A project report

HAZOP STUDY FOR VENLAFAXINE PLANT

By

SIVANESAN.M
R070207020

College of Engineering
University of Petroleum & Energy Studies
Dehradun

HAZOP STUDY FOR VENELAFAXINE PLANT

A thesis submitted in partial fulfillment of the requirements for the Degree of
Master of Technology
(Health Safety & Environment)

By
SIVANESAN.M

Under the guidance of

Internal guidance

Mr.G.Sanjay Kumar,
Asst.Professor,
University of Petroleum & Energy Studies

External guidance

Mr.M.Raj Kumar,
Asst. Manager
Shasun Chemicals & Drugs Ltd.

Approved

....
Dean

College of Engineering
University of Petroleum & Energy Studies
Dehradun

May, 2009

Shasun®

Date: 30/04/2009

To whom soever it may concern

This is to certify that Mr.Sivanesan.M, a student of final year M.Tech (HEALTH SAFETY & ENVIRONMENT) from University of Petroleum and Energy studies, DEHRADUN - 248007 has done the project work of HAZOP study for venlafaxine product in EHS department of our organisation during the period 26-03-2009 to 16-04-2009.

During the training period his character and conduct were excellent.

We wish him all success in his future endeavor.

Regards

M.Illanghovan,
(IR-General Manager).

Shasun Chemicals and Drugs Ltd
Factory : A 1/B Sipcot Industrial Complex, Kudikadu Village
Cuddalore : 607 005
Phone : 91-04142-239701 To 239705
Fax : 04142-239709

ABSTRACT

This qualitative technique was used to identify potential hazards created by deviations from design intent. The areas of the facility to be included in the HAZOP were subdivided into workable sections called "nodes" for a detailed review using the prescribed HAZOP criteria. As part of this identification, possible causes and consequences of potential hazards were noted as well as safeguards in place which would mitigate and / or control the circumstance.

As currently designed, and if used in accordance with its design and unless specifically stated herein or in the accompanying study, the equipment/unit is believed to comply with all industry standards and all applicable laws.

There commendations contained herein are intended solely to improve the efficiency of the equipment does not operate as designed to human error were to occur. Nothing contained herein is intended to constitute and admission of lack of due care, deviation from an industry standard or non-compliance with any applicable law. There were total recommendations developed during this HAZOP study and then assigned a number to indicate a priority ranking. This ranking can then be used as a guideline for further review for the recommendations.

ACKNOWLEDGEMENT

I am greatly indebted to **University of Petroleum and Energy Studies** for having given me this opportunity. With the support and cooperation of one and all at SHASUN, I could complete my project as well as the training program in a successful manner.

I also have to express my sincere thanks to **Mr.DEVARAJAN (Deputy General Manager) safety, SHASUN** for their help without which my project would not have been completed.

My sincere thanks to **Mr.S.JOSEPH (Assistant General Manager) Production, SHASUN** process engineering, who had guided and motivated throughout for the development of my project.

I also have to express my sincere thanks to **Mr.M.RAJKUMAR (Asst.Manager) safety, SHASUN** for their help without which my project would not have been completed.

I am very much pleased to express my heartfelt and sincere thanks to **Mr.SANJAY KUMAR (Asst.Professor)**, for his consistent encouragement and extended support.

At the outset, I render my thanks at the golden feet of my **family members** who led me all the way to complete the project successfully.

I express my sincere thanks to all of my friends for their moral support, help and encouragement for completing my project.

LIST OF TABLES

TABLE OF CONTENTS

AIM & OBJECTIVE

CHAPTER I

AIM AND OBJECTIVE OF THE PROJECT

The main aim and objectives of the project are,

- To get acquaintance with industrial environment.
- To study the safety aspects in the design and operation of Venelafaxine Unit
- To identify drawbacks in the design affecting safety and basic operation of the plant with the aid of Hazard & Operability (HAZOP) Study.
- To suggest recommendations based on the study.

METHODOLOGY

CHAPTER II

METHODOLOGY

- To study the significance of conducting a HAZOP Study in the design stage, modification stage and operation stage of a plant.
- To study the relevant Piping and Instrumentation diagrams, documents related to the plant design and operations in the plant.
- To identify the important operations as study nodes, sub nodes etc
- Discussion with the officials of the plant.
- To visit the various units of the plant, interact with supervisors & operators and to study the basic operations of each unit.
- To investigate how the plant might deviate from the design intent and thereby identifying hazards & operability problems and the safeguards available.
- To record the data in HazOp worksheets with relevant recommendations based on the study for further improvement in the design and operations.

HAZARD AND OPERABILITY STUDY

CHAPTER III

HAZARD AND OPERABILITY STUDY...

An Introduction:

A HAZOP is an extremely detailed & through method of hazard analysis on a process plant. The whole purpose of HAZOP is to identify deficiencies in both the design & operation of the plant.

It is defined as "Systematic critical examination of the process & engineering intentions to assess the hazard potential of maloperation or malfunction of individual item of equipment & the consequential effect on facilities as a whole."

This technique is applied to mostly process industries. The first step on the HAZOP study is to prepare lay out diagrams based on design particulars & operating instructions. Data sheets for all chemicals regarding physical chemical & toxic properties are also collected. The lay out diagram is critically examined at every stage. At each stage of examination series of questions are asked with guidewords such as NO/NOT, MORE/LESS, REVERSE, OTHER THEN ETC. These are the words used to indicate the deviation from the normal procedure in the operation of plants. These words are applied to variables such as temperature, pressure, flow level, reaction etc. The answers for the above words are analyzed for possible hazards & decisions are taken on the central aspect.

A HAZOP is clearly a very time- consuming exercise, but the results can be invaluable in identifying potentially expensive flaws in designs & procedures. This method has the disadvantage that if someone has to review the HAZOP later (possibly because of a failure on the plant) there will be no means of knowing the logical processes by which the team reached its decisions.

Once Preliminary Hazard Analysis (PHA) has established the systems or events that could cause a major hazard. It is necessary to consider which are based on the wide experience & knowledge of professional experts & specialists in the industry.

It is important to recognize that the body of established experienced expressed in codes, etc. Is limited by the extend of existing knowledge & can only be relevant to the extent to which it is possible to apply it to new products. New plants and new methods of operation involved in the new design. It has become increasingly clear in recent years that although codes of practices are extremely valuable. It is particularly important to supplement them with an imaginative anticipation of hazards when new projects involve new technology.

The need to check designs for errors & omissions has been recognized for a long time, but this gas traditionally been done on an individual basis. Experts have usually applied their special skills or experience to check particular aspects of design.

Objectives:

- To check a design.
- To decide whether & where to built
- To decide whether to buy a piece of equipment
- To obtain a list of questions to put on a supplier.
- To check running instructions
- To improve the safety of existing facilities

It is also necessary to describe the types of hazard to be considered.

For example,

- To people working in a plant
- To plant & equipment
- To or from product quality
- To the general public
- To the environment

The principle:

The examination procedure is the fundamental part of a hazard & operatibility study. It is highlighted & described separately in this chapter.

The Basic Concept:

The HAZOP examines fully the process or at least those parts of the process that have been classified as "relevant" in the PHA Hazard & operability studies are a method of providing a form of such synthetic experience. The work by suing the imagination of members of a team to visualize the ways in which a plant can malfunction or be maloperated. However imagination alone is not enough. Engineers use plenty when designing the plant. Therefore the imaginations of team members must be guided & stimulated in a systematic yet creative fashion to cover all parts of the plant & all conceivable malfunctions & mal operations. This is achieved in what is called the "examination". Essentially the examination procedure takes a full description of the process. Systematically questions every part of it to discover how deviations from the intention of the design can occur & decides whether these deviations can give rise to hazards.

In effect, the guide words are used to ensure that the question will explore every conceivable way in which that design could deviate from the design intention. The purpose of the examination is to identify all possible deviations from the way the design is expected to work all the hazards associated with these deviations. In addition, some of the hazards can be resolved. If the solution is obvious & is not likely to cause adverse effects on other parts of the design. A decision can be taken & design modified on the spot. This is not always possible for example; it may be necessary to obtain further information. Thus the output from examinations normally consists of a mixture of decisions & questions for answering at subsequent meetings.Although the approach as described may appear to generate many hypothetical deviations in a mechanistic way, the success or failure depends on four aspects.

1. The accuracy of drawings & other data used as the basis for the study.
2. The technical skills & insights of the team
3. The ability of team to sue the approach as an aid to their imagination in visualizing deviations, causes & consequences.
4. The ability of the team to maintain a sense of proportion. Particularly when assessing the seriousness of the hazards which are identified.

THE MOST important of these terms are

INTENTION:

The intention defines how the part is expected to operate. This can take a number of forms & can be either descriptive or diagrammatic. In many cases it will be a flow sheet or line diagram.

DEVIATION:

These are departure from the intention, which are discovered by systematically applying the guidewords.

CAUSES:

These are the reasons why deviations might occur. Once a deviation has been shown to have conceivable or realistic cause. It can be treated as meaningful.

CONSEQUENCES:

These are the results of the deviations should they occur.

HAZARDS:

These are consequences, which can cause damage, injury or loss.

THE GUIDE WORDS:

These are simple words, which are used to qualify the intention in order to guide & stimulate the creative thinking process & so discover deviations. The value & applicability depend upon the intentions to which they are applied & the possible modes of deviation from those intentions.

When guidewords are used on broadly expressed intentions they are all applicable. They may also be applied t the detailed level of descriptive words or phrases. However, when they are applied to intentions expressed in fine detail, restrictions & even some modifications may be found necessary.

When they are applied to an activity such as REACT or TRANSFER usual to find that all the guidewords will generate intelligible notional deviations. Sometimes more then one deviation will be generated by one-guide words. Sir when they are applied to substances. All guidewords with the possible exception REVERSE will be intelligible. Again more then one deviation may be developed. For example, MORE STEAM can mean a greater quantity or rate of steam(a capacity increase) or steam at higher pressure (an intensity increase).

When dealing at a more detailed level of design intention. Some rest will be found because the possible modes of deviation are reduced. For example suppose the design intention for a temperature of 100°C was being consider. The only possible mode of division (if we forget about the absolute zero) is MORE above 100°C & LESS. i.e. below 100°C.

When the guidewords are applied to the time aspects MORE & LESS *may* longer & shorter duration or higher & lower frequencies. However when dealing with sequences or absolute time. The extra guidewords SOONER or LATER more insight then OTHER THAN. Similarly when dealing with position, sources destination, WHERE ELSE is more useful than OTHER THAN. Again HIGE LOWER will give more meaning than MORE & LESS for deviations in elevation.

When dealing with a design intention involving a complex specification temperature, rates, composition, pressures etc. It may be better to apply the sequence of guidewords to each element individually rather then apply guideword across the whole range of the specification. Also when applying words to a sentence it may be more useful to apply to sequence of guidewords each words or phrase separately starting with the key part, which described activity. Guidewords are applied to the design intention. The design intention tells us what the equipment is expected to do.

Table 1: List of Guide words

List of Study Nodes selected for the HazOp study:

v Guide Words Parameter	**No**	**Less**	**More**	**Part of**	**As Well As**	**Reverse**	**Other Than**
Flow	Yes	Yes	Yes	No	Yes	Yes	No
Temperature	—	No	Yes	—	-	-	-
Pressure	-	Yes	Yes	-		-	-
Level		Yes	Yes			-	-
Composition	—	-	—	No	Yes	-	No

Table 2: Guide words and parameters relevant for the HazOp study

Guide Word + Parameter	Type of Deviation	Typical Problems
NO + FLOW	No Flow	Blockage; Pump failure: Valve closed; Jammed; Leak; Valve open; Suction vessel empty; Delivery side over-pressurised; Vapour lock; Control failure
REVERSE + FLOW	Reverse Flow	Pump failure; NRV failure or wrongly inserted; Wrong routing; Delivery over-pressurised; Back siphoning; Pump reverse
MORE + FLOW	More Flow	Reduced delivery head; surging; suction pressurized; Controller saturated; Valve stuck open; Leak; Incorrect instrument reading
LESS + FLOW	Lower Flow	Pump failure; Leak; Partial blockage; Sediment; Cavitation; Poor suction head; Process turndown
MORE +PRESSURE +TEMPERATURE + VISCOSITY	Higher Pressure Higher Temperature Higher Viscosity	External fires; Blockage; Hot spots; Loss of control; Foaming; Gas release reaction; Explosion; Valve closed; Loss of level in heater.
LESS +TEMPERATURE + PRESSURE + VISCOSITY	Lower Temperature Lower Pressure Lower Viscosity	Heat loss; Vaporisation; Ambient conditions; Rain; Imbalance of input and output; Sealing; Blocked vent
PART OF	Change in composition	High or low concentration of mixture; Additional reactions in reactor or other location; Feed change
MORE THAN	Impurities or Extra Phase	Ingress of contaminants such as air, Water, tube oils, corrosion products; Presence of other process materials due to internal leakage; failure of isolation; Start - up features
OTHER	Activities other than normal operation	Start-up and shutdown of plant. Testing and inspection; Sampling; Maintenance of activating catalyst; Removing blockage or scale; Corrosion; Process emergency safety procedures activated; Failure of power, fuel, steam, air, water or inert gas; Emissions and lack of compatibility with other emission and effluents.

STUDY METHOD

TABLE 3:

Probability/Risk Maximum Possible Loss	Very Unlikely	Unlikely	Even chance	Probable	Very likely	Certain
No loss	1	2	3	4	5	6
First Aid Required/short rest/recovery	2	4	5	6	7	8
Fracture of a major bone or mild temporary illness	3	5	6	7	8	9
Loss of limb, eye or permanent illness	4	6	7	8	9	10
Fatality	5	7	8	9	10	11

Low = 1 – 4

Medium 5

High 6 - 11

TABLE 4:

Frequency of Exposure (FE) calculation aid

Infrequent	Annually	Monthly	Weekly	Daily	Constantly
1	2	3	4	5	7

TABLE 5:

Table of timescales

Risk	Hazard Rating	Action timescale
Low	1 - 21	Within a month
Medium	22 - 35	Within a week
High	35 - 77	Immediately

TABLE 6:

Priority of Recommendations

Risk Action Matrix		
Risk Level	Category (Description)	Action Required
12~16	Unacceptable (Catastrophic)	Hazardous event must be mitigated with engineering and/ or administrative controls to a risk level of 2 or 3. Interim controls are required to ensure safe operation pending completion of recommendations.
6~9	Undesirable (Major)	Hazardous event must be mitigated with engineering and/or administrative controls to a risk ranking of 2 or 3. Interim controls should ensure safe operation pending completion of recommendations.
3-4	Acceptable with Controls (Improvement Opportunity)	The team must do a case-by-case analysis to determine if a recommendation is necessary due to the catastrophic consequences of the event.
1-2	Acceptable as is	PHA team verified that adequate procedures and controls are in place with acceptable mechanical integrity and reliability to prevent or control the hazardous event. No mitigation required.

VENELAFAXINE UNIT

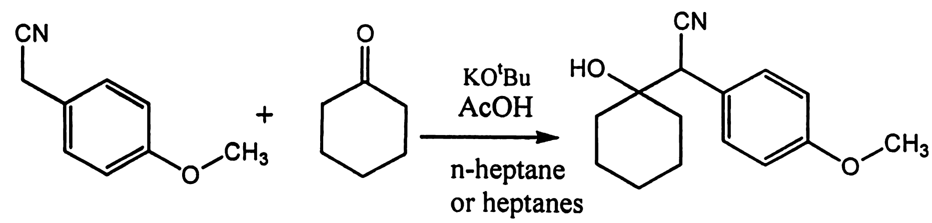
CHAPTER IV

PROCESS DESCRIPTION

Venlafaxine Hydrochloride belongs to a class of antidepressants called serotonin-norepinephrine reuptake inhibitors (SNRI).It is synthesised in four stages starting from 4-Methoxyphenylacetonitrile.

<u>Process</u>

<u>STAGE-1</u>: α- (1-Hydroxycyclohexyl)-4-methoxyphenyl acetonitrile or Methoxycyanol



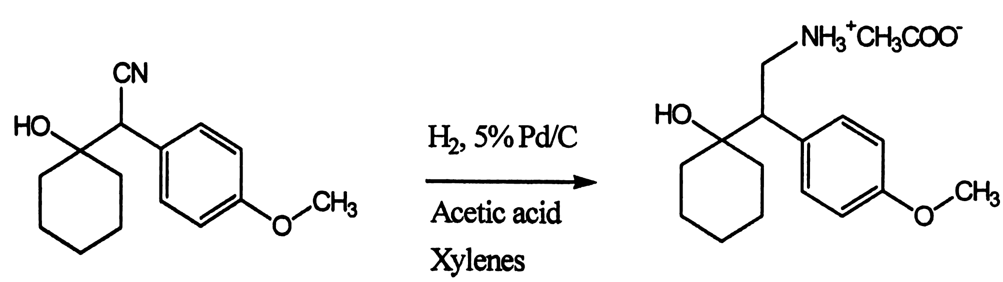
4-Methoxyphenylacetonitrile | Cyclohexanone | (1-Hydroxy-cyclohexyl)-4-methoxy phenylacetonitrile

C_9H_9NO
Mol. Wt.: 147.2

$C_{15}H_{19}NO_2$
Mol. Wt.: 245.3

To a mixture of 4-methoxyphenylacetonitrile, cyclohexanone and n-heptane or heptanes, cooled to 20-25 °C added potassium-t-butoxide (lot1). There is a temp raise of 2-3°C.The next lot is added after an hour. Lot 3, 4, 5 are then added after every 2 h maintaining a temperature between 20-25 °C. The reaction is monitored by HPLC and the sample after 12-14h showed 4-methoxyphenylacetonitrile NMT- 5 %(area %). Acetic acid is then added to the mass and stirred for 30 minutes at 20-25°C. It is then filtered, washed with 2V of 5 % ethyl acetate: n-heptane or heptanes mixture (cooled to 0-5 °C) to obtain stage 1 product

<u>STAGE-2:</u> 1-[2-Amino-1-(4-methoxyphenyl)-ethyl]-cyclohexanol acetate or Methoxyacetate



(1-Hydroxy-cyclohexyl)-4-methoxyphenyl acetonitrile
$C_{15}H_{19}NO_2$
Mol. Wt.: 245.3

1-[2-Amino-1-(4-methoxy-phenyl)-ethyl]-cyclohexanol acetate
$C_{17}H_{27}NO_4$
Mol. Wt.: 309.4

Methoxycyanol in acetic acid is charged to the vessel followed by 5 % (wet type, moisture content 45-50 %, to be added under nitrogen blanket).The vessel is pressurized to 25 Kg/cm^2 with hydrogen (after initially purging with nitrogen and cycling under vacuum to remove air from the vessel). The reaction mass is stirred at 650-750 rpm and steadily heated to 55-65°C. After 2-3 h of heating, the reaction went to completion as followed by TLC and HPLC in-process monitoring. The mass is then allowed to cool to ambient temperature 30-35 °C. The catalyst is filtered over a celite bed and washed with additional quantity of acetic acid and combined with first filtrates. The resulting filtrate, obtained above is concentrated at 55-60°C under reduced pressure (10-50 mmHg) to remove around 70-75 % of acetic acid. The residue is diluted with mixed xylenes and then the mixture of acetic acid / xylene is distilled out at 55-60°C under reduced pressure. The removed solvent is replaced by equal amount of xylenes and the same process is carried 5 more times, during the course of which solid begins to crystallize out. The solid is diluted with some mixed xylenes was then stirred at temperature below 20 °C for 1.5 h prior to filtration. The filtered product is washed with portions of cold xylenes (10-15 °C) and dried under vacuum (730-750 mmHg) at temperature 50-55°C until LOD is NMT 0.50 %

STAGE-3: 1 - [2 - (dimethylamino) – 1 - (4 – methoxyphenyl) ethyl] cyclohexanol or Venlafaxine free base

Formic acid 80 % aq. (prepared by dilution of 98-100 % formic acid) is cooled to 5-10 °C. 30 % aq.sodium hydroxide solution is added to adjust a pH between 3 and 4 while maintaining the internal temperature below 25 °C. (If needed either 80 % formic acid or 30 % NaOH can be added to get within the specified pH range). Methoxyacetate is added keeping the mass temperature below 25 °C, this is then followed by the gradual addition of 35 % aq formaldehyde with internal temperature below 25°C (Note: A moderate exotherm of 2-3 °C is observed during addition) The mixture was then slowly heated to reflux (100-110 °C) and maintained for 2-2.5 h until the evolution of CO_2 ceases.

(Note: Heating is done slowly to control excessive evolution of CO_2 and prevent foaming). HPLC analysis at the end of 2 h is done to confirm that starting material NMT 1.0 %.

The mixture is then cooled to 20-25 °C and diluted with minimum quantity of n-heptane or heptanes (0.2 X g w.r.t to methoxyacetate). 30 % aq. NaOH solution is then gradually added at 10-25 °C until a pH of not less than 12.0 is achieved. The reaction mass is left to stir at 10-20 °C for 2 h and then filtered. The crude product is isolated and washed with water.

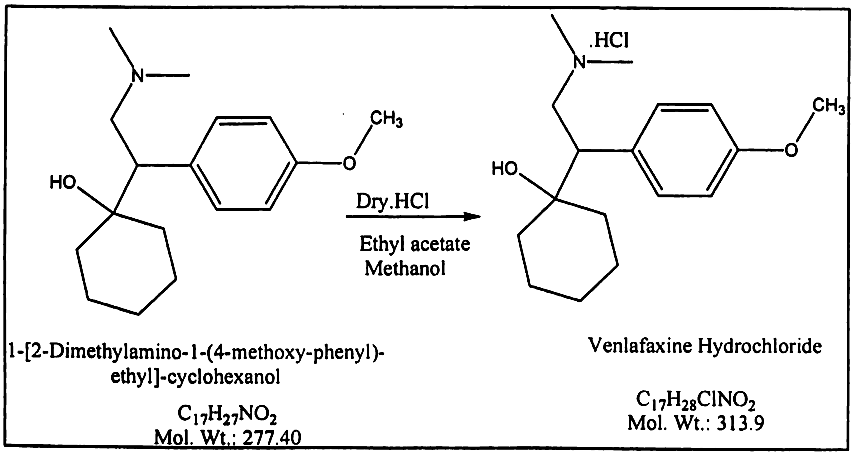
Crude venlafaxine base is purified by recrystallization from n-heptane or heptanes.

Purification

The crude venlafaxine base (wet) obtained from the above process is dissolved in n-heptane or heptanes by heating at 70-80 °C. The resulting mixture is allowed to settle and the aqueous phase that separates out is discarded. The organic layer is then thoroughly washed with hot water (60-75 °C), Layers are separated and the organic layer was filtered while hot

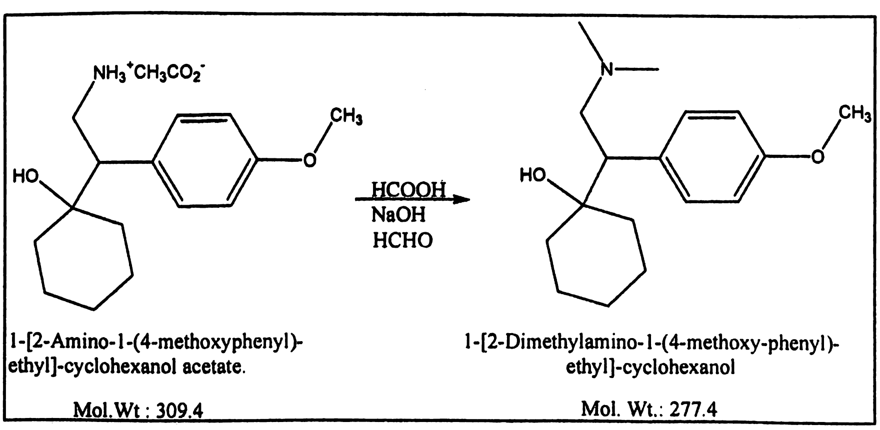
(50-70 °C) via double whatman paper. The solvent is distilled atmospherically until about 55-60% of the total volume of the solvent distillate is collected. The resulting suspension is cooled gradually to 0-5 °C and stirred for 2 h. The product is then collected by filtration and bed washed with portions of cold n-heptane or heptanes (5-10 °C). The product is dried under vacuum (740-750 mmHg) at 45-50 °C until an LOD limit of NMT 0.50 % is achieved.

Stage-4: 1-[2-(dimethylamino)-1-(4-methoxyphenyl)ethyl] cyclohexanol hydrochloride or Venlafaxine Hydrochloride



The purified venlafaxine base (dry) is dissolved in a mixture of methanol and ethyl acetate under stirring at ambient temperature 30-35 °C, the resulting solution is filtered via a double whatman filter. The filtrate was taken in a 4-necked round-bottomed flask.

Temperature of the reaction mass (internal temperature) was raised to 35-40 °C, dry hydrogen chloride is bubbled in such a rate that temperature does not exceed 50 °C. The pH of the solution is adjusted to a value less than or equal to 3.0 (typically 1.5-3.0). The change in pH is monitored using pH meter. After adjusting the pH to the required value the temperature is further increased to 65 °C and about 70-75 % of the total solvent added is distilled out. At this point the product begins to crystallize. The distilled solvent is replaced by ethyl acetate and again some portion of the solvent is distilled out. The slurry is then kept for reflux for 8 h, then cooled to10-17 °C and maintained at that temperature for 12 h. The product is isolated and washed with ethyl acetate. The white crystalline product thus obtained is dried under vacuum 730-750 mmHg typically at 55-60°C and not exceeding 65°C for approximately 10-12 h until a LOD limit of NMT 0.50 % is achieved.



HAZOP WORKSHEETS

HAZOP Worksheet – STAGE-I

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: No/Low Flow

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. NO SOLVENT IN STORAGE	1. PUMP FAILURE	2	3	6	1. TANK LEVEL ENSURED BEFORE PUMPING	LEVEL SWITCH TO BE LINKED TO PUMP START
2. LINE/VALVE BLOCKAGE	1. PUMP FAILURE	2	3	6	1. PREIODIC SUCTION SIDE STRAINER CLEARING	TO BE INCLUDED IN SCHEDULE MAINT PROGRAM
	2. PRESSURE BUILD UP IN THE LINE	2	3	6		PRESSURE GAUGE ON THE SUCTION SIDE OF THE PUMP
	3. RUPTURE OF FLANGE GASKET	2	3	6		
	4. SPILLAGE AND FIRE HAZARD	3	3	9		
	5. PUMP CAVITATION	1	3	3		
	6. HUMAN EXPOSURE	2	3	6		
						DEILVERY SIDE HIGH PRESSURE PUMP TRIP TO BE PROVIDED
						EMERGENCY PROCEDURE FOR SPILL CONTAINMENT
3. LINE LEAKAGE/RUPTURE	1. SPILLAGE AND FIRE HAZARD	2	3	6	1. PERIODIC INSPECTION OF PIPE AND FITTINGS	TO BE INCLUDED IN SCHEDULE MAINT PROGRAM
	2. HUMAN EXPOSURE	2	3	6		
4. FLOW METER MALFUNCTIONING	1. WRONG INDICATION	1	3	3	1. OPERATOR INTERVENTION BASED ON EXPERIANCE	PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
	2. WRONG BATCH INPUT	1	3	3		
	3. REACTOR OVERFLOW	2	3	6		EMERGENCY PROCEDURE FOR REACTOR ULLAGE
	4. PUMP DAMAGE	1	3	3		
						TO BE INCLUDED IN SCHEDULE MAINT PROGRAM
5. WRONG CONNECTION OF FLEXIBLE HOSE	1. SPILL, STATIC AND FIRE HAZARD	3	3	9		COLOR CODING OF HOSES WITH LABELLING

6. OPERATOR ERROR	1. DEPENDS ON MALOPERATION	2	3	6		SOP AND TRAINING FOR RELEVANT OPERATORS COLOR CODING OF HOSES WITH LABELLING
	2. CAVITATION	1	3	3		
7.PUMP SUCTION STRAINER CHOKE	1. CAVITATION	1	3	3		TO BE INCLUDED IN SCHEDULE MAINT PROGRAM
	2. HEATING UP OF MOTOR	2	3	6		PRESSURE GAUGE ON SUCTION SIDE OF PUMP
8. SUCTION/DELIVERY SAMPLING POINT/UNLOADING LINE OPEN	1. SPILLAGE	3	3	9		LOCKOUT SYSTEM OF NORMALLY CLOSED VALVES
	2. CAVITATION	1	3	3		

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: High Flow

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. LINE RUPTURE	1. FIRE HAZARD	3	1	3	1. SPILL CONTAINMENT AVAILABLE	EMERGENCY PROCEDURE FOR SPILL CONTAINMENT AND SUBSEQUENTLY DECONTAMINATION/DETOXIFICATION
	2. SPILLAGE	2	1	2		
	3. ENVIROMNETAL HAZARD	2	1	2		
	4. HUMAN EXPOSURE	2	1	2		
	5. STATIC HAZARD	3	1	3		
						FLASH GAURDS TO BE PROVIDED

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: LOW PRESSURE IN SOLVENT LINE

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. LINE RUPTURE/LEAK	1. SPILLAGE AND FIRE HAZARD	3	1	3	1. SPILL KIT AND FRE PROXIMITY MADE AVAILABLE	EMERGENCY PROCEDURE FOR SPILL CONTAINMENT AND DECONTAMINATION/DETOXIFICATION

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: LOW PRESSURE IN SOLVENT LINE

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
2. WRONG SOLVENT	1. DEPENDS ON ERROR	1	2	2	1. LABELLING OF DRUMS AVAILABLE	SOP AND TRAINING FOR RELEVANT OPERATORS
3. STORAGE TANK PROBLEMS	1. CAVITATION	2	3	6		SOP AND TRAINING FOR RELEVANT OPERATORS
	2. OVERHEATING OF HEPTANE	1	2	2		CONSIDER DIP PIPE FOR RC OR SPLASH PIPE
						CONSIDER NITROGEN BLANKETTING FOR STORAGE WITH PRESSURE VACUUM RELIEF
						NRV IN RC LINE
4. SUCTION/DELIVERY SAMPLING POINT OPEN	1. SPILLAGE AND FIRE HAZARD	3	3	9		LOCKOUT SYSTEM OR SPECKTACLE FLANGE OF NORMALLY CLOSED VALVES
5. SUCTION STRAINER CHOKE	1. CAVITATION	2	3	6		TO BE INCLUDED IN SCHEDULE MAINT PROGRAM
						PRESSURE GAUGE ON THE SUCTION SIDE OF THE PUMP
6. INSTRUMENT MALFUNCTION OF PI/PIC	1. DEPENDS ONN INSTRUMNET MALFUNCTION.NORMALLY NO COONSEQUENCE	1	3	3		TO BE INCLUDED IN SCHEDULE MAINT PROGRAM

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: HIGH PRESSURE IN SOLVENT LINE

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. THERMAL EXPANSION OF FLUID IN LOCKED LINE DUE TO EXTERNAL HEAT INPUT	1. LINE RUPTURE	4	2	8		PROVIDE THERMAL RELIEF BASED ON CALCULATION
						RISK ASSESSMENT BASED ON THE FLAMMABLE MAT NEAR THE AREA TO BE DONE

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: NEGATIVE PRESSURE IN SOLVENT LINE

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. MALOPERATION OF REACTOR VACUUM SYSTEM	1. COLLAPSE OF FLEXIBLE HOSE	2	3	6		ONLY VACUUM CERTIFIED HOSES & VIEW GLASS SHALL BE USED AND TEST CERTIFICATE MAINTAINED

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: HIGH TEMPERATURE IN STORAGE TANK

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. HIGH TEMPERATURE DUE TO EXTERNAL FIRE	1. CONCEQUENCIAL LEAKAGE/FIRE	4	2	8		THERMAL RELIEF IN RECIRCULATION LINE BACK TO TANK
	2. DAMAGE TO FITTINGS	3	2	6		
2. EXCESS RECIRCULATION	1. INCREASE IN VAPOR PRESSURE ON STORAGE	1	3	3		CONSIDER NITROGEN BLANKETTING FOR STORAGE WITH PRESSURE VACUUM RELIEF
	2. SPLASHING OF LIQUID	3	4	12		THERMAL/SAFETY RELIEF THROUGH CATCH TANKS TO FLAME ARRESTOR TO BE PROVIDED IN TANKS
	3. FIRE IN TANK/VENT	4	3	12		

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: NO/LOW LEVEL IN STORAGE TANK

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. Tank leakage	1. SPILLAGE AND FIRE HAZARD	4	2	8		ROUTINE INSPECTION OF TANK AREA
	2. ENVIROMNETAL HAZARD	3	2	6		EMERGENCY MANAGEMENT OF TANK AREA (Eg, Spill, labeling, condition, leveletc)

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: HIGH TEMPERATURE IN STORAGE TANK

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
						SECONDARY CONTAINMENT FACILITY
2. INSTRUMENT MALFUNCTION OF LG	1. PUMP OVERHEATING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
3. INADEQUATE PUMP IN	1. PUMP OVERHEATING	1	3	3		SOP AND TRAINING FOR RELEVANT OPERATORS
4. BOIL OVER DUE TO EXTERNAL HEATING	1. FIRE AND EXPLOSION HAZARD	4	2	8		ROUTINE INSPECTION OF TANK AREA AND RECORDING OF LEVELS IN STORAGE TANK EVERYDAY AND BEFORE PUMPING
	2. PUMP OVERHEATING	1	3	3		EMERGENCY MANAGEMENT OF TANK AREA (Eg, Spill, labeling, condition, leveletc)
						THERMAL/SAFETY RELIEF THROUGH CATCH TANKS TO FLAME ARRESTOR TO BE PROVIDED IN TANKS

Node: 1. LIQUID INLET OF HEPTANE STORAGE TANK TO REACTOR INLET FLANGE

Deviation: HIGH LEVEL IN STORAGE TANK

Type: Line

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. HIGHER IN FLOW	1. OVERFLOW IN STORAGE TANK	3	2	6		TRIP LINKED WITH DAY TANK LG TO BE PROVIDED FOR RM TANK PUMP
	2. FIRE HAZARD	4	2	8		SECONDARY CONTAINMENT FACILITY - DYKING
	3. ENVIROMNETAL HAZARD	3	2	6		EMERGENCY MANAGEMENT OF TANK AREA (Eg, Spill, labeling, condition, leveletc)
2. INSTRUMENT MALFUNCTION OF LG	1. OVERFLOW IN STORAGE TANK	3	2	6		PERIODIC INSPECTION TO ENSURE INSTRUMENT RELIABILITY
	2. FIRE HAZARD	4	2	8		EMERGENCY MANAGEMENT OF TANK AREA (Eg, Spill, labeling, condition, leveletc)
	3. ENVIROMNETAL HAZARD	3	2	6		

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: NO/LOW FLOW IN REACTOR JACKET COOLING

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. PUMP FAILURE	1. NO COOLING	1	3	3	1. MOTOR TRIP ALARM IS AVAILABLE	
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
2. SUCTION STRAINER CHOKE	1. NO COOLING	1	3	3	1. PG AVAILABLE IN SUCTION AND DISCHARGE	
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
	4. PUMP FAILURE	1	3	3		
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
	4. PUMP FAILURE	1	3	3		
5. VALVE MALFUNCTION	1. NO COOLING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
6. CONTROL SYSTEM MALFUNCTION	1. NO COOLING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
7. OPERATOR ERROR	1. NO COOLING	1	3	3		SOP AND TRAINING FOR RELEVANT OPERATORS
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
8. INADEQUATE CIRCULATION	1. NO COOLING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: NO/LOW NEAGATIVE PRESSSURE IN VENT LINE TO SCRUBER

Type: Reactor. CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. SCRUBBING SYSTEM FAILURE	1. FIRE/EXPLOSION HAZARD	3	3	9		SCRUBBING SYSTEM DESIGN AND OPERATION TO BE CRITICALLY REVIEWED FOR FLOW BALANCING AND BACKFLOW INTO OTHER PARTS OF THE SYSTEM
						SCRUBBER FAILURE ALARM IN PLANT
2. VALVES SHUT/BLOCKAGE	1. NO CONSEQUENCE	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
3. LINE LEAKAGE	1. NO CONSEQUENCE	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
4. CONTROL FAILURE OF PCV-101	1. NO CONSEQUENCE	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
5. DISPROPONATION OF FLOW	1. NO CONSEQUENCE	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: NO/LOW FLOW OF RM CHARGING

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. DRUM EMPTY	1. FAILURE OF INERTIZATION IN REACTOR	1	3	3		OPERATOR CHECK AND SUPERVISION
	2. AIR DRIVING THROUGHT THE LINE TO THE REACTOR					SOP TO ENSURE AIR LINE CLOSE ON ANY VIBRATION FELT ON IN AOD OR DRUM EMPTY
						INERTING TO BE DONE DURING DRUM CHARGING
2. Pump failure	1. NO/LOW CHARGING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM/EQUIPMENT RELIABILITY
3. LEAKAGE/BLOCKAGE	1. NO/LOW CHARGING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM/EQUIPMENT RELIABILITY
	2. SPILLAGE	2	3	6		

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: OTHER THAN/AS WELL AS RM

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. WRONNG RM DISPENSED	1. DEPENDS ON NATURE AND EXTENT OF IMPURITIES	3	3	9		PROPER LABELLING AND ISSUE OF RM THROUGH CONTROL PROCEDURES
						COLOR CODING OF HOSES/VALVES WITH PERMANENT LABELLING

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: SPILLAGE/STATIC/OPERATOR EXPOSURE DURING CHARGING

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. STATIC CHARGE DURING CHARGING	1. FIRE HAZARD	3	3	9	1. SPLASH LEG PROVIDED IN REACTOR	GROUNDING (Eg: conductivity and connectivity) TO BE FREQUENTLY CHECKED AND MAINTINED
2. INADEQUATE VENTILATION	1. HUMAN EXPOSURE	3	3	9	2. LEV PROVIDED	EFICEINCY OF LEV TO BE CHECKED USING ANEMOMETER BEFORE EVERY CHARGING OPERATION
3. SPILLAGE DURING UNLOADING	1. SPILL/FIRE HAZARD	3	3	9		SECONDARY SPILL CONTAINMENT TO BE MADE DURIONG DRUM UNLOADING

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: NO/LOW DISCHARGING OF REACTOR CONTENTS TO CENTRIFUGE AND ASSOCIATED EQUIPMENTS

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. BLOCKAGE/FAULT IN LINE/VALVES	1. LOW DISCHARGE RATE	1	3	3		OPERATOR CHECK AND SUPERVISION
2 LINE LEAKAGES	1. SPILLAGE	3	3	9		EMERGENCY PROCEDURE FOR SPILL CONTAINMNET
	2. LOW/NO DISCHARGE	1	3	3		

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: UNSAFE CONDITIONS IN CENTRIFUGE

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix S	Risk Matrix L	Risk Matrix RR	Safeguards	Recommendations
1. FAULTY EARTHING	1. STATIC HAZARD	3	3	9	1. ROUTINE INSPECTION OF EARTHING CONDUCTORS AND EARTH RESISTANCE MONITORING	GROUNDING TO BE REVIEWED CRITICALLY WITH RESPECT TO POINTS OF CONTACT
2. POOR O&M	1. FIRE AND EXPLOSION HAZARD	3	3	9		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM/EQUIPMENT RELIABILITY
3. INSTRUMENT MALFUNCTION OF OA-104/103,OV-026/028(NITROGEN SYSTEM)	1. FIRE AND EXPLOSION HAZARD	3	3	9		ON FAILURE OF OXYGEN ANALYSER SYSTEM THE FEED/SOLVENT LINES MUST FAIL TO CLOSE, MOTOR MUST TRIP, AND NITROGEN BY PASS LINE OPEN
4. FAILURE OF SCRUBBING SYSTEM	1. EXTERNAL FIRE AND EXPLOSION HAZARD	3	3	9		SCRUBBER SUCTION HIGH PRESSURE ALARM AVAILABLE
						SRUBBER FAILURE TO BE INTERLOCKED WITH CENTRIFUGE FOR FURTHER ACTION
						EMERGENCY PROCEDURE ON SCRUBBER FAILURE
5. IMPROPER SEPERATION IN CENTRIFUGE	1. POOR PRODUCT RECOVERY/QUALITY	1	3	3	1. MOTOR FLAME PROOF	SOP FOR CHECKING OF IMPROPER SEPERATION
	2. CENTRIFUGE OVERFLOW	4	3	12		
	3. FIRE AND EXPLOSION HAZARD	2	3	6		EMERGENCY PROCEDURE ON IMPROPER SEPERATION
						EMERGENCY PROCEDURE ON CENTRIFUGE OVERFLOW
6. HIGH OXYGEN CONTENT	1. FIRE AND EXPLOSION HAZARD	3	3	9	1. AT-101/102 PROVIDES FOR OXYGEN DETECTION AND TRIP OF CENTRIFUGE MOTOR AND FEED	

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: NO/LOW FLOW TO ML TANK

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. LINE BLOCKAGE/SHUT VALVE	1. ACCUMULATION IN CENTRIFUGE	1	3	3	1. VIBRATION TRIP AVAILABLE	EMERGENCY PROCEDURE FOR SPILL CONTAINMNET WITH DECONTAMINATION AND DETOXIFICATION
	2. VIBRATION	2	3	6		
	3. SPILLAGE	2	3	6		
2. LINE LEAKAGES	1. SPILLAGE	2	3	6		EMERGENCY PROCEDURE FOR SPILL CONTAINMNET WITH DECONTAMINATION AND DETOXIFICATION
3. ML TANK OPERATION	1. FLOODING	3	4	12		SECONDARY CONTAINMENT TO BE PROVIDED
						BLANKETTING TO BE PROVIDED
						ML PATH AFTER ML TANK TO BE SHOWN IN P&ID

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: UNSAFE PRODUCT TRANSFER FROM CENTRIFUGE

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. STATIC BUILD UP	1. FIRE AND EXPLOSION HAZARD	4	3	12	1. EARTHING ROD AVAILABLE	USE ONLY ANTISTATIC CONTAINERS FOR TRANSFER
						SCOOP USED DURING UNLOADING TO BE GROUNDED
						USE ONLY ANTISTATIC SHOES/PPE DURING UNLOADING
						CONTAINERS TO BE INERTED DURING UNLOADING
2. EXPLOSIVE CONCENTRATION	1. FIRE AND EXPLOSION HAZARD	3	3	9	1. NITROGEN SEALING OF BAGS	LEV TO BE PROVIDED IN THE CENTRIFUGE AREA
3. PRODUCT DEGRADATION/CONTAMINATION	1. POOR QUALITY OF PRODUCT	1	3	3		CONSIDER CLOSED CONTAINER
4. SPILLS	1. ENVIROMNENTAL HAZARD	2	3	6		CONSIDER CLOSED CONTAINER
5. WASTE MANAGEMENT	1. ENVIROMNENTAL HAZARD	2	4	8		CONSIDER CONTANIER WITH NO DISPOSABLE ELEMENT

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: LOW TEMPERATURE IN REACTOR

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. EXCESS COOLING	1. MASS THICKENING – AGITATOR LOAD INCREASES	1	3	3	1. AGITATOR TRIP ALARM AVAILABLE	CONSIDER PROVISION OF HIGH CURRENT INDICATION IN PLC
	2. SLOW REACTION	1	3	3		EMERGENCY PROCEDURE TO REMOVE THE THICKENED MASS
2. CONTROL MALFUNCTION	1. MASS THICKENING - AGITATOR LOAD INCREASES	1	3	3	1. AGITATOR TRIP ALARM AVAILABLE	CONSIDER PROVISION OF HIGH CURRENT INDICATION IN PLC
	2. SLOW REACTION	1	3	3		

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: HIGH TEMPERATURE IN REACTOR

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. CONTROL MALFUNCTION	1. POOR BATCH QUALITY	1	3	3	1. TI AVAILABLE	EMERGENCY PROCEDURE ON JACKET CONTROL SYSTEM FAILURE
	2. BOIL UP AND PRESSURE BUILD UP	2	3	6	2. RELIEF VENT AVAILABLE	
2. OPERATOR ERROR	1. POOR BATCH QUALITY	2	3	6	1. TI AVAILABLE	TRAINING AND SUPERVISION
	2. BOIL UP AND PRESSURE BUILD UP	2	3	6		EMERGENCY PROCEDURE ON JACKET CONTROL SYSTEM FAILURE

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: NO/LOW AGITATION

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. DRIVE FAILURE	1. NO ADVERSE CONSEQUENCES	1	3	3	1. AGITATOR TRIP ALARM AVAILABLE	

Node: 2. REACTION SYSTEM AROUND R0108-FROM UTILITY HEADER

Deviation: NO/LOW AGITATION

Type: Reactor, CENTRIFUGE AND ASSOCIATED EQUIPMENT

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
2. MASS THICKENING	1. NO ADVERSE CONSEQUENCES	1	2	2		EMERGENCY PROCEDURE TO REMOVE THE MASS AFTER FREOM THE REACTOR AFTER THICKENING
3. MECHANICAL FAILURE	1. DAMAGE/INJURY/FIRE	2	3	6		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM/EQUIPMENT RELIABILITY

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: HIGH LEVEL IN STORAGE TANK

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. HIGHER IN FLOW	1. OVERFLOW IN STORAGE TANK	3	2	6		EMERGENCY PROCEDURE TO REMOVE THE ULLAGE IN REACTOR
						TRIP LINKED WITH DAY TANK LG TO BE PROVIDED FOR RM TANK PUMP
	2. FIRE HAZARD	4	2	8		SECONDARY CONTAINMENT FACILITY FOR STORAGE TANK – DYKING
	3. ENVIROMNETAL HAZARD	3	2	6		EMERGENCY MANAGEMENT OF TANK AREA (Eg, Spill, labeling, condition, leveletc)
2. INSTRUMENT MALFUNCTION OF LG	1. OVERFLOW IN STORAGE TANK	3	2	6		PERIODIC INSPECTION TO ENSURE INSTRUMENT RELIABILITY
	2. FIRE HAZARD	4	2	8		EMERGENCY MANAGEMENT OF TANK AREA (Eg, Spill, labeling, condition, leveletc)
	3. ENVIROMNETAL HAZARD	3	2	6		

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: NO/Low Level

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. Tank leakage	1. SPILLAGE AND FIRE HAZARD	4	2	8		ROUTINE INSPECTION OF TANK AREA
	2. ENVIROMNETAL HAZARD	3	2	6		EMERGENCY MANAGEMENT OF TANK AREA (Eg, Spill, labeling, condition, leveletc)
2. INSTRUMENT MALFUNCTION OF LG	1. PUMP OVERHEATING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT RELIABILITY
3. INADEQUATE PUMP IN	1. PUMP OVERHEATING	1	3	3		SOP AND TRAINING FOR RELEVANT OPERATORS
4. BOIL OVER DUE TO EXTERNAL HEATING	1. FIRE AND EXPLOSION HAZARD	4	2	8		ROUTINE INSPECTION OF TANK AREA AND RECORDING OF LEVELS IN STORAGE TANK EVERYDAY AND BEFORE PUMPING
	2. PUMP OVERHEATING	1	3	3		EMERGENCY MANAGEMENT OF TANK AREA (Eg, Spill, labeling, condition, leveletc)
						THERMAL/SAFETY RELIEF THROUGH CATCH POT TO FLAME ARRESTOR FOR TANKS

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: As well as

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. IMPURITIES IN FEEDSTREAM	1. GENERATION OF STATIC	3	4	12	1. QC TESTED OK BEFORE COMING FROM RM	FLASH GAURDS IN FLANGES
	2. IMPACT ON PROGRESS OF STAGE1 REACTION	1	3	3		
	3. CORROSION	2	2	4		
2. WRONG SOLVENT	1. MALOPERATION	2	3	6		COLOR CODING OF HOSES WITH PERMANENT LABELLING
	2. IMPACT ON PROGRESS OF STAGE1 REACTION	1	3	3		

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: HIGH TEMPERATURE IN SOLVENT LINE

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. HIGH TEMPERATURE SUE TO EXTERNAL HEAT	1. CONCEQUENCIAL LEAKAGE/FIRE	3	2	6		
	2. DAMAGE TO FITTINGS	3	2	6		
2. EXCESS RECIRCULATION	1. INCREASE IN VAPOR PRESSURE ON STORAGE	1	3	3		CONSIDER NITROGEN BLANKETTING FOR STORAGE WITH PRESSURE VACUUM RELIEF
	2. SPLASHING OF LIQUID	3	4	12		THERMAL/SAFETY RELIEF THROUGH CATCH POT TO FLAME ARRESTOR FOR TANKS
	3. FIRE IN TANK/VENT	4	3	12		

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: NEGATIVE PRESSURE IN SOLVENT LINE

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. MALOPERATION OF REACTOR VACUUM SYSTEM	1. COLLAPSE OF FLEXIBLE HOSE	2	3	6		ONLY VACUUM CERTIFIED HOSES AND FLOW GALSS SHALL BE USED AND TEST CERTIFICATE TO BE MAINTAINED

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: HIGH PRESSURE IN SOLVENT LINE

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. THERMAL EXPANSION OF FLUID IN LOCKED LINE DUE TO EXTERNAL HEAT INPUT	1. LINE RUPTURE	4	1	4		PROVIDE THERMAL RELIEF BASED ON CALCULATION
						RISK ASSESSMENT BASED ON THE FLAMMABLE MATERIAL NEAR THE AREA TO BE DONE

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: LOW PRESSURE IN SOLVENT LINE

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. LINE RUPTURE/LEAK	1. SPILLAGE AND FIRE HAZARD	3	1	3	1.SPILL KIT AND FIRE PROXIMITY KIT AVAILABLE	EMERGENCY PROCEDURE FOR SPILL CONTAINMENT AND DECONTAMINATION/DETOXIFICATION
2. WRONG SOLVENT	1. DEPENDS ON ERROR	1	2	2	1.TAGGING OF DRUMS AVAILABLE	SOP AND TRAINING FOR RELEVANT OPERATORS
3. STORAGE TANK PROBLEMS	1. CAVITATION	2	3	6		SOP AND TRAINING FOR RELEVANT OPERATORS
	2. OVERHEATING OF HEPTANE	1	3	3		CONSIDER DIP PIPE FOR RC OR SPLASH PIPE
						CONSIDER NITROGEN BLANKETTING FOR STORAGE WITH PRESSURE VACUUM RELIEF
4. SUCTION/DELIVERY SAMPLING POINT OPEN	1. SPILLAGE AND FIRE HAZARD	3	3	9		LOCKOUT SYSTEMS OR SPECKTACLE FLANGE FOR NORMALLY CLOSED VALVES
5. SUCTION STRAINER CHOKE	1. CAVITATION	2	3	6		TO BE INCLUDED IN SCHEDULE MAINT PROGRAM
						PRESSURE GAUGE ON SUCTION SIDE OF THE PUMP
6. INSTRUMENT MALFUNCTION OF PI/PIC	1. DEPENDS ONN INSTRUMNET MALFUNCTION.NORMALLY NO COONSEQUENCE	1	3	3		TO BE INCLUDED IN SCHEDULE MAINT PROGRAM

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: OTHER THAN

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. WRONG RM DISPENSING	1. UNKNOWN	3	2	6	1. TAGGING OF DRUMS AVAILABLE	COLOR CODING OF HOSES WITH PERMANENT LABELLING
						SOP AND TRAINING FOR RELEVANT OPERATORS

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: HIGH FLOW IN SOLVENT LINE

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. LINE RUPTURE	1. FIRE HAZARD	3	1	3	1. SPILL CONTAINMENT AVAILABLE	EMERGENCY PROCEDURE FOR SPILL CONTAINMENT WITH DECONTAMINATION/DETOXIFICATION
	2. SPILLAGE	2	1	2		
	3. ENVIROMNETAL HAZARD	2	1	2		
	4. HUMAN EXPOSURE	2	1	2		
	5. STATIC HAZARD	3	1	3		

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: NO/LOW FLOW IN SOLVENT LINE

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. NO SOLVENT IN STORAGE	1. PUMP FAILURE	2	3	6	1. TANK LEVEL ENSURED BEFORE PUMPING	LEVEL SWITCH TO BE LINKED TO PUMP START
2. LINE/VALVE BLOCKAGE	1. PUMP FAILURE	2	3	6	1. PERIODIC SUCTION STRAINER CLEANING DONE	TO BE INCLUDED IN SCHEDULE MAINT PROGRAM
						PRESSURE GAUGE ON SUCTION SIDE OF PUMP
						DELIVERY SIDE HIGG PRESSURE PUMP TRIP TO BE PROVIDED
	2. PRESSURE BUILD UP IN THE LINE	1	3	3		EMERGENCY PROCEDURE FOR SPILL CONTAINMENT WITH DECONTAMINATION/DETOXIFICATION
	3. RUPTURE OF FLANGE GASKET	2	3	6		
	4. SPILLAGE AND FIRE HAZARD	3	3	9		
	5. PUMP CAVITATION	1	3	3		
	6. HUMAN EXPOSURE	2	3	6		
3. RC VALVE OPEN	1. POTENTIAL FIRE HAZARD	2	3	6	1. FLOWMETER TO REACTOR WILL REFLECT THIS SITUATIONS	SOP AND TRAINING FOR RELEVANT OPERATOR
						NRV IN RC LINE
	2. TEMPERATUR RISE IN STORAGE	1	3	3		CONSIDER DIP PIPE FOR RC OR SPLASH PIPE
						CONSIDER NITROGEN BLANKETTING FOR STORAGE WITH PRESSURE VACUUM RELIEF

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: NO/LOW FLOW IN REACTOR JACKET

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. PUMP FAILURE	1. NO COOLING	1	3	3	1. MOTOR TRIP ALARM IS AVAILABLE	
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
2. SUCTION STRAINER CHOKE	1. NO COOLING	1	3	3	1. PG AVAILABLE IN SUCTION AND DISCHARGE	
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
	4. PUMP FAILURE	1	3	3		
3. LEAKAGE IN SYLTHERM SYSTEM	1. NO COOLING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
	4. HUMAN EXPOSURE	2	3	6		
4. ICING OF SYSTEM	1. NO COOLING	1	3	3		PROGRAM FOR PERIODIC QUALITY CHECK ON SYLTHERM
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
	4. PUMP FAILURE	1	3	3		
5. VALVE MALFUNCTION	1. NO COOLING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
6. CONTROL SYSTEM MALFUNCTION	1. NO COOLING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: NO/LOW FLOW IN SOLVENT LINE

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
7. OPERATOR ERROR	1. NO COOLING	1	3	3		SOP AND TRAINING FOR RELEVANT OPERATORS
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		
8. INADEQUATE CIRCULATION	1. NO COOLING	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
	2. POSSIBLE QUALITY PROBLEMS	1	3	3		
	3. LONGER REACTION TIME	1	3	3		

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: NO/LOW NEAGATIVE PRESSSURE IN VENT LINE TO SCRUBER

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. SCRUBBING SYSTEM FAILURE	1. NO CONSEQUENCE	1	3	3	1. SCRUBBER SUCTION HIGH PRESSURE ALARM AVAILABLE	SCRUBBING SYSTEM DESIGN AND OPERATION TO BE CRITICALLY REVIEWED FOR FLOW BALANCING AND BACKFLOW INTO OTHER PARTS OF THE SYSTEM
2. VALVES SHUT/BLOCKAGE	1. NO CONSEQUENCE	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
3. LINE LEAKAGE	1. NO CONSEQUENCE	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
4. CONTROL FAILURE OF PCV-101	1. NO CONSEQUENCE	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY
5. DISPROPONATION OF FLOW	1. NO CONSEQUENCE	1	3	3		PERIODIC INSPECTION TO ENSURE INSTRUMENT/SYSTEM RELIABILITY

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: NO/LOW FLOW OF NITROGEN

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. FAILURE OF NITROGEN SUPPLY	1. INERTIZATION FAILURE	1	3	3	1. ALARM FOR TRIP IN NITROGEN SUPPLY IN PBIV	CHECK NITROGEN FLOW DISTRIBUTION DIAGRAM
	2. LONGER TIME	1	3	3		SOP AND TRAINING FOR RELEVANT OPERATORS
						EMERGENCY PROCEDURE INCASE OF NITROGEN FAILURE
2. LINE/REACTOR OPEN TO ATM	1. INERTIZATION FAILURE	1	3	3		SOP AND TRAINING FOR RELEVANT OPERATORS
	2. LONGER TIME	1	3	3		

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: HIGH OXYGEN CONTENT IN NITROGEN

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. OPEN/PASSING VALVES ON MANIFOLD	1. INERTIZATION FAILURE	1	3	3	1. MEASUREMENT THROUGH OFFLINE OXYGEN ANALYSER	SOP AND TRAINING FOR RELEVANT OPERATORS
	2. LONGER TIME	1	3	3		
	1. INERTIZATION FAILURE	1	3	3		BLANK OF BV-115/117
	2. LONGER TIME	1	3	3		
						OXYGEN ANALYSER INTERLOCK IN PSA PLANT
2. PSA UNIT FAILURE					1. MEASUREMENT THROUGH OFFLINE OXYGEN ANALYSER	SOP AND TRAINING FOR RELEVANT OPERATORS

Node: 3. OPERATIONS AROUND R-0107 CENTRIFUGE WASHING VESSELS TOGETHER WITH ALL PIPES AND EQUIPMENTS

Deviation: 27. HIGH PRESSURE IN VESSEL

Type: WASHING VESSEL

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. HIGH TEMPERATURE IN JACKET	1. BOIL UP AND PRESSURE BUILD UP	2	3	6	1. TI/PI ARE AVAILABLE	CHECK ADEQUACY OF RV/VENT LINE, VL-021
	2. RELIEF VALVE LIFTING	2	3	6		

CONCLUSION

CONCLUSION

In this project, the significance of conducting a Hazard & Operability Study at any stage of a plant from blue print stage to operation stage was studied; a detailed HazOp study was conducted for the main operations involving venelafaxine unit using the "Guide-Word" approach.

From the study it is understood that the overall safety standards and systems in the hydrogen generation unit at SHASUN is of high-quality. However, some improvements in safety can be achieved by preparing a "Safe Operating Procedures (SOP) Manual" customized for the operations in the plant. Also, training of the plant supervisors and operators with good visual aids with special emphasis on safe working and general safety awareness will supplement to the overall plant safety.

REFERENCES

REFERENCE

- A Text Book on Hazard identification Techniques
- HAZOP and HAZAN: Identification and assessment on process industry hazards — Jenson Roff
- slp.icheme.org/hazops.html
- www.lpaindia.org/technical_safaty_solutions.html