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Hazop Study of Nano DAP Plant

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ABSTRACT

HAZOP is a well-recognized method of identifying hazards and problems, which may prevent an efficient operation and lead to a hazard. HAZOP is a technique to critically examine a system, part by part, in a very systematic manner, to find out the cause and consequence of every conceivable deviation in the normal operation of the system as well as during emergencies, start-ups and shutdowns. The method enables prediction of all possible ways in which a hazard or an operating problem could arise, checks whether the design takes preventive care of them and if not, recommends changes as may be necessary.

Keywords: PHA, HAZOP, Risk Management, Process Safety Management, Nano DAP.

I. INTRODUCTION

Unexpected releases of poisonous, reactive, or flammable beverages and gases in techniques related to quite unsafe chemical substances were suggested for plenty of years, in diverse industries the use of chemical substances with such properties. Regardless of the enterprise that makes use of those quite unsafe chemical substances, there's a capability for an unintended launch any time they're now no longer nicely controlled, developing the opportunity of disaster.

Process protection control (PSM) is addressed in particular requirements for the overall and creation industries. Occupational Safety and Health Administration (OSHA)'s standard emphasizes the control of dangers related to quite unsafe chemical substances and establishes a complete control software that integrates technologies, procedures, and control practices. A PHA is described as a scientific attempt designed to pick out and examine dangers related to the processing or coping with of quite unsafe substances and a technique to offer data with a purpose to assist people and employers in making selections in an effort to enhance protection. A PHA analyzes the capability reasons and effects of fires, explosions and releases of poisonous chemical substances and the equipment, instrumentation, human moves and different elements which would possibly have an effect on the procedure. A PHA tries to decide the failure points, techniques of operations and different elements which could doubtlessly cause accidents. A PHA group ought to encompass engineers, operators, supervisors and different people who've information of the requirements, codes, specs and guidelines which follow to the procedure being studied.

Process Hazard Analysis (PHA) is a part of Process Safety Management (PSM) which deals with the key factors in the industrial safety. It permits the utilization of various analysis techniques for the eradicating and reduction of the various hazards in the process industries. Of all the techniques for the risk assessment, we will be focusing on Hazard Identification (HAZID), Hazard and Operability (HAZOP) and the Quantitative Risk Assessment (QRA) studies as they're the most important ones that scrutinize the system in detail.

II. METHODOLOGY

The HAZOP evaluation is accomplished for each and every equipment and / or every pipeline connecting the equipment of the process by various 'guide words' based on which the various queries are formulated to start possible deviations in the process. As a result, safety interlocks system, instrumentation, material of construction, unit operations and nature of chemical process are closely scrutinized. The possible reasons and the effects for every deviation are recorded, prevailing safeguards are listed and wherever needed, recommendations are provided.

Hazard and operability (HAZOP) studies should be undertaken with the application of a formal, systematized, critical and well-ordered approach to scrutinize all the design intentions for the process designed. The probability of the hazard is evaluated along with the possibility of the damage to every single piece of equipment and its effects on the entire system, are to be recognized. The scrutiny of the design revolves around a number of deviations, that later ensure full coverage of every crucial scenario of the plant.

The typical procedure for HAZOP study is given below:

1. Selecting the Node
2. Making a list of intention of the node along with the process parameters associated.
3. Starting with the guideword.
4. Establish possible and valid deviations.
5. Establish several causes for specific deviations.
6. Scrutinize the consequences.
7. Assess the risk.
8. Recognize the safeguards that are already present.
9. Give recommendations
10. Redo points 4 to 8 for every guideword.
11. Repeat for all parameters
12. Repeat for every node

Causes

Causes are identified by the team for the specified deviation. This gives a list of potential hazards. To avoid repetition, only causes arising within the node should be considered, though the consequences may be elsewhere. Realistic causes should be identified. However in deciding how much detail to record, it will be necessary to consider the magnitude of the consequence associated with each cause. If the consequence can easily be seen to

be trivial, the team may agree to record only brief detail before moving on, to avoid spending too much time discussing lower risk events.
It is important to make sure that causes are defined in sufficient detail to reflect the different consequences or different safeguards that might apply.

Consequences

Consequences are identified for each cause. There may be more than one consequence resulting from a single cause. A few points to note are given below:
• Common mode faults can make incredible coincidences happen. Be wary of the 'double jeopardy so we don't need to worry about it' argument. Question this carefully. Multiple jeopardy situations should not be discounted if the risk is high.
• HAZOP leaders should be on the lookout particularly for the high consequence, low frequency event as such events are often not readily identified by the HAZOP.
• Consider consequences inside and outside the node.

Safe Guards / Protections

Safeguards are identified against each cause – consequence entry. Consequences should be identified without taking credit for safeguards, and the safeguards then noted. The team should then assess whether the safeguards are adequate to contain or mitigate the risk and, only if agreed to be necessary, propose additional safeguards. So, if for example the HAZOP is referred to later when a modification is required which might remove or change equipment, it can be seen whether this would have an impact on the safeguards and hence the safety of the system. Note that modifications introduced after the final detailed HAZOP should also be HAZOPed.

Recommendations / Actions

Actions or recommendations may be raised at a number of points in the HAZOP. Actions may be of several basic types:
Actions for improvements / changes to the design, usually resulting from insufficient safeguards.
• Actions for further assessment or information, usually resulting from not having the complete information available during HAZOP.
• Actions for Risk Assessment. Sometimes it is not clear-cut additional safeguards are necessary. Carrying out risk assessment for a particular issue outside of the meeting can establish whether risks have already been reduced to ALARP or whether further improvement is justified.
• Actions for operating / commissioning instructions. These are raised to ensure that the system is commissioned, operated or maintained adequately.

It may conversely be possible to identify the correct solution to the problem after considerable discussion and set out a precise definition of what is required to deal with the problem. It is important to recognize that it is not the job of a HAZOP to re-design the system but merely to identify a problem.

Limitations of HAZOP Study

• It can generate a lot of causes of events which have insignificant consequences.
• It can generate a lot of causes of events which have the same consequences.
• It takes little account of the probability that an event may occur and does not work well when combinations of more than one event can lead to severe consequences.
• Its effectiveness is very dependent on the skills of the Chairperson and the team.

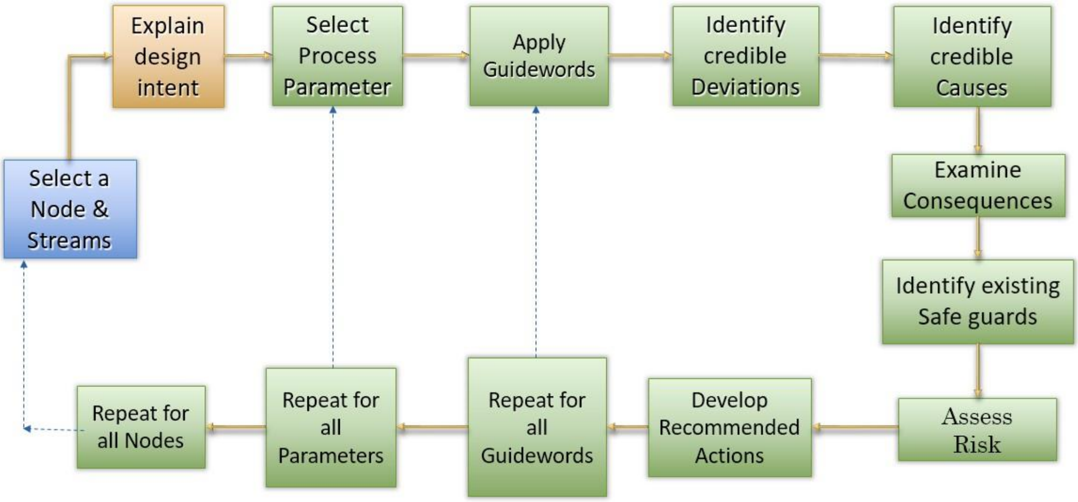

Figure 4.1: Process Flow Chart for conducting HAZOP

The following are not considered in HAZOP Study:
• Simultaneous occurrences of two unrelated incidents events unless common mode failure is possible.
• Correctness of Design Basis and Codes used
• Failures of Manual valves
• Operator negligence and assumed that adequate time for operator action is provided in SOP
• Passing of NRVs and PSVs
• Simultaneous failure of more than one protection device
• Natural Calamity
• Objects Falling from Sky
• Sabotage

The following are considered in HAZOP Study:

• Risk will be qualified. No Quantitative Assessment will be done.
• Mechanical Protection Devices are expected to work (PSVs, Rupture Discs etc.)
• Single check valve are adequate to prevent reverse flow unless:

I) Reverse flow causes pressure to exceed test pressure.
II) Reverse flow causes unacceptable contamination

The following are considered as safeguards:
• Trip/ Interlock/ Shutdown System
• Redundant/ spare Equipment
• Alarm System for Operator Action
• Operators are trained and aware of what action is required to be taken
• Mechanical Protection devices
• Sampling & quality Monitoring Systems.
• SOP / SMP & Operating Manual

The system should be divided into several nodes which are to be considered. This is the prior study that is preferably carried out by the Chairman. But it is critical for the

Chairman to carry out this all alone and hence a process engineer is usually present while node selection is done. List of the guidewords is normally bounded, else it will consume huge time to conduct the study. Following are some important guidewords that are generally taken into consideration.

Table 4.1: 'Parameters' and 'Guide Words' used in HAZOP

PARAMETER	GUIDE WORDS
FLOW	More, No, Less, Misdirected, Reverse
PRESSURE	More, Less
TEMPERATURE	More, Less
LEVEL	High, Low, No
QUALITY	More, Less
FAILURE OF UTILITIES	Power, Instrument Air, Cooling Water, Steam

Table 4.2: HAZOP Report Format

Stream	Deviation	Cause	Consequence	Safeguards	Risk Matrix			Recommendations
					P	S	RR	

The overall aims to which any HAZOP Study should be addressed are:
• To identify all deviations from the way the design intended to work, their causes and all the hazards and operability problems associated with these deviations.
• To decide whether action is required to control the hazard or the operability problem, and if so, to identify the ways in which the problems can be solved.
• To identify cases where a decision cannot be taken immediately and to decide on what information or action is required.
• To ensure actions decided are followed through (i.e. HAZOP Close-out report).

III. PROCESS DESCRIPTION

Piping and Instrumentation Diagrams

Process and Instrumentation Diagrams of the plant shows the extract of the process plant design in the computer operated 2D format which are easy to carry and to refer the piping & flow.

The following table narrates the process for which HAZOP Study has to be done.

STEP 1		**In Reactor 1 (R-201)**
	1	Take 75 L of G. Start agitation at 40-50 RPM. Start heating upto 90°C.
	2	Add 1.5 kg of A1 slowly (in around 20-30 minutes.). After completion, agitate for 15 minutes.
	3	Add 0.25 kg of K.
	4	Heat the solution upto 121°C. Depressurize R-201 and simultaneously cool upto 45°C.
	5	Take sample and analyse for pH, density and viscosity.
STEP 2		**In Reactor 3 (R-203)**
	1	Take 300 L of G. Heat G upto 121°C (Pressure 1 kg). Depressurize and cool the G upto 45°C.Start agitation at 40-50 RPM.
	2	Add 58.5 kg of F1 till it dissolves.
	3	Add 106.5 kg of M till it dissolves.
	4	Add 12.5 kg of D till it dissolves.
	5	Add 9L of B3 .Wait for 10 minutes.
	6	Add 2.5L of T and reduce the RPM to avoid foaming.
	7	Agitate for 30 minutes. Take sample and analyse for pH, density and viscosity
STEP 3		**In Reactor 6 (R-206)**
	1	Transfer R-206 solution into R-206.
	2	Agitate for 60 minutes.
	3	Provide sample to Lab
	4	Add 0.5 kg of S and agitate for 30 minutes.
	5	Provide sample to Lab for pH, heat capacity, density, size, zeta potential, Total Kjeldahl Nitrogen, P_2O_5 Content.

IV. HAZOP STUDY REPORT

Stream	Deviation	Cause	Consequence	Safeguard	Risk Matrix			Recommendation
					P	S	RR	
1. Additions of rav material G, A1 and K to Reactor R-20 A. [A1 and K ar powder material and added manually]	More/ less quantity of G	1.1. Malfunction of FIQ-PHE201 A / XV-FTPHE201 A	1.1.1. Product quality issue and delay in process.	1.1.1.1. LT-R201 A/1&2 are available to monitor level in R-201 A.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.
	More/ less quantity of A1	2.1. Human error in measuring quantity of A1	2.1.1. Product quality issue and delay in process.	1.2.1.1.	2	2	4	SOP to be developed for measuring and charging of powder material under supervision and records to be maintained in log sheet.
	More/ less quantity of K	3.1. Human error in measuring quantity of K.	3.1.1. Product quality issue and delay in process.	1.3.1.1.	3	1	3	SOP to be developed for measuring and charging of powder material under supervision and records to be maintained in log sheet.
	More pressure in R-201 A	4.1. Unlikely as reactor is operated with vent open to atmosphere.	4.1.1.	1.4.1.1. PVRV-R201A, PSV-R201A and XV-R201A/2 are provided to prevent overpressure condition.				Isolation valve upstream of vent filter should be kept lock open.
	Less pressure in R-201 A	5.1. Unlikely as reactor is operated with vent open to atmosphere.	5.1.1.	1.5.1.1. PVRV-R201A are provided to preven overpressure condition.				
	More temperature in R-201A	6.1. TICA-R201A malfunction	6.1.1. Overheating of mass in R-201A may lead to quality issue and over pressurization of reactor.	1.6.1.1. PT-R201A is provided with H pressure alarm to detect any overpressure condition. 1.6.1.2. 1.6.1.3. PVRV-R201A & PSV-R201A are provided to prevent overpressure condition	2	2	4	
	Less temperature in R-201A	7.1. TICA-R201A malfunction 7.2. TCV-R201A/2 fail close	7.1.1. Not a cause of concern.	1.7.1.1.				
	High level in R-201A	8.1. Malfunction of FIQ-PHE201 A / XV-FTPHE201 A.	1.8.1. Product quality issue and delay in process.	1.8.1.1. LT-R201 A/1&2 are available to monitor level in R-201 A.	2	2	4	
	Low level in R-201A	9.1. No material in R-201A	9.1.1. Possibility of pump suction starvation and possible pump PR-201A damage.	1.9.1.1. LT-R201A/1 is provided with L level alarm and interlock to trip the pump to prevent pump damage.	2	2	4	

					1.9.1.2. FS-PR201A is provided in pump suction with interlock to trip the pump in case of no flow.				
		Agitation in Reactor R-201 A	10.1. Faster agitation due to VFD malfunction 10.2. Slower agitation due to VFD malfunction 10.3. VFD trip due to loss of power	10.1.1. Possibility of foaming and overflow from the powder feeding hopper. 10.1.2. Inadequate mixing leading to quality issue.	1.10.1.1. VFD speed indicator is provided in control room. 1.10.1.2. Emergency power is available for the agitator.	2	2	4	
		Buildup of static charge	11.1. Powder addition	11.1.1. Possibility of dust explosion due to static charge.	1.11.1.1. Earthing is provided to avoid static charge buildup	2	3	6	Test powder material for static charge buildup and use appropriate PPEs during charging of powder.
		Dust nuisance	12.1. Charging of powder material in reactor	12.1.1. Possibility of occupational health issues due to dust inhalation.		2	3	6	Recommended to use appropriate PPEs while charging powder material in reactor.
	2. Additions of raw material G and D to Reactor R-201 B. [D is powder material and added manually]	More/ less quantity of G	1.1. Malfunction of FIQ-PHE201 B / XV-FTPHE201 B	1.1.1. Product quality issue and delay in process.	1.1.1.1. LT-R201 B/1&2 are available to monitor level in R-201 B.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.
		More/ less quantity of D	2.1. Human error in measuring quantity of D	2.1.1. Product quality issue and delay in process.	1.2.1.1.	2	2	4	SOP to be developed for measuring and charging of powder material under supervision and records to be maintained in log sheet.
		More pressure in R-201 B	3.1. Unlikely as reactor is operated with vent open to atmosphere.	3.1.1.	1.3.1.1. PVRV-R201B, PSV-R201B and XV-R201B/2 are provided to prevent overpressure condition.				Isolation valve upstream of vent filter should be kept lock open.
		Less pressure in R-201 B	4.1. Unlikely as reactor is operated with vent open to atmosphere.	4.1.1.	1.4.1.1. PVRV-R201B are provided to prevent overpressure condition.				
		More temperature in R-201B	5.1. TICA-R201A malfunction	5.1.1. Overheating of mass in R-201B may lead to quality issue and over pressurization of reactor.	1.5.1.1. PT-R201B is provided with H pressure alarm to detect any overpressure condition.	2	2	4	

				1.5.1.2. PVRV-R201B & PSV-R201B are provided to prevent overpressure condition				
	Less temperature in R-201B	6.1. TICA-R201B malfunction 6.2. TCV-R201B/2 fail close	6.1.1. Not a cause of concern.	1.6.1.1.				
	High level in R-201B	7.1. Malfunction of FIQ-PHE201 B / XV-FTPHE201 B.	1.7.1. Product quality issue and delay in process.	1.7.1.1. LT-R201 B/1&2 are available to monitor level in R-201 B.	2	2	4	
	Low level in R-201B	8.1. No material in R-201B	8.1.1. Possibility of pump suction starvation and possible pump PR-201B damage.	1.8.1.1. LT-R201B/1 is provided with L level alarm and interlock to trip the pump to prevent pump damage. 1.8.1.2. FS-PR201B is provided in pump suction with interlock to trip the pump in case of no flow.	2	2	4	
	Agitation in Reactor R-201 B	9.1. Faster agitation due to VFD malfunction 9.2. Slower agitation due to VFD malfunction 9.3. VFD trip due to loss of power	9.1.1. Possibility of foaming and overflow from the powder feeding hopper. 9.1.2. Inadequate mixing leading to quality issue.	1.9.1.1. VFD speed indicator is provided in control room. 1.9.1.2. Emergency power is available for the agitator.	2	2	4	
	Buildup of static charge	10.1. Powder addition	10.1.1. Possibility of dust explosion due to static charge.	1.10.1.1. Earthing is provided to avoid static charge buildup	2	3	6	Test powder material for static charge buildup and use appropriate PPEs during charging of powder.
	Dust nuisance	11.1. Charging of powder material in reactor	11.1.1. Possibility of occupational health issues due to dust inhalation.		2	3	6	Recommended to use appropriate PPEs while charging powder material in reactor.
3. Reaction Mixture from Reactor R-201A through Pump PR-201A to Product	More quantity from R-201A to R-206 A/B/C/D/R-207	1.1. FIQ- R206 A/B/C/D/R-207/9 malfunction	1.1.1. Quality issue and possibility of overfilling of R-206 A/B/C/D/R-207.	1.1.1.1.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.

Reactor R-206 A/B/C/D/R-207.	No/ Less quantity from R-201A to R-206 A/B/C/D/R-207	2.1. Running pump PR-201 A trip 2.2. XV-PR201 A/1 fail close 2.3. Filter F-201 A choke	2.1.1. Product quality issue and delay in process.	1.2.1.1. Pump running and trip indication is provided for operator action. 1.2.1.2. XV position indicator is provided. 1.2.1.3. DPI-F201 A is provided with H alarm to detect any choking.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.
	Reverse flow	3.1. Unlikely	3.1.1.	1.3.1.1. NRV is provided in PR-201A.				
	Misdirected flow	4.1. Unlikely	4.1.1.	1.4.1.1. Batch logic sequence is provided				
	High pressure in PR-201A	5.1. XV- R206 A/B/C/D/R-207/9 fail close due to instrumentation/ mechanical failure.	5.1.1. Pump running I shut-off condition may lead to pump damage.	1.5.1.1. PT-PR201A is provided with high pressure alarm	2	3	6	Provide interlock to stop PR-201A in case PT-PR201A detects high pressure to prevent pump running in shut-off condition.
	Low pressure in PR-201A	6.1. Pump not running 6.2. Bag filter F-201A differential pressure high	6.1.1. Low pressure in discharge header and high pressure in pump discharge may lead to filter media damage.	1.6.1.1. Differential pressure indicator DPI- F201A is available with H alarm.	2	3	6	Provide interlock to stop PR-201A pump when DPI-F201A detects high differential pressure.
	High temperature	7.1. Unlikely	7.1.1.	1.7.1.1.				
	Low temperature	8.1. Unlikely	8.1.1.	1.8.1.1.				
	High level	9.1. Not applicable for this stream	9.1.1.	1.9.1.1.				
	Low level	10.1. Not applicable for this stream	10.1.1.	1.10.1.1.				
4. Reaction Mixture from Reactor R-201 B through Pump PR- 201 B to Active Components Solution Reactor R-203 A/B/C.	More quantity from R-201B to R-203 A/B/C	1.1. FIQ-R-203 A/B/C /XXX malfunction	1.1.1. Quality issue and possibility of overfilling of R-203 A/B/C.	1.1.1.1.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.
	No/ Less quantity from R-201B to R-203 A/B/C	2.1. Running pump PR-201 B trip 2.2. XV-PR201 B/1 fail close 2.3. Filter F-201 B choke	2.1.1. Product quality issue and delay in process.	1.2.1.1. Pump running and trip indication is provided for operator action. 1.2.1.2. XV position indicator is provided.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.

				1.2.1.3. DPI-F201 B is provided with H alarm to detect any choking.				
	Reverse flow	3.1. Unlikely	3.1.1.	1.3.1.1. NRV is provided in PR-201B.				
	Misdirected flow	4.1. Unlikely	4.1.1.	1.4.1.1. Batch logic sequence is provided				
	High pressure in PR-201B	5.1. XV- R203 A/B/C/XXX fail close due to instrumentation/ mechanical failure.	5.1.1. Pump running I shut-off condition may lead to pump damage.	1.5.1.1. PT-PR201B is provided with high pressure alarm	2	2	4	Provide interlock to stop PR-201B in case PT-PR201B detects high pressure to prevent pump running in shut-off condition.
	Low pressure in PR-201B	6.1. Pump not running 6.2. Bag filter F-201B differential pressure high	6.1.1. Low pressure in discharge header and high pressure in pump discharge may lead to filter media damage.	1.6.1.1. Differential pressure indicator DPI- F201B is available with H alarm.	2	2	4	Provide interlock to stop PR-201B pump when DPI-F201B detects high differential pressure.
	High temperature	7.1. Unlikely	7.1.1.	1.7.1.1.				
	Low temperature	8.1. Unlikely	8.1.1.	1.8.1.1.				
	High level	9.1. Not applicable for this stream	9.1.1.	1.9.1.1.				
	Low level	10.1. Not applicable for this stream	10.1.1.	1.10.1.1.				
	More quantity from R-201B to R-203 A/B/C	1.1. FIQ-R-203 A/B/C/XXX malfunction	1.1.1. Quality issue and possibility of overfilling of R-203 A/B/C.	1.1.1.1.	2	2	4	
5. Additions of G, B3, M, F1, D (from R-201 B) and T to Reactor R-203 A/B/C [M & F1 are added manually].	More/ less quantity of G	1.1. Malfunction of PHE-203 A/B/C	1.1.1. Quality issue	1.1.1.1.				Develop batch logic sequence to check quantity with respect to level in R-203 A/B/C.
	More/ less quantity of B3	2.1. Malfunction of FT-203 A//B/C/1	2.1.1. Quality issue	1.2.1.1.				Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.
	More/ less quantity of M	3.1. Human error in measuring M	3.1.1. Quality issue	1.3.1.1. Load cell WT-R203 A/B/C is provided with H and L alarm to alert the operator in case of more/ less quantity addition.	2	2	4	
	More/ less	4.1. Human error in	4.1.1. Quality issue	1.4.1.1. Load cell WT-	2	2	4	

	quantity of F1	measuring F		R203 A/B/C is provided with H and L alarm to alert the operator in case of more/ less quantity				

				addition.				
	More/ less quantity of D	5.1. No flow meter available as of now.	5.1.1. Batch delay and quality issue.	1.5.1.1.	3	1	3	Provide suitable flow meter and control system to control quantity of D to R-203 A/B/C.
	More/ less quantity of T	6.1. Malfunction of FT-R203 A/B/C/2	6.1.1. Quality issue	1.6.1.1.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.
	Agitation In R-203 A/B/C	7.1. Faster agitation due to VFD malfunction 7.2. Slower agitation due to VFD malfunction 7.3. VFD trip due to loss of power	7.1.1. Possibility of foaming and overflow from the powder feeding hopper. 7.1.2. Inadequate mixing leading to quality issue.	1.7.1.1. VFD speed indicator is provided in control room. 1.7.1.2. Emergency power is available for the agitator.	2	2	4	
	More temperature in R-203 A/B/C	8.1. TICA-R203 A/B/C malfunction	8.1.1. Possibility of overheating of reactants that may lead to quality issue but no safety concern.	1.8.1.1.	2	1	2	
	Less temperature in R-203 A/B/C	9.1. TICA-R203 A/B/C malfunction	9.1.1. Possibility of precipitation that may lead to quality issue but no safety concern.	1.9.1.1.	2	1	2	
	More pressure in R-203 A/B/C	10.1. Unlikely as vent is open to atmosphere and solid charging hopper is also open to atmosphere.	10.1.1.	1.10.1.1.				
	Less pressure in R-203 A/B/C	11.1. Unlikely as vent is open to atmosphere and solid charging hopper is also open to atmosphere.	11.1.1.	1.11.1.1.				
	High level in R-203 A/B/C	12.1. Addition of more quantity of any of the raw materials.	12.1.1. Possibility of over filling and spillage through vent line / hopper.	1.12.1.1. WT-R203A/BC is provided with HH alarm to prevent overcharging of solids.	2	2	4	Provide interlock to close XV-PHE203 A/B/C in case of HH level in R- 203 A/B/C respectively.

				1.12.1.2. LT-R203 A/B/C/1&2 are provided with H level alarm to alert the operator and take corrective action to prevent overflow.				
	Low level in R-203 A/B/C	13.1. Addition of less quantity of any of the raw materials.	13.1.1. Possibility of pump PR-203 A/B/C damaged due to loss of suction.	1.13.1.1. Interlock PR-R203 A/B/C/1&2 is provided to stop the pump in case of low level in R-203 A/B/C. 1.13.1.2. Flow switch FSL-PR203 A/B/C in pump suction lines with interlock to stop the pump is provided to prevent pump damage.	2	2	4	
	Buildup of static charge	11.1. Powder addition	11.1.1. Possibility of dust explosion due to static charge.	1.11.1.1. Earthing is provided to avoid static charge buildup	2	3	6	Test powder material for static charge buildup and use appropriate PPEs during charging of powder.
	Dust nuisance	12.1. Charging of powder material in reactor	12.1.1. Possibility of occupational health issues due to dust inhalation.		2	3	6	Recommended to use appropriate PPEs while charging powder material in reactor.
6. Reaction Mixture from Active Components Solution Reactor R-203 A/B/C through Pump PR-203 A/B/C to Product Reactor R-206 A/B/C/D/R-207.	More quantity from R-203 A/B/C to R-206 A/B/C/D/R-207	1.1. Unlikely as the entire mass of R-203 A/B/C is transferred to R-206 A/B/C/D/R-207	1.1.1.	1.1.1.1.				
	No/ Less quantity from R-203 A/B/C to R-206 A/B/C/D/R-207	2.1. Running pump PR-203 A/B/C trip 2.2. XV-R203 A/B/C /3 fail close 2.3. Filter F-203 A/B/C choke	2.1.1. Product quality issue and delay in process.	1.2.1.1. Pump running and trip indication is provided for operator action. 1.2.1.2. XV position indicator is provided. 1.2.1.3. DPI-F203 A/B/C is provided with H alarm	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.

		2.4. FIQA- R-206 A/B/C/D/R-207/4 malfunction 2.5. XV- R-206		to detect any choking.				

		A/B/C/D/R-207/4 fail close						
	Reverse flow	3.1. Unlikely	3.1.1.	1.3.1.1. NRV is provided in pump discharge line.				
	Misdirected flow	4.1. Unlikely	4.1.1.	1.4.1.1. Batch logic sequence is available to control the process.				
	High pressure in Pump PR-203 A/B/C discharge	5.1. XV- R-206 A/B/C/D/R-207/4 fail close. 5.2. Filter F-203 A/B/C choked	5.1.1. Product quality issue, delay in process and possibility of pump running in shut-off condition.	1.5.1.1. PT-PR203 is available in discharge header with H pressure alarm.	2	2	4	Provide interlock to stop PR-203 A/B/C when PT-PR203 detects high pressure.
	Low pressure in Pump PR-203 A/B/C discharge	6.1. Bag filter F-203 A/B/C choked	6.1.1. Pump may run in shut-off condition and PT-PR203 will show low header pressure that may cause filter media damage or pump damage due to shut-off condition.	1.6.1.1. DPI- F203 A/B/C is provided to monitor differential pressure across bag filter.	2	2	4	Provide interlock to stop PR-203 A/B/C when DPI-F203 A/B/C detects high differential pressure to prevent media damage.
	High temperature	7.1. Not applicable for this stream	7.1.1.	1.7.1.1.				
	Low temperature	8.1. Not applicable for this stream	8.1.1.	1.8.1.1.				
	High level in	9.1. Not applicable for this stream	9.1.1.	1.9.1.1.				
	Low level in	10.1. Not applicable for this stream	10.1.1.	1.10.1.1.				
7. Product from Product Reactor R-206 A/B/C/D/207 through Product Solution Pump PR-206 A/B/C/D/207, Bag Filter F-206 A/B/C/D/207 A, Bag Filter F-206F1/2 and Exchanger for	More/ less quantity from PR-203 A/B/C	1.1. malfunction of FT-R206 A/B/C/D/207/4	1.1.1. Quality upset and possibility of overfilling of R-206 A/B/C/D/207.	1.1.1.1. H level alarm LT-R206 A/B/C/D/207/1&2 is provided.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.

Bottling Unit PHE-206 to Filling Machine.								
	More/ less quantity from PR-201A	2.1. malfunction of FT-R206 A/B/C/D/207/9	2.1.1. Quality upset and possibility of overfilling of R-206 A/B/C/D/207.	1.2.1.1. H level alarm LT-R206 A/B/C/D/207/1&2 is provided.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.

	More/ less quantity from PT- 201 A/B	3.1. Malfunction of FT-R206 A/B/C/D/207/5	3.1.1. Quality upset and possibility of overfilling of R-206 A/B/C/D/207.	1.3.1.1. H level alarm LT-R206 A/B/C/D/207/1&2 is provided.	2	2	4	Recommended to develop maintenance plan for periodic testing and calibration of flow transmitter.
	Reverse flow	4.1. Unlikely	4.1.1.	1.4.1.1.				
	Misdirected flow	5.1. Unlikely as batch logic sequence is provided.	5.1.1.	1.5.1.1.				
	High pressure in reactor R-206 A/B/C/D/207	6.1. Unlikely as the reactor is being operated at atmospheric pressure.	6.1.1.	1.6.1.1. PSV-R206 A/B/C/D/207 is available 1.6.1.2. PVRV-R206 A/B/C/D/207 is available 1.6.1.3. PT-R206 A/B/C/D/207 with H alarm is available.				
	High pressure in Product Solution Pump PR-206 A/B/C/D/207	7.1. Filter F-206 A/B/C/D/207 or F-206F 1/2 partially choked. 7.2. Filling machine stopped.	7.1.1. Possibility of Pump damage due to block discharge may lead to spillage and loss of production.	1.7.1.1. DPI-F206 A/B/C/D/207 is available with H alarm. 1.7.1.2. DPI-F206F 1/2 is available with H alarm. 1.7.1.3. PT-PHE206/1&2 is available with H alarm.	2	2	4	Recommended to provide interlock to stop pump PR-206 A/B/C/D/207 in case of high pressure n PT-PHE206/2 or DPT-F206 A/B/C/D/207 or DPI-F206-F1/2. SOP to be developed to keep recirculation valve to R-206 A/B/C/D/207 partially open during transfer of product to filling machine.
	Low pressure in reactor R-206 A/B/C/D/207	8.1. Unlikely as the reactor is being operated at atmospheric pressure.	8.1.1.	1.8.1.1. PVRV- R206 A/B/C/D/207 is available 1.8.1.2. PT- R206 A/B/C/D/207 with L alarm is available				

	Low pressure in Product Solution Pump PR-206 A/B/C/D/207	9.1. Running pump trip. 9.2. XV- R206 A/B/C/D/207/8 is fail close.	9.1.1. Delay in product transfer. 9.1.2. Pump suction will be lost that may lead to pump damage and loss of production.	1.9.1.1. Pump running and indication is provided in control room. 1.9.1.2. Position indicator XV206 A/B/C/D/207 is provided in control room. 19.1.3. FS-PR-206	2	1	2	

				A/B/C/D/207 flow switch is provided to trip the pump in case of no flow.				
	High temperature in R-206 A/B/C/D/207	10.1. Loss of CHWS 10.2. TICA-R206 A/B/C/D/207 malfunction 10.3. TCV-R206 A/B/C/D/207/2 malfunction fail closed.	10.1.1. Inadequate cooling of product that may lead to quality issue.	1.10.1.1. TIC-R206 A/B/C/D/207 is provided with H temperature alarm for operator action. 1.10.1.2. PHE-206 is provided to cool product in case of inadequate cooling in R-206 A/B/C/D/207.	2	2	4	
	Low temperature in R-206 A/B/C/D/207	11.1. TICA-R206 A/B/C/D/207 malfunction	11.1.1. No adverse consequences.	1.11.1.1.				
	High level in R-206 A/B/C/D/207	12.1. Excessive addition of reactants	12.1.1. Possibility of overfilling of R-206 A/B/C/D/207	1.12.1.1. H level alarm LT- R206 A/B/C/D/207/1&2 is provided.	2	2	4	
	Low level in R-206 A/B/C/D/207	13.1. Inadequate addition of reactants	13.1.1. Possibility of pump suction starvation during transfer.	1.13.1.1. L level alarm LT- R206 A/B/C/D/207/1&2 is provided. 1.13.1.2. FS-PR-206 A/B/C/D/207 flow switch is provided to trip the pump in case of no flow.	2	2	4	
	Agitation in R-206 A/B/C/D/207	14.1. Faster agitation due to VFD malfunction	14.1.1. Possibility of foaming and overflow from the powder feeding hopper.	1.14.1.1. VFD speed indicator is provided in control room.	2	2	4	

		14.2. Slower agitation due to VFD malfunction 14.3. VFD trip due to loss of power	14.1.2. Inadequate mixing leading to quality issue.	1.14.1.2. Emergency power is available for the agitator.				
	Plate leakage	15.1. PHE206 plate leakage	15.1.1. Product will get contaminated with chilled water leading to loss of quality and production.	1.15.1.1.	2	3	6	SOP to be developed for periodic inspection and testing of PHE to prevent internal plate leakage.

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