RISK ASSESSMENT REPORT

Gujarat Dyestuff Industries (Pharma Unit)

PLOT NO. 133/4, 133/5, 133/6, GIDC NANDESARI, NANDESARI, AND
DIST: VADODARA-391340

Prepared By :

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PREFACE

The Risk Assessment is prepared on the basis of information and details provided by M/s. GUJARAT DYESTUFF INDUSTRIES (PHARMA UNIT), Plot No. 133/4, 133/5, 133/6, GIDC Nandesari, Nandesari, and DIST: Vadodara-391340 to HELPS during their course of the study. The assessment has been formulated by team of qualified, experienced and competent persons.

The industrial emergency / disaster resulting from the accidental release of huge quantity of volatile substances having toxic, flammable or explosive chemical properties are not new to the chemical units. Therefore, the process of the chemical industries have been continuously updating and developing its design and operating techniques to overcome such problems. Further, a technique known as “Risk Assessment” has been developed to assess the risk associated in the handling the plants, storage areas and its consequences on human environment etc, if involves either due to fire, explosion or toxic gas release.

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Vadodara

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CHAPTER 1 OBJECTIVES

1.1 INTRODUCTION

Chemical Process industries have undergone tremendous changes during the last five decades. Process Conditions such as Pressure & Temperature have become severe, concentration of stored energy has increased. Plants have grown in size and are often single stream. The Scale of possible Fire, Explosion, Toxic Release, Body Injuries, and Occupational Diseases has grown considerably. These Factors have greatly increased the risk for major industrial disasters, involving loss of human lives, plant & property and environmental degradation.

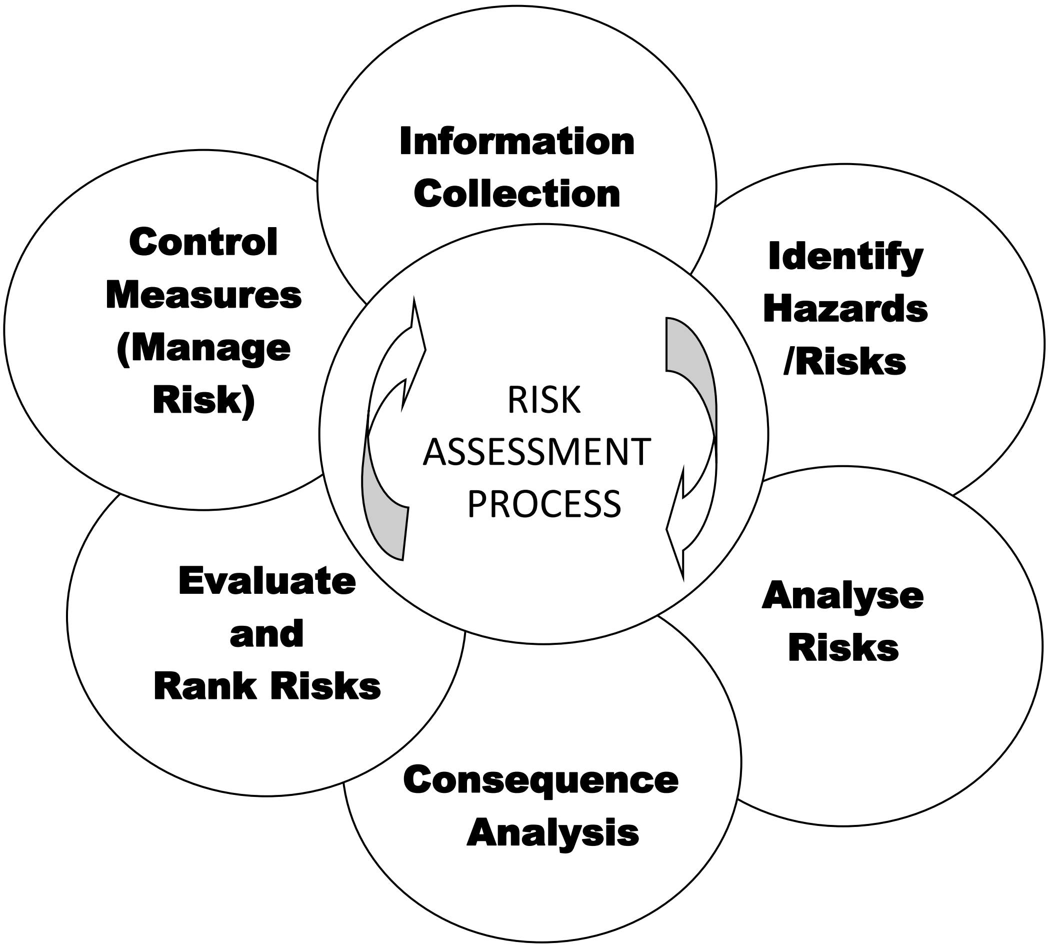
1.2 OBJECTIVES

The overall objectives considered for Risk Assessment study are as follows:

- To identify various hazards in the storage and associated area of the unit.
- Assessing the various risks involved
- To consider the consequential impact on nearby areas, population, etc. in case of any accidental emergency situation arising from the factory premises.
- To evaluate and quantify the available measures and resources for containing any eventuality.
- To study and suggest safety and control measure.

1.3 METHODOLOGY

The Risk Assessment as presented in the report is prepared based on the Maximum Credible Accident Scenario (MCA) for critical areas where potential of risks are higher. The various models are used to quantifying the loss of containment scenario by estimating discharge rate, the total quantity released, duration, extent of flash and evaporation etc. Methodology of QRA at a glance given below ;



Sequence of Risk Assessment is given below

1. Gather required information and documents
2. List out hazardous inventories and storage tank/ vessels details
3. Define the failure scenarios and identify probable hazards associated with them
4. Define parameters for each of the chemicals and each of hazards.
5. Define release type (continuous/ instantaneous) and determine release rates.
6. Simulate selected cases for consequence of failure scenarios.
7. Summarize the consequences.
8. Superimpose vulnerable zones on the plot plan.
9. Appraise the extent of damage to plant and personnel.

10. Recommendation additional control measures/ remedial measured required

1.4 Study are under this qra

This Quantitative Risk Assessment is carried out for Butanol Tank and Ethylene Oxide Day tank at the premise.

1.5 Software used

Phast Lite software version 7.1 from DNV GL is used for Consequence Analysis during this Risk Assessment.

Phast is the world's most comprehensive process industry hazard analysis software tool for all stages of design and operation. Phast examines the progress of a potential incident from the initial release to far-field dispersion including modelling of pool spreading and evaporation, and flammable and toxic effects.

Phast Lite is a user-friendly and powerful software tool with extensive modelling capabilities for hazard analysis, examining the progress of a potential incident from the initial release to far-field dispersion. At its core lies the extensively validated and verified UDM (Unified Dispersion Model) that enables rigorous modelling of various release types (jet, heavy and passive gas).

1.6 References

Some of the references which were used for QRA are illustrated as under;

1. The Factories Act 1948 (1987) and Gujarat Factories Rules – 1963 (2004)
2. Manufacture, Storage & Import of Hazardous Chemicals Rules 1989 (2000)
3. Environmental (Protection) Act – 1986 (2004)

4. World Bank Technical papers “Techniques for assessing Industrial Hazards – A Manual”.
5. Methods for calculation of Physical effects (Yellow Book) by TNO
6. The Guidelines for Chemical Process Quantitative Risk Analysis, Second Edition by CCPS
7. DNV Phast Software Manual

CHAPTER 2 PROFILE OF THE UNIT

2.1 INTRODUCTION

M/s. Gujarat Dyestuff Industries (Pharma Unit). located at Plot No. 133/4, 133/5, 133/6, GIDC Nandesari, Dist: Vadodara-391340.

This is an existing unit into manufacturing of Bulk Drugs such as Cifixime Trihydrate, Cefuroxime Axetil, Cefpodoxime Proxetil, Ampicilin, Amoxicillin Trydrydate, Clobetasole Propionate, Betamethasone Dipropionate, Betamethasone Valerate, Betamethasone Sodium Phosphate, Dexamethasone Sodium Phosphate, Beclomethasone Dipropionate, Mometasone Furoate, Methylcobalamine, Ofloxacin, Levofloxacin, Quinon Sulphate, Cloxacillin Sodium, Oxacillin Sodium, Di Cloxacillin Sodium, Flucoxacillin Sodium.

New products Ethoxylates, Metformin Hydrochloride, and additional Methylcobalamine that falls in Schedule 5(f) are planned to be manufactured and hence the application for EC is being done.

RLG Group began its journey in 1974, when the company was established and formed by Sh. Ram Lal Goyal as a Plasticizer manufacturing company. Today, the company has grown into a large & dynamic business house, which currently occupies a leading position in the field of Chemical Manufacturing, Pharmaceutical’s Manufacturing, Power Plant, Marketing & Exports in the Domestic as well as the International Market. The corporation also includes hard work & dedication by Mr. Raman Goyal, and Mr. Rahul Goyal.

As a global manufacturer of pharmaceuticals, chemicals & power the vision and leadership of those at the helm is critical to success. The team of approx 800 people (as counted in the year 2015), comprises of skilled and experienced professionals, who are technically sound and enterprising. Foreseeing the standards that would be expected for manufacturing of world class quality, they implement the same ahead of time. It is because of this focused dedication and hard work that RLG had accounted total revenue of 60 Million Dollars in the year 2014-15.

The team in the organization has been carefully handpicked to provide right mix of diverse skills that complement each other. Under the guidance of RLG' management, the technical team and support personnel have achieved exceptional levels of productivity and success in product development, quality control, quality assurance and all aspects of business and operations.

The Corporate Headquarters at New Delhi, India, houses capable staff that is thoroughly dedicated in understanding the requirements of RLG's partners and provides realistic customer solutions. With this balanced mix of young dynamism and experienced perspective, the company has unfurled its flag across the globe and is doggedly stepping into new territories, widening the customer across the globe.

Over a period of years, RLG has grown as a company and achieved greater heights. Today, the business has 9 state-of-the-art manufacturing facilities which includes chemical manufacturing units for production of Acetic Anhydride, Monochloro Acetic Acid, Acetanilide Flakes, Power Alcohol, Aniline Oil, and Nitro Benzene.

The group has around 50% market share of total production of Acetic Anhydride in India and is one of the top 10 manufacturers of Acetanilide Flakes in the world.

The group has a combined Cycle Power Plant of 225 MW at Kashipur is the 1st Gas Based power Plant of Uttrakhandand is one of the leading power supplier to Uttrakhand government, the power plant cost about Rs. 850.00 cr.

2.2 Location and layout of unit

The Unit is located at Plot No. 133/4, 133/5, 133/6, GIDC Nandesari, Nandesari, and DIST: Vadodara-391340. National Highway No. 8 is located about 8 Km and Vadodara City is about 16 KM away from the Unit.

Nearest village is Nandesari, which is about 1 Km from unit. Nearest Railway station is also Nandesari, However Vadodara is nearest main railway station. Mumbai- Ahmedabad broad gauge Railway line is passing at North-East side of the Unit.

The land occupied by Unit is irregular shape.

The surroundings of the unit are described as below;

- *North Side* : *GIDC Units like Alcatraz Chemicals, etc. and Open Land*
- *South Side* : *Main Entry of Unit and GIDC Road*
- *East Side* : *Open Land*
- *West Side* : *Panoli Intermediate*

The Location Plan of the Unit is given at Annexure – 1.

2.3 LAY OUT

The unit is working factory and having various departments / sections. The Plot Area of Factory is irregular shape & having total area of 40515 sq. mtr approx. GIDC road is passing at South Side of the unit. The main entrance gate is in South Side and another gate is in North side also.

The Layout Plan is given at Annexure-2.

2.4 Manufacturing Process - Proposed Products

The process description of proposed products are given below ;.

2.4.1 POLY ETHYLENE GLYCOL

Charge Di Ethelene Glycol in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$HOCH_2OH + n(CH_2CH_2O) \longrightarrow HO(CH_2CH_2O)_{n+1}H$

Where n: Average no of Oxyethylene group

2.4.2 HYDROGENATED CASTOR OIL ETHOXYLATE

Charge Hydrogenated Castor Oil in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{57}H_{110}O_9 + n(CH_2CH_2O) \longrightarrow C_{57}H_{110}O_9(CH_2CH_2O)_nH$

Where n: No of moles of ethylene oxide

2.4.3 CASTOR OIL ETHOXYLATE

Charge Castor Oil in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{57}H_{104}O_9 + n(CH_2CH_2O) \longrightarrow C_{57}H_{103}O_9(CH_2CH_2O)_nH$

Where n: No of moles of ethylene oxide

2.4.4 NONYL PHENOL ETHOXYLATES

Charge Nonyl Phenol in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{15}H_{24}O + nC_2H_4O \longrightarrow C_9H_{19}C_6H_4(OCH_2)_nOH$

Where n: No of moles of ethylene oxide

2.4.5 OCTYL PHENOL ETHOXYLATES

Charge Octyl Phenol in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{12}H_{22}O + nC_2H_4O \longrightarrow C_9H_{19}C_5H_2(OCH_2CH_2)n\ OH$

Where n: No of moles of ethylene oxide

2.4.6 CARD PHENOL ETHOXYLATES

Charge Card Phenol in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{21}H_{30}O + n(CH_2CH_2O) \longrightarrow C_9H_{19}C_{12}H_{10}(CH_2CH_2O)_nOH$

Where n: No of moles of ethylene oxide.

2.4.7 STYRUNATED PHENOL ETHOXYLATES

Charge Styrunated Phenol in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{30}H_{30}O + n(CH_2CH_2O) \longrightarrow C_9H_{19}C_{21}H_{10}(CH_2CH_2O)_nOH$

Where n: No of moles of ethylene oxide

2.4.8 LAURYL ALCOHOL ETHOXYLATES

Charge Lauryl Alcohol in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{12}H_{26}O + n(CH_2CH_2O) \longrightarrow C_{12}H_{25}(OCH_2CH_2)_NOH$

Where n: No of moles of ethylene oxide

2.4.9 TRIDECYL ALCOHOL ETHOXYLATES

Charge Tridecyl Alcohol in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{13}H_{28}O + n(CH_2CH_2O) \longrightarrow C_{13}H_{27}(CH_2CH_2O)_nOH$

Where n: No of moles of ethylene oxide

2.4.10 CESTOSTYRYL ALCOHOL ETHOXYLATES

Charge Cetostyryl Alcohol in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction:

$C_{18}H_{38}O + n(CH_2CH_2O) \longrightarrow C_{18}H_{37}(CH_2CH_2O)_nOH$

Where n: No of moles of ethylene oxide

2.4.11 TALLOW AMINE ETHOXYLATES

Charge Tallow Amine in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction

$C_{18}H_{32}N + n(CH_2CH_2O) \longrightarrow C_{18}H_{30}(C_2H_4O)_nNH_2$

Where n: No of moles of ethylene oxide

2.4.12 STEARYL AMINE ETHOXYLATES

Charge Stearyl Amine in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction

$C_{18}H_{39}N + n(CH_2CH_2O) \longrightarrow C_{18}H_{37}(CH_2CH_2O)_nNH_2$

Where n: No of moles of ethylene oxide

2.4.13 COCO AMINE ETHOXYLATES

Charge Coco Amine in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction

$R\text{-}NH_2 + n(C_2H_4O) \longrightarrow R(C_2H_4O)_nNH_2$

Where n: No of moles of ethylene oxide

R: alkyl mainly C12-18

2.4.14 OLEYL AMINE ETHOXYLATES

Charge Oleyl Amine in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction

$C_{18}H_{37}N + n(CH_2CH_2O) \longrightarrow C_{18}H_{35}(CH_2CH_2O)_nNH_2$

Where n: No of moles of ethylene oxide

2.4.15 POLY SORBATE ETHOXYLATES

Charge Sorbitian Mono Laurate in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction

$C_{18}H_{34}O_6 + n(C_2H_4O) \longrightarrow C_{18}H_{34}O_6(C_2H_4O)_n$

Where n: No of moles of ethylene oxide

2.4.16 STREARIC ACID ETHOXYLATES

Charge Stearic Acid in reactor. Add caustic potash flakes as a catalyst and start heating for 125 degree C achieve. Simultaneously in vacuum condition purge nitrogen. After that add Ethylene Oxide in reactor as per mole calculation. And leave reactor for stirring for one hour. For temperature reduction up to 50 degree C apply cooling water.

Chemical Reaction

$R\text{-}COOH + n(C_2H_4O) \rightarrow RCOO(C_2H_4O)_nH$

Where n: No of moles of ethylene oxide
R: alkyl Fatty chain

2.4.17 METFORMIN HYDROCHLORIDE:

Take pipe for charging n-butanol 300ml in clean and dry vessel under nitrogen atmosphere at 25-35°C for 10 minutes. After charging of n-Butanol, Charge the Dicyandiamide (DCDA) 0.5075 MT in reaction vessel then charge Di methyl amine Hydrochloride (DMA.HCL) 0.4974 MT and start stirring for 10 min continuously. Raise the temperature up to 80°C to 100°C and maintain that temperature for 60 min and check for clear solution physically. Transfer the mass through membrane filter to crystallizer up to 60 min then raise the temperature up to 100° C to 118°C for 30 min. Maintain the reaction mass & collect water azeotrpically after 120 min. Check moisture content till it become <0.5 % after 240 min. Maintain the reaction under pressure (approx 2 kg) & slowly raise the temperature up to 132°C to136° C for 1200 min. Slowly cool the temperature of reaction mass for 120 min. Further cool the temperature up to 20° C -25° C of reaction mass up to 90 min. Maintain the reaction mass with same temperature for 60 min. Centrifuge the wet cake & slurry wash with n-butanol 200 ml up to 30 min. Spin the cake for 30 min. Again slurry wash the wet cake with n-butanol 200 ml up to 30 min. Unload the wet cake and Spin the cake. Dry the solid in oven till LOD became NMT 0.5 % in 70° C - 80° C for 360 min. Unload the solid & submit the sample for complete analysis.

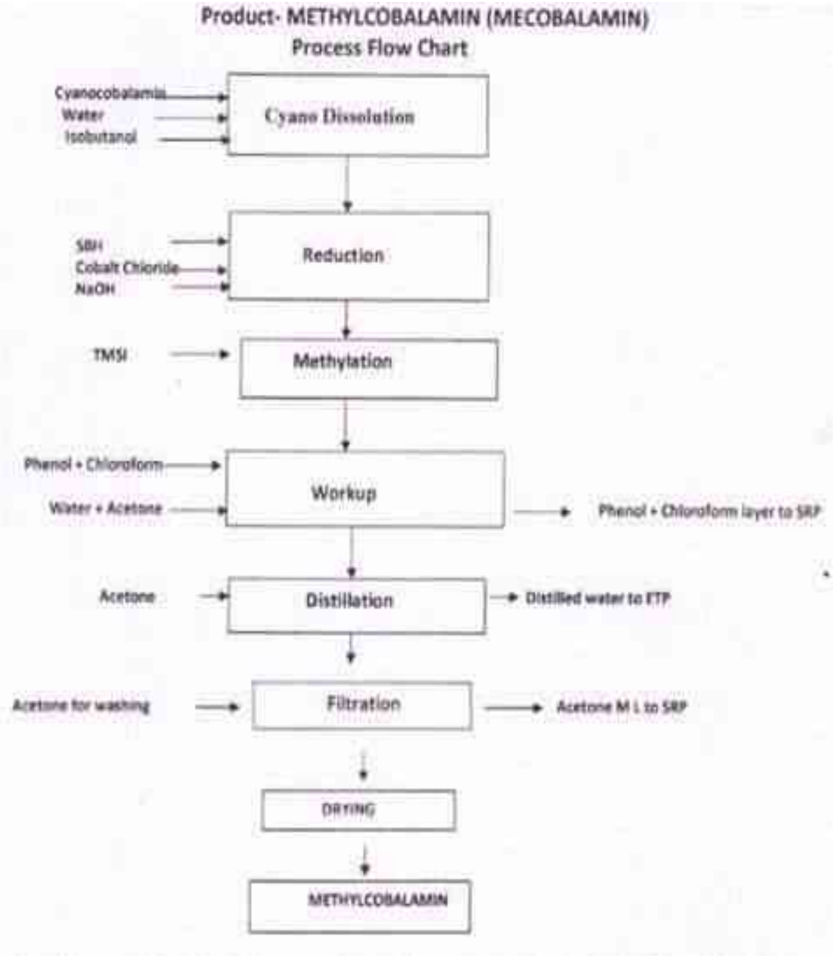
Chemical Reaction

$C_2H_4N_4$	+	C_2H_8NCl	$\longrightarrow$	$C_4H_{12}N_5Cl$
Dicyandiamide		Dimethyl amine Hydrochloride		Metformin Hydrochloride

2.4.18 METHYLCOBALAMIN

Cyanocobalamin is charged in GLR with process water and allow to stir. Add cobalt chloride and isobutanol and cool. Add Sodiumboro hydrate for reduction of Cyanocobalamin. After reduction add trimethyl sulfoxonium Iodide for methylation of reduction mass. Give Phenol and Chloroform washing and finally distill out water from mass and get Methylcobalamin production in acetone. Filter the acetone and dry.

2.4.19 Process Flow Chart:



2.5 STORAGE details

The proposed storage details are given below;

Sr. No.	Chemical	Capacity	MOC	Atmospheric Parameters	Hazard
1.	n-butanol	20 MT	SS Tank	ATP	Fire
2.	Di Ethelene Glycol	25 MT	SS Tank	ATP	Fire
3.	Castor Oil	25 MT	SS Tank	ATP	Fire
4.	Lauryl Alcohol	25 MT	SS Tank	ATP	Fire
5.	Tridecyl Alcohol	25 MT	SS Tank	ATP	Fire
6.	Ethylene Oxide	3.5 MT	SS Day Tank	4-5Kg/cm2	Fire Explosion

2.6 Storage Tank Safety

Company will adopt following safety measures in tank storage ;

Type of Possible Hazard	Safety measures
Leakage, Spillage, Fire, Explosion, Toxic release	• Appropriate MOC storage tank will be provided as per IS code. • Dyke wall will be provided to storage tank. • Level transmitter will be provided with low level high level auto cut-off provision. • Vent will be connected with flame arrestor. • Fire hydrant monitor with foam attachment facility will be provided. • Dumping / Drain vessel/alternate vessel will be provided to collect dyke wall spillage material. • FLP type pump will be provided. • Nitrogen blanketing will be provided to storage tank. • Double static earthing will be provided to • storage tank. • Jumper clip will be provided to all Solvent handling pipeline flanges.

2.7 Safety Measures will be PROVIDED For Ethylene Oxide day storage tank

1. Storage will be provided as per SMPV Rule requirements.
2. Excess flow check valve will be provided on EO tank inlet/outlet

nozzles.

3. Inlet /out let line of EO tank will be insulated.
4. FLP type equipment will be used in this area.
5. PPE’s will be made compulsory for handling of EO.
6. Double Safety valve will be provided on EO Tank.
7. Level indicator will be provided at local as well as on DCS
8. Safety valve outlet will be deep in water scrubber tank.
9. Safety Valve testing will be done at regular interval.
10. Jumpers will be provided on EO line.
11. Lightening arrestor will be provided on Building.
12. Low pressure switch will be provided with hooter.
13. 02 NRV will be provided on outlet line.
14. Access flow check valve (AFV) will be provided on outlet line.
15. 99.7 % N2 cylinders will be used for EO storage tank and unloading of road tanker.
16. 99.9 % pure N2 will be used for process flushing and blanketing purpose.
17. Two way regulator valves will be provided on N2 cylinder.
18. Direct line will be connected to day tank from EO bullet.
19. Caution notes will be provided.
20. Well experienced and skill employees will be employed for handling of EO.

2.8 Safety Measures will be PROVIDED For Butanol storage tank area

1. Butanol will be received through road tanker and stored in underground storage tank as per petroleum rules.
2. Tank farm will be constructed as per explosive department requirement and separation distance maintained.
3. Double static earthing will be provided to storage tank.
4. Road tanker unloading station equipped with static earthing.
5. Flame arrestor with breather valve will be provided on vent line.
6. Road tanker unloading procedure will be prepared and implemented.
7. Fire hydrant system will be provided as per requirement.

8. Spark arrestor to road tanker will be provided to all vehicles inside premises.
9. Flame proof type equipment and lighting will be provided.
10. Lightening arrestor will be provided.
11. Trained and experience operator will be employed for tank farm area.
12. NFPA label (hazard identification) capacity and content will be displayed on storage tank.
13. Jumpers will be provided on pipe line flanges.
14. Flexible SS hose will be used for road tanker unloading purpose and other temporary connection.
15. Butanol will be being transferred by pump only in plant area.

CHAPTER 3 HAZARD IDENTIFICATION

3.1 INTRODUCTION

A hazard is an inherent physical or chemical characteristic that has the potential for causing harm. A hazard Identification study is an organized effort to identify and analyze the significance of hazardous situations associated with a process or activity. Specifically, Hazard Identification studies are used to pinpoint weaknesses in the design and operation of facilities that could lead to accidental chemical releases, fires, or explosions. These studies provide organizations with information to help them to improve the safety and manage the risk of their operations.

Hazard Identification studies usually focus on storages, process safety issues, like the acute effects of unplanned chemical releases on plant personnel or the public. These studies complement more traditional industrial health and safety activities, such as protection against slips or falls, use of personal protective equipment, monitoring for employee exposure to industrial chemicals, etc. Although Hazard Identification studies typically use qualitative methods to analyze potential equipment failures and human errors that can lead to accidents, the studies can also highlight gaps in the management systems of an organization's process safety program.

3.2 TECHNIQUES OF HAZARD IDENTIFICATION

Different techniques are adopted for Hazard Identification based on hazardous substances, quantity, type of process, gravity of hazards etc.

The various techniques can be illustrated as below;

1. Personal Visits & Inspection of Plant by Team members
2. Safety Audits
3. On - Site Emergency Plan
4. Check lists

5. Feed back from plant personnel
6. Accident records
7. Safety Reports
8. Safety Manuals
9. Hazard & Operability Study (HAZOP)
10. Fault Tree Analysis (FTA)
11. Event Tree Analysis (ETA)
12. Preliminary hazard Analysis (PHA)
13. Failure Modes and Effects Analysis (FMEA), etc.

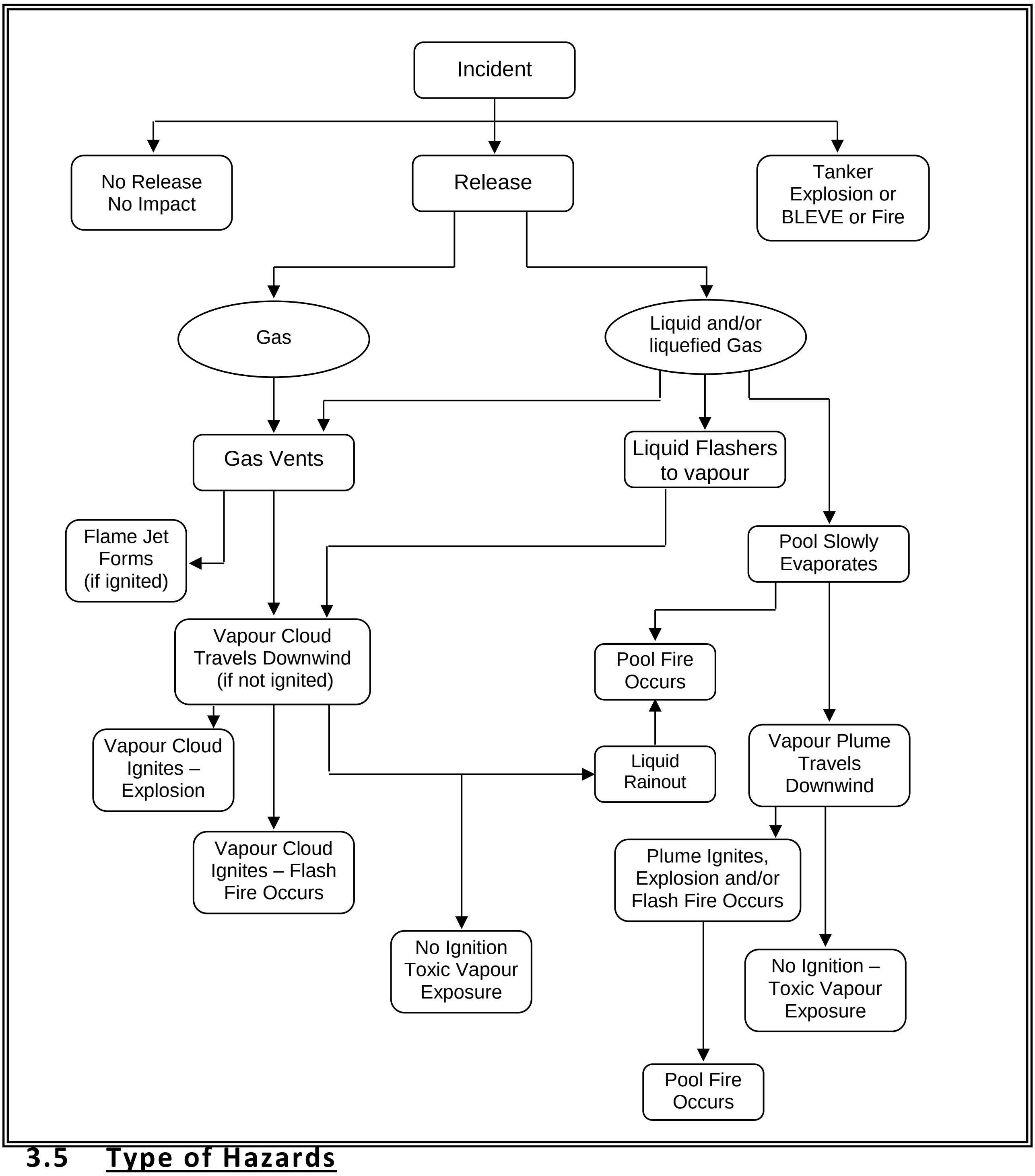
3.3 Present RISK Assessment of the Unit

Present Risk Assessment is carried out for considering the storage & handling of Ethylene Oxide (Day tank)and Butanol.

3.4 Development of various scenarios

The chart on next page is showing all potential incident outcomes from the release (loss of containment) of a hazardous chemical. Further, the properties of chemical, conditions of release etc. all influence, which of the logical paths shown in the chart. Though, it is not detailed enough to cover all possible permutations of phenomena that can immediately result from a hazardous materials release.

Chart showing development of various scenarios



3.5 Type of Hazards

3.5.1 Pool Evaporation

The released flammable material which is a liquid stored below its normal boiling point, will collect in a pool. The geometry of the pool will be dictated by the surroundings. If the liquid is stored under pressure above its normal boiling point, then a fraction of the liquid will flash into vapor and the remaining portion will form a pool in the vicinity of the release point. Once sustained combustion is achieved, liquid fires quickly reach steady state burning. The heat release rate is a function of the liquid surface area exposed to air. An unconfined spill will tend to have thin fuel depth (typically less than 5 mm) which will result in slower burning rates. A confined spill is limited by the boundaries (e.g. a dyked area) and the depth of the resulting pool is greater than that for an unconfined spill.

Vaporization scenarios

Vaporization can occur when there is a leak in any of the following Situations:

- A liquid at atmospheric temperature and pressure.
- A liquid under pressure and above normal boiling point.
- The rates of vapourisation of the liquid are different for each of the two cases. In the case
- The liquid after spillage is approximately at equilibrium and evaporates relativity slowly.
- In the case, the liquid flashes off when released, and the liquid remaining then undergoes slow evaporation. Evaporation of a liquid at atmospheric temperature and pressure.

Evaporation from a pool of liquid is essentially a mass transfer process that depends on the vapour pressure of the liquid, wind velocity across the surface of the pool and ambient weather condition.

A spillage of this kind constitutes a steady continuous source of vapour. Unless the rate of evaporation due to the combination of vapour pressure and wind velocity is high enough, it is usually assumed that the heat transfer from the air and the ground is sufficient to provide the latent heat of vapourisation.

Evaporation of a liquid under pressure and above normal boiling point When a pressurized liquid is released from containment, a portion flashes off. This heat is obtained by cooling the remaining liquid to its boiling point thus reaching a state of equilibrium from the high in equilibrium prevalent immediately on loss of containment. In practice, it frequently happens that there is a significant amount of spray formation caused by the sudden release of pressure and the violent boiling of liquid. This spray vaporizes rapidly by taking heat for vaporization from air. This spray liquid formation is assumed to equal to the gas fraction generated by flash. The proportion of liquid airborne is thus considerably high. Following flashing, the residual liquid is at its boiling point. Vaporization then continuous by gaining heat from surrounding as an essentially heat or mass transfer limited process.

This secondary stage of rate limited vaporization is usually relatively less important compared with the flash off, particularly with respect to formation of flammable gas clouds.

3.5.2 Vapour Cloud dispersion

Following a continuous leak and formation of gas cloud, if cloud does not ignite it undergoes atmospheric dispersion in accordance with the prevalent wind direction, speed, and stability category. The objective of carrying out analysis of cloud dispersion is two fold. First, it provides the distance (from the leak) at which the concentration of flammable material falls below the lower flammability limit (LEL).

Second it provides the concentration of the toxic substance to which people may be exposed for short time, at varying distance (from the leak).

3.5.3 JET FIRE

A Jet Fire, also referred to as a flame jet, occurs when a flammable chemical is rapidly released from an opening in a container and immediately catches on fire—much like the flame from a blowtorch. A two-phase Jet Fire occurs when a gas that has been liquefied under pressure is released. Because the liquid evaporates as it escapes, the chemical is released as an aerosol spray—that is, a mixture of gas and tiny liquid droplets. Software assumes the Jet Fire release is oriented vertically, although the wind can tilt the flames in the downwind direction. Thermal radiation is the primary hazard associated with a Jet Fire. Other potential Jet Fire hazards include smoke, toxic by products from the fire, and secondary fires and explosions in the surrounding area.

3.5.4 Pool fire

A pool fire occurs when a flammable liquid forms a puddle on the ground and catches on fire. Thermal radiation is the primary hazard associated with a pool fire. Other potential pool fire hazards include smoke, toxic by products from the fire, and secondary fires and explosions in the surrounding area. In some cases, heat from the pool fire may weaken a leaking tank and cause it to fail completely—in which case, a BLEVE may occur. Typically, a BLEVE poses a greater threat than a pool fire. If the chemical inside the tank is likely to BLEVE (for example, if the tank contains a liquefied gas).

3.5.5 BLEVEs

BLEVE stands for Boiling Liquid Expanding Vapour Explosion. BLEVEs typically occur in closed storage tanks that contain a liquefied gas, usually a gas that has been liquefied under pressure. A gas can be liquefied by either cooling (refrigerating) it to a temperature below its boiling point or by storing it at a high pressure. Both flammable and non flammable liquefied gases may be involved in a BLEVE. Propane is an example of a chemical that has been involved in many BLEVE accidents. Most propane tanks at service stations contain liquid propane. These tanks are neither insulated nor refrigerated, so the tank contents are at ambient temperature. Since the ambient temperature is almost always significantly above propane's boiling point of -43.7 ºF, the tanks are highly pressurized.

A common BLEVE scenario happens when a container of liquefied gas is heated by fire, increasing the pressure within the container until the tank ruptures and fails. When the container fails, the chemical is released in an explosion. If the chemical is above its boiling point when the container fails, some or all of the liquid will flash-boil—that is, instantaneously become a gas. If the chemical is flammable, a burning gas cloud called a fireball may occur if a significant amount of the chemical flash-boils. Software assumes that any liquid not consumed in the fireball will form a pool fire. Software estimates the thermal radiation hazard from a fireball and/or a pool fire. Other potential BLEVE hazards include overpressure, hazardous fragments, smoke, and toxic by products from the fire. Software focuses on the thermal radiation because in most BLEVEs thermal radiation impacts a greater area than the overpressure and is the more significant threat.

3.5.6 Fireball

When you model a BLEVE, software assumes that a fireball will form. The fireball is made up of both the chemical that flash-boils when the tank fails and the chemical that sprays out as an aerosol during the explosion. Software estimates that the amount of chemical in the fireball is three times the amount of chemical that flash boils. Any liquid that does not participate in the fireball will form a pool fire. When you choose to model a BLEVE situation, the program estimates the thermal radiation from both fires; it is not necessary to run an additional Pool Fire scenario. The primary hazard associated with a fireball is thermal radiation. However, if there are other chemicals near the fireball, it can trigger additional fires and explosions. Explosion and hazardous fragments. In a BLEVE, a high-pressure explosion typically causes the container to fragment. As the container breaks apart, it may strike objects in the surrounding area and create additional debris. The container fragments and other debris—hazardous fragments—are swept up in the explosion and rapidly propelled by the explosion over a wide area.. If a BLEVE is likely to occur, first responders must take the necessary precautions to protect themselves and others from the overpressure and hazardous fragments.

3.5.7 Flash fires (flammable area)

When a flammable vapour cloud encounters an ignition source, the cloud can catch fire and burn rapidly in what is called a flash fire. Potential hazards associated with a flash fire include thermal radiation, smoke, and toxic by products from the fire. The flammable area of the vapour cloud—that is, the area where a flash fire could occur at some time after the release. The flammable area is bounded by the Lower

Explosive Limit (LEL) and the Upper Explosive Limit (UEL). These limits are percentages that represent the concentration of the fuel—that is, the chemical—vapour in the air. If the chemical vapour comes into contact with an ignition source, it will burn only if its fuel-air concentration is between the LEL and the UEL, because that portion of the cloud is already pre-mixed to the right mixture of fuel and air for burning to occur. If the fuel-air concentration is below the LEL, there is not enough fuel in the air to sustain a fire or an explosion—it is too lean. If the fuel-air concentration is above the UEL, there is not enough oxygen to sustain a fire or an explosion because there is too much fuel—it is too rich. (This is similar to an engine that cannot start because it has been flooded with gasoline.) If a flash fire occurs, the part of the cloud where the fuel-air concentration is above the UEL may continue to slowly burn as air mixes with the cloud. You might expect that the LEL could be used as the LOC to determine the areas in which a fire might occur. However, the concentration levels estimated are time-averaged concentrations. In an actual vapour cloud, there will be areas where the concentration is higher than the average and areas where the concentration is lower than the average. This is called concentration patchiness. Because of concentration patchiness, there will be areas, called pockets, where the chemical is in the flammable range even though the average concentration has fallen below the LEL. Some experiments have shown that flame pockets can occur in places where the average concentration is above 60% of the LEL.

3.5.8 Vapour cloud explosions

When a flammable chemical is released into the atmosphere, it forms a vapour cloud that will disperse as it travels downwind. If the cloud encounters an ignition source, the parts of the cloud where the concentration is within the flammable range (between the LEL and UEL) will burn. The speed at which the flame front moves through the cloud determines whether it is a deflagration or a detonation. In some situations, the cloud will burn so fast that it creates an explosive force (blast wave). The severity of a vapour cloud explosion depends on the chemical, the cloud size at the time of ignition, the type of ignition, and the congestion level inside the cloud. The primary hazards are overpressure and hazardous fragments. Some people may prefer to use the terms Lower Flammable Limit (LFL) and Upper Flammable Limit (UFL), particularly if they are only concerned with fires.

3.5.9 Overpressure

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. Pressure waves are nearly instantaneous, travelling at the speed of sound. Although a pressure wave may sound less dangerous than a fire or hazardous fragments, it can be just as damaging and just as deadly. The pressure wave radiates outward like a giant burst of air, crashing into anything in its path (generating hazardous fragments). If the pressure wave has enough power behind it, it can lift people off the ground and throw them up against nearby buildings or trees. Additionally, 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.

3.6 Thermal Radiation Levels

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

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.

Thermal damage

The effect of thermal radiation on people is mainly a function of intensity of radiation and exposure time. The effect is expressed in terms of the probability of death and different degrees of burn. The following tables give the effect of various levels of heat flux.

DAMAGE DUE TO THERMAL RADIATION INTENSITY

Radiation intensity (kW/m2)	Observed effect
1.2	Solar heat at noon
1.6	Minimum level of pain threshold
2.0	PVC insulated cables damaged
4.0	Sufficient to cause pain to personnel if unable to reach cover within 20 Seconds. however blistering of the skin (second degree burns) is likely; 0% lethality
6.4	Pain threshold reached after 8 Seconds Second degree burns after 20 Seconds

DAMAGE DUE TO THERMAL RADIATION INTENSITY

Continue…

Radiation intensity (kW/m2)	Observed effect
12.5	Minimum energy to ignite wood with a flame; Melts plastic tubing. 1% lethality in one minute. First degree burns in 10 Seconds
16.0	Severe burns after 5 Seconds
25.0	Minimum energy to ignite wood at identifying long exposure without a flame. 100% lethality in 1 minute. Significant injury in 10 Seconds
37.5	Sufficient to cause damage to process equipment, Severe damage to plant 100% lethality in 1 minute. 50% lethality in 20 Seconds 1% lethality in 10 Seconds.

3.7 OVERPRESSURE Levels

The most basic definition of an explosion is a sudden, intense release of energy that often produces a loud noise, high temperatures, and flying debris, and generates a pressure wave. There are many types of explosions and the causes and effects will vary. Intentional explosions will generally—but not always—result in greater hazard damage. Consider three primary hazards when dealing with an explosion: thermal radiation, overpressure, and hazardous fragments (flying debris). All three of these hazards are not present in every explosion and the severity of the hazard will depend on the explosion. These hazards typically last only for a brief period directly following the explosion. However, it is important to consider the potential for secondary explosions and fires to occur before deciding that these hazards no longer exist.

Large objects (like trees and buildings) in the path of the pressure wave can affect its strength and direction of travel. For example, if many buildings surround the explosion site, expect the actual overpressure threat zone to be somewhat smaller. But at the same time, more hazardous fragments could be generated as the blast causes structural damage to those buildings. An Overpressure Level is a threshold level of pressure from a blast wave, usually the pressure above which a hazard may exist.

The overpressure values to the structural and physiological effects produced and taken from Clancey, VJ, Diagnostic Features of Explosion Damage, 6th International Meeting on Forensic Sciences, Edinburgh, Scotland, 1972.

Explosion Overpressure Damage estimates

Pressure (psig)	Level of Damage
0.02	Annoying noise (137 dB), if of low frequency (10-15 Hz)
0.03	Occasional breaking of large glass windows already under strain
0.04	Loud noise (143 dB). Sonic boom glass failure
0.1	Breakage of small windows under strain
0.15	Typical pressure for glass breakage
0.3	“Safe distance” (probability 0.95 no serious damage beyond this value) Missile limit Some damage to house ceilings; 10% window glass broken
0.4	Limited minor structural damage
0.5 - 1.0	Large and small windows usually shattered
0.7	Minor damage to house structures
1.0	Partial demolition of houses, made uninhabitable
1 - 2	Corrugated asbestos shattered Corrugated steel or aluminium panels, fastenings fail, followed by buckling Wood panels (standard housing) fastenings fail, panels blown in
1.3	Steel frame of clad building slightly distorted
2	Partial collapse of walls and roofs of houses
2 - 3	Concrete or cinder block walls, not reinforced, shattered
2.3	Lower limit of serious structural damage
2.5	50% destruction of brickwork of houses

Explosion Overpressure Damage estimates

Continue…

Pressure (psig)	Level of Damage
3	Heavy machines (3000 lb) in industrial building suffered little damage Steel frame building distorted and pulled away from foundations
3 - 4	Frameless, self-framing steel panel building demolished Rupture of oil storage tanks
4	Cladding of light industrial buildings ruptured
5	Wooden utility poles snapped Tall hydraulic press (40,000 lb) in building slightly damaged
5 - 7	Nearly complete destruction of houses
7	Loaded train wagons overturned
7 - 8	Brick panels 8-12" thick, not reinforced, fail by shearing/flexure
9	Loaded train boxcars completely demolished
10	Probable total destruction of buildings Heavy machines tools (7000 lb) moved and badly damaged Very heavy machine tools (12,000 lb) survived
300	Limit of crater lip

CHAPTER 4 CONSEQUENCES MODELLING

4.1 CONSEQUENCE MODELLING

Consequence analysis and calculations are performed by computer software using various models validated over a number of applications. Consequence modelling is carried out in Phast Lite.

4.2 WORST CASE & MAXIMUM CREDIBLE SCENARIO

Following scenario are considered for this QRA study ;

1. Catastrophic failure of Ethylene Oxide Day tank and Butanol Storage tank
2. Leak from Ethylene Oxide Day tank and Butanol Storage tank

Radiation Heat, Overpressure and Toxic Dispersion due to above scenarios are calculated and summary of the same is tabulated in next page ;

4.3 Summary OF CONSEQUENCE ANALYSIS

A) Radiation heat distance

Sr. No.	Scenario Mapping given at	Failure Case	Scenario	Weather Condition	Thermal Radiation Distance in meter at		
					Radiation Intensity (Kw/m2)		
					4	12.5	37.5
1	4.3.1	Catastrophic failure of Ethylene Oxide day tank	Late Pool Fire	1.5/F	82.91	50.90	25.92
				1.5/D	82.61	50.68	25.75
				5/D	87.07	57.69	35.40
2	4.3.4	Leak from Ethylene Oxide day tank	Late Pool Fire	1.5/F	45.10	33.16	22.53
				1.5/D	43.22	33.31	22.50
				5/D	45.10	33.16	22.53
3	4.3.7	Catastrophic failure of Butanol Tank	Late Pool Fire	1.5/F	164.2	103.33	61.00
				1.5/D	164.15	103.2	60.93
				5/D	166.2	108.8	73.58
4	4.3.8	Leak from Catastrophic Butanol Tank	Late Pool Fire	1.5/F	120.8	76.90	45.34
				1.5/D	120.5	76.68	45.21
				5/D	121.8	80.95	55.20

B) OVERPRESSURE DISTANCE

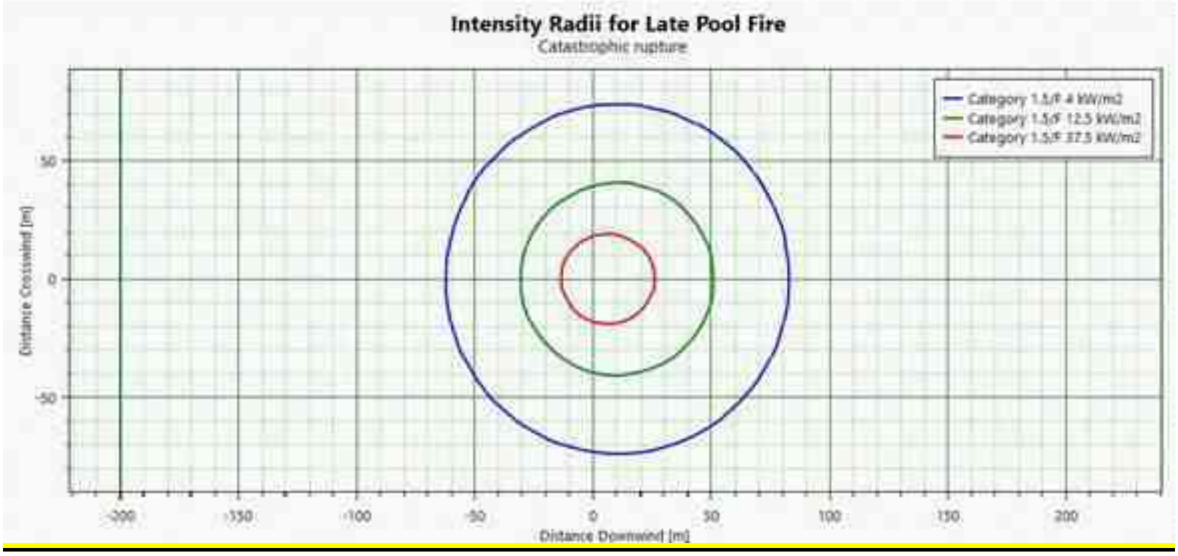
Sr. No.	Scenario Mapping given at	Failure Case	Scenario	Weather Condition	Overpressure Distance in meter at		
					Pressure (bar)		
					0.02068	0.1379	0.2068
1	4.3.2	Catastrophic failure of Ethylene Oxide day tank	Late Explosion	1.5/F	299.81	122.26	112.70
				1.5/D	299.96	124.80	116.93
				5/D	295.13	99.50	92.82
2	4.3.5	Leak from Ethylene Oxide tank day tank	Late Explosion	1.5/F	102.17	70.92	68.45
				1.5/D	89.67	60.27	17.41
				5/D	38.64	17.41	15.73

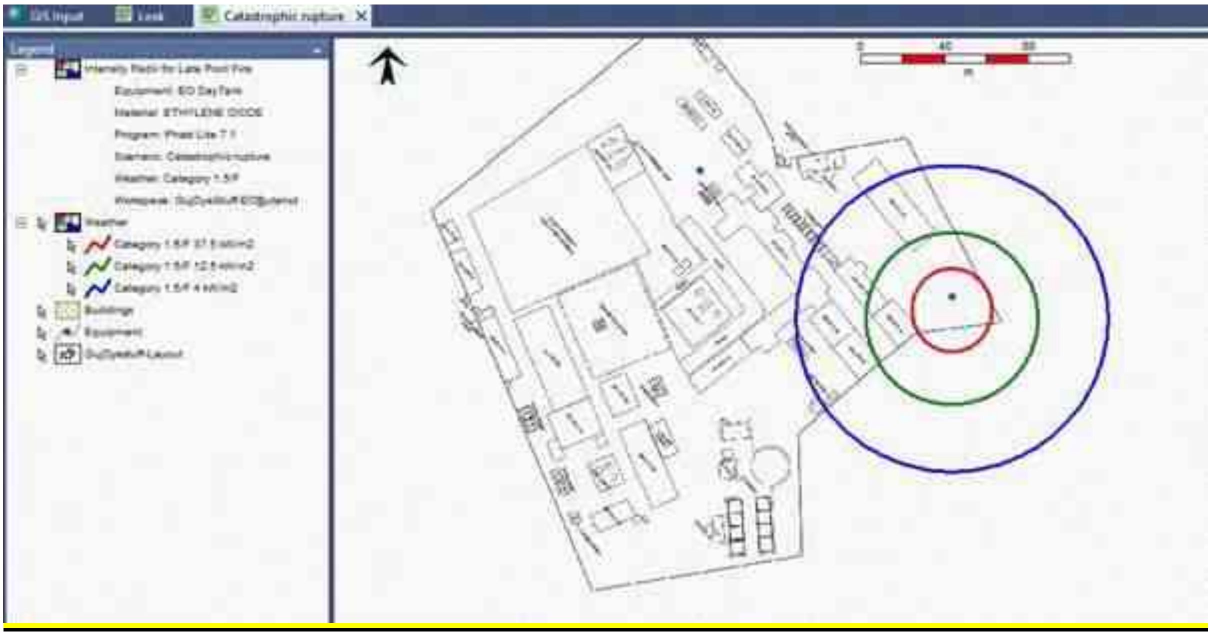
C) TOXIC DISPERSION DISTANCE

Sr. No.	Scenario Mapping given at	Failure Case	Scenario	Weather Condition	Toxic Dispersion Distance in meter at		
					In ppm		
					30000 LFL	15000 LFL frac	800 IDLH
3	4.3.3	Catastrophic failure of Ethylene Oxide day tank	Late Explosion	1.5/F	66.29	89.57	244.92
				1.5/D	71.45	99.75	245.18
				5/D	58.79	86.90	226.18
4	4.3.6	Leak from Ethylene Oxide tank day tank	Late Explosion	1.5/F	23.65	64.57	180.30
				1.5/D	17.21	51.82	175.11
				5/D	13.92	17.96	117.07

Risk Assessment *For M/s. Gujarat Dyestuff Industries (Pharma Unit)*			
Prepared By HELPS		**July 2019**	
Consequence Analysis			**Work Sheet No.**
4.3.1	**Weather Condition : 1.5/F**	**Scenario**	1
	Catastrophic of Ethylene Oxide day tank	**Late Poolfire**	

4.3.1 *Catastrophic of Ethylene Oxide day tank*

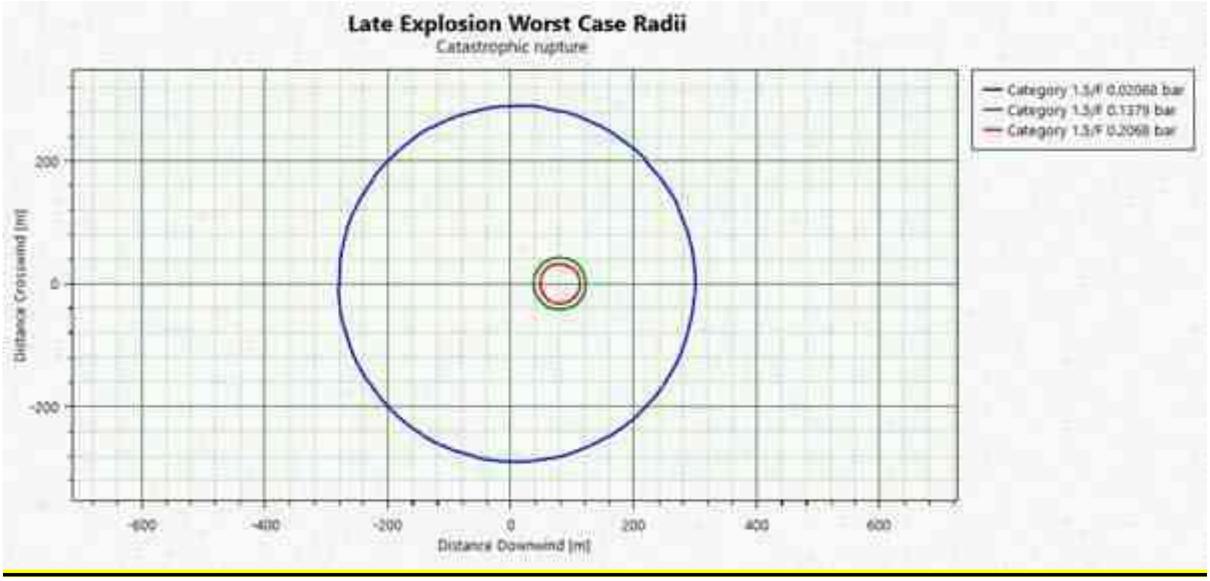


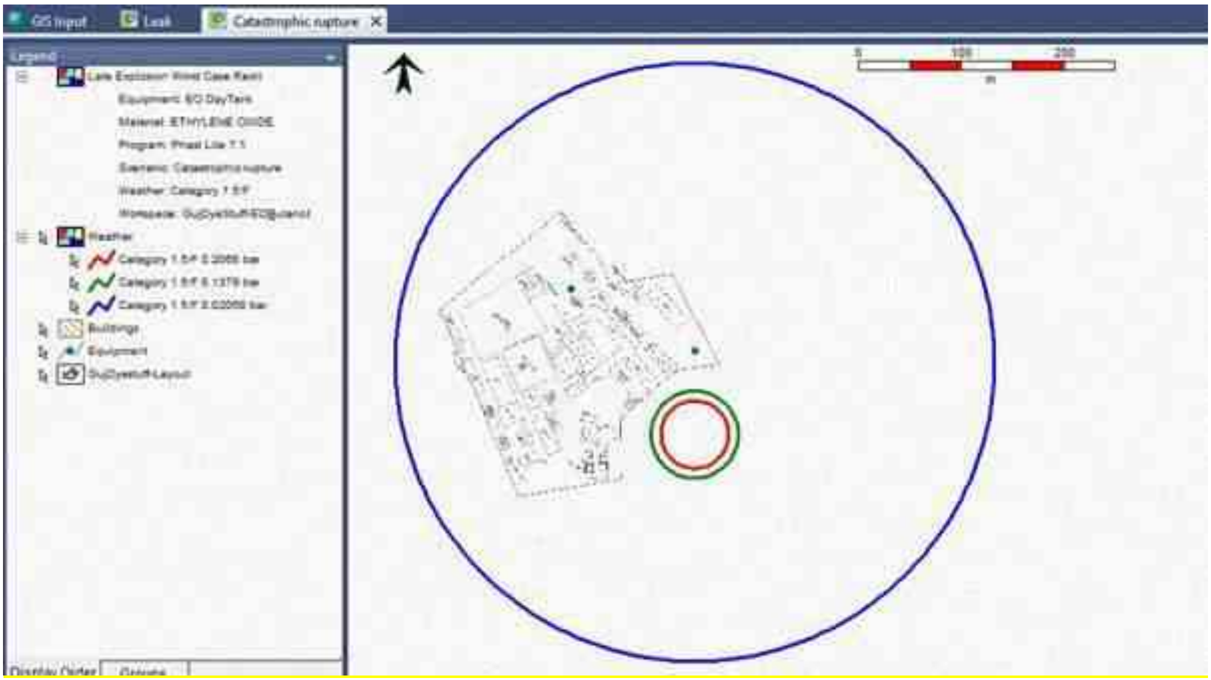


Equipment: EO Day Tank
Material: ETHYLENE OXIDE
Scenario: Catastrophic rupture
Weather: Category 1.5/F

Risk Assessment ***For M/s. Gujarat Dyestuff Industries (Pharma Unit)***			
Prepared By HELPS		**July 2019**	
Consequence Analysis			**Work Sheet No.**
4.3.2	**Weather Condition : 1.5/F**	**Scenario**	**2**
	Catastrophic of Ethylene Oxide day tank	**Late Explosion**	

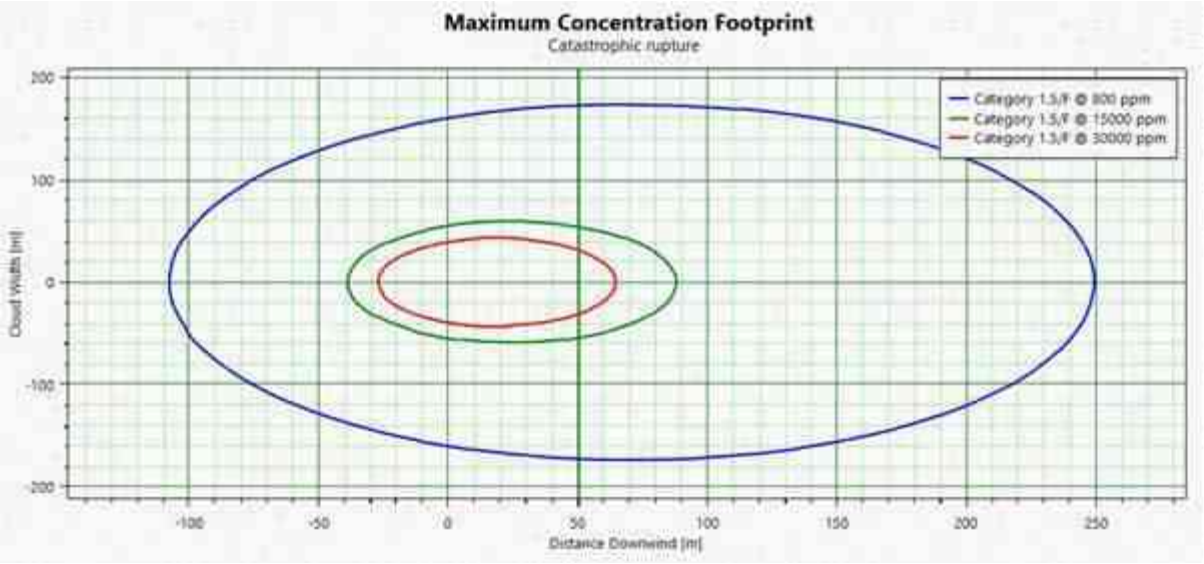
4.3.2 Catastrophic of Ethylene Oxide day tank

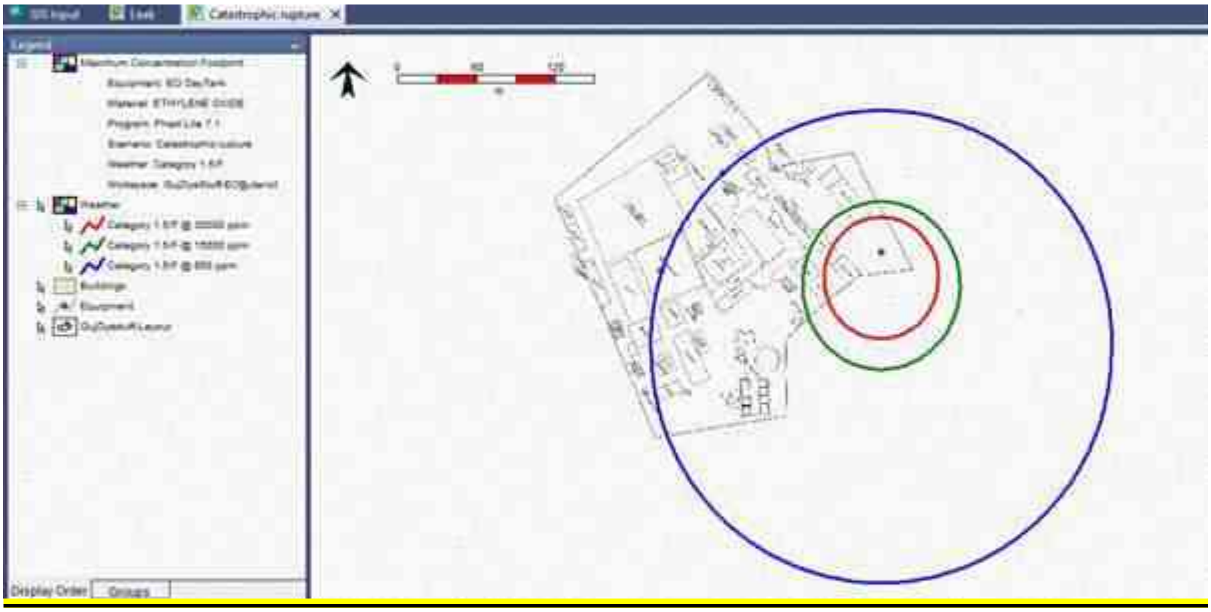




Risk Assessment ***For M/s. Gujarat Dyestuff Industries (Pharma Unit)***			
Prepared By HELPS		**July 2019**	
Consequence Analysis			**Work Sheet No.**
4.3.3	**Weather Condition : 1.5/F**	**Scenario**	**3**
	Catastrophic of Ethylene Oxide day tank	**Dispersion footprint**	

4.3.3 Catastrophic of Ethylene Oxide day tank

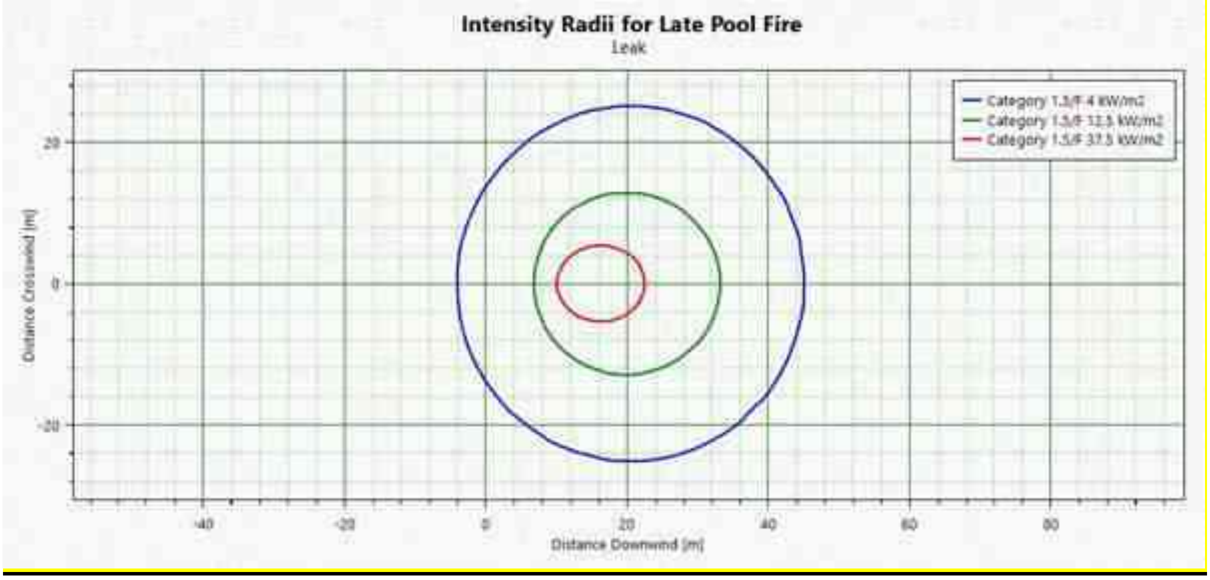


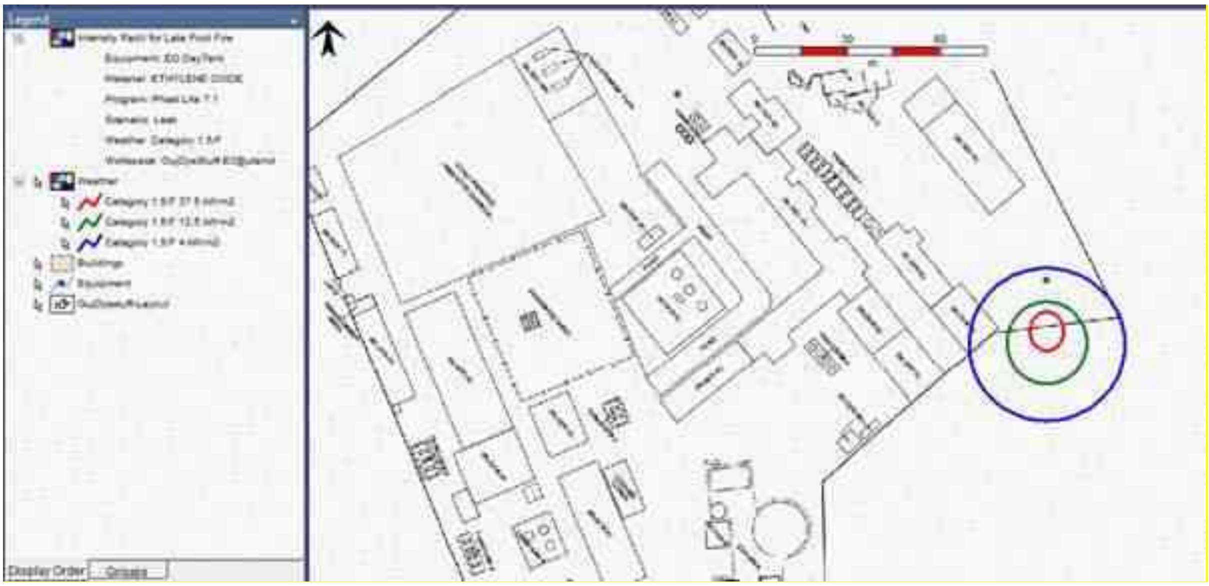


Equipment: EO DayTank
Material: ETHYLENE OXIDE
Scenario: Catastrophic rupture
Weather: Category 1.5/F
Category 1.5/F @ 30000 ppm
Category 1.5/F @ 15000 ppm
Category 1.5/F @ 800 ppm

Risk Assessment ***For M/s. Gujarat Dyestuff Industries (Pharma Unit)***			
Prepared By HELPS		**July 2019**	
Consequence Analysis			**Work Sheet No.**
4.3.4	**Weather Condition : 1.5/F**	**Scenario**	**4**
	Leak from Ethylene Oxide day tank	**Late pool fire**	

4.3.4 Leak from Ethylene Oxide





Equipment: EO DayTank
Material: ETHYLENE OXIDE
Program: Phast Lite 7.1
Scenario: Leak
Weather: Category 1.5/F

<table>
<tr><td colspan="4">Risk Assessment
<i>For M/s. Gujarat Dyestuff Industries (Pharma Unit)</i></td></tr>
<tr><td colspan="2">Prepared By HELPS</td><td colspan="2">July 2019</td></tr>
<tr><td colspan="2">Consequence Analysis</td><td colspan="2">Work Sheet No.</td></tr>
<tr><td rowspan="2">4.3.5</td><td>Weather Condition : 1.5/F</td><td>Scenario</td><td rowspan="2">5</td></tr>
<tr><td>Leak from Ethylene Oxide day tank</td><td>Late Explosion</td></tr>
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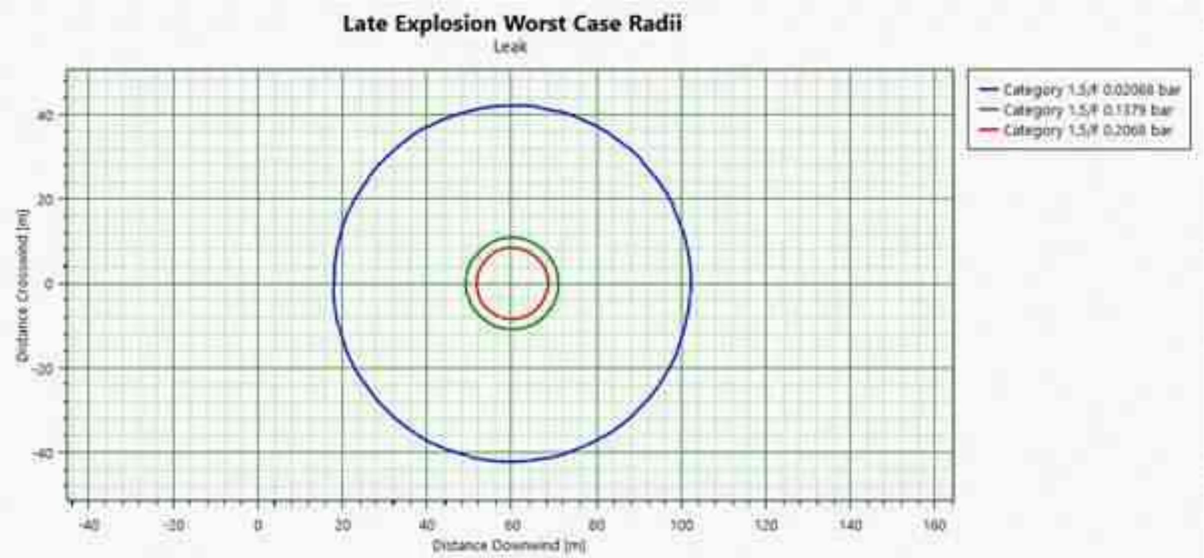
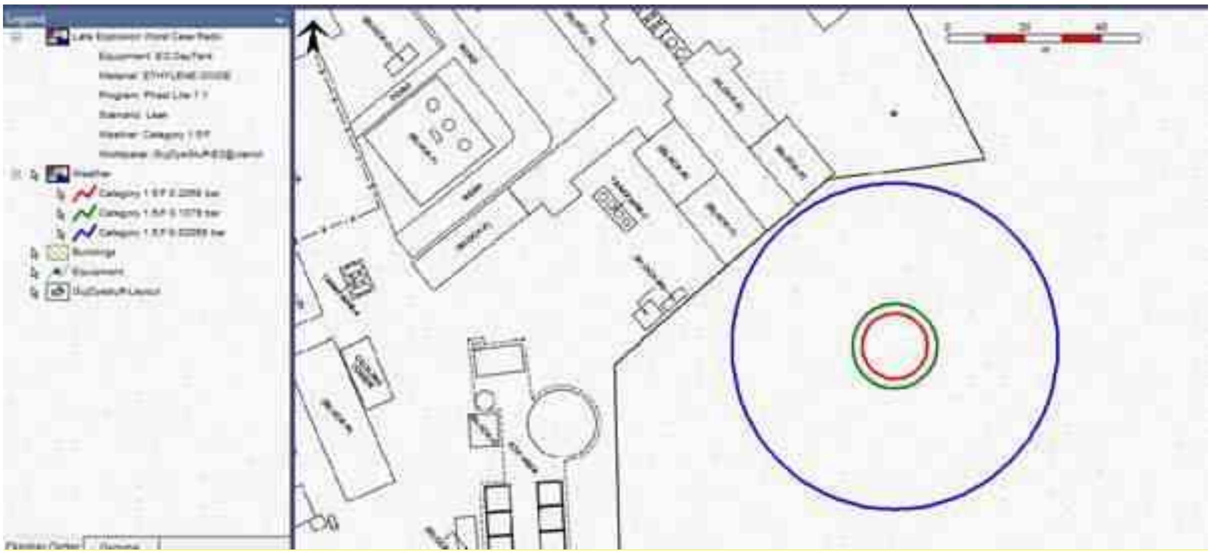
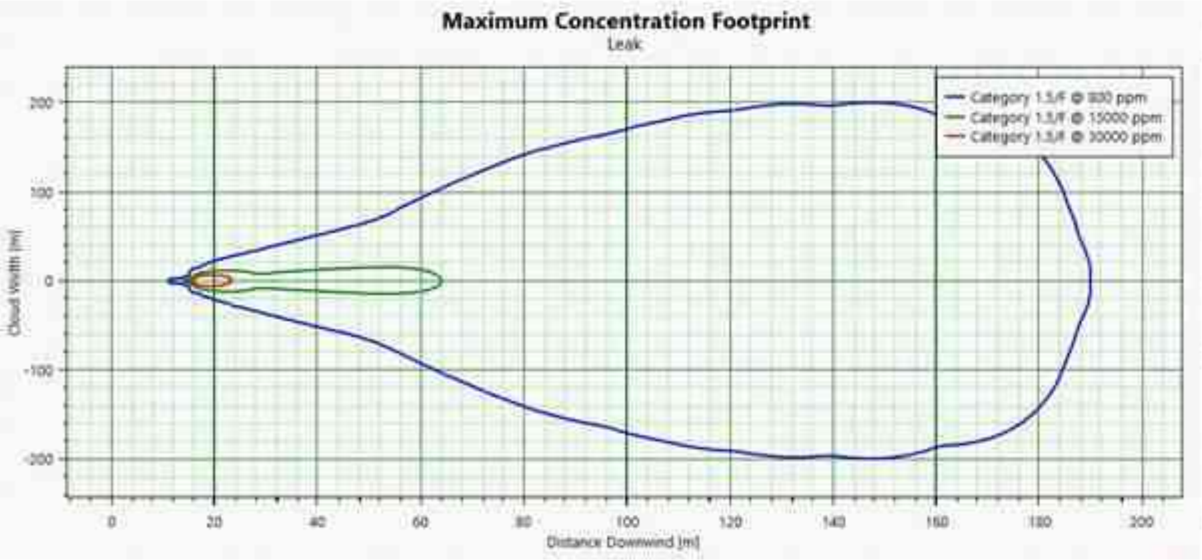
4.3.5 Leak from Ethylene Oxide day tank

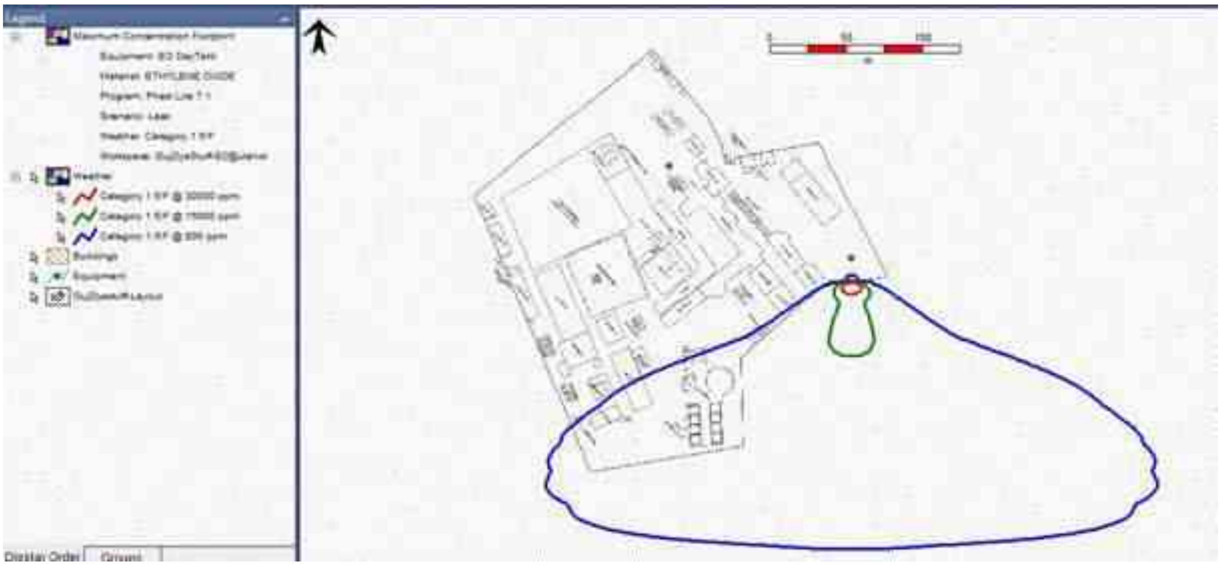




Risk Assessment ***For M/s. Gujarat Dyestuff Industries (Pharma Unit)***			
Prepared By HELPS		**July 2019**	
Consequence Analysis			**Work Sheet No.**
4.3.6	**Weather Condition : 1.5/F**	**Scenario**	**6**
	Leak from Ethylene Oxide day tank	**Dispersion footprint**	

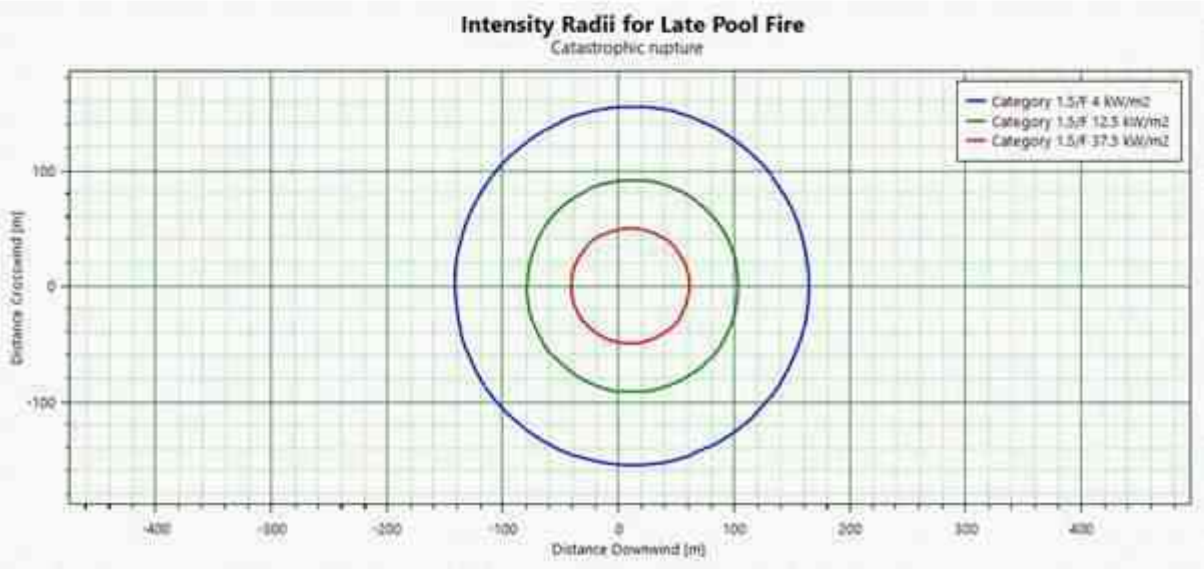
4.3.6 Leak from Ethylene Oxide day tank

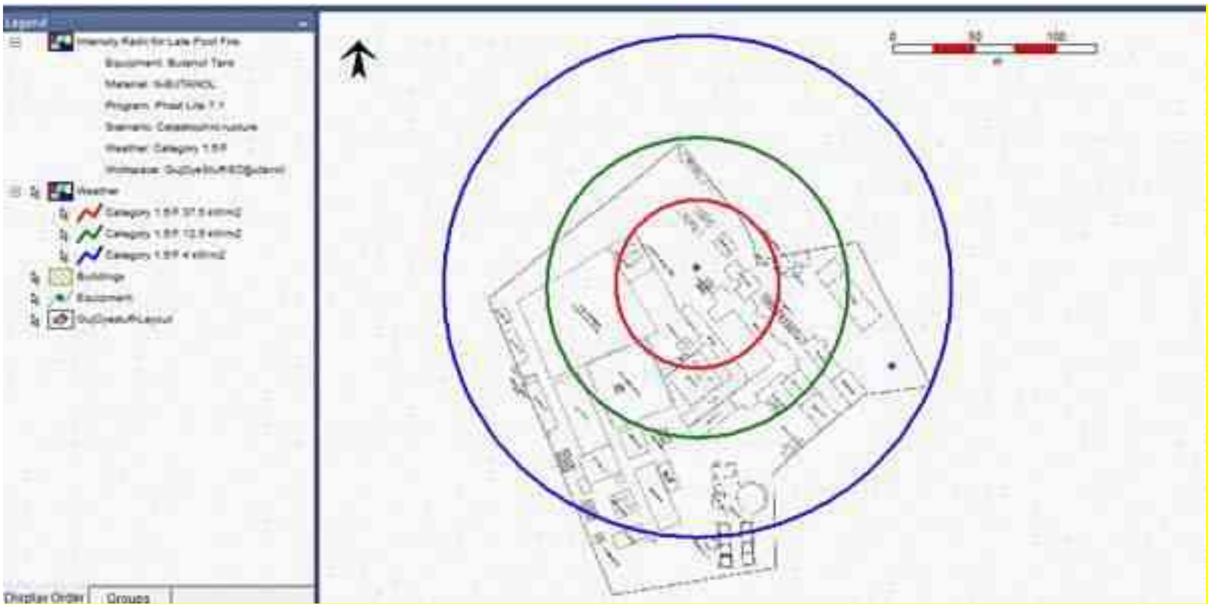




Risk Assessment ***For M/s. Gujarat Dyestuff Industries (Pharma Unit)***			
Prepared By HELPS		**July 2019**	
Consequence Analysis			**Work Sheet No.**
4.3.7	**Weather Condition : 1.5/F**	**Scenario**	7
	Catastrophic failure of Butanol Tank	**Late Pool Fire**	

4.3.7 *Catastrophic failure of Butanol Tank*




Intensity Radii for Late Pool Fire

Equipment: Butanol Tank

Material: N-BUTANOL

Program: Phast Lite 7.1

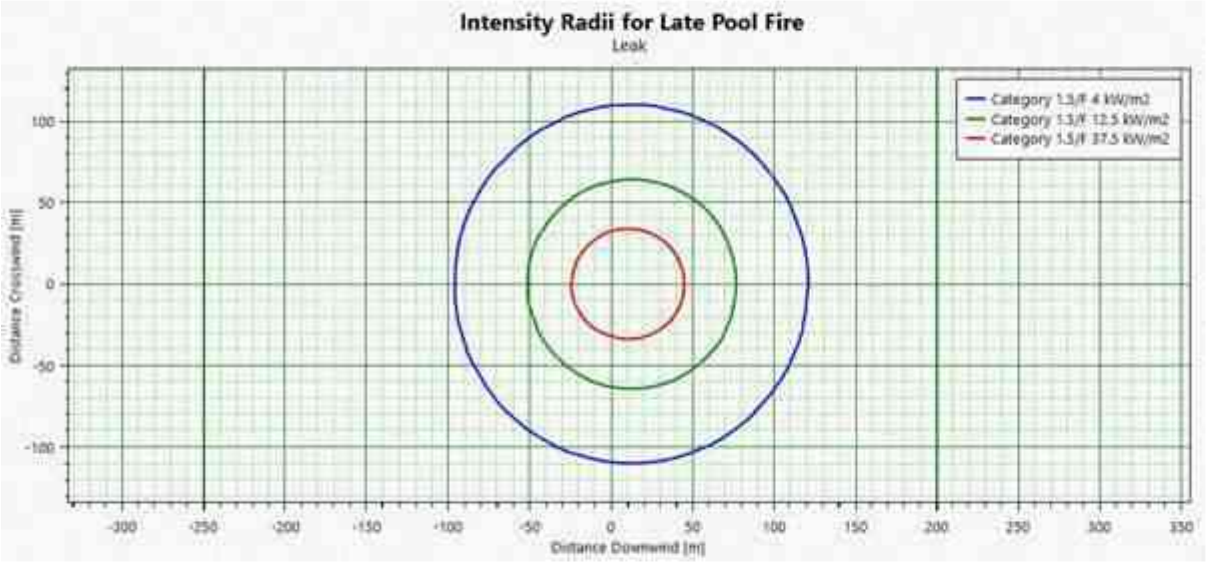
Scenario: Catastrophic rupture

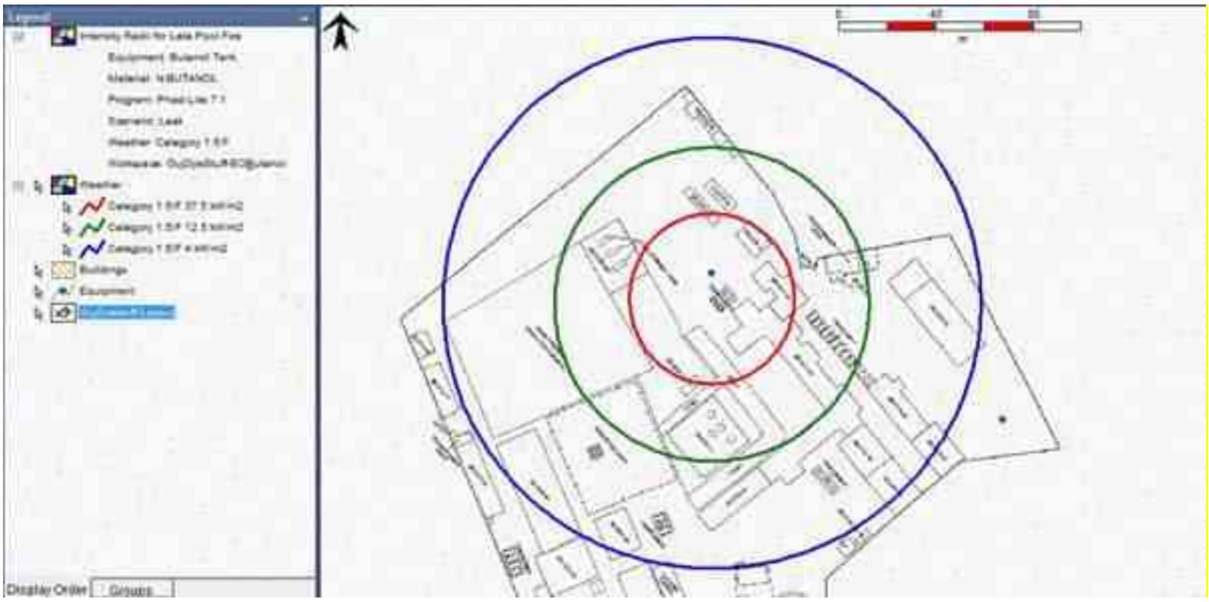
Weather: Category 1.5/F

Workspace: [illegible]

Risk Assessment ***For M/s. Gujarat Dyestuff Industries (Pharma Unit)***			
Prepared By HELPS		**July 2019**	
Consequence Analysis			**Work Sheet No.**
4.3.8	**Weather Condition : 1.5/F**	**Scenario**	**8**
	Catastrophic failure of Butanol Tank	**Late Pool Fire**	

4.3.8 Catastrophic failure of Butanol Tank





CHAPTER 5 RISK LEVEL

5.1 PRELIMINARY THREAT IDENTIFICATION

Threat identification is the stage where equipment and operations that have the potential to do harm are identified. Threats can be to damage of equipment storing or processing hazardous substances or operations that have the potential to lead to a release of hazardous material and possible ignition resulting in fire, or explosion. In order to calculate the effects of incidents, computer based models are used when the likelihood and consequence of incidents are evaluated, they can be combined to produce a numerical recantation of the risk.

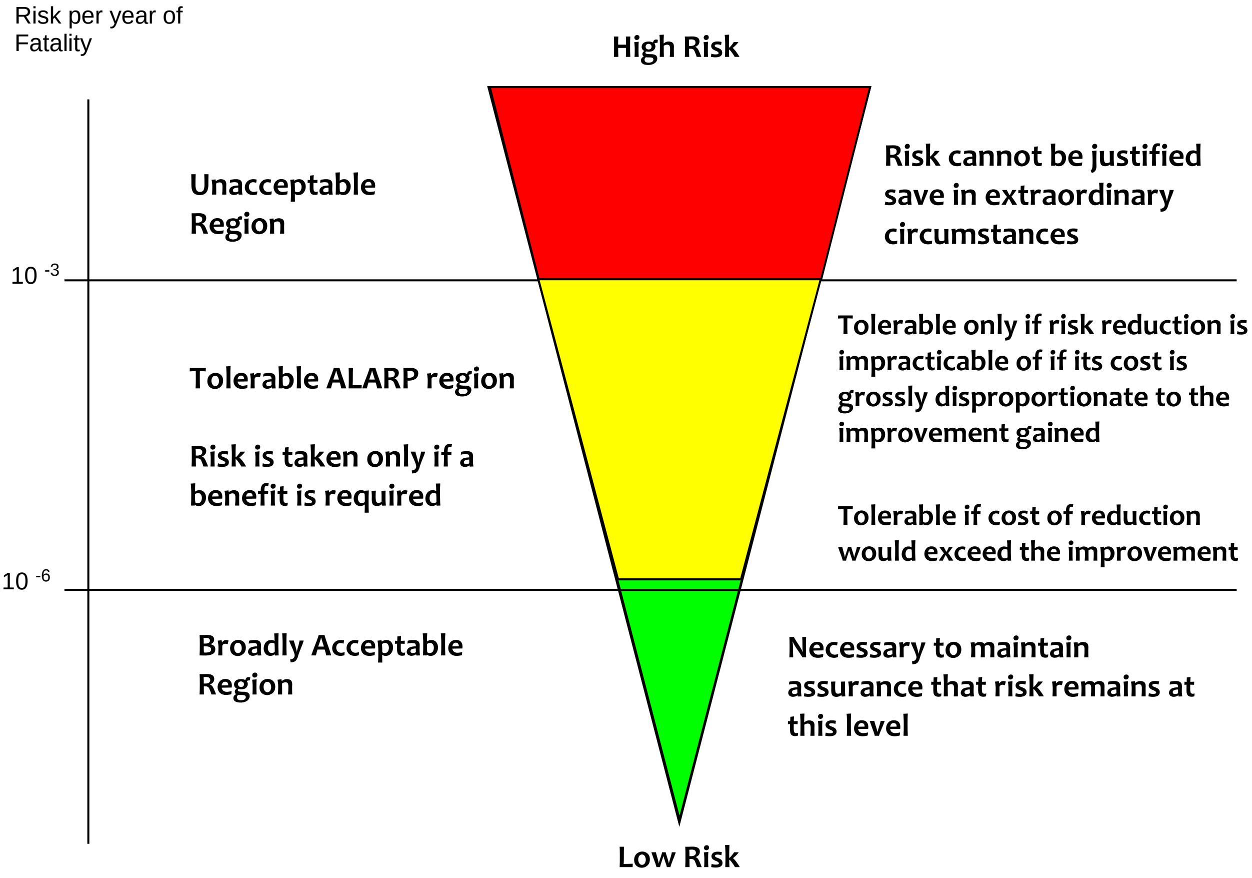
The level of risk can be represented in a number of ways. Two of the most useful ways in this context are individual and societal risk.

5.1.1 Individual Risk :

Individual risk is the risk of a nominated adverse effect, usually fatality, if an individual remained fixed at a location for a set time, usually a year, adjacent to an industrial hazard. Individual risk contours are derived by calculating at a specific location, the impacts resulting from each failure mode identification and summing the risk value associated with each failure mode.

Individual risk criteria can be presented as a diagram, known as the “Dagger Diagram”, to facilitate understanding. Figure 1 given next page shows the individual risks of fatality, and some risks experienced in day to day life.

Figure – 1 : ALARP Diagram



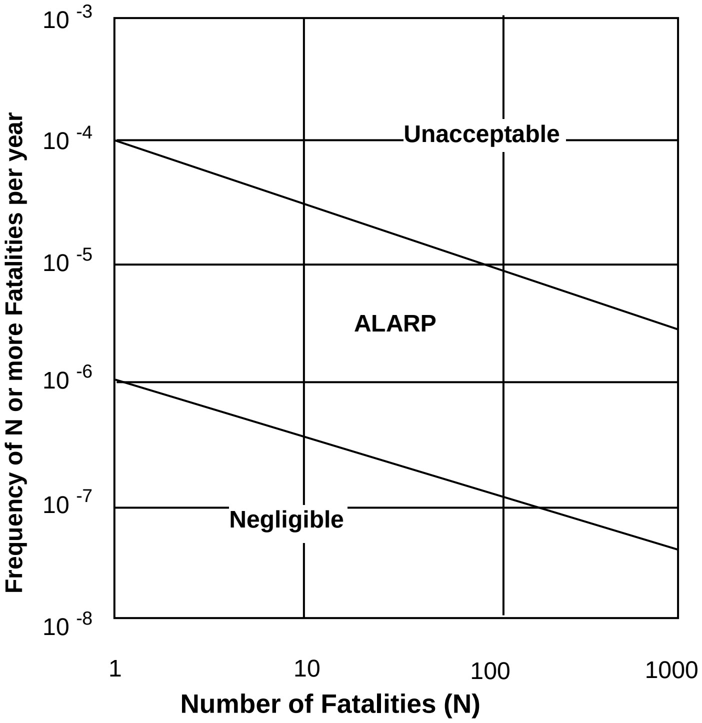
5.1.2 *Societal Risk :*

Societal risk criteria specify levels of societal risk that must not be exceeded by a particular activity. These criteria ensure that a hazardous activity / facility does not impose a risk on society that is disproportionate to other major hazards having regard to the benefit the activity or facility brings. In particular, societal risk criteria are used to regulate the risks of an accident involving many fatalities, which individual risk criteria do not address.

Societal risk criteria are usually expressed in the form of a chart, with N, the number of fatalities across the bottom and the frequency of N or more fatalities on the vertical scale. The criteria are areas, or zones on the chart, delineated by downward sloping lines.

The criteria lines shown slope downwards reflecting how the criteria demands decreasing frequency as severity increases. Refer Figure 2 below :

Figure - 2



5.2 OFF - SITE ACCIDENT INITIATORS

The method of measuring the frequency of accidents caused by Off-Site Events should be fit for purpose. In other words it should be proportionate to the level of risk. Thus, if a site is located far away from any airport or flight path (military or civil), then it is acceptable for the safety report to refer to the background crash rate for the UK. On the other hand, if the site is located close to a busy airport then a much more detailed assessment of aircraft impact should be carried out.

5.2.1 *Table 1*

Initiator	**Method of Model**
Aircraft impact	AEA methodology
Seismic event	geological survey data
Lightning strike	Electricity council data and methodology
Severe environmental conditions:- Abnormal rainfall Abnormal snow fall Very low temperature High temperature Gale force winds	Historical data plus reasoned argument
Flooding	Site and met office data plus reasoned argument
Subsidence	Historical data plus reasoned argument
Land slip	Historical data plus reasoned argument
Fire or explosion at adjoining plant	Site environs information plus relevant data where relevant
Missile from Off-Site	Site environs information plus relevant data
Hazardous substance pipeline rupture	Site environs information plus relevant data
Collapse of high voltage cable	Site environs information plus relevant data
Impact by out of control road or rail vehicle	Site environs information plus relevant data

5.2.2 *Possible Major Accident Scenario*

Plant Item Failure	**Accident Scenarios**			
Storage or Transport Vessel	Catastrophic failure Flammable/ Toxic gas cloud	Hole in vessel wall Flammable/Toxic gas cloud		
Filling line	Rupture Flammable / Toxic gas cloud	Puncture Flammable / Toxic gas cloud	Small hole Flammable / Toxic gas cloud	Flange leak
Export line	Rupture Flammable / Toxic gas cloud	Puncture Flammable / Toxic gas cloud	Small hole Flammable / Toxic gas cloud	Flange leak
Process Equipment, Compressors, liquefied, vaporisers Pumps	Disintegration Toxic gas cloud	Leak Toxic gas cloud	Loss of control Flammable / Toxic gas cloud Explosion	
Abatement Equipment	Disintegration Toxic gas cloud	Leak Toxic gas cloud	Loss of control Flammable / Toxic gas cloud	Overload Flammable / Toxic gas cloud

5.2.3 *Probable Accident Initiators*

Off-site Events	Operator Error	Abnormal Load	Arson or Sabotage	Inadequate Management	Loss of Service
Aircraft impact	system opened	impact by vehicle	fire	corrosion	Loss of electricity.
Seismic event	filled when not closed	impact by missile	explosion	erosion	loss of cooling water.
Subsidence	system overfilled	impact by dropped load	valve opened	vibration failure of process controls.	loss of nitrogen
Extreme environmental conditions abnormal rain fall abnormal snow fall very low temperature high temperature flooding gale force winds lightening strike	containment degraded.	internal temperature or pressure outside design limit.	safety system degraded.	cyclic load	loss of compressed air
Vehicle/train impact	excess load	external temp/ pressure outside design limit.	contamination	inadequate materials or specification.	loss of steam
Land slip	failure to respond correctly to an alarm.	pressurisation.	control system degraded.	chemical attack	
Explosion	incorrect valve action.	under pressure	containment system degraded.	hidden defect in containment system.	
Fire	Contamination			failure to detect dangerous situation.	
Missile	Loss of control			failure of process controls.	

5.3 RISK LEVEL

5.3.1 *Interpretation for Risk to Workers :*

The quantitative risk assessment depends upon quantity, property, physical form, duration and frequency of handling and air borne concentration of the main hazardous raw materials. Risk Assessment is based on comparison with acceptable points and risk formula is given in para 5.6.

5.3.2 *Typical Failure Frequencies*

Type of Failure	Failure Rates per year
Catastrophic failure of Tanks	2.0×10^{-6}
Leak in Tanks (Pipeline) (Leak Dia 25mm)	5.0×10^{-6}

Ref : From Failure rate by HSE.gov.uk

5.4 RISK MATRIX

Risk assessment should be seen as a continual process. Thus, the adequacy of control measures should be subject to continual review and revised if necessary. Similarly, if conditions change to the extent that hazards and risks are significantly affected then risk assessments should also be reviewed.

Risk levels for following maximum credible scenario are calculated;

Sr. No.	Failure Mode	Scenario	Probability	Consequence	Risk
1	Leak from Acetic Acid Tank	Jet Fire	R	M	Low
		Early Pool Fire	R	M	Low
		Late Pool Fire	ER	CR	Mod

Probability
- **F** = Frequent
- **RP =** Reasonably probably
- **O =** Occasional
- **R =** Remote
- **ER =** Extremely Remote

Consequence
- **C =**Catastrophic
- **CR =**Critical
- **M =** Marginal
- **N =** Negligible

Risk
Rtn. = Routine
Low = Low risk
Mod.= Moderate risk
High = High risk

Probability Classification

Frequent (>1.0)	:	Likely to occur many times during the life cycle of the system (test/activity/operation).
Reasonably probably (0.1-1.0)	:	Likely to occur some time during the life cycle of the system
Occasional (0.01-0.1)	:	Likely to occur some time during the life cycle of the system.
Remote (10^{-4} -10^{-2})	:	Not likely to occur in the life cycle of the system, but possible.
Extremely remote (10^{-6}-10^{-4})	:	Probability of occurrence cannot be distinguished from zero
Impossible (<10^{-6})	:	Physically impossible to occur.

Hazard Consequence Classification

Catastrophic	:	May cause death or system loss
Critical	:	May cause severe injury or occupational illness or minor system damage.
Marginal	:	May cause minor injury, occupation illness, or system damage.

Negligible	:	Will not result in injury, occupational illness, or system damage.

Risk Category

Routine:	:	Risk no different from those experienced by any individual in his or her daily life
Low risk	:	Events may have impact within a facility but little or no impact to adjacent facilities, public health, or the environment.
Moderate risk:	:	Events have potential impacts within the facility but at most only minor impacts off site.
High risk	:	Events have the potential for on-site and off-site impacts to large numbers of persons or major impacts to the environment.

5.5 HISTORY OF PAST ACCIDENTS

Knowledge and Safety measures are tested when any incident / happening takes place which teaches us a lessons and we are compelled to acquire the knowledge of the causes of the accidents and of preventative measures to prevent its reoccurrences.

The management is maintaining records in respect of recorded reportable accident details.

5.6 LIMITATIONS & UNCERTAINTY

The hazard identification procedures are coupled with good engineering judgement, regulations, and guidelines together constitute a better strategy to ensuring safety. The accuracy and usefulness of risk assessment are critically dependent on the quality of the model assumptions and that of the relevant database. In case of accident frequency assessment, the sources of errors are also varied. In many instances only very general data are available on equipment failure, for which statistical accuracy is often poor. In other cases, these may be very little data available at all. In India, the databases on equipment failure and human error are not readily available. There is indeed a strong need to build up a national reliability database through co-operative effects between industry and instrument / equipment manufactures.

CHAPTER 6 SUGGESTIONS & RECOMMENDATIONS

6.1 SUGGESTION & RECOMMONDATION

1. To avoid ignition of vapours by static electricity discharge, all metal parts of the equipment must be grounded, and periodically it shall be checked.
2. Do not pressurize, cut, weld, braze, solder, drill, grind or expose tank to heat or sources of ignition, without taking proper care.
3. Prevent the creation of flammable or explosive concentrations of vapour in air and avoid vapour concentration higher than the Occupational exposure limits.
4. Non sparking tools should be used, during maintenance work.
5. Whole factory premises shall be declared as no smoking Zone and board shall be displayed.
6. Tanker un-loading checklist shall be prepared and it shall be followed for truck tanker coming for un loading hazardous chemicals.
7. Tanker un-loading shall be carried out under strict supervision only.
8. Fire Hydrant network shall be always maintained under pressure.
9. Fire mock drill shall be conducted frequently.
10. Effective grounding and Bonding shall be maintained at Flammable hazardous chemicals handling and storage area.
11. Continuity of earthing and earth Resistivity shall be checked periodically and report shall be maintained.
12. Flameproof fittings shall be used and maintained in proper condition.
13. All operator wear appropriate PPE while working that shall be ensured.

14. Operators should be trained for the hazardous properties and control measures of chemicals which are using in the installation.

15. INSPECTION & MAINTENANCE

The frequency for various activities in the plant, process & Storage are mainlined with attentively by the management, as per following:

Sr. No.	Frequency	Inspection & Maintenance Activity
1	Daily Inspection	Critical equipments, controls, indicators, levels, switches, settings, drain valves, leakages, storage tanks & TLF
2	Weekly	Inspection & maintenance of Pumps.
3	Monthly	Breather Valve, Fire Protection System
4	Quarterly	All Indicators Alarms, trips & Control
5	Half Yearly	Ultrasonic Thickness Gauge, Earthing check
6	Annual	All valves, safety valves, Painting of vessels Pipe lines.

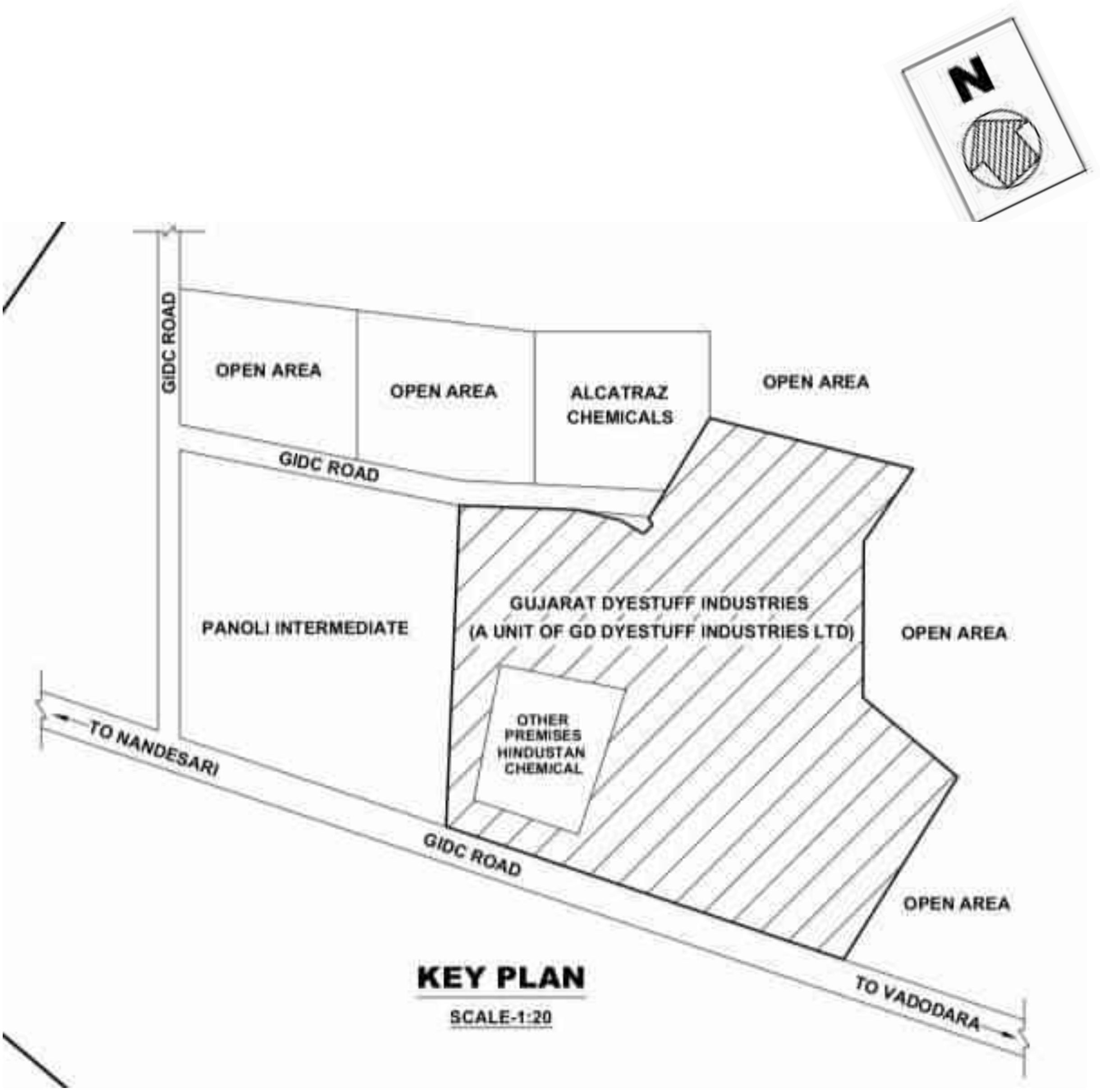
16. Test & Examination of Tanks, Pressure Vessels etc. are to be carried out & records in prescribed forms are maintained.
17. The M.S.D.S. of Hazardous Chemicals is to be prepared & available with the management.
18. Colour code system for pipe lines shall adopted as per IS Colour Code System.
19. Safety training programmes shall be organised for all level of workers, supervisors including contract workers.
20. Adequate fire fighting facility is to be provided with fire hydrant, water sprinkler facility.
21. Electrical Fire pump, Diesel Fire Pump and Jockey pump facility is provided in fire pump house.
22. Fire Hydrant system is to be maintained under pressure all the time.

23. Fire Fighting training shall be organised for all employees.
24. SOP, Safety Instruction and cautionary notice shall be displayed at conspicuous location.

ANNEXURE SECTION

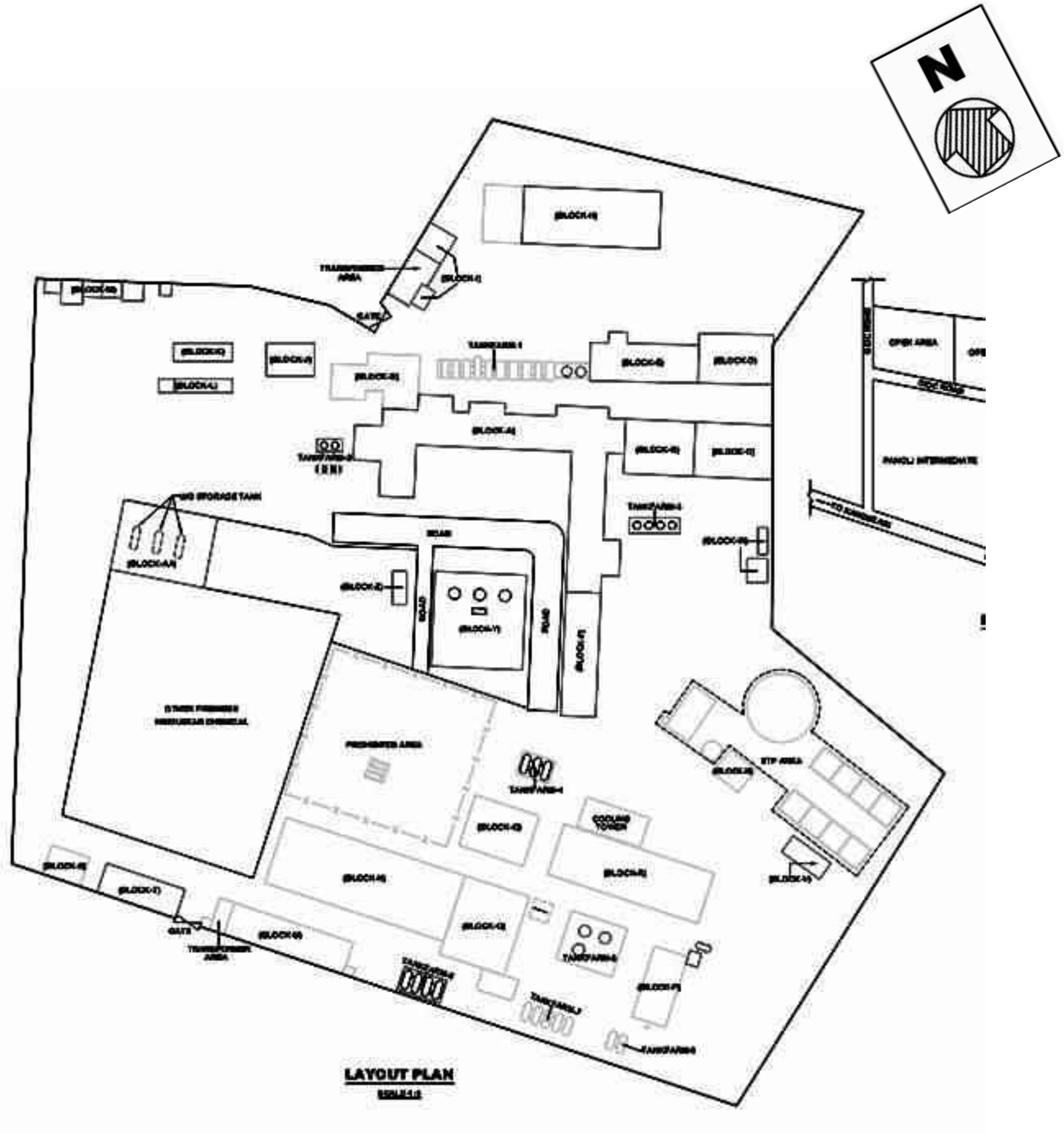
Annexure – 1

LOCATION PLAN



Annexure – 2

LAY OUT PLAN



GUJARAT DYESTUFF INDUSTRIES (Pharma Division)

STORAGE DETAILS OF MAJOR RAW MATERIALS

Sr. No.	Name Of Hazardous Substance	Max. Storage Cap.[Qty.]	Place Of It's Storage	Operating Pressure And Temp.
	Proposed Storage Details			
1	n-butanol	20 MT	SS Tank	ATP
2	Di Ethelene Glycol	25 MT	SS Tank	ATP
3	Castor Oil	25 MT	SS Tank	ATP
4	Lauryl Alcohol	25 MT	SS Tank	ATP
5	Tridecyl Alcohol	25 MT	SS Tank	ATP
6	Ethylene Oxide	3.5MT	SS Tank	3-4 Kg/cm2 and Ambient

Annexure – 4

GUJARAT DYESTUFF INDUSTRIES (Pharma Division)

SALIENT PROPERTIES OF CERTAIN HAZARDOUS CHEMICALS

Sr. No.	Name of Chemicals	State	Colour	Odour	Sp. Gravity ^{0}C	Vapour Density ^{0}C	Melting Point ^{0}C	Boiling Point ^{0}C	Flash Point ^{0}C	Explosive limit		TLV ppm	Solubility in Water	Hazchem	NFPA Code			Hazard Classification
										LEL	UEL				F	H	R	
										%	%							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.	Ethylene Oxide	Liquefied Gas	Colourless	Sweet	0.87	1.52	-111.3	10.7	-20	3	100	1	Soluble	2 P E	3	4	3	Toxic, Flammable, & Explosive
2.	Butanol	Liquid	Colourless	Alcohol Like Odour	0.807	3	-88.9	117.7	36.1	1.4	11.2	-	Partial Soluble	2 Y * E	3	1	0	Flammable