Risk Assessment

The Environmental risks are inherent in operation of any industry, or any human activity for that matter. Any system failure can lead to disaster.

These Organic Chemicals manufacturing is a simple three step process, as seen earlier. However Risk is posed by (1) Dust in various operational steps and (2) Fuel, which here is in the form of CSW and coal.

Dust is generated in many steps from raw material handling, transfer, heating, cooling, transporting out and waste treatment. In order to reduce this risk, steps like capturing the same, conveying through ducts, and controlling by multi-cyclone are attempted. Conveying by smooth internal roads, watering the roads, regular and quick sweeping and monitoring the efforts, are the minimum actions to be taken.

Fuel used here is coal and spent wash. Fuel can give rise to one Risk, namely Fire. As full fire protection and extinguishing gadgets are provided, any risk from fuel stands automatically covered. All motors are kept TEFC (totally enclosed fan cooled). Temperature and Carbon Monoxide control is undertaken by arranging carbon dioxide correct percent. This minimizes the Risk to a very great extent.

Nodes:

1. Bagasse/Coal storage.
2. Molasses storage tank farm.
3. Ethanol storage tank farm.
4. Power plant.

Identified Hazardous Events (Having Risk Rating In 16 To 25 Range)

- Bagasse/ Coal fire at storage yard.
- Fire /explosion at Molasses tank farm.
- Ethyl Alcohol pool fire at tank farm.
- Ethyl Alcohol tank fire at tank farm.
- Fire /explosion at denaturant store.
- Release of Carbon di oxide from pipeline at fermenter area.
- Release of toxic gases formed due to residual sulfur in molasses.
- Compatibility / reactivity hazard at store.
- Sulfur fire followed by release of sulfur oxides.
- Diesel fuel spill followed by fire.
- Release of toxic gases at cooling water treatment chemical such as chlorine.
- Hydrochloric acid spill and release of toxic gases.
- Boiler explosion.

Study is undertaken for emergency measures and Risk assessment for storage and handling of alcohol and mitigation measure due to fire and explosion including foam system to concerned handling areas.

Mitigation Measures Proposed:

1. Portable fire extinguishers.
2. Fire hydrant system.

3. Leak Detection Alarm system and Manual call point.
4. Smoke Detector & Alarm system.
5. Fire tender, Ambulance and regular exercises involving plant operators.
6. Provide and monitor electronic systems to provide early detection of changes in bagasse stockpile temperatures.
7. Provide arrangement at road tanker hard stand to ensure any accidental spill is routed to safe place.
8. Storage of chemicals considering reactivity/ compatibility hazards at store.
9. Fire water catchment pit.
10. Restrict the entry of untrained/ unauthorized persons in the vulnerable zone at tank farm. In case of pool fire avoid the road close to tank farm as escape route for persons working at ETP.
11. Flameproof electrical at tank farm.
12. Ensure molasses storage tank vented and avoid storage temperature above 40°C.

The key personnel would undergo special courses on Emergency, Disaster management & Occupational Health. This may preferably be in-plant training. The Managers, Senior Officers & involved staff would undergo a course on the use of personal protective equipment also. In addition, special courses will be designed team-wise. In such training, outside government agencies also will be invited to be familiar with the plant layout.

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Stocking at work place, loading and maintenance of floor area:

- The raw materials are to be placed very near to the feeding point.
- Housekeeping is most important of all dust control methods.
- Simply cleaning of all possible emission sources as quickly as possible.

Work Environment:

Dust and Heat free work environment is maintained in view of workers' safety, Health and Hygiene. The efforts taken in this respect are:

Table 59: Work Environment Care.

#	**Source**	**Attenuation by**
1.	Scrap Yard	Avoided by adopting smooth roads and yard.
2.	Plant	Avoided by adopting good foundation, good alignment, well lubricated.
3.	Generators	Fitted enclosure and tall stack
4.	Vibrations	Proper sturdy foundation provided for all the machines and equipments to avoid fugitive escapes.
5	fumes	Closed, covered and carried through ducts

Disaster Management Plan:

Objectives

- To localise the emergency

- To minimise the consequences
- To ensure that following concepts are considered, namely rescue, first aid, evacuation, rehabilitation, spreading the information

Elements of On-Site Plan:

- Assess the size of event
- Plan formulation and liaison
- Action like: Raise alarm, communication within and outside
- Appoint key personnel and deploy. Appoint Controller.
- Emergency Control Center
- Action on site
- Action off-site.
- Alarm and visual signals at strategic point, first alert sent to Incidence Controller.

Organization

The hierarchy of the Disaster Management Cell is given below in Fig.--. Chief Disaster Controller (equivalent to General Manager) shall keep vigilance on any disaster and shall report directly to Managing Director. He will be helped by heads of five different sub-cells.

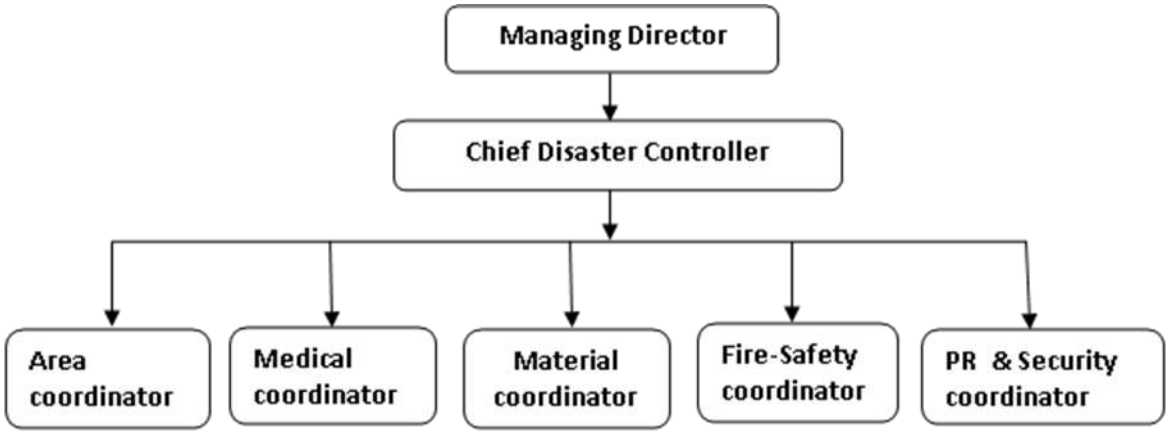

Fig: Disaster Management Cell

Duty Allocation

Chief Disaster Controller (General Manager)

- Take control and declare emergency
- Be there
- Contact Authorities and Managing Director

1 Area Coordinator

- Take steps. Make Emergency shut-down of activities. Put everything in Safe condition.
- Evacuate.
- Commence initial fire-fighting, till Fire Department comes to take up.
- Identify materials requirements and call Material Manager.

2. Medical Coordinator

- Establish Emergency Center. Treat people, Transfer – Remove patients.
- Assign Deploy staff
- Arrange medical supplies
- Summon outside help

3. Material Coordinator:

- *Dispatch necessary supplies*
- *Arrange purchases*

4. **Fire-Safety Coordinator:**

- Be Overall in-charge for Fire and Safety.
- Coordinate with Area Coordinator and Direct the Operations
- Coordinate with City and Other Fire-tenderers.

5. PR & Security Coordinator

- Remove Crowd
- Arrange Gate security
- Contact Police
- Arrange evacuation
- Contact outside Agencies if asked.
- Handle news media
- Mobilise vehicles
- Arrange Food, clothing to Officers inside.

To help these officers, Emergency Control Center shall be equipped with:

- Intercom, telephone;
- P & T telephone;
- Self contained breathing apparatus;
- Fire suit/gas tight goggles/gloves/helmets;
- Hand tools, wind direction/velocities indications;
- Public address megaphone, hand bell, telephone directories;
- (internal, P&T) factory layout, site plan;
- Emergency lamp/torch light/batteries;
- Plan indicating locations of hazard inventories, plant control room, sources of safety equipment, work road plan, assembly points, rescue location vulnerable zones, escape routes;
- Hazard chart;
- Emergency shut-down procedures;
- Nominal roll of employees;
- List of key personnel, list of essential employees, list of emergency coordinators;
- Duties of key personnel;

- Address with telephone numbers and key personnel, emergency coordinator,
- essential employees; and
- Important address and telephone numbers including government agencies, neighboring industries and sources of help, outside experts, chemical factsheets, population details around the factory.

After the disaster ends, Post Disaster Analysis shall be done by Disaster Management Cell and report shall be submitted to Managing Director. The report shall include:

- Why happened
- How to avoid in future
- Whether on-site operations failed? In what respect?
- How to avoid such failure in future
- Report to be submitted in detail to Authorities
- Compensation arrangements if any, commenced?
- Call suggestions on shortfalls observed.
- Give rewards openly, pull defaulters individually

Hazard Analysis

Preliminary Hazard analysis is used to identify typical and often relatively apparent risk sources and damage events in a system. A characteristic of Alcohol is a clear, colorless and flammable liquid. It has the boiling point of 78^0 C, ignition point of 363 ^{0}C and explosive limits of 3.3 % - 19.0 % by volume. It is listed as hazardous substance by ACGIH, DOT, NFPA, MSIHC Rules and NIOSH and is regulated by OSHA.

It is important to control or eliminate all potential ignition sources in areas that might lead to ignition of vapour. The potential sources of ignition are: Open flames, Electrical wiring / devices, Smoking, Heat sources / hot surfaces, Welding and cutting, Friction, Sparks and Arcs, Static sparks, Gas Compression. Following are the precautions that will be taken to minimize the probability of ignition:

- Electrical equipment and wiring should be suitable for the hazard.
- If a heating operation is necessary, use only indirect heating methods.
- Do not allow any open flames.
- Provide grounding and bonding for all equipment handling using these liquids.
- Maintenance program will be established to assure that all equipment and safety controls are functioning satisfactorily.

a) Characteristics of Ethanol

Rectified spirit (RS), Absolute Alcohol and Extra Neutral Alcohol (ENA) are basically ethanol of different grades and have the same hazard characteristics. Hence, all these products are considered as ethanol in hazard analysis. Ethanol is a clear, colorless and flammable liquid. It has the boiling point of 78^0 C, ignition point of 363 ^{0}C and explosive limits of 3.3 % - 19.0 % by volume. It is listed as hazardous substance by ACGIH, DOT, NFPA and NIOSH and is regulated by OSHA. The characteristics of ethanol are given below.

Properties of Ethanol

Physical State	Liquid
Appearance	Clear
Color	Colorless
Physical Form	Volatile Liquid
Odour	Alcohol odour
Taste	Burning taste
Molecular Weight	46.07
Molecular Formula	C_2H_5OH
Boiling Point	172^0F (78^0 C)
Freezing point	-179^0F (-117^0C)
Vapor Pressure	40 mm Hg @ 19 C
Vapor Density	1.59
Specific Gravity	0.789
Water Solubility	Soluble
Volatility	100 %
Odour Threshold	5 – 10 ppm
Viscosity	1.22 – 1.41 cp @ 20^0C
Solvent Solubility	Benzene, ether, acetone, chloroform, methanol, organic solvents

Hazard Rating of Alcohol is based on flammability, reactivity and toxicity as given in National Fire Protection Association codes 49 and 345 M as

CHEMICAL	**NH (Health Factor)**	**NF (Fire Factor)**	**NR (Reactivity)**
Ethanol	2	3	0

(Least-0, Slight-1, Moderate-2, High-3, Extreme-4)

Based on Manufacture, Storage and Import of Hazardous Chemical Rules, GOI Rules 1989, we find applicability of GOI Rules 1989 to the notified threshold quantities, analysis of products and quantities of storage in the plant has been carried out.

Product	**Listed In Schedule**	**Total Quantity**	**Threshold Quantity**		**Applicable Rule**
			Rules 5,7-9 and 13-15	**Rule 10-12**	
Ethanol	1 (2)	>1000 T	1000 t	50000 t	Rule 5, 7-9 and 13-15

Based on the above, it is noted that alcohol produced and stored in the plant attract the rules of GOI 1989.
Degree of Hazard based on Fire explosion and Toxicity indices for the storages:

Section	**Fire Explosion**	**Toxicity**
Ethanol	Intermediate	Light

Thus, the following minimum preventive and protective measures are recommended.

Preventive and Protective measures

Features	FE & I Rating	
	Light	**Intermediate**
Fire Proofing	2	3
Water Spray Directional	2	3
Curtain Special Instr.	1	2
Flow Control	2	4
Blow down-spill	1	3
Internal Explosion	2	3
Combustible gas Monitors	1	3
Remote Operation	1	2
Dyking	4	4
Blast and Barrier wall separation	1	3

(1= optional, 2= suggested, 3= recommended, and 4= required)

Maximum Credible Accident Analysis (MCA Analysis) is one of methodologies evolved to identify worst credible accident with maximum damage distance which is still believed to be probable.

The probable fire hazard in the plant is in the area of ethanol and is due to storage and handling. It is proposed to store about 60 day's production of both the products within a common dyke of 40x55 m. As a worst case it is assumed that the entire contents are leaked out. In the event of spilling its contents through a small leakage or due to rupture of the pipeline connecting the tank and on ignition fire will eventually forming pool of fire. In order to assess the radiation levels, Heat Radiation model has been used the algorithm of the models is based on the formulae published in the yellow book by the TNO, Netherlands.

Alcohol Storage is as Day receiver, IS Receiver, Fusel alcohol, Bulk receiver, IS Bulk Storage and DN Spirit, as totally 10 tanks.

With a dike area as 40 x 55 m, the results are computed for Pool Fire Scenarios and Distances and accordingly fire protection is designed.

Site Specific Consequences: In order to assess the site-specific consequences, information pertaining to the site such as nearest habitation, nearest industry etc was collected. The nearest village to the plant site is Kundal village with a population of about 3000 located in the vicinity. **Consequences of Heat Radiation** is also seen**.** As the project is located for away from any human habitation and surrounded by dry lands & hillocks with scrubs the offsite damage to the general public and property is negligible.

A] Heat Radiation

As a worst case, it is assumed that the entire contents are leaked out & on ignition; fire will eventually form a pool of fire. The resultant radiation has to be assessed of the pool fire.

The heat load on objects outside the burning pool of liquid can be calculated with the heat radiation model. This model uses an 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 influences by the following factors:

a) Distance from the fire

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

b) Visualization and Simulation of Maximum Accidental Scenarios

The worst case scenario which is considered for MCA analysis is Pool fire due to failure of storage of ethanol storage tanks in the farm area. The proposed industry will provide 15 days storage of the final product within the plant premises. The following table provides the storage details of ethanol and Rectified spirit.

Alcohol Storage Details

NO	DESCRIPTION	SPECIFICATIONS
1.	RS Daily Receivers	Type: Vertical/Cylindrical Capacity: 85 m3 Quantity: 3 No's.
2.	Ethanol Daily Receivers	Type: Vertical/Cylindrical Capacity: 85 m3 Quantity: 3 No's
3.	ENA Daily Receiver	Type: Vertical/Cylindrical Capacity: 85 m3 Quantity: 3 No's
4.	Impure Spirit Daily Receivers	Type: Vertical cylindrical Capacity: 10 m3 Quantity: 3 No's
5.	Impure Spirit Bulk Storage Tank	Type: Vertical cylindrical Capacity: 300 m3 Quantity: 1 No
6.	Fusel Oil Tank	Type: Vertical cylindrical Capacity: 10 m3 Quantity: 1 No
7.	Bulk Ethanol Storage Tank	Type: Vertical cylindrical Capacity: 700 m3 Quantity: 3 No's
8.	Bulk RS Storage Tank	Type: Vertical cylindrical Capacity: 700 m3 Quantity: 3 No's
9.	Bulk ENA Storage Tank	Type: Vertical cylindrical Capacity: 700 m3 Quantity: 3 No's

(*) This is with existing sugar unit. Along with these tanks, we will also provide storage facility for RS, ENA, AA, IS Receiver tanks, Fusel Oil, Denatured spirit and RS Feed Tank.

As a worst case it is assumed that the entire contents are leaked out. In the event of spilling its contents through a small leakage or due to rupture of the pipeline connecting the tank and on ignition fire will eventuate forming pool fire. As the tanks are provided within the dyke the fire will be confined within the dyke wall.

Fires affect surroundings primarily through radiated heat, which is emitted. If the level of heat radiation is sufficiently high, other objects, which are inflammable, can be ignited. In addition, any living organism may be burned by heat radiation. The damage caused by heat radiation can be calculated from the dose of radiation received, a measure of dose is the energy per unit area of surface exposed to radiation over the duration of exposure.

B] Effect of Pool Fire

Pool fire may result when bulk storage tanks will leak/burst, and the material released is ignited. As these tanks are provided with dyke walls to contain the leak and avoid spreading of flammable material, the pool fire will be confined to the dyke area only. However, the effects of radiation may be felt to larger area depending upon the size of the plant and quantity of material involved.

Thermal radiation due to pool fire may cause various degrees of burns of human bodies.

More ever, their effects on objects like piping, equipment are severe depending upon the intensity. The heat radiation intensities due to the pool fire of the above tank farms are computed using the pool fire model.