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Hazard Analysis and Risk Assessment (HARA) Report for New Product

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Abstract: The HARA study is distinguishing the hazards related to process, equipment and working methods and evaluating the probability of taking control measures to protect the workers and company assets. In this project, analysis details hazards and operation failure modes to affect the production and legal requirements. Such as the Atmospheric gas monitoring equipment needs to be installed around the machines to detect LEL and TVOC compounds to eliminate environmental concerns and workers' health. The overall purpose of the study is to identify the hazards and risks, then remove/minimize the hazards by providing recommendation control measures. And create a danger-free zone workplace. In this paper I have used quantitative and quantitative methods used to find the Operation failures and Possible Hazards. I have analyzed and exam pined the work/process locations have more hazards to make work more difficult even though good housekeeping and preventive measures.

I. INTRODUCTION

A. Company Profile

M/s Maithili Life Sciences Pvt Ltd., Plot No.: 2, APPIC Industrial Area, Gajulamandyam (V), Renigunta (M), Tirupati- 517520, Andhra Pradesh. The organization initiated a process for carrying out a Hazard Analysis and Risk Assessment Study for the proposed new products to identify possible hazards with reference to the new products & to evaluate risks so as to take appropriate safety measures or to implement alternative design solutions by the Management to mitigate or control the risks or to reduce associated risks to an acceptable level and improve reliability writ safety of the plant operations.

B. Need For Hara

As per rules 10 to 13 under manufacture, Storage and Import of Hazardous Chemicals Rules, 1989 of Environment (Protection) Act, 1986, the Occupier of the Industry using hazardous chemicals in its manufacturing activities should submit a report on Hazard Analysis and Risk Assessment to the Chief Inspector of Factories appointed under the factories Act, 1948 towards an objective evaluation of Safety related to Industrial activity and measures taken and to identify what further measures are required to operate the plant in a safety manner. Hence, the organization initiated a process for carrying out a Hazard Analysis and Risk Assessment Study for the existing products to identify possible hazards . the existing products & to evaluate risks for taking appropriate safety measures or alternative design solutions by the Management to mitigate or control the risks or to reduce associated risks to an acceptable level and improve reliability wrt safety of the plant operations. MR.E.UMAPATHI -EHS & Safety Officer has been appointed as the for carrying out HARA Studies of the existing products. He visited the plant, discussed with the Director and Plant In charge and prepared this HARA study report based on the information provided regarding the manufacturing process, byproducts, reaction conditions, safety measures etc. The study reflects the logical analysis based on the information provided by the organization only. Manufacturing Process, Material Balance for each proposed product is presented by the Director & Plant In charge for identification of the Process Hazards. Production, Safety & Process/Production support and inputs were also taken in reviewing the design safety issues.

C. Objectives Of Hara Study

The principal objective of this study is to evaluate the potential hazards due to the plant operations of Maithili life sciences Pvt. Ltd. located at Plot No.: 2, APPIC Industrial Area, Gajulamandyam (V), Renigunta (M), Tirupati- 517520, Andhra Pradesh.
Hazard Analysis and Risk Assessment (HARA) is carried out to identify hazardous chemicals, Hazardous Operations in the process & storage and quantify the hazards and consequences. The report includes a description of the hazards arising out of the activity together with an account of the controls that are in operation, identification and assessment of major accident hazard potential in the plant operations.

Identification of major failure scenarios Consequence analysis of the scenarios with respect to areas affected by fire or explosion, etc. The HARA Report also includes the existing safety measures already taken by the Organization and the proposed safety measures required to operate the plant in a safe manner. As per the rules 10 to 13 under the Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rules, 1989 as amended in year 2000, made under Environment (Protection) Act, 1986, the Occupier of the industry using hazardous chemicals in its manufacturing activity is obliged to submit report on Hazard Analysis and Risk Assessment to the authorities.

D. Scope Of Hara Study

The Scope of the Hazard Analysis and Risk Assessment (HARA) studies is applicable to the new products proposed to be manufactured at Maithili life sciences Pvt. Ltd. Located at Plot No.: 2, APPIC Industrial Area, Gajulamandyam (V), Renigunta (M), Tirupati- 517520, Andhra Pradesh.

II. METHODOLOGY OF HARA STUDY

Study of manufacturing process, hazards related to operations, plant and equipment, chemicals in use are carried out along with the company team members comprising Production in Charge & Director & EHS & Fire Safety consultant. A site visit to plants & facilities was also done. Further, discussions were held with the Director & Plant In Charge regarding existing Safety Measures & proposed Safety Measures to be implemented.

A. Plant Facilities

1) General

Admin Block
QC & QA (Second Floor)
Security Office

2) Utilities

Refrigeration Plant
MCC/PCC Panel Room (Service Block)
Boiler Shed
Coal Storage Shed
Air compressor room
DG Set Room
HT yard
Transformer Yard

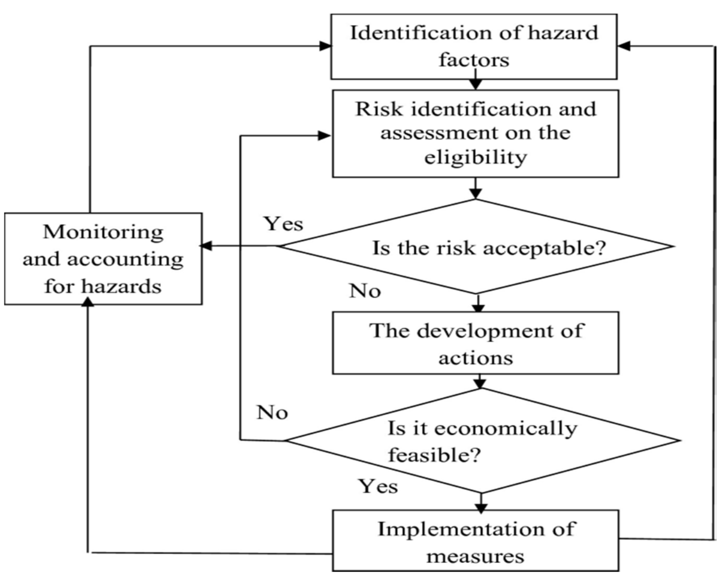

Figure 1.Methodology Of Hara Study

III. HAZARD ANALYSIS

HAZARD: potentially dangerous condition, which is triggered by an event, called the cause of the hazard.
HAZARD ANALYIS: Identify all possible hazards potentially created by a product, process or application.

The Hazard Analysis Process consists of the following steps:

1) Identification and description of the identified hazards and accident events which could lead to undesirable consequences.
2) A relative ranking of the risk of each hazard and accident event sequence using FETI (Fire Explosion and Toxicity Index).
3) A qualitative estimate of the risks in regards to the consequences and the probability and consequences of each undesirable event.

Hazard Identification and Risk Assessment
Risk is defined as the product of the frequency (probability, likelihood) of an event occurring and its consequence (severity, impact, injury/fatality rate). Risk assessment is often an iterative process that involves the major steps:

a) Define a worst case scenario (WCS) in terms of its likelihood and consequences
b) Develop line of defense appropriate to the risk
c) Evaluate the risk reduction/elimination afforded by the line(s) of defense
d) Decide if risk reduction is sufficient and complete the project if sufficient
e) Decide if additional risk reduction can be achieved – perform additional risk reduction and return to step 3
f) Decide to not perform the process if further risk reduction is not feasible .This iterative process of hazard identification and risk assessment is designed to reduce risk to an acceptable level.

A. Hazard Identification:

Preliminary Hazard Identification is used to identify typical and often relatively apparent hazards and damage events in a system.
The following are such hazards considered for detailed study
Hazards Related to Unit Operations
Hazards related to Unit Processes
Equipment Related Hazards
Other Hazards

B. Hazards Related To Unit Operations

The various unit operations often involve hazardous material handling under hazardous operating conditions, adopting hazardous reactions. The general safety considerations for such unit operations have to be taken into consideration of phase changes, catalysts used, reaction kinetics, and equilibrium and heat effects. The following are the Unit Operations and associated hazards.

TABLE-1
UNIT OPERATION HAZARDS

Sr. No.	Unit Operation	Hazards
1.	Transfer of flammable solvents-pumping, vacuum Transfer or manual transfer to reactors or containers	Spills during transfer, Containment failure, Fires due to static charges & ingress of air, exposure to toxic & harmful vapours
2.	Extraction of layers with flammable solvents or toxic solvents	Solvent evaporation, leaking of vapour and igniting
		Air entry with flammable mixture may result in explosion
		Exposure to Toxic vapours during extraction & layer separation
3.	Heat Transfer during Reaction	If the temperature increases beyond the set limit, then the hot reaction mass may bump through the reactor openings or vents , resulting in loss of material confinement
		Runaway reaction due to high exothermic

4.	Distillation	Ingress of air while breaking vacuum , resulting in fire & explosion
		Impurity/ un reacted raw material/ by product getting decomposed at higher temperature than the set point, resulting in explosion
		Static charges generation during collection and transfer of distilled solvent , resulting into fire
5.	Filtration	Choking of filter resulting in over pressurization and loss of containment of filtrate
		Vibration due to uneven cake settling in centrifuge- may result in fire and accidents
		Fire due to static charges & ingress of air
6.	Drying	Over heating during drying may result in fires and explosions
		Air ingress and static charges during Fluid Bed Drying may result in explosions
		Fire & explosion due to static charges due to low ignition energy & thermal decomposition
7.	Milling &Sifting	Potential explosion hazard if the powder has very low minimum ignition energy & Kst value and prone to generate static charges
8.	Blending	Fall hazard & caught in Hazard during Blending operation

IV. HAZARD RELATED TO UNIT PROCESS

A. Hydrogenation

Though the use of hydrogen in a plant is hazardous, hydrogenation is not excessively troublesome. They are usually exothermic and frequently require the use of a catalyst in order to proceed at a the heat released by the reactions is on the surface of the catalyst, local high temperatures may cause sintering. Such high temperatures may also lead to cracking and other unwanted side reactions. After, the completion of reaction, hydrogen feeding is cut off. Sampling of reaction mass through venting by depressurization of the reactor may be hazardous. Probability of occurrence of fire at reactor vent, which should be left at a safe height. A large leak from a high pressure gaseous Hydrogen container would produce a large vapour cloud. Ignition of vapour-air mixture would generate considerable heat and, if the quantities are large enough then a pressure pulse may occur.

B. Oxidation

Oxidation reactions are highly exothermic. Equilibrium is nearly always in favor of the complete reactions and steps must be taken to limit the extent of the oxidation to prevent loss of product. Typical hazardous oxidizing agents are permanent and hypothalamus acids and salts, sodium chloride and chlorine dioxide, chloride's, peroxides, nitric acid and nitrogen hydroxide and ozone. Safe operation is usually achieved by maintaining a low concentration of oxidizing agents and fuel and at lower temperatures. Though they are not limited by thermodynamic equilibrium, there can be problems due to the complete combustion and of side reactions to unwanted by-products. Usually it is necessary to employ catalysts and to use only moderate temperatures to minimize these undesired reactions. The air inlet line can be a source of hazard in liquid phase oxidation processes since the liquid from the reactor flows back up the air line, stays there until the plant is started up and then catches fire when the air flow resumes. The temperatures reached are sufficient to melt the air pipe. There is thus a hazard that the reactor contents may escape through this line.

C. Grignard Reaction

In the Grignard Reaction, organo metallic reagent is prepared by the reaction of alkyd halite with magnesium Metal. The Magnesium Chloride compound is highly sensitive and water reactive. The presence of water leads to a violent reaction with the formation of Hydrogen Chloride gas. Moreover, peroxide formation in THF can lead to critical condition.

D. Nitration

All nitration reactions are potentially hazardous because of the explosive nature of the end products and strong oxidizing characteristics of most nitrating agents. This dual nature of nitrating agents contributes to unwanted side reactions which are rapid and uncontrollable. Both nitration and oxidation reactions are highly exothermic. Temperature control must be exceptionally good if runaway reactions or explosions are to be at reasonable price.

avoided. Sensitivity to temperature is enhanced in liquid phase nitration by the presence of impurities, particularly oxides of nitrogen, since they act as catalysts for the further oxidation. Rapid, auto catalytic decomposition sometimes occurs without an explosion. These “fumes offs" may be quite violent.

Temperature control of both liquid and vapor phase nitration is difficult. Continuous Nitrations are most attractive because they limit the amount of material in process and hence greatly reduce the explosion potential.Nitration accidents are the most frequent and also the most destructive in the chemical industry. A number of explosions in nitration reactors have been reported due to temperature runaways. The temperature differences between the main and runaway reactions are of the order of 10-50ºC.Explosions have occurred in nitration plants due to the reactivity of the nitration products. They have a low decomposition temperature (100-150ºC) and are thus hazardous. Another hazard in nitration reactions is the ingress of water. The addition of water to the nitration mixture may result in a large heat release which causes an explosion either directly or by initiating some other effect.Nitrations are frequently carried out in stirred batch reactors. These reactors have certain characteristics hazards. They occur while charging reactants in incorrect quantities or sequence and the accumulation of unmixed reactants which react violently when the agitator is switched on. Explosions can occur if the acid feed to the reactor is not cut off on stoppage of the agitator.

E. Chlorination

Indirect Chlorination with other Chlorinating agents such as Thionyl Chloride etc Hydrogen Chloride Gas & sulphur Dioxide gas are liberated in the process and are neutralized through a scrubbing system, hence scrubber failure can cause emission of Hydrogen Chloride gas & sulphur Dioxide gas.

V. CHEMICAL STORAGE HAZARDS

The chemicals involved are corrosive, flammable, toxic water reactive and irritant. Spills and containment failures from storage tanks, pipe leaks, flange leaks, pump glands etc. may take place. Over flows can occur during transfer of these chemicals by pumps or by pneumatic pressure. Hence, there is possibility of Fire & Toxic Release.

Bulk chemicals are drawn by pump to a holding tank/ receiving tanks/ Charge Tanks and there , the chemicals are transferred by gravity to reactors. Hence, there is a possibility of large scale spills resulting in Fire & Toxic Release.

VI. EQUIPMENT RELATED HAZARDS

A. Boiler

Boilers, being fired pressure vessels, there are high potential for explosions and may result in loss of life and property. The common causes of boiler explosions are faulty design, usage of substandard or incorrect equipment or operational upsets and errors, improper maintenance and failure of safety devices. Boiler startups, shutdowns are the situations have hazard potential. While, burns, fire hazards are the normal hazards connected with any hot work or related operations, there are boiler-specific hazards and they are as follows:

1) Furnace back pressure b. Fuel-air explosions
2) Tube failure leading to explosion
3) Accidental failure of rotating components

B. Centrifuges

Centrifuges often handle volatile flammable liquids and, unless special precautions are taken, are almost certain to contain a flammable mixture at some stage in the operational cycle.The probability of ignition of the flammable mixture is quite high. Main sources of ignition are mechanical friction, hot surfaces and static electricity. A centrifuge rotates at high speed and a mechanical fault, leading to a spark, or a hot surface, can cause ignition. The movement of the slurry in an operating centrifuge favors the generation of static electricity, particularly if the liquid has high resistivity. Alternatively, if the centrifuge is stopped and open, a static electricity hazard may occur from an operator who has too high an insulation to earth.

The most suitable system depends on the degree of hazard. But the system based on the measurement of oxygen concentration, which is the variable of direct interest, is the most positive and should be used for the high risk situations. If there is a toxic hazard, the centrifuge system should be enclosed as far as practicable. Local exhaust ventilation should be provided. Alternatively, it is possible to extract from the casing and operate under a negative pressure, provided that the liquid is not flammable. Other measures which may be required include provision of a forced air supply or of breathing equipment for the operator. Spark generation if the centrifuge is not having static & electrical earthing, and due to friction. Solvent vapours spreading around the centrifuge, if the ML's are not collected in closed system. Accumulation of solvent vapours if there is no local/general exhaust system.

C. Dryers

The product (filtered or centrifuged) is spread on trays and is loaded in tray dryers. Indirect steam application and heating is done. Since Low Pressure or Hot water circulation system with auto cut off steam is used, the temperature of the operation may not exceed 60 to 70 deg. C. However, the solvents evaporate and escape from the vent. Depending upon the inlet steam condition, over heating of product can take place. Therefore, thermostats are often fitted to the dryers. The solvent vapours (if they are hydrocarbons) can escape into room area and may lead to fire accidents or may form explosive mixture with air and may lead to explosions. The probability becomes more if the vent is let off in the work area with the chances of sparks or naked fires. To prevent propagation of flame into dryers, flame arresters are recommended to the vents. FBDs present distinct hazard of forming explosive mixture and static charge accumulation.

VII. OTHER HAZARDS

A. Mechanical Hazards

Various mechanical equipment is in use in the plant. Reaction vessels are fitted with stirrers, agitators driven by reduction gearing and motors.

Pumps are in use for transfer of liquid chemicals. Centrifuges are used for separation. Utility equipment like Diesel Generators, Air Compressors, and Brine/ Chilled Water Plant etc has mechanical equipment. Most important hazard in such equipment is due to rotating components which may cause traumatic injuries. In case of centrifuges, improper erection of equipment and balancing may result in damage to bearing, breakage and violent throw-offs which may have secondary effects of fires etc. Over pressurization of pressure systems is another mechanical hazard associated with the operations.

B. Electrical Hazards

Electrical equipment in flammable atmosphere is an important hazard in pesticide manufacture. Hazard Area Classification for the selection & installation of right type, class & group of electrical equipment play an important role .Electrical equipment are also selected based on the type of flammable gases being used in the area.Further, due to operating conditions, wet conditions in floors and around equipment may prevail. This may result in electrical shocks etc from exposed or un- insulated electrical conductor terminals. Sparks from electrical equipment may result in fire accidents.

C. Maintenance Hazards

Maintenance operations are critical in process industry and more so in a batch operation industry. Each time, between the batches or change- over of campaign or products, the maintenance works are taken up and cleaning operations are carried out. There is need to enter reactor vessels and cleaning. Deleterious atmosphere during such entries is a known hazard. Cleaning of different tanks & reactors is again hazardous operation due to the presence of toxic/ hazardous gas/ vapour/ solid present in pockets not easily accessible. Persons engaged in maintenance operations may gain contact with hazardous chemicals which may be toxic or skin sensitizer or irritant etc.

D. Corrosive Hazards

Corrosion hazards are likely to be encountered in the storage areas and reactor areas. Corrosion may slowly lead to structural failures. Here structural failures include pipe supports, pipes, columns of the reactors and production blocks, storage tanks walls and storage tank supports, columns of scrubbers, distillation columns etc. Hence, stability evaluation of structural supports/ civil foundations etc need to be done based on the nature of corrosive atmosphere or changes / modifications in the civil structures.

E. Containment Failure Hazards

Any structural failures often lead to containment failures. Containment failures are related to Storage tanks, columns and reactor supports etc. Solvents such as Methanol & Toluene are being stored in above ground tanks.Liquid Raw Materials & Acids and Hazardous Chemicals as per the list of hazardous chemicals are being stored in liquid drums storage shed .Liquor Ammonia is stored in above ground HDPE tank in the factory. Solid hazardous chemicals & Raw Materials are stored in Solid RM Warehouse.Spill hazards are associated with unloading of acids/alkalis and solvents, sampling and pumping operations. Overflowing from the tanks or overfilling of the tanks is another reason for spills. Main storages and intermediate storage tanks can fail due to vacuum during drawl operation. This may lead to buckling of the storage tanks and spread of corrosive & flammable solvent all over.Most of the times, dilute solution of Acids & CS Flakes also being prepared in the production blocks which may cause containment failure during transfer by vacuum or using AOD Pump or centrifugal pump. Probability of gasket failure cannot be ruled out.

The following could be few situations, where solvents, hazardous chemicals /RM or acids or Alkalis can get released:

1) Spillage of flammable solvents during transfer from road tankers to storage Tanks, may cause spreading and catching fire hazard.
2) Spillage of flammable solvents from Storage Tanks due to leakage of tanks or while drawing of solvents to production block.
3) Failure of Charge Tanks/Receivers, Intermediate storage tanks or failure of level gauges, pipes etc leading to containment failure of solvents, Hazardous Chemicals and flammable materials
4) Emission of solvent vapours from condensers due to overheating or failure of condensation mechanism
5) Reaction mass getting overheated and bumping of mass of reaction due to chilling system failure, agitation failure or failing to control temperature or uncontrolled addition of reactants.
6) Spillage of Acids & CS Lye or other Chemicals during transfer from carboys or drums to reactor or receives.
7) Spillage of Acids & CS & Potash flakes during addition in plant area during preparation of dilute solutions.
8) Overflow of receivers/ Addition Flask during transferring of solvents from day tanks to Charge Tanks or receivers or collection of distillate in receivers.
9) While unloading solvent from road tanker into underground tanks, hosepipe failure can result into containment failure and solvents flow out, till someone detects and stops the valve to the road tanker.
10) Discharge valves of one of the compartment of road tanker can fail and result in escape of solvent on to ground & may cause fire hazard.
11) Overflow of solvents during pumping operation from ground level to plant area (either a reactor or overhead measuring tank or receiver)
12) Contents of reactor are discharged inadvertently or containment failure due to valve defects.
13) Overheating of contents of reactor resulting in fire accidents.
14) Due to external sources, spills in plant area, catching fire and resulting in involvement of entire inventory in reactor area/distillation column and measuring/day tanks.
15) Solvent vapours accumulation around the reactor, if there are any leaks, this may result into fire.
16) Pressure buildup within the reactor due to any of the process parameter variation or system malfunctioning.
17) Containers of Flammable solvents failure for example barrels of 200 liter
18) Containers of toxic raw materials failure for example 200 Liter barrels of MDC , Monomethyl Amine Solution

Flammable solvents (Methanol & Toluene) and corrosive chemicals (Liquor Ammonia) are also stored in tanks in the factory. Regular replenishment and drawing of the chemicals to the consuming points is a continuous process. Spill hazards are associated with unloading of acids/alkalis, sampling operations. Main storages and intermediate storage tanks can fail due to vacuum during drawl operation. This may lead to buckling of the storage tanks and spread of corrosive material all over.

VIII. RISK ASSESSMENT

1) *Risk:* Hazard that is associated with a severity and a probability of occurrence.
2) *Risk Assessmment:* It is the next step after the collection of potential hazards. Risk in this context is the probability and severity of the hazard becoming reality. Risk Assessment follows Hazard Analysis. It involves identification and assessment of risks to the plant, personnel and neighboring population. For this, failure probability, credible accident scenario is essential. Thereby, the Risk assessment examines the probability of occurrence of credible worst case scenarios and determines the potential

adverse effects on plant, personnel &community through consideration of various direct and indirect impacts resulting from the occurrence of a hazard. In the absence of extensive historical data, probabilities and impacts are subjective assessments drawn from interview information, rational observations and experience.

A. *Probability Of Failure*

Failure rate for various critical equipment is very important in risk assessment. Very limited data in this regard is available in our country. However, Safety & Reliability Directorate of UK and IEEE of USA have certain data in this regard.A rationale approach of converting these to one year depending upon the operations, no. Of shifts, etc has been done. It cannot be claimed as accurate procedure. However, in the absence of any other reliable data as well as procedure, this method can be considered as useful.

Supply pipe	0.25 x 10^-3/Hour
Spillage of road tanker/loading	5 x 10^-3/Hour
Motors for blowers	10.5 x 10^-6/Hour
Rotating Equipment	24.7 x 10^-6/Hour
Pressure Vessel Failure	In 100 x 300 vessel
Catastrophic Failures	0.7 x 10^-4 Failures/Year
Valves	12.3 x 10^-6/Hour
Human errors	1800 to 5000 errors in One Million operations.

While computing pipe failures, 6 hours per day of pipe working is assumed as the pipes are called into operation while transferring the solvents to reactors. In estimating spillage of tankers, on an average 4 tanks per week at two hours each time are assumed in estimating number of hours the tanker is located in the plant. Solvent storage containment failure : Per year

Vessel failure-no ignition	0.4
Immediate-ignition	0.1

Hose pipe failure-operator failure to immediately arrests

No ignition	0.3
Immediate ignition	0.075

Reactor drain valve or pipe connection failure-operator failed

To control- no ignition	0.0015
Immediate ignition	0.0004

Condenser failure-operator failure to control or shut off

No ignition	0.3
Immediate ignition	0.075

IX. RECOMMENDED SAFETY MEASURES TO REDUCE CONSEQUENCES OF RISK OR REDUCE OR MINIMISE HAZARDS

1) Chemical Incompatibility Charts should be prepared and displayed in warehouses, Raw Materials storage areas, production blocks etc.
2) PPE Matrix chart is to be prepared & displayed at various places.The redundancy of Temperature gauge for critical reaction wrt temperature rise/ or of exothermic nature must be provided.
3) It is recommended that transfer of solvent and other chemicals shall be done by pumping and preferably not by vacuum wherever applicable.
4) The scrubber vent terminal, vented contents are to be monitored to ensure that neutralization is adequate.
5) During batch distillation and recovery or recycling of flammable solvents, it is recommended to ensure that ingress of air is avoided to prevent formation of flammable or explosive mixtures. Such ingress could occur during intentional vacuum breaking or during power failure and inert gas system is to be always in position.

6) As the over- exposure to intermediates, chemicals and finished products can be injurious to health, awareness of such conditions, avoidance of such conditions, use of suitable personal protection, early detection of undesirable health conditions and medical management measures are to be developed and included as procedures.

X. CONCLUSION

The Management has taken in built safety measures. Monitoring of already existing in built safety measures is also being done from time to time by Safety & Engineering team The house keeping standard is excellent for the entire site Various Training programme (Internal & external) are conducted covering various training topics SOPs are prepared & training on SOPs is planned. The various elements of Process Safety Management System is being reviewed and implemented as & when needed. The existing safety measures, Practices & procedures are being periodically reviewed with reference to best available technology and safety practices.The Management has proposed to provide “In Built Safety Measures” as mentioned below:

Fire Hydrant System for the entire site including the Solvent Storage Tanks Scrubbers wherever needed as per the process requirements.

1) SRV to reactors with emergency vent connection to a Dump Tank or Containment Tank
2) Electrical Siren
3) Use Nitrogen Inertisation to Flammable storage tanks, receivers & reactors
4) Shower & eye wash fountain near Liquid drum storage shed
5) SCBA-One set for Toxic emission handling
6) Separate dedicated room for Bromine reactors
7) Spill control material for Bromine spill control

A combination of proposed In Built Safety Measures and compliance of recommended safety measures would go a long way in reducing identified associated risks to an acceptable level.The measures are to be periodically reviewed with reference to best available technology and safety practices and creating awareness among employees about changes taking place. This report shall be read in conjunction with HAZOPS Report & other safety reports prepared by the Management.

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