Chapter-7
Additional Studies

(A) Risk Assessment

7.1 INTRODUCTION

The risk assessment studies have been conducted for identification of hazards, to calculate the damage distances and to spell out risk mitigation measures.

M/s. Harmony Ply-Lam Ltd. is proposed to start manufacturing of various types of resins [(Phenol Formaldehyde Resin (400 MT/month), Melamine Formaldehyde Resin (150 MT/month) and Urea Formaldehyde Resin (200 MT/month)] at Survey No. 84/1 paiki 2 Plot No. 1, Village: Ardoi, Taluka: Kotda Sangani, Dist: Rajkot.

7.1.1 Scope of Study

The scope of work is to carry out risk analysis for the proposed project activities of plant covering all the risk to be handled and stored of hazardous chemicals at the plant.

7.1.2 Study Objective

The objective of the risk analysis includes the following:

- Identification of hazards
- Selection of credible scenarios
- Consequences analysis of selected accidents scenarios
- Risk mitigation measures

7.2 STUDY APPROACH

The risk assessment study broadly comprised of the following steps:

- System Description
- Identification of hazards
- Selection of Credible Accident Scenarios
- Consequence Analysis
- Risk Mitigation Measures

7.3 HAZARDOUS IDENTIFICATION

Hazard is defined as a chemical or physical conditions those have the potential for causing damage to people, property or the environment.

Hazard identification is the first step in the risk analysis and entails the process of collecting information on:

- The types and quantities of hazardous substances stored and handled,
- The location of storage tanks & other facilities,
- Potential hazards associated with the spillage and release of hazardous chemicals and fuel.

A preliminary hazard analysis is carried out initially to identify the major hazards associated with storages and the processes of the plant. This is followed by consequence analysis to quantify these hazards. Finally the vulnerable zones are plotted for which risk reducing measures are deduced and implemented. The major aspects are described below:

In a resin manufacturing, the main hazards are storage and handling of Formaldehyde solution and Phenol solution. The primary concern has always been fire and Toxic release prevention and control as these are the main hazard posed by such unit. This concern has grown through the loss of life, property and materials experienced after experienced after major disasters, which have occurred over the years.

7.3.1 Dow's fire and Explosion Index (F & EI)

Steps of fire and explosion index calculation are summarized below:

- Select Pertinent Process
- Determine Material Factor
- Calculate GHP(F1)-General Process Hazards
- Calculate SPH(F2)-Special process Hazards
- Determine Hazard Factor F3= F1 X F2
- Determine F & E Index = F3 X Material Factor

Degree of hazard due to fire and explosion is identified based on the FEI range as per the criteria given below.

FEI Range	Degree of Hazard
1 to 60	Light
61 to 96	Moderate
97 to 127	Intermediate
128 to 158	Heavy
159 to above	Severe

Degree of hazard due to toxicity is identified as per the criteria given below:

Toxicity Index	Degree of hazard
< 6	Light
6< T1 ≤10	Moderate
>10	Severe

7.3.2 Identification of High Hazardous Areas:

From the detailed study of the brief process description and activities involved in manufacturing process & safety features of the plant indicates:

- Small batch size reaction, exothermic reaction, manual Operational plant &
- Minimum inventory of chemicals at process area.

7.3.3 Effects of releases of Hazardous Substances

Hazardous substances may be released as a result of failures/ catastrophes, causing possible damage to the surrounding area. In the following discussion, an account is taken of various effects of release of hazardous substances and the parameters to be determined for quantification of such damages. In case of release of hazardous substances, the damages will depend largely on source strength. The strength of the source means the volume of the substance released. The release may be instantaneous or semi-continuous. In the case of instantaneous release, the strength of the source is given in kg and in semi-continuous release the strength of the source depends on the outflow time (kg/s). In order to fire the source strength, it is first necessary to determine the state of a substance in a vessel. The physical properties viz., Pressure and temperature of the substance determine the phase of release. This may be gas, gas condensed to liquid, and liquid in equilibrium with its vapour or solids. Instantaneous release will occur, for example, if a storage tank fails. Depending on the storage conditions the following situations may occur. The source strength is equal to the contents of the capacity of the storage system. In the event of the instantaneous release of a liquid a pool of liquid will form. The evaporation can be calculated on the basis of this pool.

7.3.4 Pool Fire

In the event of the instantaneous release of a liquid a pool of liquid will be formed. The evaporation can be calculated on the basis of this pool. The heat load on object outside a burning pool of liquid can be calculated with the heat radiation model. This model uses average radiation intensity, which is dependent on the liquid. Account is also taken of the diameter-to height ratio of the fire, which depends on the burning liquid. In addition, the heat load is also influenced by the following factors:

- Distance from the fire
- The relative humidity of the air (water vapour has a relatively high heat-absorbing capacity)

7.3.5 Jet Fire

Jet fires are pressurized releases of hydrocarbons that result in impinging flames with significant momentum. The potential for jet fire exists wherever storage, process equipment or pipe work contains flammable gas or liquid/gas (two-phase) mixtures at pressures approximately 2 bar or greater.

7.3.6 Fire Ball

This happens during the burning of hydrocarbons and develops cloud, the bulk of which is initially over rich (i.e. above the upper flammable limit.). The whole cloud appears to be on fire as combustion is taking place at eddy boundaries where air is entrained (i.e. a propagating diffusion flame). The buoyancy of the hot combustion products may lift the cloud form the ground, subsequently forming a mushroom shaped cloud. Combustion rates are high and the hazard is primarily thermal.

7.3.7 UVCE (Unconfined Vapour Cloud Explosion):

UVCE stands for unconfined vapor cloud explosion. When a flammable vapor is released, its mixture with air will form a flammable vapor cloud. If ignited, the flame speed may accelerate to high velocities and produce significant blast overpressure. The clouds of explosion mix with air (within flammability limit) which may cause propagating flames when ignited. In certain cases flame may take place within seconds. The thermal radiation intensity is severe depending on the total mass of Gas in cloud and may cause secondary fire. When the flame travels very fast, it explodes

causing high over pressure or blast effect, resulting in heavy damage at considerable distance from the release point. Such explosion is called UVCE (Unconfined Vapour Cloud Explosion) and is most common cause of such industrial accident.

7.3.8 Hazardous Substances to be handled at Harmony Ply-Lam Ltd.

Unit will be engaged in the manufacturing of different resins, which is used as a raw material for decorative laminated sheet. During operation phase, various hazardous chemicals will be handled. Important characteristics of these hazardous materials are described in details,

(1) Formaldehyde (37-40%)

General Information

Chemical Formula	**:** HCHO
Color	**:** Colorless
Flammability	**:** Flammable

Physical Property

Physical State and appearance	**:** Liquid
Odor	**:** Pungent
Molecular weight	**:** 30.02
pH	**:** 3
Boiling Point	**:** 98^{o}C
Melting Point	**:** -15^{o}C
Specific Gravity	**:** 1.08 (water=1)
Vapor Pressure	**:** 2.4 kPa (@ 20^{o}C)
Vapor Density	**:** 100% (w/w)
Ionicity (in water)	**:** Non-ionic
Solubility	**:** Easily soluble in cold water, hot water. Soluble in diethyl ether, acetone, alcohol.

Fire Hazards:

- Flammable in presence of open flames and sparks, of heat.
- Non-flammable in presence of shocks, of oxidizing materials, of reducing materials, of combustible materials, of Organic materials, of metals, of acids, of alkalis.

Explosion Hazards:

- Non explosive in presence of open flames and sparks, of shocks
- Reaction with peroxide, nitrogen dioxide, and performic acid can cause an explosion.

Potential Acute Health Effect:

- Very hazardous in case of eye contact (irritant) of ingestion, Hazardous in case of skin contact (irritant) of eye contact (corrosive).
- Slightly hazardous in case of skin contact (corrosive).
- Sever over exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching.

Toxicity:

- The substance may toxic to Kidneys, liver, skin, central nervous system.
- Repeated or prolonged exposure to the substance can produce target organ damage. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

(2) Methanol

Physical & Chemical Properties:

Physical State & Appearance	**:** Liquid
Odor	**:** Alcohol like
Color	**:** Colorless
Molecular Weight	**:** 32.04 g/mole
Boiling Point	**:** 64.5^0C
Melting Point	**:** -97.8^0C
Specific Gravity	**:** 0.7915
Vapor Pressure	**:** 12.3 kPa
Vapor Density	: 1.11
Volatility	**:** Not Available
Odor Threshold	**:** 100 ppm
Iconicity	**:** Non ionic
Solubility	**:** Easily soluble in cold & hot water

Fire & Explosion data:

Flammability of the product	**:** Flammable

Auto ignition Temperature **:** 464^0C

Flash Point **:** Closed Cup: 12^0C. Open Cup: 16^0C

Flammable Limit **:** Lower: 6% Upper: 36.5%

Special Remarks on Explosion Hazards: Forms an explosive mixture with air due to its low flash point, Explosive when mixed with Chloroform + Sodium Methoxide and diethyle zinc. It boils violently and explodes.

Handling & Storage: Store in a Segregated and approved area. Keep container in a cool, well- ventilated area.

First Aid Measures

Eye Contact: Check for and remove any contact lenses, immediately flush eyes with running water at least 15 minutes, keeping eyelids open. Cold water may be used. Get medical attention.

Skin Contact: In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact: Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation: Evacuate the victim to a safe area as soon as possible, Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Warning: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive.

Ingestion: If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Exposure Controls/Personal Protection:

Engineering Control: Provide exhaust ventilation or other engineering controls to keep the airborne concentration of vapor below their respective threshold limit value.

Personal Protection: Splash goggle, Lab coat, Vapor respirator, be sure to use an approved respirator or equivalent, gloves.

Personal Protection in case of large spill:

Splash goggle. Full suit, Vapor respirator, Boots, Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; Consult a specialist BEFORE handling this product.

Exposure limit: TWA: 200 from OSHA (PEL) [US] TWA: 200 STEL: 250 (ppm) from ACGIH (TLV) [US] [1999] STEL: 250 from NIOSH [US] TWA: 200 STEL: 250 (ppm) from NIOSH SKIN TWA: 200 STEL 250 (ppm) [Canada] consult authorities for acceptable exposure limits.

(3) Phenol

Physical & Chemical Properties:

Physical State & Appearance	**:** Liquid
Odor	**:** Distinct, aromatic
Color	**:** Colorless to light pink
Molecular Weight	**:** 32.04 g/mole
Boiling Point	**:** 182^0C
Melting Point	**:** 42^0C
Specific Gravity	**:** 1.057 (Water = 1)
Vapor Pressure	**:** Not applicable
Vapor Density	: 3.24
Volatility	**:** Not Available
Odor Threshold	**:** 0.048 ppm
Solubility	**:** Easily soluble in methanol
Solubility in water	**:** 1g/15 ml water.

Fire & Explosion data:

Flammability of the product	**:** May be combustible at high temperature
Auto ignition Temperature	**:** 715^0C

Flash Point **:** Closed Cup: 79^0C. Open Cup: 85^0C

Flammable Limit **:** Lower: 1.7% Upper: 8.6%

Special Remarks on Explosion Hazards: Phenol + nitrides results in heat and flammable gas generation. Phenol + mineral oxidizing acids results in fire. Phenol + calcium hypochlorite is an exothermic reaction producing toxic fumes which may ignite.

Handling & Storage:

Keep locked up. Keep container dry. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not ingest. Do not breathe dust. Never add water to this product. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents, acids.

First Aid Measures

Eye Contact: Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact: In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Serious Skin Contact: Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.

Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Serious Inhalation: Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous

to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion: Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Exposure Controls/Personal Protection:

Engineering Controls: Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Splash goggles. Synthetic apron. Vapor and dust respirator. Be sure to use an approved/certified respirator or equivalent.

Personal Protection in Case of a Large Spill: Splash goggles. Full suit. Vapor and dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: TWA: 5 (ppm) from ACGIH (TLV) [United States] SKIN TWA: 19 (mg/m^3) from ACGIH (TLV) [United States] SKIN TWA: 5 from NIOSH [United States] TWA: 19 (mg/m^3) from NIOSH [United States] TWA: 5 (ppm) from OSHA (PEL) [United States] TWA: 19 (mg/m3) from OSHA (PEL) [United States] TWA: 5 (ppm) [Canada] TWA: 19 (mg/m^3) [Canada] Consult local authorities for acceptable exposure limits.

7.3.9 Quantities of Hazardous Materials

As per Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 and amendment subsequently, there will be few hazardous chemicals, which have potential for creating risk to life and property in an unlikely event of leakage or spillage followed by fire. The hazardous chemicals are stored in the plant in tank with adequate dyke. Details of storage of hazardous materials are given below:

Table 7.1 Storage of Haz. Chemicals

Sr. No.	Name of Chemicals	Maximum storage Capacity	Type of Hazard
1	Formaldehyde (37 to 40%)	Tank 60 KL x 2	Corrosive & Toxic
2	Phenol (92-95%)	Tank 60 KL	Corrosive & Toxic
3	Methanol	Tank 60 KL	Fire

7.4 HAZARDS DUE TO LEAKAGE OR CONTAINMENT

Since the proposed project is for manufacturing of resin, various hazardous chemicals will be required to be handled. Hazardous chemical to be handled and stored at the plant will be in liquid form. In the event of leakage or accidental release of these chemicals, it will create only localized effects within the short distances from fixed or spread pool in case of fire. There will be a possibility of release of some hazardous chemicals may form vapour cloud which can move towards wind direction and may explode in the event of fire if mass and concentration of air and vapour mixture is within the LEL and UEL limits. However, mass of vapour and air mixture may not be adequate to generate explosive mass.

Storage and handling of hazardous chemical will not pose any hazardous situation if these are handled or stored correctly with adequate safety provisions and fire fighting facilities. Therefore, suitable safety measures including fire fighting facilities will be provided at the plant to attend any emergency due to accidental release of these hazardous chemicals.

Among the hazardous inventories, there are few potential toxic materials that can form toxic vapour cloud in unlikely event of release.

7.4.1 Damage Criteria

Damage estimates due to thermal radiation has been arrived at by correlating recorded incidents. The consequences can then be visualized by super imposing the effects on the proposed site plan and identifying the elements within the project site as well as the neighbouring environment which may be affected. The damage criteria due to accidental release of hydrocarbon arise primarily from fire. Contamination of soil or water is not expected as fuel will vaporise quickly and would not

leave any residue as it happens with oil. The vapour of methanol/ formaldehyde is not toxic and hence no effects of toxicity are expected.

7.5 MAXIMUM CREDIBLE ACCIDENT SCENARIOS

The plant will be dealing with some hazardous substances i.e. formaldehyde, methanol described in details. This is in the form of liquid and considered as odorous. Subsequently, their consequence due to thermal radiation will be confined within short distances. If released quantities are not ignited, therefore, vapour formation can result in vapour and air mixture and may generate explosive mass which can explode if it gets the source of ignition. Toxic cloud of hazardous chemicals may also be formed and moved towards wind direction.

7.5.1 Methodology for selection of accident scenarios

Following steps are followed for scenario selection for risk analysis study:

- The hazardous materials to be handled at the plant and the associated hazards have been identified and assessed.
- Operating and storage conditions of handling and storage of hazardous materials are studied.
- An assessment is made of what inventories can get released accidentally.
- Release rates are calculated considering different cases. For further analysis of selected release sources, representative failure modes and failure sizes are identified.

Maximum Credible Accident Scenarios

Following maximum credible scenarios have been selected for consequence analysis as a result of accidental releases:

Sr. No.	Type of Release	Outcome Cases Considered
1.	Release of Solvent	Formation of pool and thermal radiation due to fire
		Vapour cloud explosion
		Dispersion of toxic cloud of vapours

7.6 METHODOLOGY, APPROACH AND DAMAGE CRITERIA FOR RISK ASSESSMENT

Consequence analysis is that part of risk analysis, which considers individual failure cases and the damage. It is done to predict the outcome

of potentially serious hazardous accidents to man and material in and around the plant boundary limits. The advantages of carrying out consequence analysis are given below:

- To improve plant layout
- To meet statutory requirements
- Protection of public in the nearby areas (no residential nearby)
- Disaster management planning
- Training tool
- The findings of a consequence analysis provide information about hazardous effects resulting from an accident scenario

7.6.1 Hazards Evaluation: Exposure due to Vapors

Leakage in process plant from failure of nozzles, joints (flange joint), welding failures or dripping from non-holding valves/glands at times goes unnoticed. If the leaky dust or fluids being toxic and odorless it is a potential source of risk, which may cause fatal/serious hazards. Liquids with high saturation vapor pressures evaporate faster because the evaporation rate (mass/time) is essentially proportional to the saturation vapor pressure. In the case of vaporization into stagnant air, the vaporization rate is proportional to the difference between the saturation vapor pressure and the partial pressure in the stagnant air.

7.6.2 Liquid Pool Evaporation or Boiling

The pool boiling cases may be encountered during heavy leakage in enclosed area and with heat source nearby (ambient or fire) the vapor can explode or catch fire (in case the material is flammable and sparks/ flame contact is made).

7.6.3 Plant Leakage in Confined Space

A fuel spill is a common type of process incident and can lead to potentially serious accident. If the spilled material gives rise to aerosol these may interact with plant environment resulting in explosion or harm to plant's personnel/damage to plant equipment/machinery (if vapors are inflammable). The plant will be in open with natural ventilation.

7.7 PROBABLE HAZARDS & CONSEQUENCE ANALYSIS

The facilities at the Material Storage Dyke area terminal mainly comprise of Phenol, Methanol and formaldehyde storage tanks. The hazards posed

by them are mainly in the form of fire. There is a possibility of flash fire taking place in the event of large spill of hydrocarbons, mainly major failure scenarios were evaluated to assess the effect on people and property inside the plant area as well as outside.

The effect of fire on people and property outside will chiefly manifest itself in the form of thermal radiation. A criteria was selected for deciding the maximum level of thermal radiation to which the outside population can be subjected. Thermal radiation levels from fire scenarios of each tank are worked out at various distances and their effects are evaluated against the set criteria. In consequence calculation, use is made of a number of calculation models to estimate the physical effects of an accident (spill of hazardous material) and to predict the damage (lethality, injury, material destruction, other property damage).

The risk assessment modelling can be roughly divided into three groups:

- Determination of source strength parameters;
- Determination of consequential effects;
- Determination of damage or damage distances (with specific severity rates)

7.7.1 Thermal Radiation

Thermal radiation due to pool fire may cause various degrees of burns on exposed human bodies. Moreover their effects on inanimate objects like piping, equipment or vegetation also need to be evaluated to assess their impact. For continuous presence of persons, the following thermal radiation intensity levels are usually adopted:

- 1.6 Kw/m^2 for outside population.
- 4.5 Kw/m^2 for plant operators.

This is the criteria that are followed in case of flare design where peak load condition may occur for a short time but mostly without warning. The operators are usually trained and properly clothed; they are expected to run for shelter quickly. For secondary fire, an incident radiation intensity of 12.5 Kw/m^2 is required. This is usually taken as the minimum criteria. The facilities at the storage area mainly comprises of vertical cylindrical tanks of structural steel (IS-2062 Grade-A). The hazard posed

by them is mainly in the form of fire. There is a possibility of tank fire taking place and is evaluated to assess the effect on people and property.

7.7.2 Thermal Damage

The following table presents the damage and effects due to thermal radiation on inanimate objects like piping, equipment or vegetation in addition to effects on human beings.

Incident radiation (in kW/m^2)	Type of damage
62.0	Spontaneous ignition of wood
37.5	Sufficient to cause damage to process equipment.
32.0	Maximum thermal radiation intensity allowed on thermally protected adjoining equipment
25.0	Minimum energy required to ignite wood at infinitely long exposure (non-piloted)
12.5	Minimum energy required for piloted ignition of wood, melting of plastic
8.0	Maximum thermal radiation intensity allowed on thermally unprotected adjoining equipment
4.5	Sufficient to cause pain to personnel if unable to reach cover within 50 seconds, however blistering of skin (1st degree burns)
1.6	Causes no discomfort on long exposures
0.7	Equivalent to solar radiation

7.7.3 Radiation Exposure and Lethality

The effect of incident radiation and exposure time on lethality is stated in the following table:

Incident Radiation (Kw/m^2)	Exposure time (seconds)	Lethality (%)	Degree of burns
4.5	20	0	1st
4.5	50	0	1st
8.0	20	0	1st
8.0	50	<1	3rd
8.0	60	<1	3rd
12.0	20	<1	2nd
12.0	50	8	3rd

7.7.4 Modes of Failure:

Storage systems can fail in different ways depending on the materials stored, storage conditions & it may also involve other systems in their vicinity. Conditions such as overfilling, over pressure & missile, lightening

or bomb attack, earthquake resultant release scenarios have been identified. Outcomes of such incidents are determined by presence of ignition either immediate or delayed. As can be seen different scenarios are possible like continuous release and Instantaneous release.

This may be of gas/liquid depending upon type of material stored/ released & its characteristics. More examples, a liquid boiling at ambient conditions, will immediately be converted to gas upon exposure to atmosphere & will behave accordingly. An instantaneous release is any release occurring for a period less than 15 seconds. Failure mode responsible for instantaneous releases may be catastrophic failure of tank. For an instantaneous gas release important parameters are release height & quantity released whereas for instantaneous liquid release, important parameters are amount spilled, spill area & pool temperature, evaporation rate, vapour mass etc.

Continuous release occurs when the material is released over a period greater than 15 seconds. For a continuous release, important parameters include height of leak above ground, emission rate & total time of release. For a continuous liquid release important parameters are spill rate, duration, area & pool temperature, evaporation rate and vapour mass or Gas mass.

7.7.5 Consequence analysis

Consequence analysis has been carried for the selected accident scenarios to estimate the vulnerable zones. When the vulnerable zones are identified for failure cases, mitigation measures can be taken for risk mitigation and to eliminate/avoid damage to the plant and injury to personal. In the risk analysis study, probable damages due to worst case scenarios were quantified and consequences were analyzed with object of emergency planning. Various measures taken by the company and findings of the study were considered for deciding acceptability of risks. Based on above, we have considered following scenarios considered.

Sr. No.	Type of Failure	Consequence
1	Catastrophic failure of Phenol Tank	Pool Fire
2	Catastrophic failure of Methanol Tank	Pool Fire

3	Formalin (considered as 100% Formaldehyde) Pool evaporation due to pool	Toxic release due to pool evaporation and toxic effect up to TLV, IDLH & LC50 distances.

Note: Due to the limitation of the model, the scenarios for Formalin (37-40%) were run for 100% Formaldehyde.

Pool fire for Phenol tank catastrophic failure

Input data	
Spillage Quantity	60 KL
Pool Dia	10 (m)
Pool liquid depth	1 (m)
Wind speed	2.5 m/s
Liquid Density	1072 kg/m^3

Radiation Intensity (kw/m^2)	**Distance of Occurrence (meters)**	**Effect**
Tank Capacity (KL)	**60**	
37.5	7.1	Damage to process equipment. 100% Fatal in 1 Min. 1% fatal in 10 sec.
32.0	8.7	Min. to ignite wood (without flame contact). 100% fatal in 1 Min. Significant injury in 10 sec.
12.5	12.1	Min. to ignite wood (with flame contact). 1% fatal in 1 min. 1st deg. burn in 10 sec
8.0	18.3	Pain after 10 secs. Blistering unlikely.
4.5	22.9	Pain after 20 secs. Blistering unlikely.
1.6	36.2	Pain after 20 secs. Blistering unlikely.

Pool fire for Methanol tank catastrophic failure

Input data	
Spillage Quantity	60 KL
Pool Dia.	12 (m)
Pool liquid depth	1.8 (m)
Wind speed	2.5 m/s
Liquid Density	786.5 kg/m^3

Radiation Intensity (kw/m^2)	**Distance of Occurrence (meters)**	**Effect**
Tank Capacity (KL)	**60**	
37.5	2.07	Damage to process equipment.

		100% Fatal in 1 Min. 1% fatal in 10 sec.
32.0	2.23	Min. to ignite wood (without flame contact). 100% fatal in 1 Min. Significant injury in 10 sec.
12.5	3.55	Min. to ignite wood (with flame contact). 1% fatal in 1 min. 1st deg. burn in 10 sec
8.0	4.44	Pain after 10 secs. Blistering unlikely.
4.5	5.94	Pain after 20 secs. Blistering unlikely.
1.6	9.95	Pain after 20 secs. Blistering unlikely.

Pool fire for Formaldehyde tank catastrophic failure

Input data	
Spillage Quantity	60 KL
Pool Dia	12.5 (m)
Pool liquid depth	1.4 (m)
Wind speed	2.5 m/s
Liquid Density	812 kg/m^3

Radiation Intensity (kw/m^2)	**Distance of Occurrence (meters)**	**Effect**
Tank Capacity (KL)	**60**	
37.5	5.28	Damage to process equipment. 100% Fatal in 1 Min. 1% fatal in 10 sec.
32.0	5.71	Min. to ignite wood (without flame contact). 100% fatal in 1 Min. Significant injury in 10 sec.
12.5	9.14	Min. to ignite wood (with flame contact). 1% fatal in 1 min. 1 st deg. burn in 10 sec
8.0	11.42	Pain after 10 secs. Blistering unlikely.
4.5	15.21	Pain after 20 secs. Blistering unlikely.
1.6	25.52	Pain after 20 secs. Blistering unlikely.

7.7.6 Conclusion

1. The following arrangements are available for the storage tanks:
   - Independent high level alarm and trip off liquid inlet-line.
   - Low level alarm.

- Provision of auto deluge water sprinkler system for each bulk storage tank. The auto deluge water sprinkler would be set to start working at a temperature of 66^0C.

2. The switchyard, transformer yard, administrative building, pantry, first aid center etc. should be located safely, if viewed in the light of worst accident scenarios.
3. In case of any tank on fire or fire in the vicinity, the cooling of adjoining tank should be resorted promptly in addition to tank on fire so that the tank shell of neighboring tanks does not give away.
4. The night vision wind sock is mounted on top of administrative building and the Dyke area with adequate illumination so that people can move in upwind directions in the event of massive spillage.
5. No machinery of vital importance like fire fighting pump house, Hydrant and Fuel oil pump house should be placed within radiation contours of 32.0 kw/m^2 heat intensity. Strict adherence to standards and accepted maintenance and operation of the plant plays a vital role in maintaining the plant. The monitoring of the health of equipment, pipeline and machines, thickness survey will improve plant performance and safety.

7.8 RISK REDUCTION MEASURES

For risk mitigation/reduction, attempts should be made either to reduce inventories that could get released in the event of loss of containment or failure likelihoods or both as feasible. Risk analysis identifies the major risk contributors, which enables prioritization of the plant that deserve special attention in terms of inspection and maintenance in particular and over all safety management as a whole. For the risk reduction at the plant, the following salient suggestions and recommendations are made:

- On site and off site emergency response plan should be prepared and circulated to concern persons.
- Personnel at the proposed plant and public in surrounding area should be made aware about the hazardous substance stored at the plant and risk associated with them.
- A written process safety information document should be compiled for general use.

- The document compilation should include an assessment of the hazards presented including (i) toxicity information (ii) permissible exposure limits. (iii) Physical data (iv) thermal and chemical stability data (v) reactivity data (vi) corrosivity data (vii) information on process and mechanical design.
- The process design information in the process safety information compilation must include P&IDs/ PFDs; process chemistry; maximum intended inventory; acceptable upper and lower limits, pressures, flows and compositions and process design and energy balances.
- The adequate numbers of heat and smoke detectors should be provided at strategic locations in the plant and indication of detectors/ sensors should be provided in main control room.
- Predictive and preventive maintenance schedule should be prepared for equipment, piping, etc. and thickness survey should be done periodically as per standard practices.
- A written procedure (Management of Change) must be developed to manage changes to process chemicals, technology, equipment and procedures that affect a covered process.
- Safe work practices should be developed to provide for the control of hazards during operation and maintenance such as: (i) lockout/tag out (ii) Confined space entry (iii) Opening process equipment or piping (iv) Control over entrance into a facility by maintenance, contractor, laboratory, or other support personnel.
- Personnel engaged in handling of hazardous chemicals should be trained to respond in an unlikely event of emergencies.
- The plant should check and ensure that all instruments provided in the plant are in good condition and documented.
- Safety measures in the form of "Do" and "Don't do" should be displayed at strategic locations especially in local language and English.
- Regular mock drills should be carried out once in every 3 months and shortcomings should be recorded and rectified.

7.8.1 Personnel Protective Equipment (PPEs)

- The required PPEs for each area/operation should be identified and the necessary PPEs, like, helmets, goggles, hand gloves, mask, safety belts, ear muff and plug, etc. should be made available to the personnel.
- The workers should be trained in proper use of PPEs.
- The system should exist for replacement/issue of PPEs by testing and as per requirement.
- Lockers should be provided to the workers for safe custody and storage of PPEs.

7.8.2 Handling of hazards

- PPEs should be replaced after certain time.
- Any spillage of hazardous chemicals should be cleaned and disposed off as per standard practice.
- Empty drums of hazardous chemicals should be neutralized immediately.
- Personnel engaged in handling of hazardous chemicals should be made aware of properties of hazardous chemicals.

7.9 GENERAL WORKING CONDITIONS

(a) House Keeping

- All the passages, floors and stairways should be maintained in good condition. The system should be available to deal with any spillage of dry or liquid chemical at the plant.
- Sufficient disposable bins should be clearly marked and these should be suitably located in the plant.
- Walkways should be clearly marked and free from obstructions & maintained neat and clean.
- In the plant, precaution and instructions should be displayed at strategic locations.

(b) Ventilation

- Adequate ventilation should be provided in the work floor environment.
- The work environment should be assessed and monitored regularly.

- Local ventilation is most effective method for controlling dust and gaseous emissions at work floor.

7.9.1 Safe Operating Procedures

- Safe operating procedures should be available for mostly all operations and equipment.
- The workers should be informed of the consequences of failure to observe the safe operating procedures.

7.9.2 Work permit system

- Work permit system should be followed at the plant. Hazardous work permit should be used for hot work, electrical works, etc.

7.9.3 Emergency Preparedness

- On-site emergency plan should be prepared and readily available for an unlikely event of emergency.
- Emergency telephone numbers should be available and display properly strategic locations.

7.9.4 Static Electricity

- All equipment and storage tanks/containers of flammable chemicals should be bounded and earthed.
- Electrical resistance for earthing circuits should be maintained. Periodic inspections should be done for earth pit and record should be maintained.

7.9.5 Access

- Adequate safe access should be provided to all places where workers need to work and all such access should be in good condition.

7.9.6 Material Handling

- Material handling areas should be clearly defined.
- The workers should be made aware about the hazards associated with manual material handling.

7.9.7 Communication System

- Adequate communication facilities should be available at the plant and supported with uninterrupted power supply.
- Communication facilities should be checked periodically for its proper functioning.

7.9.8 First Aid facilities

- First aid box should be provided at strategic locations within the plant.
- List of important telephone numbers should be displayed in first aid room.

7.9.9 Accident Reporting, Investigation and Analysis

A system should be initiated for accident and near miss reporting, investigation and analysis. To motivate and awareness among the personnel at the plant about safety, total accident (lost time injury) free days can be displayed on the board prominently at strategic location.

7.9.10 Safety Inspections

The system should be initiated for checklist based routine safety inspection and internal audit of the plant periodically. Safety inspection team should be formed from various disciplines and departments.

7.9.11 Safe Operating Procedures

Safe operating procedures should be formulated and updated, specific to process & equipment and distributed to concerned plant personnel.

7.9.12 Transportation of hazardous materials

Spills of hazardous materials, including oil, are the result of a combination of actions and circumstances, all of which contribute in varying degrees to the outcome. Most spills from tankers result from routine operations such as loading, discharging; however, the majority of these spills are small. Accidental causes such as groundings and collisions generally give rise to much larger spills.

Guidelines Principle

- Ensure that their operations, where applicable, are in compliance with:
- Recommendations on the Transport of Dangerous Goods;
- Implement guidance for the prevention and consequence minimization of catastrophic releases of hazardous materials, which may result in toxic, fire, explosion, or other hazards during transportation.
- Prepare a Hazardous Material Transportation Plan for transport hazardous materials;

- Information on the hazards and control measures at the time of emergency is vital for minimizing the effect of such accidents hence it shall be available with transporter.

Following information keeps ready with driver;

- Hazardous information systems
- U.N. Classification for hazard and substance identification
- HAZCHEM
- Responsibilities of consignor
- Responsibilities of the transporter or owner of goods carriage;
- Details with driver for report to police station about accident;
- Correct extinguishing techniques for different type of fires
- Knowledge about initial isolation and proactive action distance.

7.9.13 Safe Handling Procedure for Key hazardous materials

(a) Precautions for Loading, Unloading, Transport and Storage of Methanol

Methanol requires to two specific attentions in order to avoid accidental release and ignition of methanol. Hazards associated with loading, unloading, transportation and tank storage of methanol is essentially the same regardless of intended use. The severity of the hazards varies depending on circumstances and ambient conditions. Accidental release of methanol from a gravity transfer system results in liquid pooling and substantially less vapor generation. Combustion and corrosion hazards are always present to a greater or lesser extent when handling methanol.

Best Practice

In order to prevent fire, practices for loading, unloading, transporting and storing methanol should consider taking the following precautions:

- Avoid accumulation and subsequent discharge of static electricity within low methanol concentration blends which may result from turbulence:
- Control flow rate in and out of containers to minimize turbulence and avoid accumulation of static electricity within the flowing liquid;
- Discharge through a liquid seal dip leg pipe rather by free-falling through air to prevent air entrainment, absorption of moisture, and accumulation of static electricity in the falling liquid;, Bond and ground tanks, vessels, containers, and associated piping.

- Isolate liquid and vapors from recognizable ignition sources (electrically-caused sparking, electrically-generated hot spots, welding, brazing, grinding, oxy-acetylene cutting, air-arc gouging, internal combustion engines, space heaters, etc.) to a radial distance of 50 feet.
- Prevent contact with air (oxygen) and consider using a combination of gravity and pressure transfer using nitrogen rather than pump transfer.
- Cordon the area surrounding transfer to a radial distance of 50 feet and use caution tape and signage indicating presence of a flammable hazard.
- Use appropriate Personal Protection Equipments (PPEs).

(b) Treatment of workers affected by accidental spillage of methanol/phenol

Methanol:

Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid immediately.

Skin: Immediately flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists. Wash clothing before reuse.

Ingestion: If victim is conscious and alert, give 2-4 cupfuls of milk or water. Never give anything by mouth to an unconscious person. Get medical aid immediately. Induce vomiting by giving one teaspoon of Syrup of Ipecac.

Inhalation: Get medical aid immediately. Remove from exposure to fresh air immediately. If breathing is difficult, give oxygen. Do NOT use mouth-to-mouth resuscitation. If breathing has ceased, apply artificial respiration using oxygen and a suitable mechanical device such as a bag and a mask.

Phenol:

Eye Contact: Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact: In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be

used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately. Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream.

Inhalation: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately. Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

7.10 ONSITE AND OFFSITE EMERGENCY PLAN DURING CHEMICAL DISASTER

On-site Emergency: If an accident/incident takes place in a factory, its effects is confined to the factory premises, involving only the persons working in the factory and the property inside the factory it is called as On-site Emergency.

Off-site Emergency: If the accident is such that its affects inside the factory are uncontrollable and it may spread outside the factory premises, it is called as Off-site Emergency.

The main objectives of an emergency plan are-

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

Each factory or industrial unit should prepare an emergency plan incorporating details of action to be taken in case of any major accident/disaster occurring inside the factory. The plan should cover all types of major accident/occurrences and identify the risk involved in the plant. Mock drills on the plant should be carried out periodically to make the plan full proof and persons are made fully prepared to fight against any incident in the plant.

7.10.1 Onsite Emergency Plan

Disaster/Emergency Management Plan is essential for a chemical plant as the processes adopted for manufacturing are classified under Factory Act as Hazardous due to handling and storage of toxic, flammable and explosive hazardous materials. Over the years, the chemical process plant has created adequate infrastructure and adopted risk mitigation measures to tackle any emergency that may arise during the manufacturing process. The important aspect in emergency planning is to control an emergency by technical and organizational means, minimize accidents and consequent losses. Emergency planning also brings to light deficiencies, such as, lack of resources necessary for effective emergency response. It also demonstrates the organization's commitment to safety of employees and physical property as well as increases the awareness among management and employees. Disaster Management Plan for the plant is necessarily a combination of various actions which are to be taken in a very short time but in a pre-set sequence to deal effectively and efficiently with any disaster, emergency or major accident with an aim to keep the loss of men, material, plant/machinery etc. to the minimum.

A major emergency in a pesticide plant is one, which has the potential to cause serious injury or loss of life. It may cause extensive damage to property and serious disruption of both inside and outside the plant. Sometimes, it would require the assistance of outside emergency services to handle it effectively. Although the emergency at the plant may be caused by a number of different factors, e.g. leakage of toxic and flammable materials from piping/tanks, total/partial power failure, earthquake or sabotage, it will normally manifest itself in fire/toxic release. Primarily, DMP is prepared to furnish details which may require at the time of the emergency, to delegate responsibility, to estimate the consequences in advance and to prepare ourselves to control any type of emergency. The plan explains basic requirements as follows:

- Definition,
- Objectives,
- Organization set up,
- Communication System,

- Action on site,
- Link with Off-site Emergency Plan,
- Training rehearsal and record aspect.

7.10.2 Definitions

Various definitions on different analogy used on On-site & Off-site Emergency Plan are as follows:

Accident: An accident may be defined as "an undesirable and unplanned event with or without or major damage consequence of life and /or property.

Major Accident: It is a sudden, unexpected, unplanned event resulting from uncontrolled developments during an industrial activity, which causes or has the potential to cause, death or hospitalization to a number of people, damage to environment, evacuation of local population or any combination of above effects.

Emergency: This can be defined as any situation, which presents a threat to safety of person's or/and property. It may require outside help also.

Major Emergency: Occurring at a work is one that may affect several departments within and/or may cause serious injuries, loss of life, extensive damage to properly or serious disruption outside the works. It will require the use of outside resources to handle it effectively.

Disaster: Disaster is a sudden calamitous event, bringing great damage, loss or destruction.

Hazards: Hazard may be defined as "the potential of an accident". Hazard exists in man and the system of materials and machines.

Chemical Hazards: It is a hazard due to chemical(s) (including its storage, process, handling, etc.) and it is realized by fire, explosion, toxicity, corrosively, radiation, etc.

Risk: Risk may be defined as the combination of consequence and probability or likelihood of an accident being caused in a given man-material – machine system.

On-Site Emergency plan: It deals with measures to prevent and control emergencies within the factory and not affecting outside public or environment.

Off-Site Emergency plan: It deals with measures to prevent and control emergencies affecting public and the environment outside the premises.

7.10.3 Objective of Onsite emergency plan

The primary purpose of this Onsite emergency Management Plan is to equip the Plant with required resources and information for prompt implementation of the set of actions to be undertaken in the event of an accident posing hazards to the people and community after commissioning of the plant.

The objective of Onsite emergency Management Plan for the plant is to be in a state of perceptual readiness through training, development and mock drills, to immediately control and arrest any emergency situation so as to avert a full fledge disaster and the consequence of human and property damage and in the event of a disaster still occurring, to manage the same to that the risk of the damage consequences to life and property are minimized and thereafter, proper rehabilitation, review and revisions of the DMP to overcome the shortcomings noticed are undertaken.

The DMP document is prepared keeping in view and to conform the requirements of the provisions of The Factories Act 1948 under section 41 B (4), Guidelines issued by the Ministry of Environment and Forests, Govt. of India and Manufacture, Import and Storage of Hazardous Chemicals Rules, 1989 amended in 2000, Schedule 11 under Environmental Protection Act 1986.

Following are the main objectives of the plan to:

- Defined and assess emergencies, including hazards and risk
- Control and contain incidents.
- Safeguard employees and people in vicinity.
- Minimize damage to property and/or the environment.
- Minimization of risk and impact of event accident.
- Preparation of action plan to handle disasters and to contain damage.
- Inform employees, the general public and the authority about the hazards/risk assessed and to provide safeguard, and the role to be played by them in the event of emergency.
- Be ready for 'mutual aid' if need arises to help neighbouring unit.
- Inform authorities and mutual aid centres to come for help.
- Effect rescue and treatment of casualties.

- Effective rehabilitation of the affected persons and prevention of damage to the property.
- Identify and list any fatalities.
- Secure the safe rehabilitation of affected areas and to restore normalcy.
- Provide authoritative information to the news media.

7.11 EMERGENCY ORGANIZATION

7.11.1 Incident Controller

Incident Controller's role is to control the emergency at the incident site.

7.11.2 Duties of Incident Controller

Incident Controller will proceed to the place of emergency after hearing siren/announcement. He will:

Assess the scale of emergency and decide if a major emergency exists or is likely, accordingly activate emergency procedure.

Immediately give his feedback to Emergency Control Centre (ECC) regarding emergency.

Direct all operations within the area with following priorities.

- Secure the safety of personnel
- Minimize damage to plant property and environment.
- Minimize loss of material.

Direct rescue and fire fighting operations till the arrival of the outside Fire Brigade; he will relinquish control to Sr. Officer of Fire Brigade.

Ensure that the affected area is searched for causalities.

Ensure that all non-essential workers in the affected area evacuate to the appropriate assembly point.

Set up communication point to establish Radio/Telephone/Messenger contact as with emergency control centre. Pending arrival of works site controller, assume the duties of the post in particular to:

- Direct the shutting down and evacuation of plant and areas likely to be threatened by emergency.
- Ensure that the outside emergency services have been called in.

Ensure that the key personnel have been called in.

Report all significant development to the Site Main Controller.

Provide advice and information, as required to the Senior Officer of the Fire Brigade. Preserve evidence that would facilitate any subsequent inquiry into the cause and circumstances of emergency.

Dy. Incident Controller will carry out above said duties in absence of Incident Controller.

7.11.3 Site Main Controller

Site Main Controller will be overall in-charge of emergency organization:

7.11.4 Duties of site main Controller:

Relieve the Incident Controller of responsibility of overall main control.

Co-ordinate ECC or if required, security for raising evacuation siren and also all clear siren, in case emergency is over.

Declaration of major emergency ensures that outside emergency services will be called and when required nearby firms will be informed.

- Ensure that key personnel will be called in.
- Exercise direct operational control on parts of the works outside the affected area.
- Direct shutting down and evacuation of plants in consultation with key personnel.
- Ensure causalities are receiving adequate attention; arrange for additional help if required. Ensure relatives are advised.
- Liaison with Chief Officers of the Fire and Police services for providing assistance in tackling the emergency.
- Ensure the accounting of personnel.
- Control traffic movement within the work.
- Arrange for a chronological record of the emergency to be maintained.
- Contact the local office to receive early notification of impending changes in weather conditions, in case of prolonged emergency.
- Issue authorized statements to the news media and informs H.O.
- Control rehabilitation of affected areas after control of the emergency.

7.11.5 Other key Personnel

The key personnel required for taking decision about further action for shutting down the plant, evacuate the personnel, and carry out

emergency engineering works in consultation with Site Main Controller in light of the information received.

HOD's /Senior Managers/ Section Heads will be responsible for safety, security, fire, gas and pollution control, spillage control, communication system including telephone, wireless etc. Also medical services, transport, engineering, production, technical services, will form part of advising team.

7.11.6 Emergency response Team

The role of Emergency Response Team members is to actually combat the emergency at the site and control the emergency situation and carry out rescue operations. All team members will be thoroughly trained to deal with fires, explosions, chemical spills and atmospheric releases, first aid. As per priority list during emergency, the activities will be carried out as per emergency control plan.

7.11.7 Emergency personnel's responsibilities outside normal working hours of the factory

The duties of Shift In-charge & **team members** have been brought out in emergency control plan. **All team members** after evacuating the area shall report to ECC/ Incident Place. The non-essential workers shall be evacuated from the plants if need arises and this will be determined with the forcible rate with which incident may escalate. Non-essential workers shall assemble at the earmarked/specified point of assembly.

7.11.8 Assembly points

At the proposed plan, at least 2 assembly points will be identified and marked properly.

7.11.9 Emergency Control Centre

It will be headed by Site Main Controller, HOD – PD, HOD- P&A and it is sited in **Office of Site Main Controller in Admin Building & New security office** (after office hours), which is readily accessible & with minimum risk, equipped with telephone facilities and other announcements extra communications facilities needed. It has enough means to receive and transmit information and directions from site main controller to incident controller and other areas. In emergency control center due to its safer location and advantage of easier accessibility, all

necessary personnel protective equipment's firefighting extinguishers will be stocked in sufficient quantity.

7.11.10 Role of emergency control centre

In case of mishap or accident like fire, toxic gas leakage, explosion in the factory, The Emergency Control Center will be Office of Head- Operations. The plot plan indicating all the activities in the factory premises including that of storage's utility services, production area, administration, will be kept for ready reference, showing the location of fire hydrant and firefighting aids. Normal roll of employees, work permits, gate entries and documents for head count, employees blood group, other information and addresses will be available and the person, who will handle this operation will HOD P & A. Stationery required is available in the Control Centre (ECC) and HOD (P & A) looks after it.

The requirement of personnel protective equipment and other material, like torches, have been worked out and the quantity required during emergency will be kept in the Control Room (ECC). The responsible person for maintaining the said requirement/inventory will be HOD- HSE.

7.11.11 Fire & toxicity control arrangements

The plant will be well equipped with suitable numbers of firefighting and personnel protective equipment. The staff will be trained regularly to handle the various emergency situations.

7.11.12 Medical arrangements

Availability of first aid facilities in sufficient quantity will be always ensured. In case of emergency arrangements will be made to avail outside medical help immediately. Emergency transport facility will be available.

7.11.13 Transport & evacuation, mutual aid arrangements:

Transport & Evacuation and Mutual Aid arrangements will be available in the factory.

7.12 COMMUNICATION SYSTEM

7.12.1 Declaring the Emergency

In case of any emergency in the plant, speedy and effective communication of the same to all concerned in least possible time is the most important aspect of any emergency-handling plan. An early

communication increases the chances of control of emergency in the bud stage. Blowing siren will be adopted as method of communication of emergency, to all employees in the plant.

7.12.2 Types of sirens

Three different types of sirens have been identified for communication of emergency.

Alert Siren: Single Continuous Siren for One Minute. This indicates that there is some accidental happening in the plant. All have to become alert. Incident controller will be rush to the site of emergency. Plant area people have to start safe shut down. Rescue team and other emergency control teams have to reach at the site of emergency.

Siren for evacuation: Wailing & waning siren for three minutes. This siren indicates that emergency is of serious proportion and everybody has to leave his work place. All people having their role in emergency control have to assume their assigned role. All non-essential workers have to proceed immediately to assembly area and wait for further instruction.

All clear siren: Long continuous siren for two minutes. This is a sign of return of normalcy. On hearing this siren everybody should go back to his or her respective workplace.

7.12.3 Location of siren

Siren will be located in center of the pant for wide coverage of the whole campus. Switch for siren will be provided at security gate. The switch at security gate should be operated only as a general rule.

Emergency manual call bell will be installed which will be used in case of total failure of electricity. It is responsibility of HOD (HSE) to maintain the upkeep of electric call bell and HOD- security and administration to maintain manual and hand operated siren.

7.12.4 Raising alarm

Any person noticing any emergency situation in the plant should immediately call security gate with following information:

- Identify oneself
- State briefly the type of emergency i.e. whether fire, explosion, toxic gas release etc.

- Give the location of the incident
- Estimated severity of the incident.

Security personnel after ensuring genuineness of the call shall raise the alert siren. At the same time he will also contact the incident controller and ECC in order and inform about the incident. He will keep the gate open and rush his two security personnel at the site of emergency. ECC will be located at the office of head- operations on normal working hours and at security gate after normal working hours (during night). ECC shall be immediately manned on hearing alert siren. if the authorized people to handle ECC are not available, any senior most people out of the available person nearby shall occupy ECC till authorized person comes. Incident controller, on hearing alert siren or by any other way of information of the emergency, will immediately reach at the site of incident and assess the situation. He will immediately give his feed back to ECC. ECC shall direct security gate to raise evacuation siren, if the need arise. Siren for evacuation shall be raised on instruction from site main controller or any manager of the plant in the ECC. Security gate person will be authorized to raise all clear Siren on instruction from site main controller or ECC, after the emergency is over. Incident controller shall assume the responsibility of site main controller in his absence.

7.12.5 Internal Communication

It shall be responsibility of ECC to communicate to all employees in the plant. They may take help of telephone operator for such communication. However, telephone operator can directly communicate information about emergency to all internal departments, if such message comes from incident controller or site main controller. Telephone operator will continue to operate the switchboard advising the callers that staffs are not available and pass all calls connected with the incident to ECC.

7.12.6 Availability of key personnel outside normal working hours

The details of key personnel availability after working hours will be made available at security gate, ECC, telephone operator as well as production units. Security personnel shall call required key personnel from their residence in case emergency occurs outside normal working hours. Availability of emergency vehicle / ambulance will be ensured to fetch the

key personnel residing outside. It will be the responsibility of HOD (P&A) to maintain it.

7.12.7 To the outside emergency services

Decision to call outside help to deal with emergency like fire brigade, ambulance, police, etc., shall be taken by site main controller. However, in absence of site main controller, if the incident controller realizes the situation going out of control, he may ask for immediate help from outside. ECC will be responsible for calling help from outside. A list of emergency services available in the area with their telephone numbers will be provided at ECC, at security gate and with telephone operator. Facilities such as phones, emergency vehicle, and security personnel will be available to help calling outside emergency services and authorities.

7.12.8 Communication to the authorities

The emergency will be immediately communicated to the government officers and other authorities such as GPCB, police, district emergency authority, factory inspectorate, hospital etc. by emergency control centre.

7.12.9 To neighboring firms & the general public

In case of emergency having its outside impact, public will be cautioned regarding the same. Co-Ordination of police will be sought for speedy action. This is to be ensured by ECC.

7.13 PRE-EMERGENCY ACTIVITIES

Internal safety survey with regard to identification of hazards, availability of protective equipment's, checking for proper installation of safety devices will be carried out periodically.

- Periodic pressure testing of equipment & lines
- Periodic safety/relief valve & fire hydrant system testing
- Mock drill to check up level of confidence, extent of preparedness of personnel to face emergency is being contemplated.
- Regular training is being imparted to all personnel to create awareness.
- Adequate safety equipment will be made available.
- Periodic check-up of emergency lights.
- Safer assembly points will be identified.

- Storage of adequate first aid treatment facilities.

Post emergency activities.

Following post emergency actions will be carried out to study in detail and In case of emergency, evacuation and preventive measures to be taken.

- Collection of records
- Inquiries
- Insurance claims
- Preparation of reports comprising suggestion and modification.
- Rehabilitation of affected personnel.

7.13.1 Evacuation and transportation

transportation of non-essential workers will be carried out immediately. The affected personnel will be transported for medical aid.

7.13.2 Safe close down

During emergency plant shut down will be carried out if situation warrants. This will be as per the instruction of site main controller under guidance of incident controller.

7.13.3 Use of mutual aid

Mutual aid agreement with nearby industries will be ensures to provide help to each other in the emergency,

7.13.4 Use of external authorities

As and when necessary, statutory authorities, police, pollution control personnel, medical aid/ center, ambulance etc. will be contacted.

7.13.5 Medical Treatment

The affected personnel will be brought to safer place immediately to give them first aid. Immediate medical attention will be sought.

7.13.6 Accounting for personnel

Proper accounting for personnel will be laid down in all the shifts. The number of persons present inside the plant premises, their duty etc. will be available with the P & A. This record will be regularly updated and will be made available.

7.13.7 Access to records

The relatives of affected personnel will be informed. The details regarding all employees will be made available to administration building.

7.13.8 Public relations

In case of emergency, manager p & a will be available for official release of information pertaining to the incident.

7.13.9 Rehabilitation

The affected area will be cleared from emergency activities only after positive ascertaining of the system in all respects. The entry to affected area will have to be restricted until statutory authorities visit and inspect the spot of incident. Nothing should be disturbed from the area till their clearance. The site main controller will be in charge of the activities to be undertaken. The plan will cover emergencies, which can be brought under control by the works with the help of emergency team/fire services. The disaster control plan for gas leak and fire will be prepared for entire factory.

7.14 CAUSES OF EMERGENCY:

7.14.1 Risk

7.14.2 Nature

In the plant, the nature of dangerous events could be of the following:

Fire	:	chemical/electrical
Toxic release	:	from chemicals & chlorine gas.
Leakages	:	equipment, pipe lines, valves, etc.

Release of vapors like pyridine or chlorine gas or hexane can result in highly toxic environment or in fire or explosion.

Improper handling of products (raw materials/finished products)

Large spillage to ground floors resulting in pollution & fire.

Failures of Equipment/Instruments. Release of safety valves or ruptures of vessels due to excessive pressures.

7.14.3 Various Emergency Actions

a. Onsite

- Safe shut down of the plant and utilities.
- Emergency control measures.
- To attempt with the help of trained crew in fire fighting to contain the fire spread up/gas emission and limit within limited space.

- To cut off source of oxygen by use of fire fighting appliances/to cut off source of gas emission.
- Cut off fall sources of ignition like electrical gadgets.
- To protect fire prone area from the fire.
- Evacuation of non-essential persons.

b. Medical Facilities/Treatment

- Doctor will visit two times a week for two hour each time.
- Depending on seriousness the injured person shall be shifted to any other hospital.
- Vehicle will be available round the clock for transportation. Ambulance will be also made available in the campus on regular basis.

c. In the event of Fatal Accidents

The information shall be given to following authorities:

- Inspector of Police
- Inspector of Factories
- Mamlatdar
- Corporate Office
- Regd. Office
- Insurance the plant
- Regional Officer

d. Emergency Siren

Emergency siren shall be blown for announcing the emergency which shall have different sound for identification/differentiation than the normally used for commencement of factory working etc.

- Location of Siren Above Plant
- Type of Siren Industrial Siren
- Position of siren switch Located at Main Gate

e. Seeking Help From Neighbouring Industries/Sources For Fire Engine

f. Advise for vacation of other areas

Since the effect of fire/gas emission shall be contained within the area of the plant advice of vacation of other areas is not necessary.

7.14.4 Response Time-Minutes

Hazard	Fire Fighting	Police	Medical Services
Fire & Explosion	Immediate with whatever facilities available with the plant	10 minutes	10 minutes
	External Help within 15 minutes		

7.15 OFF-SITE EMERGENCY PLAN

7.15.1 Need of the Site Emergency Plan

Depending upon the wind direction and velocity of the effects of accident in factory may spread to outside its premises. To avert major disaster it is essential to seek guidance/assistance of statutory authorities, police and health department. The movement of traffic may have to be restricted. Required information will be given to the authority and consultation will be sought for remedial measures.

A purpose of the off-site emergency plan is:

- To provide the local/district authorities, police, fire, brigade, doctors, surrounding industries and public the basic information of risk and environmental impact assessment and appraise them of the consequences and the protection/prevention measures and to seek their help to communicate with public in case of major emergency.
- To assist district authorities for preparing the off-site emergency plan for district or particular area and to organize rehearsals from time to time and initiate corrective actions on experience.

7.15.2 Structure of the off-Site Emergency Plan

Available with concerned authorities.

7.15.3 Role of the Factory Management

The site main controller will provide a copy of action plan to the statutory authorities in order to facilitate preparedness of district/area off-site emergency plan.

7.15.4 Role of Emergency Co-Ordination Office (ECO)

He will be a senior police or fire officer co-ordination with site main controller. He will utilize emergency control center.

7.15.5 Role of local authority

Preparation of Off Site Plan lies with local authorities. An emergency-planning officer (EPO) works to obtain relevant information for preparing basis for the plan and ensures that all those organization involved in offsite emergency and to know their role and responsibilities.

7.15.6 Role of fire authorities

The fire authorities will take over the site responsibility from incident controller after arrival. They will be familiarized with site of flammable materials, water and foam applies points, firefighting equipment.

7.15.7 Role of the police and evacuation authorities

Senior Police Officer designed, as emergency co-ordination officer shall take over all control of an emergency. The duties include protection of life, property and control of traffic movement. Their functions include controlling standards, evacuating public and identifying dead and dealing with casualties and informing relatives of dead or injured. There may be separate authorities/agencies to carry out evacuation and transportation work. Evacuation depends upon the nature of accident, in case of fire only neighboring localities shall be alerted. Whole areas have to be evacuated in case of toxic release.

7.15.8 Role of Health Authorities

After assessing the extent of effect caused to a person the health authorities will treat them.

7.15.9 Role of Mutual Aid Agencies

Various types of mutual aid available from the surrounding factories and other agencies will be utilized.

7.15.10 Role of factory inspectorate

In the event of an accident, the Factory Inspector will assist the District Emergency Authority for information and helping in getting Neighboring Industries/mutual aid from surrounding factories. In the aftermath, Factory Inspector may wish to ensure that the affected areas are rehabilitated safely.

7.16 TRAINING REHEARSAL AND RECORDS

7.16.1 Need of rehearsal & training

Regular training and rehearsal program of emergency procedures shall be conducted with elaborate discussions and testing of action plan with mock drill. If necessary, the co-operation/guidance of outside agencies will be sought.

7.16.2 Some check points

- The extent of realistic nature of incidents.
- Adequate assessment of consequences of various incidents.
- Availability of sufficient resources such as water, fire-fighting aids, personnel.
- The assessment of time scales.
- Logical sequences of actions.
- The involvement of key personnel in the preparation of plan.
- At least 24 hours covers to take account of absences due to sickness and holiday, minimum shift manning.
- Satisfactory co-operation with local emergency services and district or regional emergency planning offices.
- Adequacy of Site.

7.16.3 Records and updating the plan

All records of various on-site and off-site emergency plans of the factory will be useful alone with those of the factors by which statutory authorities draw a detailed plan for the whole area/district. The records of the activity will be updated regularly.

(B) Social Impact Assessment

No any negative Social Impact envisaged from the proposed expansion project activities. Infact, positive social impact will occur as necessity of unskilled and skilled person will increase for proposed activities and unit will give opportunity to the local people. There will be no R&R due to proposed activities.

(C) Public Consultation

The public hearing was held on 05.05.2017 on the basis of the draft EIA/EMP incorporating the Terms of References. Report is finalized after incorporating the comments and suggestions by the public during pubic consultation is given below.

Table 7.2 Points raised during public hearing

Issues/objections raised by the participants and responded to by the representative of the applicant during the Public Hearing:			
Sr. No.	**Name and Address**	**Issue raised**	**Reply from Project Proponent/Other**
1	Shri Mayur Bhudarbhai Pipaliya Village: Rib	What is the possibility of generation of wastewater by unit and what will be the necessary action taken by unit?	• Representative of the Project proponent informed that, there is no usage of water in process. Only 3450 lit/day total wastewater generated from condensation process and other sources. This wastewater is treated in treatment plant and evaporated and its condensate water of around 3000 lit/day will be reused. This way unit will not discharge any type of wastewater.
2	Shri Lalitbhai Savjibhai Gorasiya Village: Ribda	What about the employment of local educated people?	• Representative of the Project proponent informed that, when unit will start up, there will be requirement of 50 to 55 people. In such case, first priority will be given to the local people.
3	Shri Vinubhai Chunibhai Sardhara Village: Pipaliya	How much noise pollution created in the nearby environment due to Generator used in industry?	• Representative of the Project proponent informed that, CPCB has made acoustic enclosure mandatory for the D.G. Set manufactured after 2005. Due to this, there will be no noise pollution more than 70

			dB beyond 2 meter distance. Therefore, beyond unit boundary there will be no effect of noise pollution.
4	Shri Bhaveshbhai Narsinhbhai Sarvaiya Village: Bharudi	What safety measures will be taken for working employees in the unit?	• Representative of the Project proponent informed that, there may be possibility of fire accident due to usage of Formaldehyde and Methanol in the process by unit. For that, unit will provide flame proof electric fitting in solvent storage area. Personal Protective Equipments will be provided to the employees of the industry and care will be taken for compulsory usage of the same.
5	Shri Arvindbhai B. Manvar Village: Ardoi	What will be the damage in nearby area due to accident occurred in the unit?	• Representative of the Project proponent informed that, there is always possibility for the accident in any industry. Unit will prepared on-site emergency plan and follow all the suggestion given in the plan. List of emergency telephone numbers will be displayed on the main gate. Also 37% concentrated formaldehyde will be used so there is negligible possibility of fire due to formaldehyde. At high temperature, there is possibility of fire in Methanol, for that flame proof electric fitting will be provided in storage area and that area will be disclose as 'no smoking' zone and 'no spark' zone.