CHAPTER – 6
ADDITIONAL STUDIES

6.0 ADDITIONAL STUDIES

This chapter describes the Risk Assessment and Disaster Management Plan, Rehabilitation and Resettlement (R&R) Plan and Occupational Health & Safety Plan. The details of Public Consultation shall be added after the Public Consultation is done and Minutes of Meeting are issued by the Jharkhand State Pollution Control Board (JSPCB).

6.1 RISK ASSESSMENT

An industrial disaster arises when a major accident occurring in the factory becomes uncontrollable and its consequences go out of the factory boundaries. Hazards are inherent to all industrial operations since they involve handling of hazardous materials (flammable, explosive, corrosive and toxic materials).

Risk assessment is a methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend.

Risks are inherent in proposed thermal power plant operations since they involve working with:

- High pressure super-heaters, re-heaters, economizer units exchanging heat with the hot flue gases;
- Turbines that utilize the HP steam to generate power;
- Fuel oil handling units;
- Hydrogen as a coolant in turbo generators drawn from hydrogen cylinders; and
- Switchyard including transformers, isolators.

Nevertheless, a properly designed and operated plant will have a very low probability (to a level of acceptable risk) of accident occurrence. Subsequently, a properly designed and executed management plan can further reduce the probability of any accident turning into an on-site emergency and/ or an off-site emergency.

The four major steps in risk assessment are hazard identification, dose response assessment, exposure assessment, and risk characterization.

Hazard identification is a process that determines the potential human health effects that could result from exposure to a hazard. This process requires a review of the scientific literature. The literature could include information published by the Environmental Protection Agency (EPA), federal or state agencies, and health organizations. Identification of causes and types of hazards is the primary task for planning for risk assessment.

Hazard can happen because of the nature of chemicals handled and also the nature of process involved. So for risk analysis first step is to identify the hazardous chemicals which are to be studied for risk analysis.

Identification of Hazardous Chemicals is done in accordance with "The Manufacture, Storage and import of Hazardous Chemical Rules, 1989". Schedule 1, of the Rule provides a list of the Toxic and Hazardous chemicals and the flammable chemicals. It defines the flammable chemicals based on the flash point and boiling point.

"Major Accident Hazards (MAH) installations" is defined as the isolated storage and industrial activity at a site handling (including transport through carrier or pipeline) of hazardous chemicals equal to or, in excess of the threshold quantities

Dose-response or toxicity assessment is the determination of how different levels of exposure to a hazard or pollutant affect the likelihood or severity of health effects. Responses/ effects can vary widely since all chemicals and contaminants vary in their capacity to cause adverse effects. The dose-response relationship can be evaluated for either carcinogenic or no carcinogenic substances.

Exposure assessment is the determination of the magnitude of exposure, frequency of exposure, duration of exposure and routes of exposure by contaminants to human populations and ecosystems. There are three components to this step.

1. Identification of contaminants being released;
2. Estimation of the amounts of contaminants released from all sources or the source of concern; and
3. Estimation of the concentration of contaminants.

6.1.1 Scope of the Study

The risk analysis/ assessment study covers the following:

(a) Site assessment;

(b) Identification of potential hazard areas;

(c) Identification of representative failure cases;

(d) Visualization of the mode of chemical releases and the resulting accident scenarios;

(e) Assess the overall damage potential of the identified hazardous events and impact zones from the accident scenarios;

(f) Furnish specific recommendations on the minimization of the worst accident possibilities;

(g) Preparation of Disaster Management Plan (DMP), On-site and Off-site Emergency Plan; and

(h) Preparation of the Occupational and Health safety plan.

6.1.2 Brief Description

6.1.2.1 Hazard Identification

Identification of hazards is of primary significance in the analysis, quantification and cost effective control of accidents involving chemicals and processes. A classical definition of hazard states that it is the characteristic of system/ process that presents potential for an accident. Hence, all the components of a system/ 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.

Estimation of probability of an unexpected event and its consequences form the basis of quantification of risk in terms of damage to property, environment or personnel. Therefore, the type, quantity, location and conditions of release of a toxic or flammable substance have to be identified in order to estimate its damaging effects, the area involved, and the possible precautionary measures required to be taken. Based on the areas and unit operations involved in generation of power various hazards are identified which are given in **Table 6.1**.

Table 6.1: Potential Risk Areas Due To Proposed Thermal Power Plant

S. No.	Blocks/ Areas	Hazards Identified
1	Coal storage in open yard	Fire, Spontaneous Combustion
2	Coal Handling Plant including Bunker area	Fire and/ or Dust Explosions
3	Boilers	Fire (mainly near oil burners), steam; Explosions, Fuel Explosions
4	Turbo-Generator Buildings	Fires in: a) Lube Oil systems, b) Cable galleries, c) Short circuits in: i) *Control Rooms* *ii) Switchgears* Explosion due to leakage of Hydrogen & fire following it. Fire in Oil Drum Storage.
5	Power Transformers	Explosion and fire.
6	Switch-yard Control Room	Fire in cable galleries and Switchgear/ Control Room.
7	Hydrogen Plant Hydrogen and oxygen holders in Open Hydrogen Cylinders in R.C.C. building Oxygen cylinders in R.C.C. building	Explosion and/or fire, Physical dangers
8	Tank Farms LDO	Fire
9	Water Treatment of Chlorination plants Pre-treatment plants Hydrochloric Acid (HCl) Sodium Hydroxide (NaOH)	Release of Chlorine - Toxicity Corrosive
10	Steam turbine	Hydrogen and lube oil leak leading to fire/ smoke

6.1.2.2 Classification of Major Hazardous Units

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, transported, handled and utilized within the facility have been summarized in the **Table 6.2(a)**. The fuel storage details and properties are given in **Table 6.3** and **Table 6.4** respectively.

Table 6.2(a): Hazardous Materials Proposed to be Stored/ Transported

Materials	Hazardous Properties
Light Diesel Oil (LDO)	UN 1203. Dangerous Goods class 3 – Flammable Liquid
HFO (Heavy Fuel Oil)	Dangerous Goods class 3 – Flammable Liquid

Table 6.2(b): Properties of Fuels Used in the Plant

Chemical	Codes/ Label	TLV	FBP	MP	FP	UEL	LEL
			°C			%	
LDO	Flammable	5 mg/m^3	400	-	98	7.5	0.6
HFO	Flammable	5 mg/m^3	350	-26	66	6.0	0.5

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

Table 6.3: Category Wise Schedule of Storage Tanks

S. No.	Material	No. of Tanks	Design Capacity (KL)	Classification
1	LDO	2	500 each	Non-dangerous Petroleum
2	HFO	2	3100 each	Non Dangerous Petroleum

6.1.2.3 Consequence Analysis for HFO & LDO (Pool fire Modeling)

Details of HFO & LDO storage is mentioned below:

Table 6.4: Details of HFO & LDO Storage

Technical Parameters	Design Parameters	
	HFO	LDO
Purpose of Usage of Fuel	Start-up for Boiler	Start-up & Flame stabilization
Maximum storage capacity in KL	3100	500
No. of tanks	2	2
Size of tanks	Dia.= 18 m, Height = 12.5 m	Dia.= 10 m, Height = 8 m
Temperature in ^{0}C	50	Ambient
Pressure in mm Hg	Atmospheric	Atmospheric
Specific Gravity	0.95	0.8348
Dyke Area in m^2	480	196

The pool fire scenario has been assessed by considering worst case catastrophic rupture for various heat loads 37.5 kW/m^2, 12.5 kW/m^2 and 4 kW/ m^2.

Table 6.5: Consequence Analysis for Pool Fire Scenario for HFO & LDO

Leak size (mm)	Radiation Intensities (Kw/m^2)/ Distances (m)							
	HFO				LDO			
	37.5 (SHL-1)	12.5 (SHL-2)	4 (SHL-3)	0	37.5 (SHL-1)	12.5 (SHL-2)	4 (SHL-3)	0
Catastrophic Rupture	9.78	16.0	26.4	170	7.6	12.54	20.8	130

Note: SHL - Significant Heat Level

In case of HFO, for catastrophic rupture, three levels of thermal radiations of interests i.e. 37.5 kW/m^2, 12.5 kW/m^2 & 4 kW/m^2 are experienced at a distance of 9.78 m, 16.0 m and 26.4 m respectively.

In case of LDO, for catastrophic rupture, three levels of thermal radiations of interests i.e. 37.5 kW/m^2, 12.5 kW/m^2 & 4 kW/m^2 are experienced at a distance of 7.6 m, 12.54 m & 20.8 m respectively.

It is concluded that, the damage distance under ultimate hazard condition is upto 26.4 meter for HFO and 20.8 meter for LDO, where the heat flux is under SHL-3 as mentioned in the **Table 6.6**.

Table 6.6: Radiation Effects

Significant Heat Level (SHL)	Radiation level (kW/m^2)	Observed effect
SHL-1	37.5	Sufficient to cause damage to process equipment.
SHL-2	12.5	Minimum energy required for piloted ignition of wood, melting of plastic tubing.
SHL-3	4.0	Sufficient to cause pain to personnel if unable to reach cover within 20 seconds; however blistering of the skin (second degree burns) is likely.

Table 6.7: Heat Radiation and Escape Time

Radiation Intensity (BTU/hr/ft^2)	Time to pain Threshold (Seconds)
440 (1.39 kW/m^2)	60
550 (1.74 kW/m^2)	40
740 (2.33 kW/m^2)	30
920 (2.9 kW/m^2)	16
1500 (4.7 kW/m^2)	9
2200 (6.93 kW/m^2)	6
3000 (9.5 kW/m^2)	5
3700 (11.66 kW/m^2)	4
6300	2

Table 6.8: Tolerable Intensities for Various Objects

Object	Tolerable Intensity (kW/m^2)
Drenched Tank	38
Special Buildings (No Windows, fire proof doors)	25
Normal Buildings	14
Vegetation	10-12
Escape Route	6 (upto 30 seconds)
Personnel in Emergencies	3 (upto 30 seconds)
Plastic cables	2
Stationary Personnel	1.5

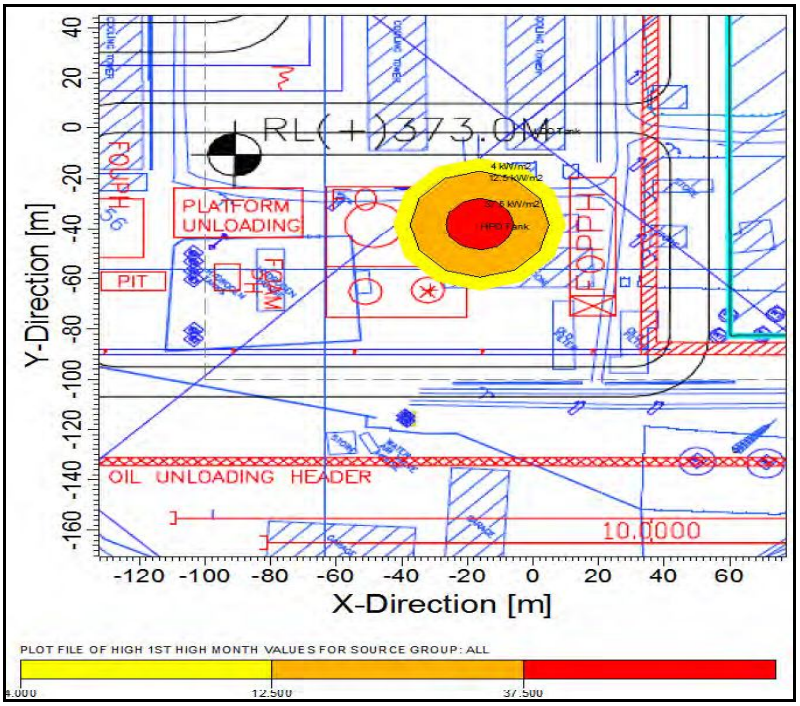

Figure 6.1: Risk Contour for Damage Distances for HFO Storage Tank

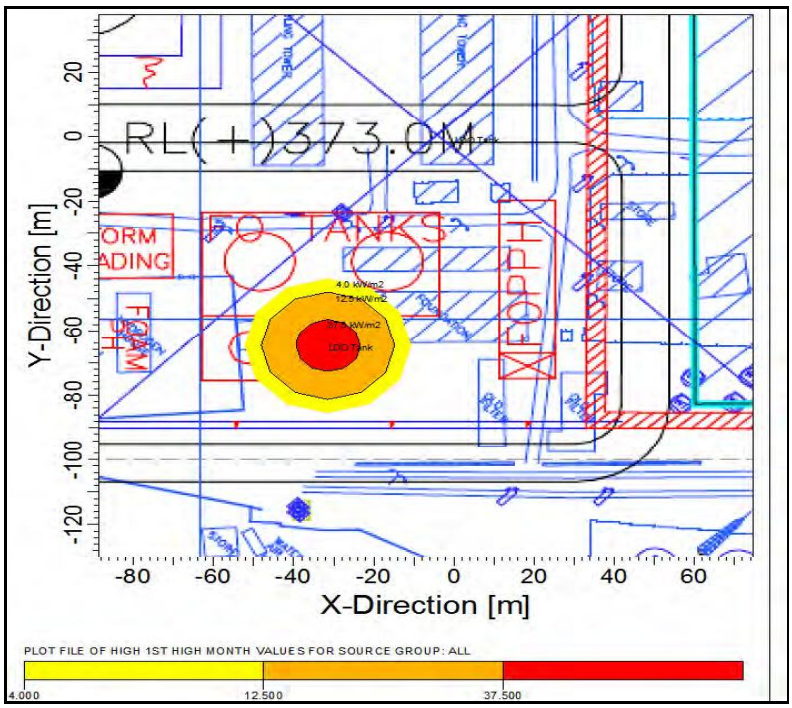

Figure 6.2: Risk Contour for Damage Distances for LDO Storage Tank

6.1.2.4 Gas Dispersion Model for Toxic Release of Chlorine

Dispersion modeling is done for toxic release of Chlorine gas during storage and handling in Tonners of 760mm diameter and 2085mm length. The dispersion modeling is done on the basis of Gaussian Model. Gaussian Model is used to predict the way gas disperses in the atmosphere.

According to this model, "Wind" and "Atmospheric Turbulence" are the main forces that move the molecules of a released gas through the air, as an escaped cloud is blown down the wind. The "turbulent mixing" causes it to spread over in the crosswind and upward directions. According to the Gaussian Model, any crosswind slice of a moving pollutant cloud looks like a bell – shaped curve, high in the center and lower on the sides.

Methodology of Modeling

While doing the dispersion modeling, the methodology adopted is as follows:

i) The plant layout, GA drawing and other related documents with respect to chlorine gas were critically studied.

ii) The site visit and physical inspection of the Tonners containing the chlorine gas was conducted; and the site data were recorded.

iii) Discussion was made with the technical team of the plant on different aspects of chlorine gas such as storage, handling and usages.

iv) Data relating to the plant and meteorological data were recorded and tabulated in a standard format for the purpose of modeling.

v) While doing the modeling, certain considerations and assumptions were made to fit the model.

vi) The input data were fed and the result (foot print) of the modeling was taken in a graphical form (colored). The color code shows the different level of chlorine gas at different distances.

vii) The contour of the gas was super-imposed on the plant lay out to indicate the extent of influence of chlorine gas in case of dispersion due to leakage.

Modeling:

While doing the modeling, care is taken in incorporating the predictions of the model under the following conditions;

- Very low wind speeds.
- Very stable atmospheric conditions.
- Wind shifts and terrain steering effects.
- Concentration patchiness particularly near the source.

The model does not incorporate the effect of following:

- Fires or chemical reactions.
- Particulates.
- Chemical mixtures.

Table 6.9: Chemical Information of Chlorine

S. No.	Parameters	Value
1	Physical Pressure	Gas
2	Appearance	Green
3	Odor	Suffocating Pungent Odor
4	Vapor Pressure	6.3 Atm at 20^{o}C
5	Vapor Density (Air=1)	2.473
6	Boiling Point (C)	34
7	Solubility in Water (cm^3/cm^3 H_2O)	4.61
8	Specific Gravity (H_2O=1)	Gas
9	Evaporation Rate	Gas
10	Odor Thershhold	0.08 to 0.4 ppm
11	ERPG-1	1 ppm
12	ERPG-2	3ppm
13	ERPG-3	20 ppm
14	IDLH	100 ppm

Note:

ERPG : *Emergency Response Planning Guidelines developed by the American Industrial Hygiene Association. This was developed as planning guidelines to anticipate the adverse effects on human health caused by exposure to toxic chemicals. The ERPGs are three tier guidelines with one common dominator i.e. hour contact duration.*

Each guideline identifies substance, its chemical and structural properties, animal toxicology data, human experience, existing exposure guidelines, the reasons behind the selected value etc.

ERPG – 1: *is the "maximum airborne concentration" below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odour.*

ERPG – 2: *is the "maximum air borne concentration" below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.*

ERPG – 3: *is the "maximum airborne concentration" below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life threatening health effects.*

The most important point to be noted about ERPG is that they do not contain safety factors usually incorporated into exposure guidelines such as the TLV (Threshold Limit Value). Rather they estimate only is how do the general public would react to the chemical exposure.

IDLH: *IDLH (Immediately Dangerous to Life or Health) level is a limit originally established for selecting respirators for use in work places by the National Institute for Occupational Safety and Health (NIOSH). A chemical's IDLH is an estimate of the maximum concentration in the air to which a healthy worker could be exposed without suffering permanent or escape – impairing health effects.*

Consideration of Scenario for modeling

While doing the modeling, we considered two rupture of 5.0 mm and 5.0 cm hole at the top of the Tonner near the valve. Chlorine Dispersion for the above two cases are depicted in **Figure 6.3 (a)** and **6.3(b)** below and threat zone are mentioned in **Table 6.10**.

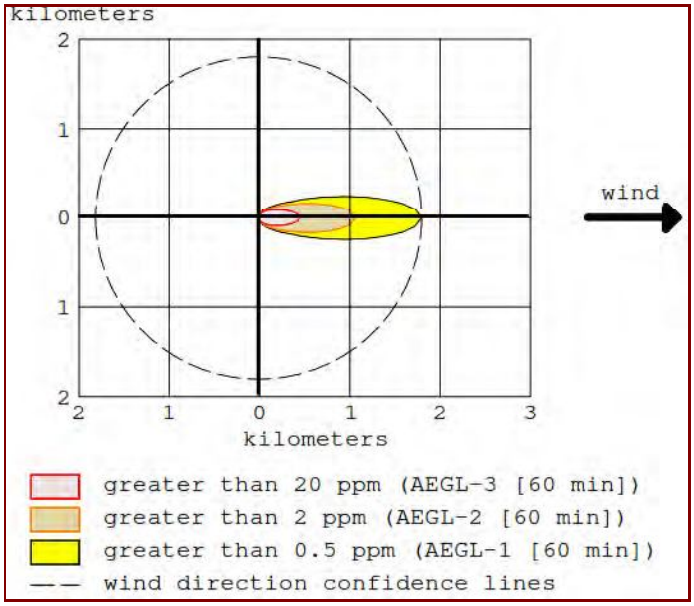

Figure 6.3 (a) Foot Print of Chlorine Dispersion- 5 mm

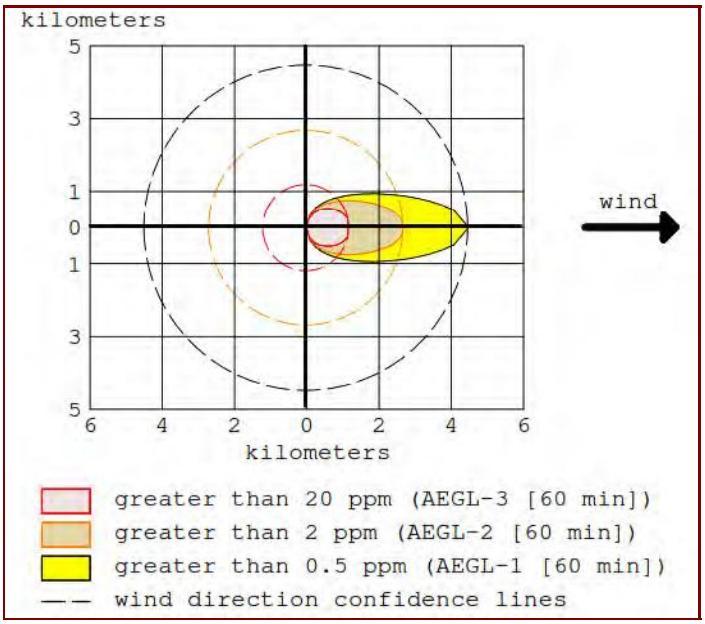

Figure 6.3(b) Foot Print of Chlorine Dispersion-5 cm

Table 6.10 Threat Zone for Chlorine

Threat Zone	5 mm Rupture	5 cm Rupture
Red	451 m (20ppm+ AEGL-3 (60 min)	1.2 Km (20ppm+ AEGL-3 (60 min)
Orange	1.1 Km (2 ppm+ AEGL-2 (60 Min)	2.7 Km (2 ppm+ AEGL-2 (60 Min)
Yellow	1.8 Km (0.5 ppm+ AEGL-1 (60 Min)	4.5 Km (0.5 ppm+ AEGL-1 (60 Min)

6.2 COAL HANDLING PLANT - DUST EXPLOSION

Coal dust when dispersed in air and ignited would explode. Crusher house and conveyor systems are most susceptible to this hazard. To be explosive, the dust mixture should have:

- Particles dispersed in the air with minimum size (typical figure is 400 microns);
- Dust concentrations must be reasonably uniform; and
- Minimum explosive concentration for coal dust (33% volatiles) is 50 gm/m^3.

Failure of dust extraction and suppression systems may lead to abnormal conditions and may increase the concentration of coal dust to the explosive limits. Sources of ignition present are incandescent bulbs with the glasses of bulkhead fittings missing, electric equipment and cables, friction, spontaneous combustion in accumulated dust.

Dust explosions may occur without any warnings with maximum explosion pressure upto 6.4 bar. Another dangerous characteristic of dust explosions is that it sets off secondary explosions after the occurrence of the initial dust explosion. Many a times the secondary explosions are more damaging than primary ones.

Stockpile areas shall be provided with automatic garden type sprinklers for dust suppression as well as to reduce spontaneous ignition of the coal stockpiles. Necessary water distribution network for drinking and service water with pumps, piping, tanks, valves etc will be provided for distributing water at all transfer points, crusher house, control rooms etc.

A centralized control room with microprocessor based control system (PLC) has been envisaged for operation of the coal handling plant. Except for locally controlled equipment like traveling tripper, dust extraction/ dust suppression / ventilation equipment, sump pumps, water distribution system etc, all other in-line equipment will be controlled from the central control room but will have provision for local control as well. All necessary interlocks, control panels, MCC's, mimic diagrams etc will be provided for safe and reliable operation of the coal handling plant.

6.2.1 Control Measures for Coal Yards

The total quantity of coal shall be stored in separate stockpiles, with proper drains around to collect washouts during monsoon season.

Water sprinkling system shall be installed on stocks of coal in required scales to prevent spontaneous combustion and consequent fire hazards. The stock geometry shall be adopted to maintain minimum exposure of stock pile areas towards predominant wind direction.

6.3 FIRE DETECTION & PROTECTION SYSTEM

A comprehensive fire detection and protection system is envisaged for the complete power station. This system shall generally be as per the recommendations of TAC (INDIA)/ IS: 3034 & NFPA- 850/ equivalent standard.

The following protection systems are envisaged:

1) Hydrant system for complete power plant covering main plant building, boiler area, turbine and its auxiliaries, coal handling plant, all pump houses and

miscellaneous buildings of the plant. The system shall be complete with piping, valves, instrumentation, hoses, nozzles, hose boxes/ stations etc.

2) Automatic high velocity water spray system for all transformers located in transformer yard and transformers having oil capacity above 2000 ltrs located within the boundary limits of plant, main and unit turbine oil tanks and purifier, Oil canal, generator seal oil system, lube oil system for turbine driven boiler feed pumps, boiler burner fronts etc. This system shall consist of QB detectors, deluge valves projectors, valves, piping & instrumentation.
3) Automatic medium velocity water spray system for cable vaults and cable galleries of main plant, switchyard control room and ESP control room consisting of smoke detectors, linear heat sensing cable detectors, deluge valves, isolation valves, piping, instrumentation, etc.;
4) Automatic medium velocity water spray system for coal conveyors, coal galleries, transfer points, Stacker reclaimer, etc. This system shall consist of QB detectors, linear heat sensing cables, deluge valves, nozzles, piping, instrumentation, etc.;
5) Automatic medium velocity water spray system for un-insulated fuel oil tanks storing fuel oil having flash point 65^{o} C and below consisting of QB detectors, deluge valves, nozzles, piping, instrumentation, etc.;
6) Fixed foam system of bladder tank foam proportioning tank type, consisting of skid mounted foam bladder tank assembly, foam makers, discharge outlets, interconnection piping, valves, fitting and instrumentation etc. shall be provided for fuel oil tanks.
7) For protection of central control room, control equipment room, programmer room and UPS room ehtc. Inert Gas extinguishing system as per NFPA-2001 (edition 2004 or latest) would be opted;
8) The clean agent (Novec-1230) automatic direct/ indirect low pressure extinguishing system shall be provided for electrical panels in switchgear room of make-up water pump house and electrical house of stacker-reclaimer machines.
9) Fire detection and alarm system – Microprocessor based analogue, addressable type Fire detection and Alarm system shall be provided to cover the complete power plant. Following types of fire detection shall be employed;
   - Multi-sensor type smoke detection system;
   - Linear heat sensing cable detector;
   - Quartzoid bulb heat detection system;
   - Infra red type heat detectors (for selected coal conveyors);
   - Beam Detector for auditorium building.
   - Portable and mobile extinguishers, such as pressurized water type, carbon-dioxide type, foam type, dry chemical powder type, shall be provided at strategic locations throughout the plant;
   - Complete Instrumentation and Control System for the entire fire detection and protection system shall be provided for safe operation of the complete system.
   - Raw/ Makeup water shall be used for supply of fire water. Fire water pumps shall be located in the fire water pump house and horizontal centrifugal pumps

shall be installed in the pump house for hydrant and spray system and the same shall be driven by electric motor and diesel engines as per the regulations of TAC. The water for foam system shall be tapped off from the hydrant system network;

- For the above fire water pumping station, automatic pressurization system consisting of jockey pumps shall be provided; and

6.4 DISASTER MANAGEMENT PLAN (DMP)

6.4.1 Disasters

A disaster is a catastrophic situation in which suddenly, people are plunged into helplessness and suffering and, as a result, need protection, clothing, shelter, medical and social care and other necessities of life.

Disasters can be divided into two main groups. In the first, are disasters resulting from natural phenomena like earthquakes, volcanic eruptions, storm surges, cyclones, tropical storms, floods, avalanches, landslides, forest fires. The second group includes disastrous events occasioned by man, or by man's impact upon the environment. Examples are armed conflict, industrial accidents, radiation accidents, factory fires, explosions and escape of toxic gases or chemical substances, river pollution, mining or other structural collapses, air, sea, rail and road transport accidents and can reach catastrophic dimensions in terms of human loss.

There can be no set criteria for assessing the gravity of a disaster in the abstract since this depends to a large extent on the physical, economic and social environment in which it occurs. What would be consider a major disaster in a developing country, ill equipped to cope with the problems involved, may not mean more than a temporary emergency elsewhere. However, all disasters bring in their wake similar consequences that call for immediate action, whether at the local, national or international level, for the rescue and relief of the victims. This includes the search for the dead and injured, medical and social care, removal of the debris, the provision of temporary shelter for the homeless, food, clothing and medical supplies, and the rapid re-establishment of essential services.

6.4.2 Objectives of Disaster Management Plan

The Disaster Management Plan is aimed to ensure safety of life, protection of environment, protection of installation, restoration of production and salvage operations in this same order of priorities. For effective implementation of the Disaster Management Plan, it should be widely circulated and personnel training through rehearsals/drills.

The Disaster Management Plan should reflect the probable consequential severalties of the undesired event due to deteriorating conditions or through 'Knock on' effects. Further the management should be able to demonstrate that their assessment of the consequences uses good supporting evidence and is based on currently available and reliable information, incident data from internal and external sources and if necessary the reports of out side agencies.

To tackle the consequences of a major emergency inside the factory or immediate vicinity of the factory, a Disaster Management Plan has to be formulated and this planned emergency document is called "Disaster Management Plan".

The objective of the Industrial Disaster Management Plan is to make use of the combined resources of the plant and the outside services to achieve the following:

- Effect the rescue and medical treatment of casualties;
- Safeguard other people;
- Minimize damage to property and the environment;
- Initially contain and ultimately bring the incident under control;
- Identify any dead;
- Provide for the needs of relatives;
- Provide authoritative information to the news media;
- Secure the safe rehabilitation of affected area;
- Preserve relevant records and equipment for the subsequent inquiry into the cause and circumstances of the Emergency.

In effect, it is to optimize operational efficiency to rescue rehabilitation and render medical help and to restore normalcy.

6.4.3 Emergencies

6.4.3.1 General, Industrial, Emergencies

The emergencies that could be envisaged in the plant and fuel storage are as follows:

- A situation of fire at the tank farm of all storages;
- Slow isolated fires;
- Fast spreading fires;
- Structural failures;
- Contamination of food/water; and
- Sabotage/Social disorder.

6.4.3.2 Specific Emergencies Anticipated

- ***Fire and Explosion***

Fire consequences can be disastrous, since they involve huge quantities of fuel either stored or in dynamic inventory in pipe lines or in nearby areas. Toxic releases can affect persons working around. Preliminary hazard analysis has provided a basis for consequence estimation. Estimation can be made by using various pool fire, tank fire consequence calculations. During the study of Risk Assessment, the nature of damages is worked out and probability of occurrence of such hazards is also drawn up.

6.4.4 Emergency Organization

It is recommended to setup an Emergency Organization. A senior executive who has control over the affairs of the plant should lead the Emergency Organization. He shall be designated at Site Controller. General Manager [O & M] shall be designated as the Incident Controller. In the case of stores, utilities, open areas, which are not under the control of the Production Heads, Senior Executive responsible for maintenance of utilities would be designated as Incident Controller. All the Incident Controllers would be reporting to the Site Controller.

Each Incident Controller, organizes a team responsible for controlling the incidence with the personnel under his control. Shift In-charge would be the reporting officer, who would bring the incidence to the notice of the Incidence Controller and Site Controller.

Emergency Co-ordinators would be appointed who would undertake the responsibilities like fire fighting, rescue, rehabilitation, transport and provide essential and support services. For this purposes, Security In-charge, Personnel Department, Essential services personnel would be engaged. All these personnel would be designated as Key personnel.

In each shift, electrical supervisor, electrical fitters, pump house in-charge, and other maintenance staff would be drafted for emergency operations. In the event of power or communication system failure, some of staff members in the office/plant offices would be drafted and their services would be utilized as messengers for quick passing of communications. All these personnel would be declared as essential personnel.

6.4.4.1 Emergency Communication

Whoever notices an emergency situation such as fire, growth of fire, leakage etc would inform his immediate superior and Emergency Control Centre. The person on duty in the Emergency Control Centre would appraise the Site Controller. Site Controller verifies the situation from the Incident Controller of that area or the Shift In-charge and takes a decision about an impending On Site Emergency. This would be communicated to all the Incident Controllers, Emergency Co-ordinators. Simultaneously, the emergency warning system would be activated on the instructions of the Site Controller.

6.4.5 Emergency Responsibilities

The responsibilities of the key personnel are appended below:

6.4.5.1 Site Controller

On receiving information about emergency he would rush to Emergency Control Centre (ECC) and take charge of ECC and the situation and;

- Assesses the magnitude of the situation on the advice of incident Controller,
- Decides whether the affected area needs to be evacuated,
- Whether personnel who are at assembly points need to be evacuated,
- Declares Emergency and orders for operation of emergency siren,
- Organizes announcement by public address system about location of emergency,
- Assesses which areas are likely to be affected, or need to be evacuated or are to be alerted,
- Maintains a continuous review of possible development and assesses the situation in consultation with Incident Controller and other Key Personnel as to whether shutting down the plant or any section of the plant required and if evacuation of persons is required,
- Directs personnel for Rescue, rehabilitation, transport, fire, brigade, medical and other designated mutual support systems locally available, for meeting emergencies,
- Controls evacuation of affected areas, if the situation is likely to go out of control or effects are likely to go beyond the premises of the factory, informs to District Emergency Authority, Police, Hospital and seeks their intervention and help,

- Informs Inspector of Factories, Deputy Chief Inspector of Factories, SPCB and other statutory authorities,
- Gives a public statement if necessary,
- Keeps record of chronological events and prepares an investigation report and preserves evidence,
- On completion of On Site Emergency and restoration of normalcy, declares all clear and orders for all clear warning.

6.4.5.2 Incident Controller

- Assembles the incident control team;
- Directs operations within the affected areas with the priorities for safety to personnel minimize damage to the plant, property and environment and minimize the loss of materials;
- Directs the shutting down and evacuation of plant and areas likely to be adversely affected by the emergency;
- Ensure that key personnel help is sought;
- Provides advice and information to the Fire and Security Officer and the Local Fire Services as and when they arrive;
- Ensures that all non-essential workers/staff of the affected areas evacuated to the appropriate assembly points, and the areas are searched for casualties;
- Has regard to the need for preservation of evidence so as to facilitate any inquiry into the caused and circumstances, which caused or escalated the emergency;
- Co-ordinates with emergency services at the site;
- Provides tools and safety equipment to the team members;
- Keeps in touch with the team and advise them regarding the method of control to be used; and
- Keeps the Site Controller of Emergency informed on the progress.

6.4.5.3 Emergency Coordinator - Rescue, Fire Fighting

- On knowing about emergency, rushes to ECC;
- Helps the incident Controller in containment of the emergency;
- Ensure fire pumps in operating conditions and instructs pump house operator to ready for any emergency with standby arrangement;
- Guides the fire fighting crew i.e. firemen, trained plant personnel and security staff;
- Organizes shifting the fire fighting facilities to the emergency site, if required;
- Takes guidance of the Incident Controller for fire fighting as well as assesses the requirements of outside help;
- Arranges to control the traffic at the gate and the incident area;
- Directs the security staff to the incident site to take part in the emergency operations under his guidance and supervision;
- Evacuates the people in the plant or in the nearby areas as advised by Site Controller;
- Searches for casualties and arranges proper aid for them;

- Assembles search and evacuation team;
- Arranges for safety equipment for the members of this team;
- Decides which paths the evacuated workers should follow; and
- Maintains law and order in the area, and if necessary seeks the help of police.

6.4.5.4 Emergency Coordinator-Medical, Mutual Aid, Rehabilitation, Transport and communication

- In the event of failure of electric supply and thereby internal telephone, sets up communication point and establishes contact with the ECC;
- Organizes medical treatment to the injured and if necessary will shift the injured to near by hospitals;
- Mobilizes extra medical help from outside, if necessary;
- Keeps a list of qualified first aid providers of the factory and seek their assistance;
- Maintains first aid and medical emergency requirements;
- Makes sure that all safety equipment is made available to the emergency team;
- Assists Site Controller with necessary data and to coordinate the emergency activities;
- Assists Site Controller in updating emergency plan, organizing mock drills verification of inventory of emergency facilities and furnishing report to Site Controller;
- Maintains liaison with Civil Administration;
- Ensure availability of canteen facilities and maintenance of rehabilitation center;
- He will be in liaison with Site Controller/Incident Controller;
- Ensure transportation facility;
- Ensures availability of necessary cash for rescue/rehabilitation and emergency expenditure;
- Controls rehabilitation of affected areas on discontinuation of emergency; and
- Makes available diesel/petrol for transport vehicles engaged in emergency operation.

6.4.5.5 Emergency Coordinator - Essential Services

- He would assist Site Controller and Incident Controller;
- Maintains essential services like Diesel Generator, Water, Fire Water, Compressed Air/Instrument Air, power supply for lighting;
- He would plan alternate facilities in the event of power failure, to maintain essential services such as lighting, refrigeration plant etc.;
- He would organize separate electrical connections for all utilities and emergency services so that in the event of emergency or fires, essential services and utilities are not affected;
- Gives necessary instructions regarding emergency electrical supply, isolation of certain sections etc. to shift in-charge and electricians;
- Ensures availability of adequate quantities of protective equipment and other emergency materials, spares etc.

6.4.5.6 General Responsibilities of Employees during an Emergency

During an emergency, it becomes more enhanced and pronounced when an emergency warning is raised, the workers if they are in-charge of process equipment, should adopt safe and emergency shut down and attend any prescribed duty as essential employees. If no such responsibility is assigned, they should adopt a safe course to assembly point and await instructions. They should not resort to spread panic. On the other hand, they must assist emergency personnel towards objectives of DMP.

6.4.6 Emergency Facilities

6.4.6.1 Emergency Control Centre (ECC)

For the time being Office Block will be identified as Emergency Control Center. It would have external Telephone, Fax, Telex facility. All the Site Controller/ Incident Controller Officers, Senior Personnel would be located here. Also, it would be an elevated place.

The following information and equipment are to be provided at the Emergency Control Centre (ECC).

- Intercom,
- P and T telephone,
- Safe contained breathing apparatus,
- Fire suit/gas tight goggles/ gloves/ helmets,
- Hand tools, wind direction/ velocities indications,
- Public address megaphone, hand bell, telephone directories,
- (internal, P and T) factory layout, site plan,
- Emergency lamp/torch light/ batteries,
- Plan indicating locations of hazard inventories, plant control room, sources of safety equipment, work road plan, assembly points, rescue location vulnerable zones, escape routes.
- Hazard chart,
- Emergency shut-down procedures,
- Nominal roll of employees,
- List of key personnel, list of essential employees, list of Emergency Co-ordinators,
- Duties of key personnel,
- Address with telephone numbers and key personnel, emergency coordinator, essential employees.
- Important address and telephone numbers including Government agencies, neighbouring industries and sources of help, out side experts, chemical fact sheets population details around the factory.

6.4.6.2 Assembly Point

Number of assembly depending upon the plant location would be identified wherein employees who are not directly connected with the disaster management would be

assembled for safety and rescue. Emergency breathing apparatus, minimum facilities like water etc. would be organized.

In view of the size of plant, different locations are ear marked as assembly points. Depending upon the location of hazard, the assembly points are to be used.

6.4.6.3 Fire Fighting Facilities

First Aid Fire fighting equipment suitable for emergency should be maintained in each section in the plant. This would be as per statutory requirements. However, fire hydrant line covering major areas would be laid. It would be maintained as 6 kg/cm^2 pressure. Fire alarms would be located in the bulk storage areas. Fire officer will be the commanding officer of fire fighting services.

6.4.6.4 Location of Wind Sock

On the top of the Administration block, top of each production blocks, wind socks shall be installed to indicate direction of wind for emergency escape.

6.4.6.5 Emergency Medical Facilities

Stretchers, gas masks and general first aid materials for dealing with chemical burns, fire burns etc would be maintained in the medical centre as well as in the emergency control room. Medical superintendent of the township will be the head of the casuality services ward. Private medical practitioners help would be also be sought. Government hospital would be approached for emergency help.

Apart from plant first aid facilities, external facilities would be augmented. Names of Medical Personnel, Medical facilities in the area would be prepared and updated. Necessary specific medicines for emergency treatment of Burns Patients, and for those affected by toxicity would be maintained.

Breathing apparatus and other emergency medical equipment would be provided and maintained. The help of near by industrial management in this regard would be taken on mutual support basis.

6.4.6.6 Ambulance

An ambulance with driver availability in all the shifts, emergency shift vehicle would be ensured and maintained to transport injured or affected persons. Number of persons would be trained in first aid so that, in every shift first aid personnel would be available.

6.4.7 Emergency Actions

6.4.7.1 Emergency Warning

Communication of emergency would be made familiar to the personnel inside the plant and people outside. An emergency warning system shall be established.

6.4.7.2 Emergency Shutdown

There are number of facilities, which can be provided to help deal with hazardous conditions, when a tank is on fire. The suggested arrangements are:

1. Stop feed;
2. Dilute contents;

3. Remove heat;

4. Deluge with water; and

5. Transfer contents.

Whether a given method is appropriate depends on the particular case. Cessation of agitation may be the best action in some instances but not in others. Stopping of the feed may require the provision of by pass arrangements.

Methods of removing additional heat include removal through the normal cooling arrangements or use of an emergency cooling system. Cooling facilities, which use vapouring liquid may be particularly effective, since a large increase in vaporization can be obtained by dropping pressure.

6.4.7.3 Evacuation of Personnel

There could be more number of persons in the storage area and other areas in the vicinity. The area would have adequate number of exits, staircases. In the event of an emergency, unconnected personnel have to escape to assembly point. Operators have to take emergency shutdown procedure and escape. Time Office shall maintain a copy of deployment of employees in each shift, at ECC. If necessary, persons can be evacuated by rescue teams.

6.4.7.4 All Clear Signal

Also, at the end of an emergency, after discussing with Incident Controllers and Emergency Co-ordinators, the Site Controller orders an all clear signal. When it becomes essential, the Site Controller communicates to the District Emergency Authority, Police, Fire Service personnel regarding help required or development of the situation into an Off-Site Emergency.

6.4.8 General

6.4.8.1 Employee Information

During an emergency, employees would be warned by raising siren in specific pattern. Employees would be given training of escape routes, taking shelter, protecting from toxic effects. Employees would be provided with information related to fire hazards, antidotes and first aid measures. Those who would be designated as key personnel and essential employees should be given training to emergency response.

6.4.8.2 Public Information and Warning

The industrial disaster effects related to this plant may mostly be confined to the plant area. The detailed risk analysis has indicated that the pool fire effects would not be felt outside. However, as an abundant precaution, the information related to chemicals in use would be furnished to District Emergency Authority for necessary dissemination to general public and for any use during an off site emergency. Factories of this size and nature are in existence in the district since long time.

6.4.8.3 Co-ordination with Local Authorities

Keeping in view of the nature of emergency, two levels of coordination are proposed. In the case of an On Site Emergency, resources within the organization would be mobilized and in the event of extreme emergency local authorities help should be sought.

In the event of an emergency developing into an off site emergency, local authority and District emergency Authority (normally the Collector) would be appraised and under his supervision, the Off Site Disaster Management Plan would be exercised. For this purpose, the facilities that are available locally, i.e. medical, transport, personnel, rescue accommodation, voluntary organizations etc. would be mustered. Necessary rehearsals and training in the form of mock drills should be organized.

6.4.8.4 Mutual Aid

Mutual aid in the form of technical personnel, runners, helpers, special protective equipment, transport vehicles, communication facility etc should be sought from the neighbouring industrial management.

6.4.8.5 Mock Drills

Emergency preparedness is an important on that of planning in Industrial Disaster Management. Personnel would be trained suitably and prepared mentally and physically in emergency response through carefully planned, simulated procedures. Similarly, the key personnel and essential personnel should be trained in the operations.

6.4.8.6 Important Information

Once the Plant goes into stream, important information such names and addresses of key personnel, essential employees, medical personnel, out side the plant, transporters address, address of those connected with Off Site Emergency such as Police, Local Authorities, Fire Services, District Emergency Authority should be prepared and maintained. The on-site emergency organization chart for various emergencies is shown in **Figure 6.4.**

6.5 Off-site Emergency Preparedness Plan

The task of preparing the Off-Site Emergency Plan lies with the district collector, however the off-site plan will be prepared with the help of the local district authorities. The proposed plan will be based on the following guidelines.

6.5.1 Introduction

Off-site emergency plan follows the on-site emergency plan. When the consequences of an emergency situation go beyond the plant boundaries, it becomes an off-site emergency. Off-site emergency is essentially the responsibility of the public administration. However, the factory management will provide the public administration with the technical information relating to the nature, quantum and probable consequences on the neighbouring population.

The off-site plan in detail will be based on those events, which are most likely to occur, but other less likely events, which have severe consequence, will also be considered. Incidents which have very severe consequences yet have a small probability of occurrence should also be considered during the preparation of the plan. However, the key feature of a good off-site emergency plan is flexibility in its application to emergencies other than those specifically included in the formation of the plan.

The roles of the various parties who will be involved in the implementation of an off-site plan are described below. Depending on local arrangements, the responsibility for the off-site plan should be either rest with the works management or, with the local

authority. Either way, the plan should identify an emergency co-ordinating officer, who would take the overall command of the off-site activities. As with the on-site plan, an emergency control centre should be setup within which the emergency co-ordinating officer can operate.

An early decision will be required in many cases on the advice to be given to people living "within range" of the accident - in particular whether they should be evacuated or told to go indoors. In the latter case, the decision can regularly be reviewed in the event of an escalation of the incident. Consideration of evacuation may include the following factors:

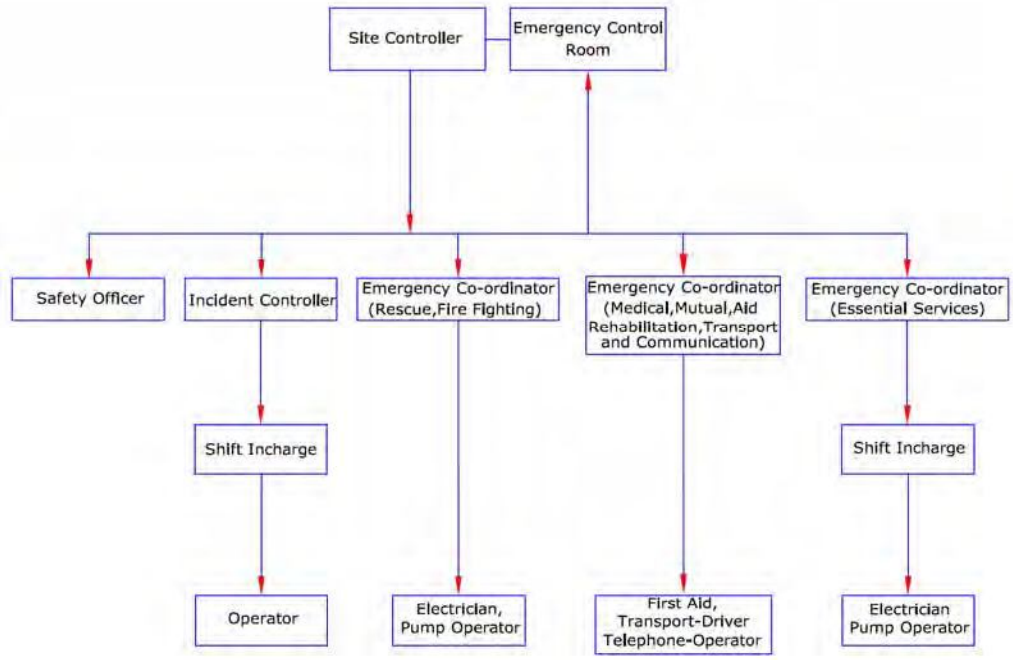

Figure 6.4: On-Site Emergency Organization Chart

- In the case of a major fire but without explosion risk (e.g. an oil storage tank), only houses close to the fire are likely to need evacuation, although a severe smoke hazard may require this to be reviewed periodically;
- If a fire is escalating and in turn threatening a store of hazardous material, it might be necessary to evacuate people nearby, but only if there is time; if insufficient time exists, people should be advised to stay indoors and shield themselves from the fire. This latter case particularly applies if the installation at risk could produce a fireball with vary severe thermal radiation effects; and
- For release or potential release of toxic materials, limited evacuation may be appropriate down wind if there is time. The decision would depend partly on the type of housing "at risk". Conventional housing of solid construction with windows closed offers substantial protection from the effects of a toxic cloud, while shanty house, which can exist close to factories, offer little or no protection.

The major difference between releases of toxic and flammable materials is that toxic clouds are generally hazardous down to much lower concentrations and therefore

hazardous over greater distances. Also, a toxic cloud drifting at, say 300 m per minute covers a large area of land very quickly. Any consideration of evacuation should take this into account. Although the plan will have sufficient flexibility built in to cover the consequences of the range of accidents identified for the on-site plan, it will cover in some detail the handling of the emergency to a particular distance from each major hazard works.

6.5.2 Aspects Proposed to be considered in the Off-Site Emergency Plan

The main aspects, which should be included in the emergency plan are:

- **Organization**

Detail of command structure, warning systems, implementation procedures, emergency control centres.

Names and appointments of incident controller, site main controller, their deputies and other key personnel.

- **Communications**

Identification of personnel involved, communication center, call signs, network, list of telephone numbers.

- **Specialized knowledge**

Details of specialist bodies, firms and people, whom it may be necessary to call e.g. those with specialized chemical knowledge and laboratories.

- **Voluntary organizations**

Details of organizers, telephone numbers, resources etc.

- **Chemical information**

Details of the hazardous substances stored or procedure on each site and a summary of the risk associated with them.

- **Meteorological information**

Arrangements for obtaining details of weather conditions prevailing at the time and whether forecasts.

- **Humanitarian arrangements**

Transport, evacuation centres, emergency feeding treatment of injured, first aid, ambulances and temporary mortuaries.

- **Public information**

Arrangements for (a) dealing with the media press office; (b) informing relatives, etc.

- **Assessment of emergency plan**

Arrangements for:

(a) Collecting information on the causes of the emergency;

(b) Reviewing the efficiency and effectiveness of all aspects of the emergency plan.

6.5.3 Role of the Emergency Co-ordinating Officer

The various emergency services should be co-ordinated by an emergency co-ordinating officer (ECO), who will be designated by the district collector. The ECO should liaison closely with the site main controller. Again depending on local arrangements, for very severe incidents with major or prolonged off-site consequences, the external control should be passed to a senior local authority administrator or even an administrator appointed by the central or state government. The ECO will be equipped with address and phone numbers of important agencies.

6.5.4 Role of the Local Authority

The duty to prepare the off-site plan lies with the local authorities. The emergency planning officer (EPO) appointed should carry out his duty in preparing for a whole range of different emergencies within the local authority area. The EPO should liaison with the works, to obtain the information to provide the basis for the plan. This liaison should ensure that the plan is continually kept up to date.

It will be the responsibility of the EPO to ensure that all those organizations which will be involved off site in handling the emergency, know of their role and are able to accept it by having for example, sufficient staff and appropriate equipment to cover their particular responsibilities. Rehearsals for off-site plans should be organized by the EPO.

6.5.5 Role of Police

Formal duties of the police during an emergency include protecting life and property and controlling traffic movements.

Their functions should include controlling bystanders evacuating the public, identifying the dead and dealing with casualties, and informing relatives of death or injury.

6.5.6 Role of Fire Authorities

The control of a fire should be normally the responsibility of the senior fire brigade officer who would take over the handling of the fire from the site incident controller on arrival at the site. The senior fire brigade officer should also have a similar responsibility for other events, such as explosions and toxic release. Fire authorities in the region should be apprised about the location of all stores of flammable materials, water and foam supply points, and fire-fighting equipment. They should be involved in on-site emergency rehearsals both as participants and, on occasion, as observers of exercises involving only site personnel.

6.5.7 Role of Health Authorities

Health authorities, including doctors, surgeons, hospitals, ambulances, and so on, should have a vital part to play following a major accident, and they should form an integral part of the emergency plan.

For major fires, injuries should be the result of the effects of thermal radiation to a varying degree, and the knowledge and experience to handle this in all but extreme cases may be generally available in most hospitals.

Major off-site incidents are likely to require medical equipment and facilities additional to those available locally, and a medical "mutual aid" scheme should exist to enable the assistance of neighbouring authorities to be obtained in the event of an emergency.

6.5.8 Role of Government Safety Authority

This will be the factory inspectorate available in the region. Inspectors are likely to satisfy themselves that the organization responsible for producing the off-site plan has made adequate arrangements for handling emergencies of all types including major emergencies. They may wish to see well-documented procedures and evidence of exercise undertaken to test the plan.

In the event of an accident, local arrangements regarding the role of the factory inspector will apply. These may vary from keeping a watching brief to a close involvement in advising on operations in case involvement in advising on operations. In cases where toxic gases may have been released, the factory inspectorate may be the only external agency with equipment and resources to carry out tests.

The action plan suggested for control of the off-site emergencies is given in **Table 6.11**.

Table 6.11: Offsite Action Plan

S. No.	Action required to be taken to mitigate disaster by aid giving agency	Responsible agencies for taking action	Equipments/material facilities required at site to mitigate emergency
A1	Arrangements for evacuation/rescue of persons from zone of influence to predetermined camps	Police Department	Self Breathing apparatus with spare cylinder Chemical gas mask with spare canister Vehicle with PA system Transportation for evacuation of people
2	Caution to public by announcement		
3	Traffic and Mob control by cordoning of the area		
4	Law & order		
5	Request to railway authority for keeping the nearer by railway gate open & to stop the up & down trains at the nearest railway station		
B1	Control of fire	District Fire Brigade	Self breathing apparatus with spare cylinders Foam/water fire tenders Gas mask with spare canisters Lime Neck to toe complete asbestos suit, PVC hand gloves, gumboots, safety goggles Mobile scrubbing system along with suction arrangement.
1	Scrubbing of the flashed of gas cloud with water curtain		
2	To rescue trapped persons		
3	Communication to UPSEB to continue or cut off electric supply		
4	Communication to water supply department for supplying water		
C1	Medical facilities for affected persons (first aid and treatment)	Hospital and public health	Ambulance with onboard resuscitation unit first aid, antidotes for toxicity, stretchers
D1	Identification of concentration	Pollution control	Gas detector

S. No.	Action required to be taken to mitigate disaster by aid giving agency	Responsible agencies for taking action	Equipments/material facilities required at site to mitigate emergency
	of gas in zone of influence	board	
2	Communication to PHED for decontamination of affected water		
E1	Removal of debris and damaged structures	Municipal corporation	Provide bulldozers Provide cranes
F1	Monitor the incoming and out going transports	Transport department	Provide traffic police at site Provide emergency shifting vehicles at site Provide stock of fuel for vehicles
02	Arrange emergency shifting of affected persons and non affected person to specified area		
03	Arrange diesel/petrol for needed vehicles		
G1	Give all information related to meteorology for safe handling of affected area for living beings	Meteorological Department	Provide wind direction and velocity instruments with temperature measure Mobile van for meteorological parameter measurements
02	Forecast if any important weather change		
H1	Representative of all department are in local crisis group therefore it is expected to tender services available with them since it is a group of experts and authority, the mitigating measures can be implemented in speed up way. The representative from locals are also there, so communication with local people is easy and fast		Must have all resources at hand, specially disaster management plan and is implementation method. All relevant information related to hazardous chemical industry are generally available with crisis group News paper editor is a part of the group so right and timely media released can be done
02	The district emergency or disaster control officer is the president and he is used to mock drill etc so action can be taken in right direction in time		
I1	Collector is the President of District Crisis Group therefore all district infrastructure facilities are diverted to affected zone	District Crisis group	All necessary facilities available at district can be made available at affected zone Control of law and order situation
02	All other functions as mentioned in local crisis group		