Risk Assessment

Risk assessment is an essential part of the risk management process and is the overall term covering the risk identification, analysis and risk evaluation part of the risk management process. The Risk management process involves the following steps,

1. System Definition

2. Risk Identification

3. Risk Estimation

4. Risk Evaluation

5. Risk Control

6. Risk Monitoring

7. Risk Communication

As indicated in the earlier chapter the company proposed to manufacture seven products and two by products. The manufacturing activity poses various types of hazards due to storage, handling and manipulation of different chemicals.

In order to study the risks envisaged by the proposed expansion activities, the following methodology was adopted.

Detailed study of all manufacturing activities

7.2.1 M.S.D.S.s

Brief M.S.D.S.s of all the above chemicals and other raw materials which would be used in the manufacturing processes of products are used as reference for preparation of HAZOP study.

7.3 HAZOP Study

Introduction

The HAZOP Study for both the products has been prepared considering all the unit operations and processes involved in the manufacturing of products.

Methodology

The documents pertaining to the processes such as rough P&I D made available by the client, MSDS of the substances involved, etc. were studied. Detailed discussions were held with the concerned officials of the factory.

Based on the above, HAZOP worksheets were prepared by applying standard procedures of using guide words to generate deviations in the process parameters. Corrective actions wherever necessary were indicated and presented below as HAZOP recommendations. The complete HAZOP report is attached as **annexure 7.1**.

Table No.7.1: HAZOP Study Recommendations

HAZOP Worksheet No.	Recommendation	
	No.	**Action to be taken**
1,2,5	01	Provide flange guards to all the flange joints of pipelines carrying corrosive substances under pressure.
1	02	Provide spill kit to scrubber and train the concerned personnel on the spill control procedure.
1	03	Provide manometer across the scrubber tower to monitor the pressure drop across the scrubber tower. Higher than the desired pressure drop will indicate chocking of the tower packing.
1	04	Provide gas leak detector at the vent of the scrubber tower.
1	05	Provide a stand-by circulation pump for system which can be activated on very short notice
1	06	Provide an indication lamp near the operating level to show the healthy working of the ID fan
1	07	Provide a scrubber log book to monitor the effective function of the scrubber system. The log book should be signed by supervisor of the shift. The log book should address the issues of concentration of scrubbing caustic, temperature of the scrubbing sol., Healthy working of the scrubbing pump and scrubbing exhaust fan.
1	08	Provide spill kit to the reactor and train the concerned personnel on the spill control procedure.
1	09	Provide designed rupture disc to protect safety valve form corrosion. Provide a tell tale pressure gauge between rupture disc and safety valve.
1	10	Provide level indicator for scrubber tank.
1	11	Ensure that the tonner is mounted on rotating wheels so that these can be turned to allow leakage from the gas valve.
1	12	Provide a hood system for the tonner which could be connected to scrubber in case of leakage.
1	13	Provide chlorine valve leakage kit and ensure that the concerned employees are trained in the usage of the same.
1	14	Provide a barometric leg with a non return valve for chlorine line.
2,5	15	Provide flange guards to all the flange joints of pipelines carrying corrosive substances under pressure.
2,5	16	Ensure that the centrifuge is maintained as indicated in the MFR 57 (schedule V)- further safety precautions for centrifugal machines
3,6,7,9	17	Formulate a procedure for periodic of the flame arrester.
3,6,7,9	18	Ensure that the linear velocity of solvent is not more than 1m/sec.
3,6,7,9	19	Use of anti-static ball valves recommended for provide electrical continuity

		for the s. s. ball to the valve body by flexible wire
3,6,7,9	20	Bend the inlet line of the solvent towards reactor wall to ensure that the solvent glides along the wall.
3,6,7,9	21	Procedure for inertization of vapour space with nitrogen gas from cylinders to be finalized and included in the log book
3,6,7,9	22	Procedure to be established for periodic cleaning of the condenser with de-scaling agents
3,6,7,9	23	Checklist for ensuring the FLP equipment to be prepared and strictly followed (body earthing of the fitting, condition of the double compression gland, closure of all Allen screws, all extra openings to be plugged, visual inspection for pitting etc.)
3,6,7,9	24	SOP for measurement of earth pit resistance to be prepared and followed
3,6,7,9	25	Continuity of earthing to be checked once in a year.
3,6,7,9	26	Earthing standard to be developed , location at which the earth connection is given, double earthing
3,6,7,9	27	Procedure to be followed during receipt of belts to ensure that these are antistatic
3,6,7,9	28	Explore the possibility of providing powder charging system
4,8,10	29	Establish the properties of residue from safety point view.
4,8,10	30	Compatibility of thermo-well fluids to be established with the vessel contents.
4,8,10	31	Provide flame arrester at the vents of the intermediate storage tanks.

7.4 Aerial Location of Hazardous Atmosphere (ALOHA):

A Quantitative Risk Assessment based on the software ALOHA – Aerial Locations of Hazardous Atmospheres was carried out. The criteria failure scenarios considered for ALOHA depend on the type of storage whether above ground tank, drums in storage area or pressurized cylinders as well as physical state of the chemical stored and chemical properties of the chemical.

ALOHA (Arial Locations of Hazards Atmosphere) is an atmospheric dispersion model used for evaluating releases of hazardous chemical vapors. ALOHA is a part of software called CAMEO (Computer Aided Management of Emergency Operation). CAMEO is one of the tools developed by EPA's Chemical Emergency Preparedness and Prevention Office (CEPPO) and the National Oceanic and Atmospheric Administration Office of Response and Restoration (NOAA), to assist front-line chemical emergency planners and responders. For the present calculation version 5.4.4 is used.

CAMEO suite consists of three parts viz.

1. **CAMEO**: It is basically a chemical data base provided for calculations.
2. **ALOHA**: ALOHA allows the user to estimate the downwind dispersion of a chemical cloud based on the toxicological/physical characteristics of the released chemical, atmospheric conditions, and specific circumstances of the release.
3. **MARPLOT** (Mapping Applications for Response, Planning, and Local Operational Tasks): Graphical outputs include a "cloud footprint" that can be plotted on maps with MARPLOT to display the location of other facilities storing hazardous materials and vulnerable locations, such as hospitals and schools. Specific information about these locations can be extracted from CAMEO information modules to help make decisions about the degree of hazard posed.

Acute Exposure Guideline Levels (AEGL):

What do the AEGL levels represent?

AEGL-1: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.

AEGL-2: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

AEGL-3: The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Figure No. 7.1: Description of AEGL levels

THERMAL RADITION EFFECTS:

A Thermal Radiation Level of Concern (LOC) is a threshold level of thermal radiation, usually the level above which a hazard may exist.

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

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

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

Below are some effects at specific thermal radiation levels for which software was run.

37.5 kw / m2 (100% lethality),

12.5 kw/m2 (1% lethality),

1.6 kw/m2 (no discomfort)

The thermal radiation effects that people experience depend upon the length of time they are exposed to a specific thermal radiation level. Longer exposure durations, even at a lower thermal radiation level, can produce serious physiological effects.

OVERPRESSURE EFFECTS:

A major hazard associated with any explosion is overpressure. Overpressure, also called a blast wave, refers to the sudden onset of a pressure wave after an explosion. This pressure wave is caused by the energy released in the initial explosion—the bigger the initial explosion, the more damaging the pressure wave. Blast waves can damage buildings or even knock them flat—often injuring or killing the people inside them. The sudden change in pressure can also affect pressure-sensitive organs like the ears and lungs. The damaging effects of the overpressure will be greatest near the source of the explosion and lessen as you move farther from the source.

An Overpressure Level of Concern (LOC) is a threshold level of pressure from a blast wave, usually the pressure above which a hazard may exist. In vapour cloud explosion scenario, ALOHA will suggest three default LOC values. ALOHA uses three threshold values to create the default threat zones:

• Red: 8.0 psi (destruction of buildings);

• Orange: 3.5 psi (serious injury likely); and

• Yellow: 1.0 psi (shatters glass).

ALOHA software is used to estimate the risk associated with release of pressurized gases. The list of pressurized gases stored in the plant with respective quantity is listed in following table.

Table No 7.2: Tank Storage Details

Sr. No.	Service	Diameter, mm	Length, mm	Capacity, kl
1	Methanol	2400	6000	26 X 2 Nos
2	30% HCl	2300	4900	20
3	50% Caustic Soda Lye	2300	4900	20
4	Liq. Ammonia	2000	3200	10
5	FO	2300	4900	20

The summary of ALOHA for different scenarios for above chemicals attached in **Annexure 7.2**. ALOHA footprints for different hazard scenarios are presented in table 7.3

Substance	**Scenario.**	**Effects considered**	**LOC**		**Distance, m**
Methanol	The rupture of road tanker	Toxic area of vapor cloud	AEGL-3	530 ppm	668
			AEGL -2	2100 ppm	1100
			AEGL -1	7200 ppm	1900
		Flammable area of vapour cloud		43080 ppm = 60% LEL	230
				7180ppm = 10% LEL	669
		Blast area of vapour cloud explosion		8.0 psi = destruction of buildings	LOC never exceeded
				3.5 psi = serious injury likely	LOC never exceeded
				1.0 psi = shatters glass	179
	Leak of the tranfer pump discharge line	Toxic area of vapour cloud	AEGL-3	7200 ppm	23
			AEGL-2	2100 ppm	48
			AEGL-1	530 ppm	100
		Flammable area of vapour cloud		43080 ppm = 60% LEL	11
				7180 ppm = 10% LEL	26
		Blast area of vapour cloud explosion		8.0 psi = destruction of buildings	-
				3.5 psi =	

				serious injury likely	
				1.0 psi = shatters glass	11m
Liquor Ammonia 25%	Evaporating puddle of filmable chemical	Toxic Area of vapour cloud	AEGL-3	30 ppm	60
			AEGL -2	160 ppm	161
			AEGL -1	1100 ppm	379
	Evaporating puddle of filmable chemical	Flammable Area of vapour cloud		90000 ppm = 60% LEL = Flame Pockets	10
				15000 ppm = 10% LEL	11
	Evaporating puddle of filmable chemical	Blast Area of vapour cloud		-	-
Hydrochloric Acid	Evaporating puddle	-	AEGL-3	100 ppm	29
			AEGL -2	22 ppm	74
			AEGL -1	1.8 ppm	273
Liquid Chlorine	Evaporating puddle.	-	AEGL-3	20 ppm	240
			AEGL -2	2 ppm	796
			AEGL -1	0.5 ppm	1.6 km

Recommendations – for tonners

- Each Chlorine tonner to be weighed individually before receipt.
- The lifting arm for the tonners should be examined and tested as independent lifting tackle.
- Robust procedure should be developed to check the condition of the toner received (color coding, valve caps, condition of the valves, external pitting corrosion of the toner/cylinder, date of hydro test of cylinder etc.)
- Valve kits to be maintained for toners
- 2 nos. Fire Extinguishers (DCP type, 10 kg.each) & 4 nos. Sand Buckets will be kept near each gate.
- NO SMOKING / NO NAKED LIGHT' board will be prominently displayed.
- There are no HT / LT lines passing directly above the storage installation.
- The shed and the surrounding facilities will be constructed of non-combustible material like Cement, Steel, Bricks, AC Sheets etc.
- Wind socks will be provided at height on a structure, near the storage shed.
- Leakage Emergency Tool Kit one each for Chlorine, Ammonia. Self Contained Breathing Apparatus (SCBA) will be provided in storage shed.

Recommendations – For storage tanks

- The periodic inspection and maintenance program on the tank would be ensured.
- The periodic maintenance on the pump and piping would be ensured.
- Least number of flanged joints will be provided in the pipelines.
- The pipelines will be supported adequately so as to avoid sagging of the same during operation.
- Visual inspection of the pipelines will be done periodically to ascertain external pitting and corrosion.
- Protective painting on the tank and pipeline shall be provided.
- Protective equipment such as gloves, lab coat, vapor respirator, splash goggles shall be ensured while handling the substance.
- Prominent signage of hazards (such as "Danger", No smoking") of the substances shall be provided on the tank and surroundings
- The tank installation will be protected against lightening.
- All Electric Equipment & Fittings (e.g. Pump-motors, lamps, junction boxes, switches etc.) shall be of Flame-proof Type, conforming to IS/IEC 60079 i.e. old IS 2148:1981, suitable for GR. II A/II B and shall be of type approved by the CCoE.

Mitigation measures for Chlorine Handling

Chlorine (Cl2)			**ICSC**	**0126**
CAS No.	7782-50-5		**Molecular Formula**	Cl_2
RTECS No	FO2100000			
UN. No	1017		**Molecular Weight**	70.90 g/mole
EC. No.	017-001-00-7			

TYPES OF HAZARD	**ACUTE HAZARDS / SYMPTOMS**	**PREVENTION**	**FIRST AID / FIRE FIGHTING**
Fire	Not combustible but enhances combustion of other substances. Many reactions may cause fire or explosion	NO contact with combustibles, acetylene, ethylene, hydrogen, ammonia and finely divided metals.	In case of fire in the surroundings: use appropriate extinguishing media.
Explosion	Risk of fire and explosion on contact with combustible substances, ammonia and finely divided metals	----	In case of fire: keep cylinder cool by spraying with water but NO direct contact with water.
Exposure		AVOID ALL CONTACT!	IN ALL CASES CONSULT A DOCTOR!
Inhalation	Corrosive. Burning sensation. Shortness of breath. Cough. Headache. Nausea. Dizziness. Laboured breathing. Sore throat. Symptoms may be delayed (see Notes).	Breathing protection. Closed system and ventilation.	Fresh air, rest. Half-upright position. Artificial respiration may be needed. Refer for medical attention.
Skin	ON CONTACT WITH LIQUID: FROSTBITE. Corrosive. Skin burns. Pain.	Cold-insulating gloves. Protective clothing.	First rinse with plenty of water, then remove contaminated clothes and rinse again. Refer

			for medical attention.
Eyes	Corrosive. Pain. Blurred vision. Severe deep burns.	Safety goggles or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
Ingestion			

Spillage Disposal	**Packing & Labeling**
Evacuate danger area! Consult an expert! Ventilation. NEVER direct water jet on liquid. Remove gas with fine water spray. Personal protection: complete protective clothing including self-contained breathing apparatus. Do NOT let this chemical enter the environment.	T Symbol N Symbol R: 23-36/37/38-50 S: (1/2-)9-45-61 UN Hazard Class: 2.3 UN Subsidiary Risks: 8
Emergency Response	**Safe Storage**
Transport Emergency Card: TEC (R)-20S1017 NFPA Code: H 4; F 0; R 0; OX	Separated from strong bases, combustible and reducing substances. Cool. Dry. Keep in a well-ventilated room

IMPORTANT DATA	
PHYSICAL APPEARANCE: (APPEARANCE) GREENISH-YELLOW GAS, WITH PUNGENT ODOUR.	ROUTE OF EXPOSURE:- The substance can be absorbed into the body by inhalation of its vapor and by ingestion.
PHYSICAL DANGER:- The Gas is heavier than Air	INHALATION RISK:- A harmful contamination of the air can be reached rather quickly on dusting of this substance
CHEMICAL DANGER:- The solution in water is a strong acid, it reacts violently with bases and is corrosive. Reacts violently with many organic compounds, ammonia, hydrogen and finely divided metals causing fire and explosion hazard. Attacks many metals in presence of water. Attacks plastic,	EFFECT OF SHORT TERM EXPOSURE:- Tear drawing. The substance is corrosive to the eyes, the skin and the respiratory tract. Inhalation of gas may cause pneumonitis and lung oedema, resulting in reactive airways dysfunction syndrome (RADS) (see Notes). Rapid evaporation of the liquid may cause frostbite. Exposure far above the OEL may

rubber and coatings.	result in death. The effects may be delayed. Medical observation is indicated.
OCCUPATIONAL EXPOSURE LIMIT:- TLV: 0.5 ppm as TWA; 1 ppm as STEL; A4 (not classifiable as a human carcinogen); (ACGIH 2004). MAK: 0.5 ppm, 1.5 mg/m³; Peak limitation category: I(1); Pregnancy risk group: C; (DFG 2004).	EFFECT OF LONG TERM EXPOSURE:- The substance may have effects on the lungs, resulting in chronic bronchitis. The substance may have effects on the teeth, resulting in erosion.

7.5 DOW Fire and Explosion Index

The Dow index has been calculated for chemicals stored chemical storage area. Dow Index has been calculated for F.O Tank and Butanol, Dimethylformamide Drum storage. Details of DOW index is given in table below,

Table No. 7.4: List of hazardous chemicals and its respective DOW F& E Index

Sr. No	Chemical	Quantity at any given time,	Nh	Nf	Nr	Material Factor	F&EI	Degree of hazard
	PESO Storage							
1	Furnace Oil (20 KL)	16 KL	0	2	0	10	18.7	Light
	Raw Material Godown							
2	Butanol	0.8 Tones	1	3	0	16	35.52	Light
3	Dimethyl Formamide	5.4 Tones	2	2	0	10	15.0	Light

The DOW index work sheet and the respective recommendations for each chemical are as below with its recommendation

Dow Index for FO Tank

Tank No.	--			Equipment Name		Furnace Oil Tank (20 KL)					
Basic Material for Material factor		MS		Density, kg/l		**0.86**					
Properties of material											
N h	**0**	N f	**2**	N r	**0**	M.F.	**10**				
Boil.	-	0F	-	0C	Flash pt.	**150**	0	**66**	0C		
ΔHC = Heat of	**18700**	BTU / lb									
Quantity of the	**16000**	l		**1**	kg	**30335.60**	Lb				
Storage conditions	Temp	**30**	0	Pressu	**1.0**	bar					

		Penalty factor	**Penalty factor used**
1.General	Base Factor	1.00	1.00
	Exothermic Chemical Reaction	0.30 to 1.25	0.00
	Endothermic Processes	0.20 to 0.40	0.00
	Material handling and transfer	0.25 to 1.05	0.25
	Enclosed or Indoor Process Units	0.25 to 0.90	0.00
	Access	0.20 to 0.35	0.00
	Drainage and Spill Control	0.25 to 0.50	0.00
	General Process Hazard Factor (F1)		**1.25**
2.Special	Base Factor	1.00	1.00
	Toxic material(s)	0.20 to 0.80	0.00
	Sub atmospheric pressure (< 500 mm Hg)	0.50	0.00
	Operation in or near flammable range	0.00 to 0.80	
	1. Tank farm storage flammable liquids	0.50	0.00
	2. Process upset or purge failure	0.30	0.00
	3. Always in contact of Flame	0.80	0.00
	Dust Explosion	0.25 to 2.00	0.00
	Pressure Operating pressure psig		0.00
	Low temperature	0.20 to 0.30	0.00
	Quantity of flammable / unstable material		
	1. Liquids or gases in process		0.00
	2. Liquids or gases in storage		0.30
	3. Combustible Solids in Storage, Dust in		0.00
	Corrosion & Erosion	0.10 to 0.75	0.10
	Leakage - Joints & Packing	0.10 to 1.50	0.10
	Use of Fired Equipment		0.00
	Hot oil heat exchange system	0.15 to 1.15	0.00
	Rotating Equipment	0.50	0.00

	Special Process Hazard Factor (F2)		**1.5**
Process Unit Hazard Factor (F3 = F1 x F2)			**1.87**
Fire & Explosion Index (F.& E.I.= F3 x M.F.)			**18.7**
Degree of Hazard		**Light**	
Radius of Exposure		**4.78 meters**	
Area of Exposure		**71.74 sq. m**	

Recommendations for FO Tank

Preventive & Protective Features	Fire & Explosion Index Number						**Index for the present case**		
	0-20	20-40	40-60	60-75	75-90	>90	**18.7**		
							Suggested	Recommended	Feature required
1) Fireproofing	1	2	2	3	4	4		√	
2) Water spray									
a) directional	1	2	3	3	4	4		√	
b) area	1	2	3	3	4	4		√	
c) curtain	1	1	2	2	2	4	√		
3) Special instrumentation									
a) temperature	1	2	3	3	4	4		√	
b) pressure	1	2	3	3	3	4		√	
c) flow control	1	2	3	4	4	4			√
4) Dust, blowdown, spill control	1	1	2	3	3	4		√	
5) Internal examination	1	2	3	3	4	4		√	
6) Combustible gas monitors									
a) signal alarm	1	1	2	3	3	4		√	
b) actuate equipment	1	1	2	2	3	4	√		
7) Remote operation	1	1	2	3	3	4		√	

8) Diking, (Not Applicable as barrel storage)	1	4	4	4	4	4			√
9) Blast & barrier walls separation	1	1	2	3	4	4		√	

1) Feature optional 2) Feature suggested 3) Feature recommended 4) Feature required

Dow Index for Butanol Drum storage

Tank No.	--			Equipment Name		Butanol (0.8 KL)			
Basic Material for Material factor		MS		Density, kg/l		**0.81**			
Properties of material									
N h	**1**	N f	**3**	N r	**0**	M.F.	**16**		
Boil.	243	0F	117	0C	Flash pt.	**84**	0F	**28.8**	0C
ΔHC = Heat of	**14300**	BTU / lb							
Quantity of the	**860**	l	**696.6**	kg	**1535.7**	Lb			
Storage conditions	Temp	**30**	0C	Pressu	**1.0**	bar			

		Penalty factor	**Penalty factor used**
1.General	Base Factor	1.00	1.00
	Exothermic Chemical Reaction	0.30 to 1.25	0.00
	Endothermic Processes	0.20 to 0.40	0.00
	Material handling and transfer	0.25 to 1.05	0.85
	Enclosed or Indoor Process Units	0.25 to 0.90	0.00
	Access	0.20 to 0.35	0.00
	Drainage and Spill Control	0.25 to 0.50	0.00
	General Process Hazard Factor (F1)		**1.85**
2.Special	Base Factor	1.00	1.00
	Toxic material(s)	0.20 to 0.80	0.00
	Sub atmospheric pressure (< 500 mm Hg)	0.50	0.00
	Operation in or near flammable range	0.00 to 0.80	
	1. Tank farm storage flammable liquids	0.50	0.00
	2. Process upset or purge failure	0.30	0.00
	3. Always in contact of Flame	0.80	0.00
	Dust Explosion	0.25 to 2.00	0.00
	Pressure Operating pressure psig		0.00
	Low temperature	0.20 to 0.30	0.00
	Quantity of flammable / unstable material		
	1. Liquids or gases in process		0.00

	2. Liquids or gases in storage		0.10
	3. Combustible Solids in Storage, Dust in		0.00
	Corrosion & Erosion	0.10 to 0.75	0.10
	Leakage - Joints & Packing	0.10 to 1.50	0.00
	Use of Fired Equipment		0.00
	Hot oil heat exchange system	0.15 to 1.15	0.00
	Rotating Equipment	0.50	0.00
	Special Process Hazard Factor (F2)		**1.2**
Process Unit Hazard Factor (F3 = F1 x F2)			**2.22**
Fire & Explosion Index (F.& E.I.= F3 x M.F.)			**35.52**
Degree of Hazard		**Light**	
Radius of Exposure		**9.09 meters**	
Area of Exposure		**259 sq. m**	

Recommendations for Butanol Drum Storage

Preventive & Protective Features	Fire & Explosion Index Number						**Index for the present case**		
	0-20	20-40	40-60	60-75	75-90	>90	**35.52**		
							Suggested	Recommended	Feature required
1) Fireproofing	1	2	2	3	4	4		√	
2) Water spray									
a) directional	1	2	3	3	4	4		√	
b) area	1	2	3	3	4	4		√	
c) curtain	1	1	2	2	2	4	√		
3) Special instrumentation									
a) temperature	1	2	3	3	4	4		√	
b) pressure	1	2	3	3	3	4		√	
c) flow control	1	2	3	4	4	4			√
4) Dust, blowdown, spill control	1	1	2	3	3	4		√	
5) Internal examination	1	2	3	3	4	4		√	

6) Combustible gas monitors									
a) signal alarm	1	1	2	3	3	4		√	
b) actuate equipment	1	1	2	2	3	4	√		
7) Remote operation	1	1	2	3	3	4		√	
8) Diking, (Not Applicable as barrel storage)	1	4	4	4	4	4			√
9) Blast & barrier walls separation	1	1	2	3	4	4		√	

2) Feature optional 2) Feature suggested 3) Feature recommended 4) Feature required

Dow Index for DMF Drum storage

Tank No.	--			Equipment Name		Dimethylformamide (5.4 Tones)			
Basic Material for Material factor		MS		Density, kg/l		**0.949**			
Properties of material									
N h	**2**	N f	**2**	N r	**0**	M.F.	**10**		
Boil.	307.4	0F	153	0C	Flash pt.	**136**	0F	**57.7**	0C
ΔHC = Heat of	**11428**	BTU / lb							
Quantity of the	**5400**	l		**5124**	kg	**11296**		Lb	
Storage conditions	Temp	**30**	0C	Pressu	**1.0**	bar			

		Penalty factor	**Penalty factor used**
1.General	Base Factor	1.00	1.00
	Exothermic Chemical Reaction	0.30 to 1.25	0.00
	Endothermic Processes	0.20 to 0.40	0.00
	Material handling and transfer	0.25 to 1.05	0.25
	Enclosed or Indoor Process Units	0.25 to 0.90	0.00
	Access	0.20 to 0.35	0.00
	Drainage and Spill Control	0.25 to 0.50	0.00
	General Process Hazard Factor (F1)		**1.25**
2.Special	Base Factor	1.00	1.00
	Toxic material(s)	0.20 to 0.80	0.00
	Sub atmospheric pressure (< 500 mm Hg)	0.50	0.00
	Operation in or near flammable range	0.00 to 0.80	
	1. Tank farm storage flammable liquids	0.50	0.00

	2. Process upset or purge failure	0.30	0.00
	3. Always in contact of Flame	0.80	0.00
	Dust Explosion	0.25 to 2.00	0.00
	Pressure Operating pressure psig		0.00
	Low temperature	0.20 to 0.30	0.00
	Quantity of flammable / unstable material		
	1. Liquids or gases in process		0.00
	2. Liquids or gases in storage		0.10
	3. Combustible Solids in Storage, Dust in		0.00
	Corrosion & Erosion	0.10 to 0.75	0.10
	Leakage - Joints & Packing	0.10 to 1.50	0.00
	Use of Fired Equipment		0.00
	Hot oil heat exchange system	0.15 to 1.15	0.00
	Rotating Equipment	0.50	0.00
	Special Process Hazard Factor (F2)		**1.2**
Process Unit Hazard Factor (F3 = F1 x F2)			**1.5**
Fire & Explosion Index (F.& E.I.= F3 x M.F.)			**15**
Degree of Hazard		**Light**	
Radius of Exposure		**3.84meters**	
Area of Exposure		**46.3 sq. m**	

Recommendations for DMF Drum Storage

Preventive & Protective Features	Fire & Explosion Index Number						**Index for the present case**		
	0-20	20-40	40-60	60-75	75-90	>90	**15**		
							Suggested	Recommended	Feature required
1) Fireproofing	1	2	2	3	4	4		√	
2) Water spray									
a) directional	1	2	3	3	4	4		√	
b) area	1	2	3	3	4	4		√	
c) curtain	1	1	2	2	2	4	√		
3) Special instrumentation									
a) temperature	1	2	3	3	4	4		√	

b) pressure	1	2	3	3	3	4		√	
c) flow control	1	2	3	4	4	4			√
4) Dust, blowdown, spill control	1	1	2	3	3	4		√	
5) Internal examination	1	2	3	3	4	4		√	
6) Combustible gas monitors									
a) signal alarm	1	1	2	3	3	4		√	
b) actuate equipment	1	1	2	2	3	4	√		
7) Remote operation	1	1	2	3	3	4		√	
8) Diking, (Not Applicable as barrel storage)	1	4	4	4	4	4			√
9) Blast & barrier walls separation	1	1	2	3	4	4		√	

3) Feature optional 2) Feature suggested 3) Feature recommended 4) Feature required

7.6 Toxicity (Monds) Index

The principle and general approach used in the DOW method of hazard evaluation have been further developed by ICI Mond Division, the revised Mond Fire, Explosive and Toxicity index is a series of papers by Lewis (1979). The main developments made to the DOW Index in the Mond Index are:

1. It covers a wider range of process and storage installation
2. It covers the processing of chemicals with explosive properties
3. A calculation procedure is included to allow for the off-setting effects of good design and control and safety instrumentation
4. The procedure has been extended to cover plant layout
5. Separate indices are calculated to access the hazards of fire, internal explosion and aerial explosion.

To estimate the Monds Index for raw materials in storage area following,

All the raw materials stored in the industry premises are tabulated and data for their N (H) levels and TLV levels are obtained. Based on their highest toxicity factor and lowest TLV level Mond's Index was calculated for Dimethyl Sulfate, Hydrogen Peroxide for drum storages. Similarly Hydrochloric acid are stored in tank farms, Mond's index was performed is performed for both of them.

A) Monds Index Calculation for Dimethyl Sulfate

Toxicity Index :$\frac{Th + Ts\ (1+GPH+SPH)}{100}$

Where, SPH = Special Process Hazard

GPH = General Process Hazard

Th = Toxicity factor based on the NFPA hazard index (0 – 4)

Ts = Correction factor (additional penalty) for toxicity based on Maximum

Allowable Concentration (MAC) value in ppm

Th (Toxicity Factor): For Dimethyl Sulfate will be 325 as the Nh factor for Dimethyl Sulfate is 4 from below table

Ts (Correction Factor): For Dimethyl Sulfate will be 125 as the MAC is 0.5 ppm from below table

Toxicity factor Index

NFPA Index Number	**Toxicity Factor (Th)**
0	**0**
1	**50**
2	**125**
3	**250**
4	**325**

Correction factor for Toxicity

MAC (in ppm)	Ts
5 and below	125
Between 5 and 50	75
50 and more	50

General & Special Process Hazard

1.General Process	Base Factor	1.00	1.00
	Exothermic Chemical Reaction	0.30 to 1.25	0.00
	Endothermic Processes	0.20 to 0.40	0.00
	Material handling and transfer	0.25 to 1.05	0.00
	Enclosed or Indoor Process Units	0.25 to 0.90	0.00
	Access	0.20 to 0.35	0.00
	Drainage and Spill Control	0.25 to 0.50	0.50
	General Process Hazard Factor (F1)		**1.50**
2.Special Process	Base Factor	1.00	1.00
	Toxic material(s)	0.20 to 0.80	0.80
	Sub atmospheric pressure (< 500 mm	0.50	0.00
	Operation in or near flammable range _____inerted _____noninerted	0.00 to 0.80	
	1. Tank farm storage flammable	0.50	0.00
	2. Process upset or purge failure	0.30	0.00
	3. Always in Flammable range	0.80	0.00
	Dust Explosion	0.25 to 2.00	0.00
	Pressure Operating pressure psig		0.00
	Low temperature	0.20 to 0.30	0.00
	Quantity of flammable / unstable		
	1. Liquids or gases in process		0.00
	2. Liquids or gases in storage		0.0
	3. Combustible Solids in Storage, Dust in Process		0.00

	Corrosion & Erosion	0.10 to 0.75	0.10
	Leakage - Joints & Packing	0.10 to 1.50	0.00
	Use of Fired Equipment		0.00
	Hot oil heat exchange system	0.15 to 1.15	0.00
	Rotating Equipment	0.50	0.00
	Special Process Hazard Factor (F2)		**1.90**

Therefore from the above table the GPH and SPH is coming to be around 1.50 and 1.90 respectively.

Calculation of Toxicity Index:

Toxicity Index :$\frac{Th + Ts (1+GPH+SPH)}{100}$

Toxicity Index : [325 + 125 (1 + 1.50 + 1.90)]/100

Toxicity Index :8.75

Toxicity Index

The resulting TI values are ranked into three categories:	
1-5	Light
6-9	Moderate
10-up	High

The Toxicity Index for Dimethyl Sulfate is calculated to be around 8.62 which indicate that the degree of hazard is Moderate from above table.

B) Monds Index Calculation for Hydrochloric Acid

Toxicity Index :$\frac{Th + Ts\ (1+GPH+SPH)}{100}$

Where, SPH = Special Process Hazard

GPH = General Process Hazard

Th = Toxicity factor based on the NFPA hazard index (0 – 4)

Ts = Correction factor (additional penalty) for toxicity based on Maximum Allowable Concentration (MAC) value in ppm

Th (Toxicity Factor): For Hydrochloric acid will be 250 as the Nh factor for Hydrochloric acid is 3 from below table

Ts (Correction Factor): For Hydrochloric acid will be 125 as the MAC is 5 ppm from below table

Toxicity factor Index

NFPA Index Number	Toxicity Factor (Th)
0	**0**
1	**50**
2	**125**
3	**250**
4	**325**

Correction factor for Toxicity

MAC (in ppm)	Ts
5 and below	125
Between 5 and 50	75
50 and more	50

General & Special Process Hazard

1.General Process	Base Factor	1.00	1.00
	Exothermic Chemical Reaction	0.30 to 1.25	0.00
	Endothermic Processes	0.20 to 0.40	0.00
	Material handling and transfer	0.25 to 1.05	0.00
	Enclosed or Indoor Process Units	0.25 to 0.90	0.00
	Access	0.20 to 0.35	0.00
	Drainage and Spill Control	0.25 to 0.50	0.50
	General Process Hazard Factor (F1)		**1.50**
2.Special Process	Base Factor	1.00	1.00
	Toxic material(s)	0.20 to 0.80	0.60
	Sub atmospheric pressure (< 500 mm	0.50	0.00
	Operation in or near flammable range _____inerted _____noninerted	0.00 to 0.80	
	1. Tank farm storage flammable	0.50	0.00
	2. Process upset or purge failure	0.30	0.00
	3. Always in Flammable range	0.80	0.00
	Dust Explosion	0.25 to 2.00	0.00
	Pressure Operating pressure psig		0.00
	Low temperature	0.20 to 0.30	0.00
	Quantity of flammable / unstable		
	1. Liquids or gases in process		0.00
	2. Liquids or gases in storage		0.0

	3. Combustible Solids in Storage, Dust in Process		0.00
	Corrosion & Erosion	0.10 to 0.75	0.10
	Leakage - Joints & Packing	0.10 to 1.50	0.00
	Use of Fired Equipment		0.00
	Hot oil heat exchange system	0.15 to 1.15	0.00
	Rotating Equipment	0.50	0.00
	Special Process Hazard Factor (F2)		**1.70**

Therefore from the above table the GPH and SPH is coming to be around 1.50 and 1.70 respectively.

Calculation of Toxicity Index:

Toxicity Index :$\frac{Th + Ts (1+GPH+SPH)}{100}$

Toxicity Index : [250 + 125 (1 + 1.50 + 1.70)]/100

Toxicity Index :7.75

Toxicity Index

The resulting TI values are ranked into three categories:	
1-5	Light
6-9	Moderate
10-up	High

The Toxicity Index for Hydrochloric acid is calculated to be around 7.75 which indicate that the degree of hazard is Moderate from above table.

C) Monds Index Calculation for Hydrogen peroxide

Toxicity Index :$\frac{Th + Ts (1+GPH+SPH)}{100}$

Where, SPH = Special Process Hazard

GPH = General Process Hazard

Th = Toxicity factor based on the NFPA hazard index (0 – 4)

Ts = Correction factor (additional penalty) for toxicity based on Maximum Allowable Concentration (MAC) value in ppm

Th (Toxicity Factor): For Hydrogen peroxide will be 250 as the Nh factor for Hydrogen Peroxide is 3 from below table

Ts (Correction Factor): For Hydrogen peroxide will be 125 as the MAC is 1 ppm from below table

Toxicity factor Index

NFPA Index Number	**Toxicity Factor (Th)**
0	**0**
1	**50**
2	**125**
3	**250**
4	**325**

Correction factor for Toxicity

MAC (in ppm)	Ts
5 and below	125
Between 5 and 50	75
50 and more	50

General & Special Process Hazard

1.General Process	Base Factor	1.00	1.00
	Exothermic Chemical Reaction	0.30 to 1.25	0.00
	Endothermic Processes	0.20 to 0.40	0.00
	Material handling and transfer	0.25 to 1.05	0.00
	Enclosed or Indoor Process Units	0.25 to 0.90	0.00
	Access	0.20 to 0.35	0.00
	Drainage and Spill Control	0.25 to 0.50	0.50
	General Process Hazard Factor (F1)		**1.50**
2.Special Process	Base Factor	1.00	1.00
	Toxic material(s)	0.20 to 0.80	0.60
	Sub atmospheric pressure (< 500 mm	0.50	0.00
	Operation in or near flammable range _____inerted _____noninerted	0.00 to 0.80	
	1. Tank farm storage flammable	0.50	0.00
	2. Process upset or purge failure	0.30	0.00
	3. Always in Flammable range	0.80	0.00
	Dust Explosion	0.25 to 2.00	0.00
	Pressure Operating pressure psig		0.00
	Low temperature	0.20 to 0.30	0.00
	Quantity of flammable / unstable		
	1. Liquids or gases in process		0.00
	2. Liquids or gases in storage		0.0
	3. Combustible Solids in Storage, Dust in Process		0.00
	Corrosion & Erosion	0.10 to 0.75	0.10
	Leakage - Joints & Packing	0.10 to 1.50	0.00

	Use of Fired Equipment		0.00
	Hot oil heat exchange system	0.15 to 1.15	0.00
	Rotating Equipment	0.50	0.00
	Special Process Hazard Factor (F2)		**1.70**

Therefore from the above table the GPH and SPH is coming to be around 1.50 and 1.70 respectively.

Calculation of Toxicity Index:

Toxicity Index :$\frac{Th + Ts (1+GPH+SPH)}{100}$

Toxicity Index : [250 + 125 (1 + 1.50 + 1.70)]/100

Toxicity Index : 7.75

Toxicity Index

The resulting TI values are ranked into three categories:	
1-5	Light
6-9	Moderate
10-up	High

The Toxicity Index for Hydrogen peroxide is calculated to be around 7.75 which indicate that the degree of hazard is Moderate from above table.

Table no. 7.5 : Calculated Mond's Index and degree of Hazard for Hazardous chemicals.

Sr. No.	Raw Materials	Th (Toxicity factor)	Ts (Correction factor)	Mond's Index	Degree of hazard
1.	Dimethyl Sulfate	325	125	8.62	Moderate
2.	Hydrochloric Acid	250	125	7.75	Moderate
3.	Hydrogen Peroxide	250	125	7.75	Moderate

Toxicity (Mond) Index recommendations:

1. Toxic material should be stored in cool place. It should be away from heat and temperature.
2. Toxic material can cause breathing difficulty therefore storage area should be well ventilated.
3. Dyke or Spill kit should be provided for storage to limit the spill of materials. Suitable Absorbent like sodium bi carbonate should be used to absorb the spill.
4. The storage area should not be congested and good housekeeping practice should be implemented.
5. The chemicals should be stored considering their compatibility with each other.
6. PPE's should be used wherever necessary.

Chemical wise precautions to be taken during handling, storage of chemicals are tabulated below

Sr. No.	Name Of Material	Hazards Associated	Precautions to be taken during Handling	Precautions to be taken during Storage
1	Phthalic Anhydride / Ptthalamide	i) ***Health Hazards*:** Inhalation causes irritation to nose, throat and also irritant to skin & eyes. ii) ***Fire Hazards*:** Molten and solid phthalic anhydride burn if ignited. It can react with oxidizing materials.	i) All containers should be labeled properly with caution. ii) Containers should be dry and locked & keep it away from sources of ignition. iii) Avoid contact with skin and eyes.	i) Storage area should be well ventilated. ii) Containers should be closed tightly and keep in a cool place & Do not store in temp above 25°C (77°F).
2	Chlorine	i) ***Health Hazards*:** It can cause irritation to the eyes, skin and the respiratory system. ii) It causes intensify fire.	i) Do not attempt to handle it without proper training. ii) Avoid heat, sparks, open flames and other ignition sources.	i) Storage area should be cool, dry & well ventilated. ii) Storage area should be away from flammable materials.
3	Dimethyl Sulphate	***Health Hazards:*** It can cause irritation to the eyes. If contact with skin, skin produces initial reddening and possibly itching, followed by severe burns that may extend through the skin to the underlying tissues if the liquid is not rapidly removed	i) Containers should be keep dry and locked & keep it away from heat & sources of ignition. ii) Do not breathe gas/fumes/vapour/spray. iii) Avoid contact with skin & eyes.	i) Storage area should be well ventilated. ii) Keep container tightly closed and store in a cool place.
4	Methanol	i) ***Health Hazards:*** The substance is toxic to eyes. It can cause irritation to the eyes & skin. toxic to blood, kidneys, liver, brain, peripheral nervous system, upper respiratory tract, skin, central nervous system (CNS),optic nerve. ii) Explosive & Flammable.	i) Keep it away from heat & ignition sources and loked up the containers ii) Do not breathe gas/fumes/vapor/spray. iii) Wear suitable protective clothing. iv) Do not handle in areas that have potential ignition sources	i) Should be Store in a segregated and approved area& area should be cool and well ventilated. ii) Keep container tightly closed and sealed until ready for use. iii) Avoid all possible sources of ignition (spark or flame).
5	Caustic Soda Lye 50%	i) ***Health Hazards:*** Causes severe skin burns and eye damage. Hazardous in case of inalation. ii) Solution is corrosive to	i) During handling, prevent contact with skin and eyes by using adequate PPEs. ii) Do not breathe gas/fumes/ vapor/spray.	i) Store in closed containers, well ventilated area and cool place. ii) Store away from

		body tissues and metallic materials. iii) Product may react violently with acids.	iii) Do not drink, eat or smoke while handling.	sources of heat and ignition, strong acids, aluminum, zinc & magnesium.
6	Liquor Ammonia 25%	i) Causes severe skin burns and eye damage. May cause respiratory irritation.	i) Do not breathe dust/fume/gas/mist/vapors spray. ii) Wash thoroughly after handling. iii) Wear PPEs while handling. iv) Keep away from incompatibles such as metals, acids.	i) Storage area should be well ventilated. ii) Containers should be closed tightly and keep in a cool place & Do not store in temp above 25°C (77°F).
7	Hydrochloric Acid	i) ***Health Effects***: It is very corrosive to the eyes, skin, and mucous membranes. Inhalation causes irritation to eyes, nose, and respiratory tract.	i) Avoid contact with skin and eyes. ii) Keep away from incompatibles such as oxidizing agents, organic materials, metals, alkalis, moisture.	i) Should be stored in a cool, dry, well-ventilated area away from sources of moisture. ii) Containers should be closed tightly.
8	Normal Butanol	i) ***Health Effects***: It can cause irritation to the eyes and possible eye damage. ii) Inhalation causes irritation to nose, throat & lungs causing coughing, wheezing & shortness of breath. iii) Exposure can cause headache, dizziness, nausea & vomiting. iv) It is a flammable liquid and react with oxidizing agents	i) Wear PPEs while handling. ii) Use explosion-proof electrical equipments and fittings while handling. iii) Do not use compressed air or oxygen for filling, discharging or handling.	i) Storage area should be cool, dry & well ventilated. ii) Should be stored away from sources of ignition such as smoking and open flames.
9	Sodium Bi Sulphite	i) ***Health Hazard:*** It is irritating to the eyes, skin, & mucous membranes. ii) Toxic and corrosive.	i) Avoid contact with skin and eyes. ii) Wear PPEs while handling. iii) Do not breathe dust or vapour.	i) Store in areas, away from heat and moisture. ii) Protect from physical damage. iii) Should be segregate from acids and oxidizers.
10	Hydrogen Peroxide	i) ***Health Effects***: Inhalation causes sore throat, cough. dizziness, headache.	i) Do not breathe gas/fumes/ vapor/spray ii) Never add water to this product.	v) Should be stored away from sources of ignition and

		nausea, shortness of breath. Corrosive to skin and eyes. cause abdominal distension, nausea & vomiting.	iii) Avoid contact with skin and eyes. iv) Do not ingest.	combustible materials. vi) Should stored in light resistant, closed containers & keep it away from heat. vii) Keep away from incompatibles such as oxidizing agents, reducing agents, combustible materials, organic materials, metals, acids, alkalis.
11	Hydrobromic acid	i) ***Health Effects***: Inhalation causes severe irritation of nose and upper respiratory tract, lung injury. Ingestion causes burns of mouth and stomach. Contact with eyes causes severe irritation and burns. Contact with skin causes irritation and burns. ii) Extremely corrosive in presence of steel, aluminum, of zinc. Highly corrosive in presence of copper.	i) Use PPEs while handling drums containing hydrobromic acid. ii) Avoid the use of metals which are attacked by hydrobromic acid.	i) Store in a metallic or coated fiberboard drum using a strong polyethylene inner package. ii) Keep it away from water sources.
12	Soda Ash	i) ***Health Effects***: Inhalation causes irritation to the respiratory tract and can cause burning pain in the nose and throat, coughing, wheezing and shortness of breath. Contact with skin can cause irritation, blisters and burns. ii) Toxic and explosive.	i) Avoid contact with skin and eyes. ii) Do not ingest and do not breathe. iii) Wear PPEs while handling.	i) Should be stored in weather tight storage area. ii) Do not store in temp above 24°C (75.2°F).

13	Dimethyl formamide	***Health Effects***: Irritant to Skin and eye contact. Inhalation causes Abdominal pain, Diarrhoe, Nausea& Vomiting.	i) Containers should be dry and locked & keep it away from sources of ignition. ii) Do not breathe gas/fumes/ vapor/spray. iii) Do not ingest. iv) Use PPEs while handling. v) Avoid contact with skin and eyes.	i) Keep container in cool, well ventilated area. ii) Keep away from sources of ignition. iii) Keep container tightly closed and sealed until ready for use.
14	Ammonium Bicarbonate	i) ***Health Effects***: Irritant to Skin and eye contact. ii) Breathing causes irritation to nose, throat and lungs causing coughing, wheezing and shortness of breath.	i) Avoid contact with skin and eyes. ii) Use proper equipment for lifting and transporting all containers. iii) Wash thoroughly after handling.	i) Store in a cool, dry and well-ventilated place. ii) Keep away from incompatibles. iii) Keep container tightly closed.
15	Ammonium Chloride	***Health Effects***: Inhalation causes cough, sore through Contact with skin and eyes causes redness and pain. Ingestion causes nausea, vomiting.	i) Avoid contact with skin and eyes. ii) Keep away from incompatibles such as oxidizing agents, acids, alkalis. iii) Do not breath dust.	i) Store in a cool, dry and well-ventilated place. ii) Keep container tightly closed.
16	Methyl Anthranilate	i) ***Health Effects***: Irritant to the skin. ii) Combustible.	i) Avoid contact with skin and eyes. ii) Do not breath and ingest.	v) Keep away from heat. & from sources of ignition. vi) Store in a cool, dry and well-ventilated place. vii) Keep container tightly closed.
17	Isatoic Anhydride	***Health Effects***: May cause an allergic skin reaction. Causes serious eye irritation.	i) Avoid contact with skin and eyes. ii) Avoid formation of dust and aerosols. iii) Provide appropriate exhaust ventilation at places where dust is formed.	i) Store in cool place. ii) Keep container tightly closed in a dry and well-ventilated place.

7.7 DISASTER MANAGEMENT PLAN

Objectives of Disaster Management Plan [DMP]

The Disaster Management Plan (DMP) is aimed to ensure safety of life, protection of environment, protection of installation, restoration of production and salvage operations in the same order of priorities. For effective implementation of the DMP, it should be widely circulated and personnel training through rehearsals/drills should be organized. Further, the management should be able to demonstrate that its assessment of the consequences as good supporting evidence. To tackle the consequences of a major emergency inside the factory or immediate vicinity of the factory, a DMP 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 causalities
- Safeguard other people
- Minimize damage to property and the environment
- Initially control and ultimately bring the incident under control
- Identify any casualties
- 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.

7.7.1 Onsite Emergency Plan

Salient Features of the Project and key personnel in formation and implementation of onsite emergency plan is listed in table 7.7.

Table No. 7.6: Salient Features of Project

Name of Project	M/s Ambernath Organics Pvt. Ltd.
Address (Plant)	Plot No : 21/2, Dhatav MIDC, Roha, Raigad, Mahrashtra.
Nature of the Project	Synthetic Organic Chemicals
Capacity	Products –5825 MT/A By Products – 710.16 MT/A
Man Power	105 Nos
Name of Director	Santosh R. Nandan
Key Persons in the Emergency Plan	EHS Officer
	Safety Officer
	Fire Officer

7.7.2 OBJECTIVES OF THE PLAN

On-Site emergency preparedness plan has the following objectives:

1. Safeguard lives and property at site and in its vicinity area.
2. Contain the incident and bring it under control;
3. Minimize damage to lives, property and environment;
4. Rescue and treat affected human beings;
5. To train the people to act efficiently and with confidence in an emergency.
6. Evacuate people to safe areas;
7. To minimize its occurrence.

7.7.2.1 Pre – Emergency Plans:

Pre – Emergency means the preparatory stage of the plan. It should be ensured that the prepared plan contains all required provisions and details of facility to handle and to contain the emergency situation successfully. The unit has to consider maximum and possible worst scenario for emergency purpose while planning. The unit has to develop and maintain the essential

facilities, so that the emergency can be controlled and the damages are minimized in the shortest period with proper use of all available resources.

The unit should be duly prepared and ready all the time to encounter any possible emergency, while it may strike or not. Being a Specialty Chemicals Manufacturing unit various type of chemicals are used possessing varied types of hazards and knowing the hazards of the chemical, stored, handled or processed in the factory, the quick response action must be created within unit.

The structure of the plan may vary depending on the number of employees, materials, process, and availability of recourses, location of site, size and complexity of the unit. It should ensure to work out a plan with possibilities of various emergencies with likely to arise within unit. Further the periodical rehearsal is also to be carried out to check and examine the effectiveness, awareness and preparedness of the plan as well as services. The emergency planning is not a substitute for good design, plant operating and maintenance practices. Therefore, the Onsite Emergency Action Plan must be followed to avoid emergency.

7.7.2.2 Periodic Checking Schedule-

To check availability, work ability and take necessary actions for replacement and maintenance, if required. Check resources of water. Keep all emergency and essential Telephone Nos. with contact persons, suppliers for the same handy. Contact details may be displayed on the boards installed at prominent locations in the plant and offices. Maintain the co- ordination with other fire – services. Also the Firefighting system and PPE should be checked if they are in working condition and proper maintenance should be done.

7.7.2.3Preventive Maintenance (To Avoid Emergency)

A scheduled periodical preventative maintenance and inspection of the plants, Reactors, centrifuges, equipment's, storage tanks, air compressors etc. are as per laid down procedures and check that records are maintained properly. Check the test, examination and certification have been carried out within reasonable period.

7.7.2.4Training

By imparting an effective training to the plant supervisors, inspectors, and education and training of the workers from time to time, the awareness is to be kept alive all the time to ensure safety awareness, preparedness for emergency situations, good housekeeping, discipline, etc. Display of safety slogans, operative instructions and motivation for safety should be made part of the company's normal activities. All the persons earmarked for the emergency services are to be trained to respond to the emergency. The company conducts internal & external training for Environment Health & safety. The training should be conducted at a documented frequency. The external training should be conducted six monthly and internal training is conducted every month.

7.7.2.5 Monitoring the Environment

Continuous and periodic monitoring of environment is required for detection of a possible damage or a risky situation arises.

7.7.2.6Mock Drill

Organize the periodical mock drill / rehearsal as per suggested format by creating an emergency situation so as to verify preparedness and awareness as well as shortcomings on the part of the person to overcome the same. Provide sufficient time prior to mock drill to the emergency services and public for proper response to exercise and provide training also. Record the deficiencies of the system during the trial and take appropriate actions to improve the efficiency of the plan in terms of preparedness and response.

7.7.2.7 Maintenance of Records

Keep the records of the monitoring conditions, safety systems, storage levels, process condition, etc. and maintain the log- books, registers etc. Keep the M.S.D.S. and onsite emergency plan with required details in a place from where they are readily available.

7.7.2.8 Emergency Control Room

The equipped Emergency Control Room should be in working order. The plant layout maps, drawing, storage details, Material safety Data Sheets (MSDS), emergency operations, manuals etc. should be kept and should be updated continuously. List of essential telephone Nos. is also maintained up to date. The senior and expert person should be posted as in charge of the control room.

7.7.2.9 Command & Control

The organization chart, for the emergency plan has been given which explains the chart of command, channel of information flow, and actions as required during the emergency. The single organizational structure has been created on striking emergency and the same shall be continued till the emergency over. The Shift Supervisor shall take the initial charge as incident controller; he will be coordinating with various agencies effectively to combat the situation. The security office room will be used as emergency control Room. The security gate will be used as Assembly point. The Factory Manager will act as site main controller for the unit. On arrival, he will supervise all activities with the help of asst. Plant in- charge.

7.7.2.10 Identification of Hazards

The type of hazards have been identified in the previous section accordingly and risk quantification is also been done for all hazardous raw materials.

7.7.3 Fire controlling measures in case of emergency situation:

In the plant premise different control measures shall be applied to control and extinguish fire in accidental situations. Following list details the availability of such measures available at different plant locations.

List of fire extinguishers provided

1. No. of fire extinguishers – 22 no.

2. Type of extinguishers – DCP/CO2

7.7.4 Fire Fighting Systems

Table No.7.7: Details of fire fighting system

Fire Fighting Tank Details	
Capacity of Fire Fighting tanks	200 KL
Type of tank Overhead/ Below head	Underground
Material of Construction	RCC
Pump Capacity of fire fighting tank	Main pump – 171 m^3/hr
No of assembly points	2 no. Gate – 2
Fire Hydrant system	Yes
No of fire hydrant points in the premises	20 no.

7.7.4.1 Water requirement for Fire Fighting and Back – up Time Calculation.

The amount of water required for firefighting purpose can be estimated by the below formula:

Water required in liters per minutes = (A + B +C + D)/20

A) The total area in sq.mtr of all Floors including galleries in all building of the Factory = 3754.0m^2

B) The total area in sq.mtr of all Floors and galleries including open spaces in which combustible materials=878m^2

C) The total area in sq.mtr of all Floors over 15 mtr above ground level = NA

D) The total area in sq.mtr of all floors of buildings other than those of fire resisting construction of various floors is so certified by any fire association or fire insurance company

= 3754+878+00+00

= 4632/20

=**232** liters water required per minute

- Fire Hydrant tank has been provided of the capacity : **200 m^3(2,00,000 L)**

The total firefighting tank capacity is 2,00,000 lit. The back-up water supply can be calculated as,

Time (min) = [Total water in fire fighting tank (l)]/water required, l/min

= 2,00,000/232

= **14.3 hours**

7.7.4.2 Justification considering pump capacity

The pump capacity in the plant is 171m^3/hr, therefore according to the discharge capacity of the pump installed. The back-up time by which the tank will be empty is calculated below,

Time (min) = [Total water in fire fighting tank (m^3)]/discharge capacity (m^3/hr)

= 200/171

= 1.17 Hours

Back-up time will be 1.17 Hrs

7.7.5 Flow Diagram showing Key Persons involved in Emergency Situation and their hierarchy.

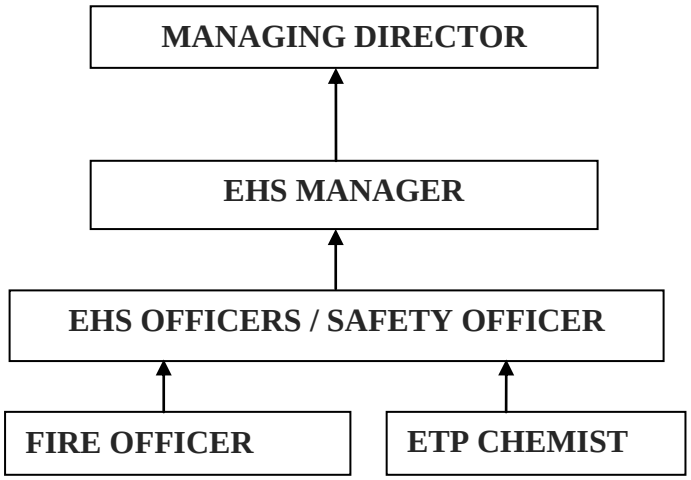

Figure No. 7.2: Schematic Representation of organizational structure of environment management

7.7.6 Emergency Responsibilities

The responsibilities of the key personnel are appended below.

Sr. Executive

- On knowing about emergency, rushes to ECC.
- Helps the Incident Controller in containment of the emergency.
- Ensures fire pumps in operating conditions and instructs pump house operator to be 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 firefighting 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 a search and evacuation team.
- Arranges for safety equipment for the members of this team.
- Decides which paths the evacuated workers should follow.
- Maintains law and order in the area and, if necessary, seeks the help of police.

EHS Manager - 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 Emergency Control Centre (ECC).
- Organizes medical treatment to the injured and, if necessary, arrange to shift the injured to nearby hospitals.
- Mobilizes extra medical help from outside, if necessary.
- Keeps a list of qualified first aiders of the factory and seeks 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 the emergency plan, organizing mock drills, verification of inventory of emergency facilities and furnishing report to Site Controller.
- Maintains liaison with Civil Administration.
- Ensures availability of canteen facilities and maintenance of rehabilitation centre.
- He will liaise with Site Controller/Incident Controller.
- Ensures transportation facility.
- Ensures availability of necessary cash for rescue/rehabilitation and emergency expenditure.

- Controls rehabilitation of affected areas on discontinuation of emergency.
- Makes available diesel/petrol for transport vehicles engaged in emergency operation.

7.7.9 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 to any prescribed duty as essential employee. If no such responsibility is assigned, he should adopt a safe course to assembly point and await instructions. He should not resort to spread panic. On the other hand, he must assist emergency personnel towards objectives of DMP.

7.7.10 Emergency Facilities

7.7.10.1 Emergency Control Centre (ECC)

M/s Ambernath Organics Pvt. Ltd. will establish an Emergency Control Centre. It will have external telephone, telefax and telex facility. All the Site Controller/ Incident Controller Officers, Senior Personnel would be located here. The following information and equipment will be provided at the Emergency Control Centre (ECC):

- Intercom, telephone
- P and T telephone
- Safe contained breathing apparatus
- Fire suit/gas tight goggles/gloves/helmets
- Hand tools, wind direction/velocities indicators
- Public address megaphone, hand bell, telephone directories
- (Internal, P and T) factory layout, site plan
- Emergency lamps/torch lights/batteries
- Plan indicating locations of hazard inventories, plant control room, sources of safety equipment, work road plan, assembly points, rescue location, vulnerable zones, and 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
- Addresses with telephone numbers of key personnel, emergency coordinator, and essential employees.
- Important addresses and telephone numbers including Government agencies, neighboring industries and sources of help, outside experts, chemical fact sheets, population details around the factory.

7.7.10.2 Assembly Point

Number of assemblies 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 earmarked as assembly points. Depending upon the location of hazard, the assembly points are to be used.

7.7.10.3 Emergency Power Supply

Plant facilities would be connected to Generator and would be placed in auto mode. Thus, water pumps, plant's lighting and emergency control centre, administrative building and other auxiliary services are connected to emergency power supply. In all the blocks, flameproof type emergency lamps would be provided**.**

7.7.10.4 Fire Fighting Facilities

First Aid and Firefighting equipment suitable for emergency are maintained well in each section in the plant. This would be developed according to the statutory requirements. However, fire hydrant line covering major areas has been laid. Fire alarms have been located in the bulk storage areas.

7.7.10.5 Location of Wind Sock

Windsocks exist in the plant.

7.7.10.6 Emergency Medical Facilities

Stretchers, gas masks and general first aid materials for dealing with chemical burns, fire burns etc. will be maintained in the medical centre as well as in the emergency control room. Private medical practitioners' help would 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 and 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 nearby industrial managements in this regard would be taken on mutual support basis.

7.7.11 Emergency Actions

7.7.11.1 Emergency Warning

Communication of emergency will be made familiar to the personnel inside the plant and people outside. An emergency warning system has already been established in the plant.

7.7.11.2 Emergency Shutdown

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

- Stop feed
- Dilute contents
- Remove heat
- Deluge with water
- 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 bypass arrangements.

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

7.7.11.3 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 and 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 maintains a copy of deployment of employees in each shift. If necessary, persons can be evacuated by rescue teams.

7.7.11.4 All Clear Signal

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

7.7.12 General parameters

7.7.12.1Employee 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 in emergency response.

7.7.12.2 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 (normally the Collector) for necessary dissemination to general public and for any use during an offsite emergency.

7.7.12.3 Co-ordination with Local Authorities

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

In the event of an emergency developing into an offsite 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.

7.8 Off-Site Emergency Preparedness Plan

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.

7.8.1 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 neighboring 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 either rest with the works management or, with the local authority. Either way, the plan should identify an emergency coordinating officer, who would take the overall command of the off-site activities. As with the on-site plan, an emergency control centre should be set up within which the emergency coordinating 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 indoor. 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:

- 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 For release or potential release of toxic materials, limited evacuation may be appropriate downwind 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, offers little or no protection

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

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

7.8.2.1 Organization

Details of command structure, warning systems, implementation procedures, emergency control centers. Names and appointments of incident controller, site main controller, their deputies and other key personnel.

7.8.2.2 Communications

Identification of personnel involved, communication centre, call signs, network, lists of telephone numbers.

7.8.2.3 Specialized knowledge

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

7.8.2.4 Voluntary organizations

Details of organizers, telephone numbers, resources etc.

7.8.2.5 Chemical information

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

7.8.2.6 Meteorological information

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

7.8.2.7 Humanitarian arrangements

Transport, evacuation centers, emergency feeding treatment of injured, First aid, ambulances, temporary mortuaries.

7.8.2.8 Public information

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

7.8.2.9 Assessment

Arrangements for: (a) collecting information on the causes of the emergency; (b) reviewing the efficiency and effectiveness of all aspects of the emergency plan.

7.8.2.10 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 liaise closely with the Site Controller. Again, depending on local arrangements, for very severe incidents with major or prolonged off-site consequences, the external control should be passed on to a senior local authority administrator or even an administrator appointed by the central or state government.

7.8.2.11 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 liase 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.

7.8.2.12 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 dead or injured.

7.8.2.13 Role of Fire Authorities

The control of a fire should normally be 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 on-site personnel.

7.8.2.14 Role of Health Authorities

Health authorities, including doctors, surgeons, hospitals, ambulances, and similar other persons/institutions 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. For major toxic releases, the effects vary according to the chemical in question, and the health authorities should be apprised about the likely toxic releases from the plant, which will enable them to deal with the aftermath of a toxic release with treatment appropriate to such casualties. Major off-site incidents are likely to require medical equipment and facilities inadditional to those available locally, and a medical "mutual aid" scheme shouldexist to enable the assistance of neighboring authorities to be obtained in theevent of an emergency.

7.8.2.15 Role of Government Safety Authority

This will be the factory inspectorate available in the region. Inspectors are likely to want 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 watch to a close involvement in advising on operations. While the industry will activate the DMP and take necessary alleviating measures and arrange to extend all medical and security support, the factory inspectorate may be the only external agency with equipment and resources to carry out appropriate tests to assess the impact.

7.8.3 External agencies contact details involved during emergency

Table No. 7.8: Details of external agencies to be involved during emergency

Sr No	Name of Hospital	Address	Telephone	Distances
1	Dr. Dhruv(Amrutaparicharini Hospital)	Varse village, Tal. Roha,Dist. Raigad.	02194-263218	4 km
2	Dr. Jadhav(Suman eye clinic)	Roha village, Tal. Roha, DistRagad	02194-233435	5 km
3	Jadhav Nursing Home	Roha village, Tal. Roha, DistRagad	02194-233232	5 km
Sr No	**Name of Police Station**	**Address**	**Telephone**	**Distances**
1	Dhatav Police Station	Dhatav village, Tal. Roha, Dist. Raigad	02194-263520	1 km
2	Roha Police Station	Roha village, Tal. Roha, DistRagad	02194-234933	6 km
Sr No	**Name of Fire Station**	**Address**	**Telephone**	**Distances**
1	Dhatav fire station	Dhatav village, Tal. Roha, Dist. Raigad	02194-263300 02194-263600	0.8 km
Sr No	**Name of MIDC**	**Address**	**Telephone**	**Distances**
1	Dhatav MIDC office	Office of the Deputy engineer, sub division-Dhatav, Dhatav village, Tal. Roha, Dist. Raigad	02194-263825	2 km
Sr No	**Name of Grampanchayat**	**Address**	**Telephone**	**Distances**
1	YashwantGrampanchayat, Dhtav	YashwantGrampanchayat, Dhtav village, Tal. Roha, Dist. Raigad	02194-263664	1.5 km
Sr No	**Name of PCD**	**Address**	**Telephone**	**Distances**
1	Maharashtra Pollution Control Board, Raigad	MPCB, Regional Office, RaigadBhavan, 6th floor, sector- 11, CBD Belapur, Navi Mumbai - 400614	27576031 Fax:- 2756-2132	Approx. 90 km

Sr No	Name of CETP	Address	Telephone	Distances
1	RIA CETP	RIA-CETP, C- Building, Plot No. 06, Tal. Roha, Dist. Raigad	02194-263599 Fax no- 02194-264594	0.8 km