INTERNATIONAL JOURNAL OF ADVANCE RESEARCH AND DEVELOPMENT

IJARnD

(Volume2, Issue3)
Available online at: www.ijarnd.com

Hazard Identification of Chemical Mixing Plant through Hazop Study

Appil Ora, Abhishek Nandan, Abhishek Kumar
University of Petroleum and Energy Studies, Dehradun,, India

Abstract

Hazard and Operability (HAZOP) techniques the best step for identification and analyzing the hazard and operational issues of the system. It is very organized, methodical and structured process to identify hazards of any system or process from the initiating stage till decommissioning of the project. Technology and system possess exposure to undesired events because system can fail or improper work resulting in injury, damage and deaths. Our lives are dealing with a web of different systems, each of which can affect our safety. Each of these systems contains inherent hazard that present unique risk. The major concerned is about eliminating and reducing risk which leads to undesired events. This paper discusses the hazard analysis through HAZOP technique done on a chemical mixing process producing 10% HCL as a final product and all the possible consequences arising from the deviation is identified using several guide words. The result of Hazard identification helps to suggest the control measures in order to prevent deviation and to avoid the consequences. HAZOP technique provides clear and detailed analysis of hazard associated with the process and results are easy to understand.

Keywords: Study Nodes, Design Intention, Deviation, Causes, Consequences, Guide Words etc.

INTRODUCTION

HAZOP

Hazard and Operability Study is a versatile technique used to check the operating procedure and design of a process in order to improve the safety of existing facilities. HAZOP is used identify all the possible ways in which a process can be deviated from its intended path and result in such consequences which may cause injury to human, may cause damage to equipment or harm to the environment.(Riberet 1985).

In order to carry out HAZOP Study some basic tools are required initially such as piping and instrument diagrams (P&ID), a plant layout, process flow diagram as a guide for examining every component and section of a process (Venkatasubramanian, Zhao et al. 2000). HAZOP team consists of knowledgeable and experienced people, to assess the hazard potential by which any equipment malfunctions and its further effect on the unit as a whole.

The HAZOP team should be led by a person with extensive knowledge of the process, and the team consists of experts with a different background. The HAZOP team should include people such as engineering/process design, maintenance, operations, instrumentation and other specialists as needed. It also requires a person who is familiar with the installation.(Kennedy and Kirwan 1998).

The HAZOP analysis technique implements by an experienced team and requires a full description of the process involve in plant and questioning takes place to find out several existing hazards in the system. (Ericson 2015).The basic knowledge of hazard analysis andsystem safety concepts is essential. The HAZOP analysis technique is

widely used for the chemical process industry since it involves parameters and guides words which specifically linked with the process operations and process design(Dunjó, Fthenakis et al. 2010).

The HAZOP analysis undertakes operation control methods which are fully investigated for potential varying conditions in the entire process flow, which might get resulted in any undesired events. For conducting HAZOP study, a team of experts in different areas, such as operations, chemistry, engineering, safety, and maintenance is required to join hands in order to achieve better outcomes(Kraus).The basic approach of the HAZOP study is to review the whole process involving the brainstorming of various discipline member of the HAZOP team so that objective can be attained. It also includes a various meeting of HAZOP team which can discuss all the findings and views of expert and experienced person can lead to the better outcome. Guide words play the dominant role in HAZOP so that study can be explored in every possible manner.

The HAZOP analysis is basically a chemistry develops between a list of system parameters for ex. Pressure, temperature, flow, viscosity etc. and various guide words like no, more, less, as well as etc. and it's upon the condition which guides words to be used under which circumstances. For this HAZOP study, the parameter is taken as flow and according to the nodes, applicable guide words decided(Raspotnig and Opdahl 2013).Each component undergoes detailed analysis by applying different applicable guide words so that deviations can be identified from design intent along with the possible resulting hazards. HAZOP team decides the parameters and then applies and check the feasibility of guide words, only applicable guide words are to be considered.(Crawley and Tyler 2015).In other words, the deviation is the outcome from the addition of guide word and parameter.

HAZOP technique plays a dominant role in chemical process industry in order to carry out hazard analysis. It is one of the tools generally using for hazard identification for any process. Chemical Industry consists of such scenarios that would lead to the release of flammable or hazardous material into the atmosphere, thus exposing workers to injury or severe effects. In order to make this determination team needs to investigate all such scenarios whose consequences result in such hazardous condition. So basically HAZOP results with two main outcomes as First, determines the conceivable ways in which design intent gets deviated and Second, by considering each deviation what all possible consequences can occur and how much severe they can be.

Process Description: In this process RO water, additives and 33% of HCl are mixed to form a resultant product of 10% of HCl. The reactants are added in the order such as water, additives and then acid to avoid non-uniform mixture. The acid and water are pumped to the batch mixer by a centrifugal pump, the additives (liquid) are pumped to the batch mixer by a wild pump and additives (solid) pour directly to batch mixer through the latch. The quantities of the reactants are taken as per the proportion of resultant product quantity needed. The floor of acid mixing area is coated with epoxy which serves as a secondary containment. There are total numbers of seven nodes taken in order to carry out HAZOP study as shown in the layout below. The first node is for RO water, seventhly is for 33% HCL and node number two to six for additives such as corrosion inhibitor, mutual solvent, non-emulsifying agent, surfactants and acetic acid.

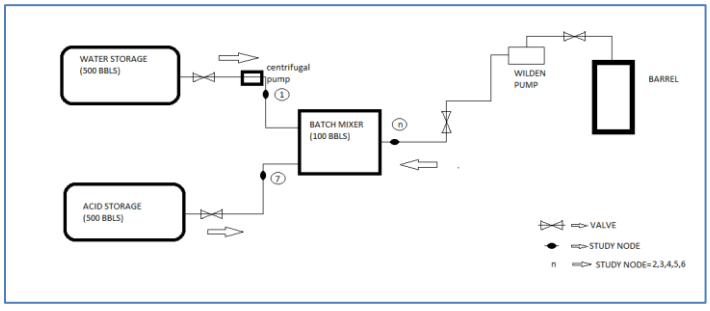

Figure 1: Acid mixing plant layout

METHODOLOGY

The HAZOP team initially focuses on nodes which can identify from the P&ID of the process because parameter and guide words apply on nodes only by taking consideration of the material involved or passes through that particular node. Process parameters are identified, say flow, and under consideration an intention is created for the node. Apply the first guide word say “no” and develop a meaning full deviation as “no flow”. Next step is to determine all the possible causes due to which such deviation can take place, on the other hand, HAZOP team needs to identify all the consequences also, if such deviation occurs then what possible outcome it leads to. Finally,

the suggestion is to be recorded along with the deviation and causes in a particular tabular format. Now, the same process needs to be repeated for all the guide words and result should be recorded, after completion of one node, the team moves to next node and repeats the same process again.

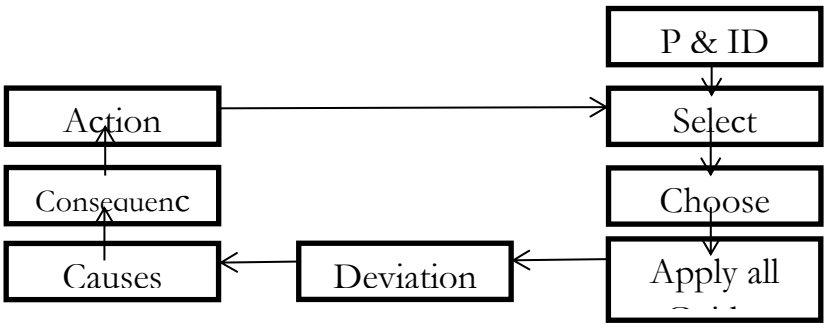

Figure 2: Process Flow Chart of HAZOP study

Prerequisites for HAZOP study:
For HAZOP study the following information should be available:

- Process flow diagrams (PFD)
- Piping and instrumentation diagrams (P&IDs)
- Layout diagrams
- Heat and material balances
- Material safety data sheets
- Provisional operating instructions
- Equipment data sheets Start-up and emergency shut-down procedures

HAZOP Worksheet: The HAZOP analysis technique is utilizing rigor and structure. It is always better to perform the HAZOP analysis using a structured worksheet format typically, columnar-type or matrix worksheets are used to maintain uniformity in the analysis. The HAZOP analysis step by step outcomes are primarily reported in the HAZOP worksheets and according to the outcomes, the team would suggest further recommendations. Here HAZOP worksheet for node 1(RO water), node 6(Acetic acid) and node 7(33% HCL) are given below.

Node: 1 Process Parameter: Flow

Intention: RO water is the first reactant pumped to the batch mixer by a centrifugal pump at atmospheric temperature and pressure.

Table 1: HAZOP worksheet for Node 1

Guide word	Deviation	Causes	Consequences	Action required
No	No flow	Centrifugal pump loses priming or valve closed totally	Resulting in highly concentrated solution	Proper monitoring of the centrifugal pump(hydraulic pressure)
Less	Less flow	Valve closed partially	Resulting in highly concentrated solution	Proper monitoring of centrifugal pump
More	More flow	Water passes through the valve even it is closed	Overflow of the batch mixer	The level indicator shall be installed
Other than	Complete substitution	Wrong delivery from vendor or wrong material is chosen while feeding RO water	Depends upon the substitution, requires testing potential substitution based on availability of other material at site	Plant procedure to provide check on material chosen before charging of material

Node: 6 Process Parameter: Flow

Intention: Acid is always added last to the mixture. Acetic acid is the last in the additives. It is pumped by a wilden pump to the batch mixer.

Table 2: HAZOP worksheet for Node 6

Guide word	Deviation	Causes	Consequences	Action required
No	No flow	The pipeline is ruptured.	The purpose is not fulfilled (fe^{3+} to fe^{2+})	Proper monitoring of wilden pump and pipeline by the operator
Less	Less flow	Plug In pipe and leak in pipeline and faulty level indicator	The purpose is not fulfilled (fe^{3+} to fe^{2+})	The Wilden pump must be free of leaks and union of the pipeline is checked for leaks
Reverse	More flow	Damage diaphragm	The additive will not get pumped instead air is accumulated	Proper function test and monitoring of the wilden pump
More	More flow	Valve malfunction	Product will have more acidic concentration	Proper inspection and testing of valves
Sooner than	Too early or in the wrong order	Wrong material is chosen from plant or poor communication	It forms non-uniform mixture if the recipe not followed properly	Discuss roles and responsibilities of all the crew members in Tool Box Talk

Node: 7 Process Parameter: Flow

Intention: Acid (33% of Hcl) is always added last to the batch mixer at atmospheric temperature and pressure.

Table 3: HAZOP worksheet for Node 7

Guide word	Deviation	Causes	Consequences	Action required
No	No flow	Less Priming of the pump	Resulting in less acid concentration solution	Chemicals added separately and monitored
Less	Less flow	Valve closed partially	Resulting in less concentrated solution	Proper monitoring
More	More flow	Acid passes through the valve even it is closed	Overflow of the batch mixer and the resulting solution will be more concentrated and corrosive	Regulate the throttle properly
Part of	Decreased concentration of acid	Vendor delivered wrong concentrated material	The ultimate product will be of less quality than the desired product	Prior test is to be conducted, QA/QC performed
Sooner than	Too early or in the wrong order	Poor communication between the crew	Corrosion in the batch mixer	Proper SOP follow and is to be discussed in TBT

RESULTS AND DISCUSSION

HAZOP focuses on identifying both operability problems as well as hazards. Most of the study resulting in recommendations about operability problems. This HAZOP study result shows about the major causes of deviation which include human error and operability problem. Although the main focus is hazard identification, operability problems should be identified to the extent that they have the potential to lead to process hazards, and the outcome can adversely affect the system, process, and profitability.

Following are the main outcomes of the HAZOP study;

Visual Inspection – It has to be done regularly in order to ensure the safety of the workplace and to check that whether all the necessary precaution is kept in place and conveyed among the workers exposed to work. Perform Quality Assurance/Quality Control–In order to increase the efficiency of operation and to get high-quality output, QA/QC has to be performed. It brings customer satisfaction and prevents undesired events to takes place, finally resulting in good growing business.

TBT is to be conducted prior to the job so that hazard associated with the activity can be discussed, all safety measures can be conveyed along with the emergency plan.
Safe working instructions are to be discussed so that activity carried out as per the organization defined process in order to minimize the level of risk associated with the activity.
Consider the use of standby person, so that proper action can be taken at the time of emergency. Ensure proper monitoring of the pumping operation in order to avoid consequences.
Ensure proper segregation so that no two non-compatible chemicals react with each other and proper labeling of the chemical barrels has to be done and discuss roles and responsibilities of all the crew.
All the deviations should be listed down and only those deviations should be considered which carry enough causes for that deviation to happen and it should be realistic in nature. However, only practical causes should be listed. HAZOP team decides about possible causes for any particular deviation on the basis of their judgment and experience.

There are three basic types of causes. They are:
1. The human error which can be committed by a designer, operator, constructor or other person creating a hazard that could possibly result in any undesired event. For ex. Miss-communication between the crew members or wrong supply of material.

2. Equipment failure includes an operating, structural or mechanical failure results in any undesired event. Forex. Valve malfunction, damage diaphragm etc. as mentioned in this HAZOP study.

3. External Events includes items outside the unit being reviewed affect the operation of the unit For ex. Natural calamities.

The HAZOP analysis is the best technique to establish how design intent can get diverted from its path, as findings of this HAZOP study helps to identify all deviation from the intention that may have an adverse effect upon the efficient and safe operation of the plant/system. Particularly, for process industry where various parameters need to be considered and carry out a study of each parameter on considering every possible deviation this technique results in a perfect manner.
All the outcomes of the HAZOP study need implementation so that system can be safer and accidents can be prevented. On the basis of such findings, finally, recommendations are listed down to reduce the level of risk and to avoid such consequences.

CONCLUSION

In this study, HAZOP team tried to find out all the deviations and use the applicable guide words for particular nodes by taking Flow as a parameter. The use of design representation aids, such as reliability block diagrams, functional diagrams etc.which simplify and greatly aids in the HAZOP analysis process. Here all the possible consequences and causes determined on the basis of which recommendation is drafted along with the experienced persons. All recommended actions need to implement in order to prevent deviations and to avoid undesired event to take place.
HAZOP is one of the best technique in order to carry out Hazard identification and analysis of any chemical process, since it uses guide words and different parameters which help to determine all possible events which are associated with any such process and by implementing preventive and corrective actions, inherent safety of the system can be accomplished and thus increase the morale and efficiency of employees exposed to such activity.

REFERENCES

1. Crawley, F. and B. Tyler (2015). HAZOP: Guide to best practice, Elsevier.
2. Dunjó, J., V. Fthenakis, et al. (2010). "Hazard and operability (HAZOP) analysis. A literature review." Journal of hazardous materials 173(1): 19-32.Ericson, C. A. (2015). Hazard analysis techniques for system safety, John Wiley & Sons.
3. Kennedy, R. and B. Kirwan (1998). "Development of a hazard and operability-based method for identifying safety management vulnerabilities in high-risk systems." Safety Science 30(3): 249-274.
4. Kraus, R. S. "Developing a process safety management program." ILO Encyclopedia of Occupational Health and Safety.
5. Labovský, J., Z. Švandová, et al. (2007). "Model-based HAZOP study of a real MTBE plant." Journal of loss prevention in the Process Industries 20(3): 230-237.
6. Raspotnig, C. and A. Opdahl (2013). "Comparing risk identification techniques for safety and security requirements." Journal of Systems and Software 86(4): 1124-1151.
7. Riberet, M. (1985). "A New Look at Operability & Safety Audits."
8. Venkatasubramanian, V., J. Zhao, et al. (2000). "Intelligent systems for HAZOP analysis of complex process plants." Computers & Chemical Engineering 24(9): 2291-2302.
9. Bartolozzi, V., L. Castiglione, et al. (2000). "Qualitative models of equipment units and their use in automatic HAZOP analysis." Reliability Engineering & System Safety**70**(1): 49-57.
10. Cagno, E., F. Caron, et al. (2002). "Risk analysis in plant commissioning: the Multilevel Hazop." Reliability Engineering & System Safety**77**(3): 309-323.
11. Catino, C. A. and L. H. Ungar (1995). "Model-based approach to automated hazard identification of chemical plants." AIChE Journal**41**(1): 97-109.
12. Crowl, D. A. and J. F. Louvar (2001). Chemical process safety: fundamentals with applications, Pearson Education.
13. Greenberg, H. R. and J. J. Cramer (1991). Risk assessment and risk management for the chemical process industry, John Wiley & Sons.
14. Ho, T. C., Y. S. Duh, et al. (1998). "Case studies of incidents in runaway reactions and emergency relief." Process Safety Progress**17**(4): 259-262.
15. Hurme, M. and M. Rahman (2005). "Implementing inherent safety throughout process lifecycle." Journal of loss prevention in the Process Industries**18**(4): 238-244.
16. Kletz, T. A. (1986). Cheaper, safer plants. Chemeca 86 The Fourteenth Australasian Chemical Engineering Conference; Chemical Engineering; Initiatives, Attitudes, Cycles, Institution of Chemical Engineers, Institution of Engineers, Australia, Royal Australian Chemical Institute.
17. Ko, D. C., E. L. Mui, et al. (2004). "Production of activated carbons from waste tire–process design and economic analysis." Waste Management**24**(9): 875-888.
18. Labovský, J., Z. Švandová, et al. (2007). "Model-based HAZOP study of a real MTBE plant." Journal of loss prevention in the Process Industries**20**(3): 230-237.
19. McDermid, J. and D. Pumfrey (1994). A development of hazard analysis to aid software design. Proceedings of COMPASS.
20. Noakes, N., C. Chow, et al. (2011). "Safety education for chemical engineering students in Hong Kong: Development of HAZOP Study teaching module." Education for Chemical Engineers**6**(2): e31-e55.
21. Parmar, J. and F. Lees (1987). "The propagation of faults in process plants: hazard identification." Reliability Engineering**17**(4): 277-302.
22. Ruiz, D., J. Nougués, et al. (2000). "Neural network based framework for fault diagnosis in batch chemical plants." Computers & Chemical Engineering**24**(2): 777-784.
23. Vaidhyanathan, R., V. Venkatasubramanian, et al. (1996). "HAZOPExpert: An expert system for automating HAZOP analysis." Process Safety Progress**15**(2): 80-88.
24. Zhao, C., M. Bhushan, et al. (2005). "Phasuite: an automated HAZOP analysis tool for chemical processes: part I: knowledge engineering framework." Process Safety and Environmental Protection**83**(6): 509-532.

