a probability of occurrence less than 10^{-2}, but greater than 10^{-3}	Occasional/Rare
2	Unlikely but possible to occur in the life of a project, with a probability of occurrence less than 10^{-3}, but greater than 10^{-6}	Remote
1	So unlikely it can be assumed that occurrence may not be experienced, with a probability of occurrence less than 10^{-6}	Improbable

Source: Guidelines for Developing Quantitative Safety Risk Criteria – Centre for Chemical Process and Safety

Frequency Analysis – Pipeline

An effort has also been made to understand the primary failure frequencies of pressurised natural gas pipeline to be supplied to the site to serve as a fuel source. Based on the European Gas Pipeline Incident Data Group (EGIG) database the evolution of the primary failure frequencies over the entire period and for the last five years has been provided in ***Table 1.2*** below.

Table 1.2 Primary Gas Pipeline Failure Frequency

Period	No. of Incidents	Total System Exposure (km.yr)	Primary failure frequency (1000 km.yr)
1970-2007	1173	$3.15.10^6$	0.372
1970-2010	1249	$3.55.10^6$	0.351
1970-2013	1309	$3.98.10^6$	0.329
1974-2013	1179	$3.84.10^6$	0.307
1984-2013	805	$3.24.10^6$	0.249
1994-2013	426	$2.40.10^6$	0.177
2004-2013	209	$1.33.10^6$	0.157
2009-2013	110	$0.70.10^6$	0.158

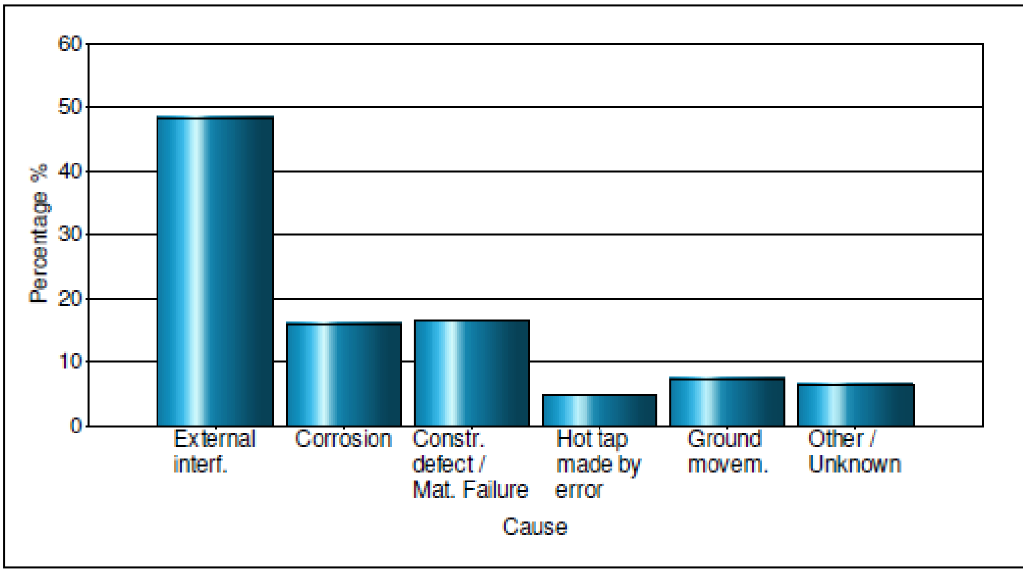
Source: 9th EGIG Report

As referred in the above table the overall failure frequency (0.33) of the entire period (1970-2013) is slightly lower than the failure frequency of 0.35 reported in the 8th EGIG report (1970-2010). The failure frequency of the last 5 years was found to be 0.16 per 1000km.year, depicting an improved performance over the recent years.

Incident Causes

Gas pipeline failure incidents can be attributed to the following major causes viz. external interference, construction defects, corrosion (internal & external), ground movement and hot tap. The distribution of incidents with cause has been presented in the ***Figure 1.2*** below.

Figure 1.2 Gas Pipeline Failure – Distribution of Incident & Causes



Source: 8th EGIG Report

The interpretation of the aforesaid figure indicated external interference as the major cause of pipeline failure contributing to about 48.4% of the total failure incidents followed by construction defects (16.7%) and corrosion related problems (16.1%). Ground movement resulting from seismic disturbance, landslides, flood etc. contributed to only 7.4% of pipeline failure incident causes.

Review of the 9th EGIG report indicates that primary failure frequency varies with pipeline diameter, and the same has been presented in ***Table 1.3*** below.

Table 1.3 Primary Failure Frequency based on Diameter Class (1970-2013)

Nominal Diameter (inch)	Primary failure frequency (per km.yr)		
	Pinhole/Crack	Hole	Rupture
diameter < 5"	4.45 X 10^{-4}	2.68 X 10^{-4}	1.33 X 10^{-4}
5" ≤ diameter < 11"	2.80 X 10^{-4}	1.97 X 10^{-4}	6.40 X 10^{-5}
11" ≤ diameter < 17"	1.27 X 10^{-4}	0.98 X 10^{-4}	4.10 X 10^{-5}
17" ≤ diameter < 23"	1.02 X 10^{-4}	5.00 X 10^{-5}	3.40 X 10^{-5}
23" ≤ diameter < 29"	8.50 X 10^{-5}	2.70 X 10^{-5}	1.20 X 10^{-5}
29" ≤ diameter < 35"	2.30 X 10^{-5}	5.00 X 10^{-6}	1.40 X 10^{-5}
35" ≤ diameter < 41"	2.30 X 10^{-5}	8.00 X 10^{-6}	3.00 X 10^{-6}
41" ≤ diameter < 47"	7.00 X 10^{-6}	-	-
diameter ≥ 47"	6.00 X 10^{-6}	6.00 X 10^{-6}	6.00 X 10^{-6}

Source: 9th EGIG Report

The pipeline failure frequency viz. leaks or rupture for the natural gas pipeline has been computed based on the aforesaid table. For pipeline with diameter varying within 5 to 11 inches, the probability of pinhole is estimated to be **2.80 x 10^{-4} per km year,** while full bore rupture is considered to be **6.40 x 10^{-5} per km year. This is considered for estimating failure probability of the natural gas pipeline having a 8 inch diameter which supplies to gas receiving station onsite. (Refer** ***Table 1.4*** below).

Table 1.4 Natural Gas Pipeline - Failure Frequency

Sl. No	Pipeline Failure Case	EGIG Failure Frequency (per km.year)	Avg. Pipeline Length (km)	Project Pipeline Failure Frequency (per year)	Frequency
1	Natural Gas Pipeline Rupture	6.40 x 10^{-5}	0.45	2.88 x 10^{-5}	Remote
2	Natural Gas Pipeline Leak	2.80 x 10^{-4}	0.45	1.26 x 10^{-4}	Remote

Thus the probability of pipeline leak and rupture with respect to the pipeline transportation of natural gas as fuel to the site is identified to be as "*Remote*" (Refer ***Table 1.1***).

Pipeline Failure – Ignition Probability

The ignition probability of natural gas pipeline failure (rupture & leaks) with respect to the proposed expansion project is derived based on the following equations as provided in the IGEM/TD/2 standard

$P_{ign} = 0.0555 + 0.0137pd2$; for $0 \le pd^2 \le 57$
(For pipeline ruptures)
$P_{ign} = 0.81$; for $pd^2 > 57$

$P_{ign} = 0.0555 + 0.0137(0.5pd2)$; for $0 \le 0.5pd^2 \le 57$
(For pipeline leaks)
$P_{ign} = 0.81$; for $0.5pd^2 > 57$

Where:

P_{ign} = Probability of ignition
p = Pipeline operating pressure (bar)
d = Pipeline diameter (m)

The ignition probability of natural gas release from a leak/rupture of 8inch natural gas pipeline is calculated based on the above equations utilizing the following input parameters as discussed below.

Natural Gas Pipeline

Normal Pipeline Inlet Pressure (bar) = p= 34 bar

Pipeline diameter = d = 12 inch or 0.20 m

For pipeline rupture $pd^2 = (34) X (0.20)^2 = 1.36$

For pipeline leak $0.5 pd^2 = 0.5 X (41.3) X (0.20)^2 = 0.68$

$0 \leq pd^2 \leq 57$ and **$0 \leq 0.5pd^2 \leq 57$,**

Since the following equation has been utilized for deriving the ignition probability for failure.

$P_{\text{ign for pipeline rupture}} = 0.0555 + 0.0137pd^2 = 0.0555 + 0.0137 (1.36) = 0.07$

$P_{\text{ign for pipeline leak}} = 0.0555 + 0.0137(0.5pd^2) = 0.0555 + 0.0137 (0.68) = 0.06$

The probability of ignition for an accidental release of natural gas from pipeline supplying the site is presented in ***Table 1.5*** below:

Table 1.5 Natural Gas Pipeline –Jet Fire Probability

Sl. No	Pipeline Failure Case	Project Pipeline Failure Frequency (per year)	Ignition Probability	Jet Fire Probability
1	Natural Gas Pipeline Leak	1.26×10^{-4}	0.06	0.75×10^{-5}
2	Natural Gas Pipeline Rupture	2.88×10^{-5}	0.07	0.20×10^{-5}

Hence from the above table it can be concluded that ignition probability of natural gas that may be released from the supply pipeline due to any accidental event is considered to be "***Remote***".

1.1.6 Consequence Analysis

In parallel with the frequency analysis, hazard prediction / consequence analysis exercises were undertaken to assess the likely impact of project related risks on onsite personnel, infrastructure and environment. In relation to the proposed expansion project as well as the existing activities have been considered, the estimation of the consequences for each possible event has been based either on accident frequency, consequence modeling or professional judgment, as appropriate. Overall, the consequence analysis takes into account the following aspects:

- Nature of impact on environment and community;
- Occupational health and safety;
- Asset and property damage;
- Corporate image; and
- Timeline for restoration of property damage.

The following criteria for consequence rankings (Refer ***Table 1.6)*** have been drawn up in context of the possible consequences of the risk events that may occur during the proposed project expansion operations:

Table 1.6 Severity Categories and Criteria

Consequence	Ranking	Criteria Definition
Catastrophic	5	• Multiple fatalities/permanent total disability to more than 50 persons. • Net negative financial impact of >10 crores • International media coverage • Loss of corporate image and reputation
Major	4	• Single fatality/permanent total disability to one or more persons • Net negative financial impact of 5 -10 crores • National stakeholder concern and media coverage.
Moderate	3	• Short term hospitalization & rehabilitation leading to recovery • Net negative financial impact of 1-5 crores • State wide media coverage
Minor	2	• Medical treatment injuries • Net negative financial impact of 0.5 – 1 crore • Local stakeholder concern and public attention
Insignificant	1	• First Aid treatment • Net negative financial impact of <0.5 crores. • No media coverage

<u>*Risk Evaluation*</u>
Based on ranking of likelihood and frequencies, each identified hazard has been evaluated based on the likelihood of occurrence and the magnitude of consequences. The significance of the risk is expressed as the product of likelihood and the consequence of the risk event, expressed as follows:

Significance = Likelihood X Consequence

The ***Table 1.7*** below illustrates all possible product results for the five likelihood and consequence categories while the ***Table 1.8*** assigns risk significance criteria in three regions that identify the limit of risk acceptability. Depending on the position of the intersection of a column with a row in the risk matrix, hazard prone activities have been classified as low, medium and high thereby qualifying for a set of risk reduction / mitigation strategies.

Table 1.7 Risk Matrix

			Likelihood →				
			Frequent	**Probable**	**Unlikely**	**Remote**	**Improbable**
			5	**4**	**3**	**2**	**1**
Consequence →	**Catastrophic**	**5**	25	20	15	10	5
	Major	**4**	20	16	12	8	4
	Moderate	**3**	15	12	9	6	3
	Minor	**2**	10	8	6	4	2
	Insignificant	**1**	5	4	3	2	1

Table 1.8 Risk Criteria and Action Requirements

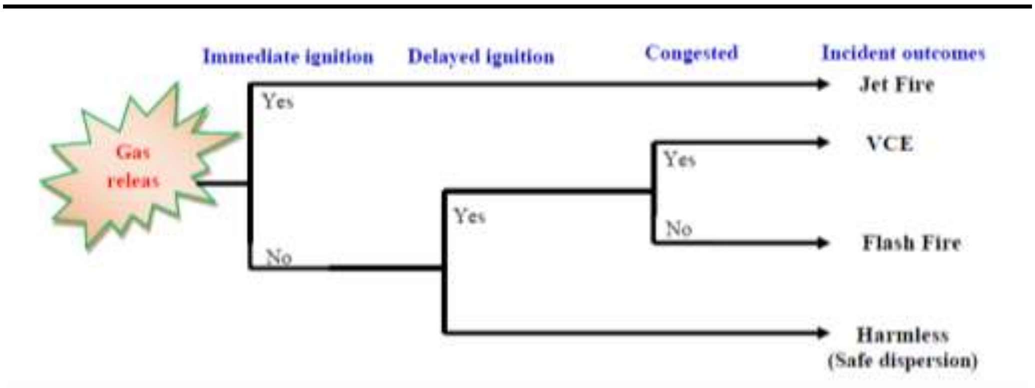
S.N.	Risk Significance	Criteria Definition & Action Requirements
1	**High (16 - 25)**	**"Risk requires attention"** – Project HSE Management need to ensure that necessary mitigation are adopted to ensure that possible risk remains within acceptable limits
2	**Medium (10 – 15)**	**"Risk is tolerable"** – Project HSE Management needs to adopt necessary measures to prevent any change/modification of existing risk controls and ensure implementation of all practicable controls.
3	**Low (5 – 9)**	**"Risk is acceptable"** – Project related risks are managed by well-established controls and routine processes/procedures. Implementation of additional controls can be considered.
4	**Very Low (1 – 4)**	**"Risk is acceptable"** – All risks are managed by well-established controls and routine processes/procedures. Additional risk controls need not to be considered

Consequence Analysis – Pipelines

Pipeline generally contains large inventories of oil or gas under high pressure; although accidental releases from them are remote they have the potential of catastrophic or major consequences if related risks are not adequately analysed or controlled. The consequences of possible pipeline failure is generally predicted based on the hypothetical failure scenario considered and defining parameters such as meteorological conditions (stability class), leak hole & rupture size and orientation, pipeline pressure & temperature, physicochemical properties of chemicals released etc.

In case of pipe rupture containing highly flammable natural gas, an immediate ignition will cause a jet fire. Flash fires can result from the release of natural gas through the formation of a vapour cloud with delayed ignition and a fire burning through the cloud. A fire can then flash back to the source of the leak and result in a jet fire. Flash fires have the potential for offsite impact as the vapour clouds can travel considerable distances downwind of the source. Explosions can occur when a flammable gas cloud in a confined area is ignited; however where vapour cloud concentration of released material is lower than Lower Flammability Limit (LFL), consequently the occurrence of a VCE is highly unlikely. VCE, if occurs may result in overpressure effects that become more significant as the degree of confinement increases (Refer ***Figure 1.3***).Therefore, in the present study, only the risks of jet fires for the below scenarios have been modelled and calculated.

Figure 1.3   Natural Gas Release – Potential Consequences



[Source: "Safety risk modelling and major accidents analysisof hydrogen and natural gas releases: Acomprehensive risk analysis framework" - Iraj Mohammadfam, Esmaeil Zarei]

Based on the above discussion and frequency analysis as discussed in the earlier section, the following hypothetical risk scenarios (Refer ***Table 1.9***) have been considered for consequence analysis of the natural gas supply pipeline (8inch dia) of 0.45km length.

Table 1.9   Pipeline Risk Modelling Scenarios

Scenario	Pipeline	Accident Scenario	Design Pressure (bar)	Pipeline Temperature	Potential Risk
1	Natural Gas Supply Pipeline	Leak of 25mm dia	34.0	24°C	Jet Fire
2	Natural Gas Supply Pipeline	Leak of 50mm dia	34.0	24°C	Jet Fire
3	Natural Gas Supply Pipeline	Complete rupture	34.0	24°C	Jet Fire VCE

The pipeline failure risk scenarios have been modeled using ALOHA and interpreted in terms of Thermal Radiation Level of Concern (LOC) encompassing the following threshold values (measured in kilowatts per square meter) for natural gas (comprising of ~95% methane[1]) to create the default threat zones:

Red: 10 kW/ (sq. m) -- potentially lethal within 60 sec;

Orange: 5 kW/ (sq. m) -- second-degree burns within 60 sec; and

Yellow: 2 kW/ (sq. m) -- pain within 60 sec.

For vapour cloud explosion, the following threshold level of concern has been interpreted in terms of blast overpressure as specified below:

Red: 8.0 psi – destruction of buildings;

[1] https://www.naesb.org//pdf2/wgq_bps100605w2.pdf

http://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=18&ved=0ahUKEwjF7MiDttPRAhVCMI8KHd7aD6cQFghrMBE&url=http%3A%2F%2Fwww.springer.com%2Fcda%2Fcontent%2Fdocument%2Fcda_downloaddocument%2F9781848828711-c1.pdf%3FSGWID%3D0-0-45-862344-p173918930&usg=AFQjCNEaJklfYKl3fRUdi6xiRYeW-FJb2A

Orange: 3.5 psi – serious injury likely; and

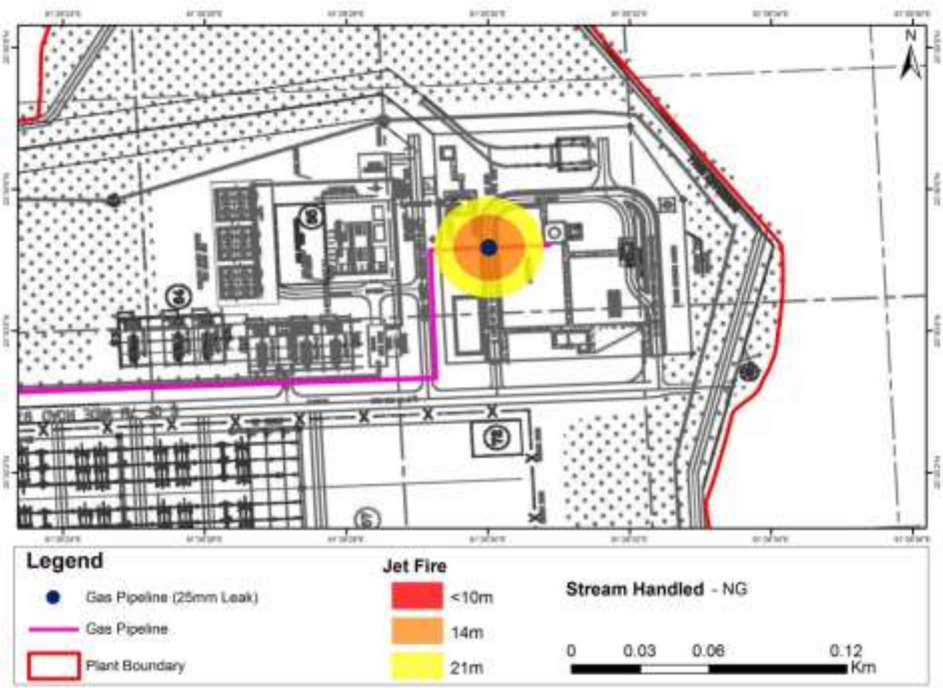
Yellow: 1.0 psi – shatters glass

The risk scenarios modelled for natural gas pipeline has been presented below

Scenario 1: Natural Gas Pipeline Leak (25mm dia)

The jet fire threat zone plot for release and ignition of natural gas from pipeline leak of 25mm dia is represented in ***Figure 1.4*** below.

Figure 1.4 Threat Zone Plot – Natural Gas Pipeline Leak (25mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : <10 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 14 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

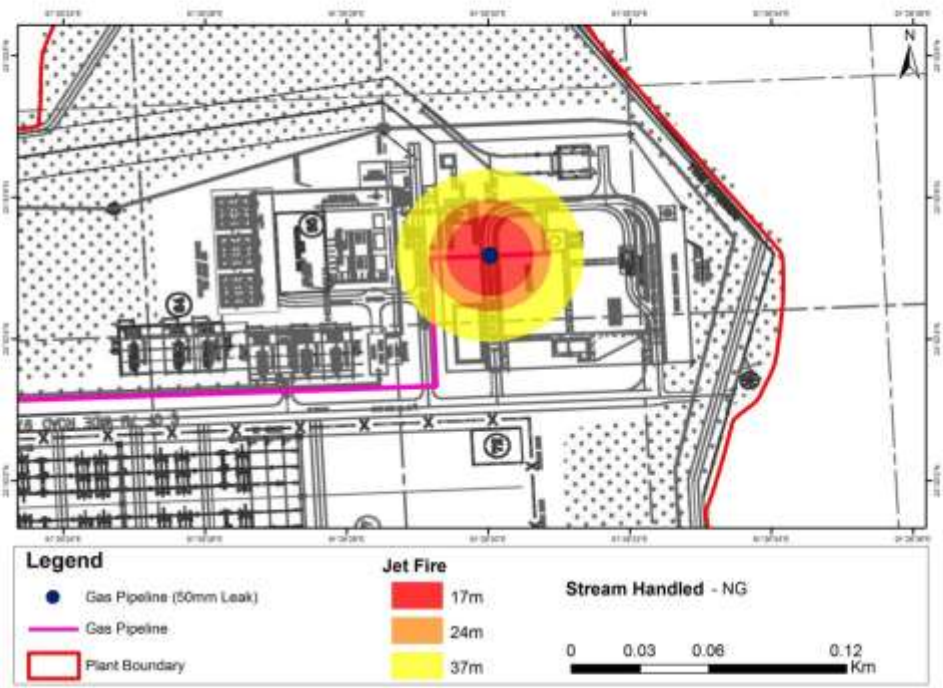
Yellow: 21 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from the pipeline leak of 25mm dia will be experienced to a maximum radial distance of less than 10m from the source with potential lethal effects within 1 minute.

Scenario 2: Natural Gas Pipeline Leak (50mm dia)

The jet fire threat zone plot for release and ignition of natural gas from pipeline leak of 50mm dia is represented in ***Figure 1.5*** below.

Figure 1.5 Threat Zone Plot – Natural Gas Pipeline Leak (50mm dia)



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 17 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 24 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

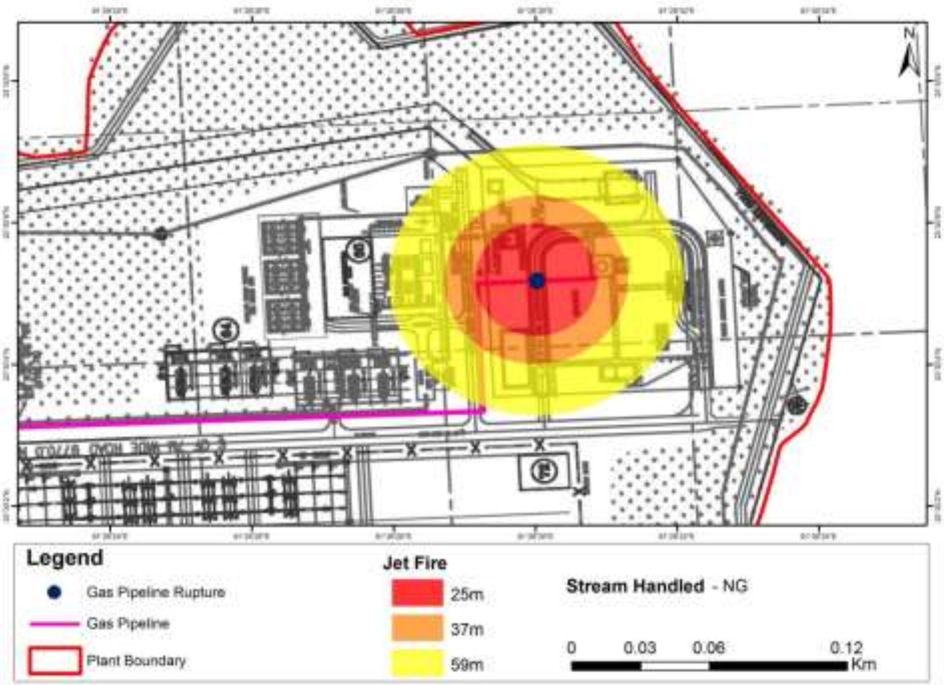
Yellow: 37 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from the pipeline leak of 50mm dia will be experienced to a maximum radial distance of 17m from the source with potential lethal effects within 1 minute.

Scenario 3: Natural Gas Pipeline Rupture

The jet fire threat zone plot for release and ignition of natural gas from pipeline rupture (worst case) is represented in ***Figure 1.6*** below.

Figure 1.6 Threat Zone Plot – Natural Gas Pipeline Rupture



Source: ALOHA

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 25 meters --- (10.0 kW/ (sq. m) = potentially lethal within 60 sec)

Orange: 37 meters --- (5.0 kW/ (sq. m) = 2nd degree burns within 60 sec)

Yellow: 59 meters --- (2.0 kW/ (sq. m) = pain within 60 sec)

The worst hazard for release and ignition of natural gas from the pipeline rupture will be experienced to a maximum radial distance of 25m from the source with potential lethal effects within 1 minute.

For VCE modelled for catastrophic failure of natural gas pipeline onsite, the LOC level was never exceeded

THREAT ZONE:

Threat Modeled: Overpressure (blast force) from vapor cloud explosion

Type of Ignition: ignited by spark or flame

Level of Congestion: uncongested

Model Run: Heavy Gas

Red : LOC was never exceeded --- (8.0 psi = destruction of buildings)

Orange: LOC was never exceeded --- (3.5 psi = serious injury likely)

Yellow: LOC was never exceeded --- (1.0 psi = shatters glass)

For calculating the risk significance of natural gas pipeline, the likelihood ranking is considered to be “2” as the probability of pipeline rupture is computed to be ~2.88×10^{-5} per year; whereas the consequence ranking has been identified to be as "3" as given for a worst case scenario (rupture) lethal effects is likely to be limited within a radial zone of ~25m. Also no social sensitivities in the form of village settlements, educational institutions etc. were found to be located within this zone. Further as discussed in the earlier section, adequate number of gas leak and fire detection system of appropriate design will be provided for the pipeline supply of natural gas to prevent for any major risk at an early stage of the incident.

Risk Ranking – Natural Gas Pipeline Rupture (Worst Case Scenario)

Likelihood ranking	**2**	**Consequence ranking**	**3**
Risk Ranking & Significance = 6 i.e. "Low" i.e. Risk is Acceptable and can be managed through use of existing controls and evaluation of additional controls.			

1.1.7 Disaster Management Plan

Disaster Management is a process or strategy that is implemented when any type of catastrophic event takes place. The Disaster Management Plan envisages the need for providing appropriate action so as to minimize loss of life/property and for restoration of normalcy within the minimum time in event of any emergency. Adequate manpower, training and infrastructure are required to achieve this.

The objectives of Disaster Management Plan are as follows:

- Rapid control and containment of the hazardous situation;
- Minimising the risk and impact of occurrence and its catastrophic effects;
- Effective rehabilitation of affected persons and prevention of damage to Property and environment;
- To render assistance to outside the factory.

The following important elements in the disaster management plan (DMP) are suggested to effectively achieve the objectives of emergency planning:

- Reliable and early detection of an emergency and careful response;
- The command, co-ordination, and response organization structure along with efficient trained personnel;
- The availability of resources for handling emergencies;
- Appropriate emergency response actions;
- Effective notification and communication facilities;
- Regular review and updating of the DMP;
- Proper training of the concerned personnel.

1.1.8 Emergency Identified

Emergencies that may arise:

- Such an occurrence may result in on-site implications like :
  - Fire or explosion;
  - Leakage of natural gas.

- Incidents having off-site implications can be:
  - Natural calamities like earthquake, cyclone, lightening, etc.
- Other incidents, which can also result in a disaster, are :
  - Agitation / forced entry by external group of people;
  - Sabotage.

The Hazards Identification & Risk Assessment (HIRA), carried out in the existing Plant, emergency conditions are identified; and to prevent these emergencies, SHEOP are prepared.

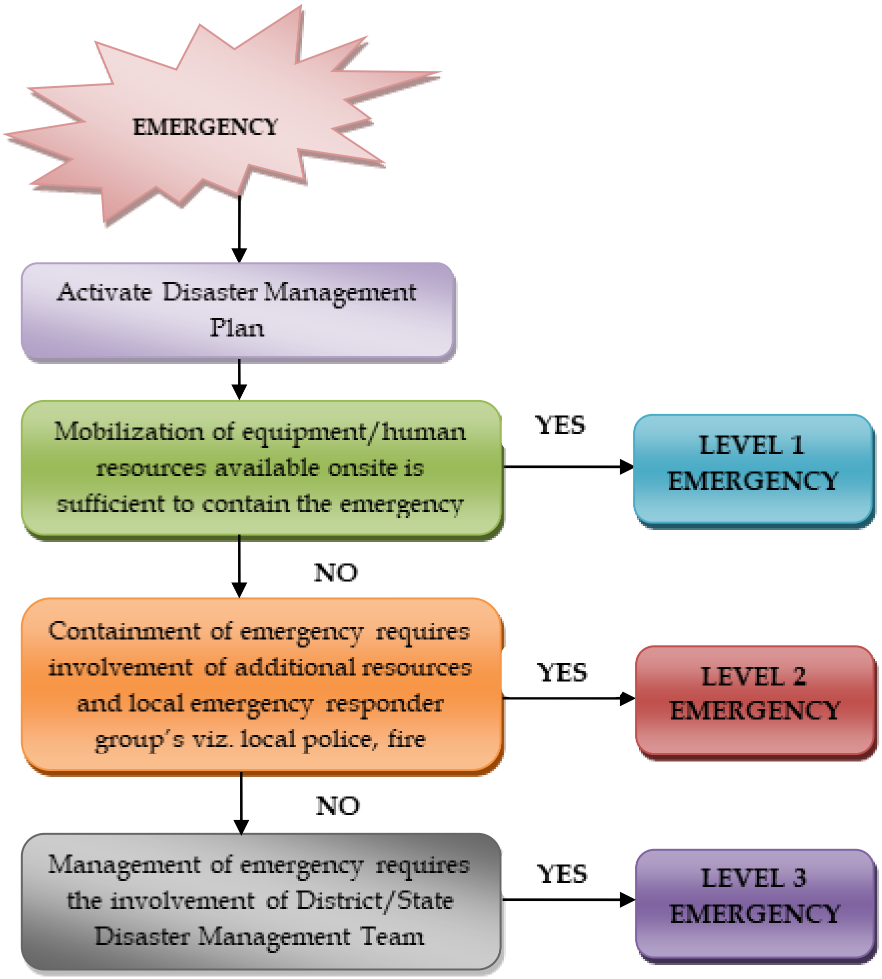
Table 1.10 Emergency Conditions in the Plant

Sl. No.	Area	Aspect/ Hazards	Impact/ Risk
1.	Hydrogen cylinder storage	Jet fire, flash fire BELVE (fire ball)	Burn/ injuries
2.	Chlorine tonner storage	Toxic gas release	Serious effect on health, loss of life and property inside and nearby society and impact on environment.
3.	CO_2 storage tank	Toxic gas release	Frost barite
4.	NG pipeline	Jet fire, flash fire/ VCE	Serious injuries and catastrophic event
5.	Transformer oil storage and transformer	Pool fire	Burn/ injuries
6.	Lubricating oil storage	Pool fire	Burn/ injuries
7.	Caustic soda container	Corrosive	Injuries
8.	Sulfuric acid storage tank	Corrosive	Injuries
9.	HCl storage tank	Corrosive	Injuries
10.	Switchyard	Fire	Burn/ injuries
11.	Boiler	Explosion	Injuries/ casualties

1.1.9 Emergency Classification

Due consideration is given to the severity of potential emergency situation that may arise as a result of accident events as discussed in the **Risk Analysis (RA**) study. Not all emergency situations call for mobilization of same resources or emergency actions and therefore, the emergencies are classified into three levels depending on their severity and potential impact, so that appropriate emergency response procedures can be effectively implemented by the Emergency Response Team. The emergency levels/tiers defined with respect to this project based on their severity have been discussed in the subsequent sections with 'decision tree' for emergency classification being depicted in ***Figure 1.7.***

Figure 1.7 Emergency Classification "Decision Tree"



The emergency situations have been classified in three categories depending upon their magnitude and consequences. Different types of emergencies that may arise at OTPC gas based power plant can be broadly classified as:

Level 1 Emergency

The emergency situation arising in any section of one particular plant / area which is minor in nature, can be controlled within the affected section itself, with the help of in-house resources available at any given point of time. The emergency control actions are limited to level 1 emergency organization only. But such emergency does not have the potential to cause serious injury or damage to property / environment and the domino effect to other section of the affected plant or nearby plants/ areas.

Level 2 Emergency

The emergency situation arising in one or more plants / areas which has the potential to cause serious injury or damage to property / environment within the affected plant or to the nearby plants / areas. This level of emergency situation will not affect surrounding community beyond the power plant facility. But such emergency situation always warrants mobilizing the necessary resources available in-house and/or outsources to mitigate the emergency. The situation requires declaration of On – Site emergency.

Level 3 Emergency

The emergency is perceived to be a kind of situation arising out of an incident having potential threat to human lives and property not only within the power plant facility but also in surrounding areas and environment. It may not be possible to control such situations with the resources available within OTPC power plant facility. The situation may demand prompt response of multiple emergency response groups as have been recognized under the off-site district disaster management plan of Gomati district.

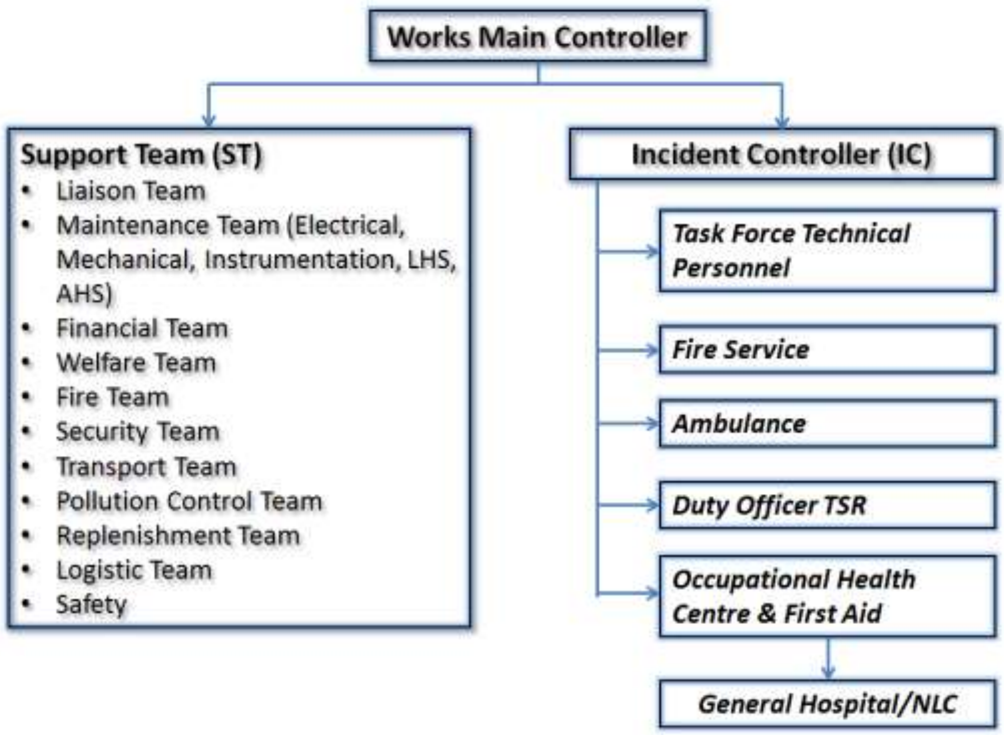
1.1.10 Onsite Disaster Management Team & their Responsibility

Responsibility for establishing and maintaining record of disaster management belongs to Works Main Controller. He is responsible for distribution & control of the plan, and for ensuring that the plans are implemented, reviewed and revised annually. Incidence Controller is responsible for the training of personnel to ensure that adequate emergency response capabilities are maintained in accordance with the plan.

Works Main Controller and Incidence Controller are responsible for ensuring the efficacy of the conduct of drills, as outlined in the DMP. All employees of various departments are responsible for carrying out their responsibilities, as defined in DMP.

In order to handle disaster/emergency situations, an organizational chart entrusting responsibility to various site personnel has been prepared along with their specific roles during an emergency. The disaster management team OTPC-Palatana plant is given in ***Figure 1.8***.

Figure 1.8 OTPC Disaster Management Team



1.1.11 Emergency Resources Available

The DMP include emergency preparedness plan, emergency response team, emergency communication, emergency responsibilities, emergency facilities, and emergency actions.

Facilities and Resources during Emergencies

OTPC is maintaining the following facilities in a state of readiness with equipment to detect the emergency and respond effectively during any disaster.

Emergency Control Centre (ECC)

It is a location, where all key personnel like Combat Team Leader, Rescue Team Leader and Auxiliary Team Leader, etc. can assemble in the event of onset of emergency and carry on various duties assigned to them.

During an emergency, the Incident Controller including Combat Team Leader, Rescue Team Leader and Auxiliary Team Leader will gather in the ECC. Therefore, the ECC is equipped with adequate communication systems in the form of telephones and other equipment to allow unhampered communication with the teams involved in bringing the incident under control, and with the external response organisations and other nearby facility personnel.

The ECC is always ready for operation and provided with the equipment and supplies necessary aids during the emergency such as:

- Latest copy of the On-site Disaster Management Plan;

- Emergency telephone rosters;
- Factory Layout, Site Plan
    - Plans indicating locations of hazardous inventories, sources of safety equipment, hydrant layout, location of pump house, road plan, assembly points, vulnerable zones, escape routes;
- Emergency shut-down procedures;
- Nominal roll of employees;
- List and address of key personnel, Emergency coordinators, first aiders, firefighting employees.

Emergency Communication

The plant has Local Audio Alarm System, PA system, & Emergency siren with siren code to make the emergency known both inside and outside of the facility, and co-ordinating among the various groups involved in response operations.

Warning/Alarm/Communication of Emergency: The emergency would be communicated by operating electrical siren for continuously for three minutes with high and low pitch mode.

Personal Protective Equipment

This equipment is used mainly for three reasons:
- To protect personnel from a hazard while performing rescue/accident control operations,
- To do maintenance and repair work under hazardous conditions, and
- For escape purposes.

The list of Personal Protective Equipment provided at the facility and their locations are available in ECC.

Fire Fighting Facilities

- Internal hydrant system;
- Portable extinguishers.

Fire Protection System

These systems are available to protect the plant by means of different fire protection facilities and consist of
- Hydrant system for exterior as well as internal protection of various buildings/areas of the plant.
- Portable extinguishers and hand appliances for extinguishing small fires in different areas of the plant.
- Water monitor will be provided in hypo plant area.
- Fire water pumps.
- Two (2) independent motor driven pumps each of sufficient capacity and head are proposed for the hydrant system which is capable to extinguish Fire or cooling purpose.

Medical Facilities, Equipment and Supplies

- Doctor and preliminary treatment facilities in the plant;
- Ambulance; and
- Mutual aid with nearby industries.

Emergency Escapes

The objective of the emergency escape is to escape from the hazardous locations, to the nearest assembly point or the other safe zone, for rescue and evacuation. Emergency escape routes have been provided within the plant. Wind socks are also provided in various locations.

Emergency Transport

Emergency Ambulance is stationed at the main gate and round the clock-driver is available for emergency transportation of injured personnel, if any.

The other vehicles of the company also would be available for emergency services.

Security and Access Control Equipment

In case of an emergency the incoming response teams and resources will be directed to assembly place. Admission to contaminated area / effected area will be restricted. The response team and resources coming from outside will reach to event place after permission from Works Main Controller.

Assembly Point

Assembly point is location, where, persons not-connected with emergency operations would proceed at assembly point and await for rescue operation.

Emergency Power and Lighting

Plant has equipped with a Diesel generator sets, which are auto started on the loss of all On-site power to the primary bus. The DG set is sized to provide emergency lighting in required areas and to meet the requirement to run the essential service equipment and critical equipment to safety & environment including emergency siren.

Mutual Aid

While necessary facilities will be made available and updated from time to time, sometimes, it may be necessary to seek external assistance; it may be from the neighbouring factories or from the State Government.

Command, Co-ordination and Response Team

One of the most important objectives of emergency planning is to create a response organisation structure capable of being developed in the shortest time possible during an emergency.

Command and control of an emergency condition, encompasses the key management functions necessary to ensure the least impact on environment, health and safety of employees, as well as the public living in the vicinity. These primary functions are summarised as follows:

- Detection of the emergency conditions;
- Assessment of the conditions;
- Classification of emergency;
- Mitigation of the emergency conditions;
- Notification to management personnel;
- Notification to local, state, and government agencies;
- Activation and response of the necessary on-site and off-site support personnel;
- Continuous assessment and reclassifications, as necessary;
- Initiation of proactive actions;
- Aid to affected personnel;
- Recovery and re-entry.

The plant has well defined command co-ordination and response team (***Figure 1.7***) and their responsibilities are well defined.

Emergency Training, Exercises, and Planned Maintenance

Training Program

Training is one of the basic components of disaster management. In principle, anyone who occupies a position within the disaster management plant organisation undergoes some kind of training, followed by refresher courses at periodical intervals.

The main goal of training for emergencies is to enable the participants to understand their roles in the response organisation, the tasks associated with each position, and the procedures for maintaining effective communications with the other response functions and individuals.

An in-house team will be appointed for the development of such training programme. This team is composed of the same people in-charge of developing and reviewing the response plan.

Mock Drill

In spite of detailed training, it may be necessary to try out whether, the OSEP works out and will there be any difficulties in execution of such plan. In order to evaluate the plan and see whether the plan meets the objectives of the OSEP, periodical mock drills are contemplated. Before undertaking the drill, it would be very much necessary to give adequate training to all staff members and also information about possible mock drill. After few pre-informed mock drills, few un-informed mock drills would be taken. All this is to familiarize the employees with the concept and procedures and to see their response. These scheduled and unscheduled mock drills would be conducted during shift change, public holidays, in night shift etc. To improve preparedness once in 6 months mock drill will be conducted. Incident Controller (IC) coordinates this activity.

PPEs

In certain circumstances, personal protection of the individual maybe required as a supplement to other preventive action. It should not be regarded as a substitute for other control measures and must only be used in conjunction with substitution and elimination measures. PPEs must be appropriately selected individually fitted and workers trained in their correct use and maintenance. PPEs must be regularly checked and maintained to ensure that the worker is being protected.