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HAZARD AND OPERABILITY STUDY WITH QUANTITATIVE RISK ASSESSMENT OF PROPANE YARD

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Abstract

Hazard and operability study (HAZOP) is one of the safety management techniques and it is a qualitative study, quantitative risk assessment (QRA) is the risk identification technique in the form of quantitative. In this study, the propane yard which is located in TVS motor company is taken and studied. HAZOP study is to check the design, decide what is the safety equipment needed; check running instructions, to improve the safety of existing facilities. The study is done by dividing the system into various nodes and each node is analyzed with deviations, causes, and consequences of failure, and recommendations are given if needed to improve the system. In case of accidental release of propane gas, there may be the chance for effects like Boiling Liquid Expanding Vapor Explosion (BLEVE), jet fire, and pool fire as propane is high flammable liquid gas this study helps to prevent this kind of effects. QRA analysis is done with a probability of occurrence, the severity of consequences, and risk assessment for identifying the most risk that has taken place in the propane yard. Propane is used for the paint shop, decoding, cooking, and boilers and it is the heart of TVSM. Based on the findings, several preventative and mitigating actions have been implemented to lessen the severity of the consequences of accidents, therefore improving the safe environment.

Keywords: Probability, severity, HAZOP, QRA, recommendation, investigated.

1. INTRODUCTION

One of the most thorough and rational qualitative hazard detection approaches is the HAZOP research. However, it necessitates the use of multidisciplinary words and is a time-consuming and repetitive effort. [1] If in the design of the machine, a systematic research approach that considers the operator's safety is proposed, it may add to the safety of the process plant if it is developed via the follow-up investigations. [2] The incidence of accidents due to leakage, fire, explosion, and other causes has grown as the use and complexity of natural gas pipelines have increased. they proposed a QRA simulation model for natural gas pipeline, combined with a different level grid-based pre-warning model, based on (QRA) As a consequence, they may implement a targeted and firm strategy in places where there are some possible flaws ahead of time, and even resurrect urban planning, reconstructing it to eliminate the danger. [3] Hazard and Operability Study were used to identify the possibility of unintended mishaps in the oil storage farm (HAZOP). Second, Fault Tree Analysis (FTA) was used to examine all of the detected dangers and successfully identify the fundamental events (BES) that cause them. [4] Natural Gas must be in a liquid form for transportation, and liquefying it necessitates lowering the temperature to a very less. This necessitates extreme temperatures and pressures. This article says a risk assessment research on a Node in the Natural Gas Plant, which is a propane heat exchanging unit that progressively lowers the temperature of the flow to remove heavy liquids at the start. HAZOP, DMRA, and LOPA are three risk assessment methodologies that are used. [5] The dangers in a double-shell stainless-steel tank for high-level radioactive liquid waste storage were identified using a hazard and operability (HAZOP) technique, and a risk matrix was utilized to estimate the risks caused by the hazard. Relevant process parameters and guidewords were chosen to define the storage tank deviation, and the causes and likely implications of deviations, as well as current protective mechanisms, were assessed during the HAZOP process. [6] This information, when combined with the plant's operational, technical, and theoretical knowledge, permitted for the evaluation of deviations for operational factors such as temperature, pressure, and level, among others, in identifying potential hazards associated scenarios during anhydrous ammonia storage. To decrease or avoid accidents that hurt people, the ecosystem, or the firm, suggestions were suggested based on the HAZOP study. The qualitative aberrations and variables that demand constant monitoring and control for safe anhydrous ammonia storage are the subject of this study case. [7] The petroleum and chemical industry is a tool for discovering safety hazards in existing facilities as well as those under development or construction. The risk assessment approach used in this study was designed to underline the significance of safety when pipetting from the a tanker truck to an underground tanks or from an underground tank to barrel filling equipment. Xylene is very flammable and may cause a boiling liquid expanding vapour explosion, often known as a (BLEVE). We utilised the risk analysis (HAZOP) technique to identify the relevant probable hazards and apply the appropriate controls to reduce or eliminate the possibility of fire or explosion during this explosion since it might result in death or major property damagethe decanting of toluene storage to dispatch. [8]

The study offers better value for money than the daily list approach inside the art of identifying risks, and can also be used for (a) future developments and (b) as just a support document for trying to prepare a 'Safety Case' for experienced a significant events as well as establishing fault/event trees for the further frequency analysis. [9] According to the report, the industry's reactor and storage units are particularly prone to accidents and require complex safety measures. [10]

2. METHODOLOGY

It is the step by step process, from selecting the node and analyzing the node with help of parameters and guide words and identifying the deviation which helps us to provide the action that can reduce the hazards

QRA study is done with help of probability, severity, and risk matrix with this we can identify most risks and we can reduce the risk according to risk priority. And this is shown in the tables below.

Table1. QRA probability

P	PROBABILITY OF OCCURRANCE	MEANING
1	<0.0001	VERY LESS
2	0.001-0.0001	LESS
3	0.01-0.001	MEDIUM
4	0.1-0.01	HIGH
5	>0.1	VERY HIGH

Table2. Severity

S	LOSS (INR)	HARMS
1	<83,960	NO HARMS
2	83,960 - 8,39,600	MINOR HARMS
3	8,39,600 – 83,96,000	SERIOUS HARMS
4	83,96,000 – 8,39,60,000	1 DEATH
5	>8,39,60,000	>1 DEATH

Table3. Risk assessment

RISK	R= P X S
1 – 3	NON HAZARDOUS
3 – 7	LOW HAZARDOUS
8 – 25	HAZARDOUS

P	NO INJURY	MINOR INJURY	SERIOUS INJURY	DEADLY INJURY	>1 DEADLY INJURY
VERY LOW	LOW	LOW	MODERATE	HIGH	HIGH
LOW	LOW	LOW	MODERATE	HIGH	EXTREME
MIDDLE	LOW	MODERATE	HIGH	EXTREME	EXTREME
HIGH	MODERATE	HIGH	HIGH	EXTREME	EXTREME
VERY HIGH	HIGH	HIGH	EXTREME	EXTREME	EXTREME

Figure1. Risk matrix

3. PROCESS DESCRIPTION

Liquefied propane from the road truck is unloaded in the mounded storage bullet. The liquid propane is unloaded using a liquid transfer pump and the vapor propane is unloaded using the compressor. Provision to unload liquid propane by pressurizing the road truck using vapor sucked from the compressor is also available for unloading propane from road truck to mounded bullet.

Liquid propane is stored in the mounded bullet and two number of bullets are provided. The vaporizer is installed to increase the temperature and thereby increase the pressure of propane vapor. The liquid outlet valve on the bottom of the tank is opened and the liquid is passed through a pressure regulating station and can be ultimately used in the system. Two types of vaporizers are used to generate propane electrical heater vaporizer and heater less vaporizer. Then the vapor is transferred to the user end with the help of pipelines. A simplified P and I diagram are shown in figure 3.

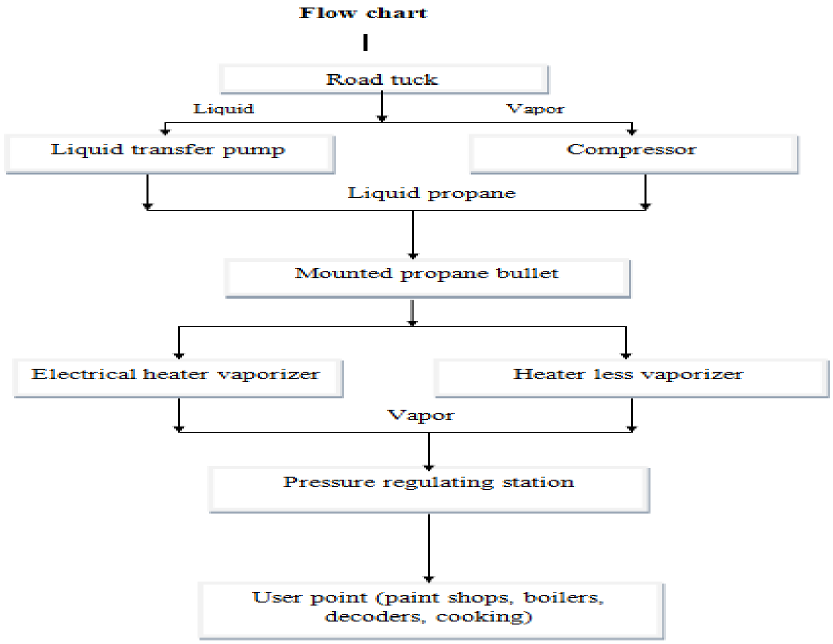

Figure2. Flow chart for process

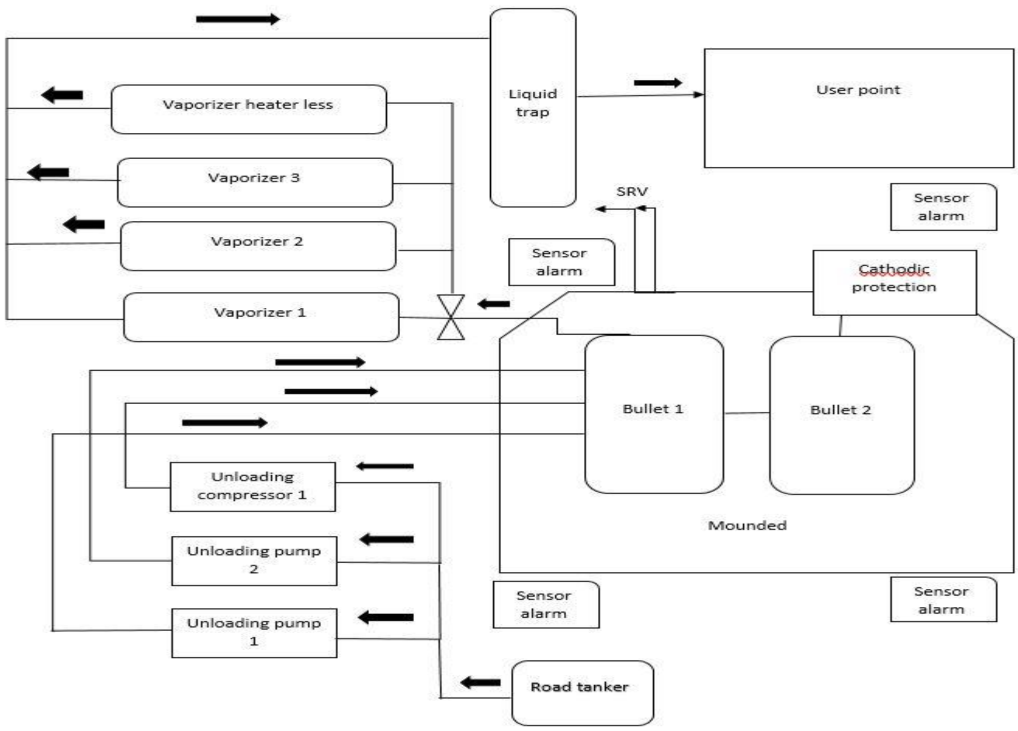

Figure4. Simplified P and I diagram

5. RESULTS

Selected vaporizer as the node point for HAZOP study which is located in propane yard.

PARAMETER	DEVIATIONS	CAUSES	P	CONSEQUENCE	SAFETY FUNCTIONS	S	R	PREVENTIVE MEASURE
NODE: VAPORIZER								
FLOW	NO FLOW	1. No flow of liquid propane from bullet to vaporizer 2. no flow of liquid propane to vaporizer due to solenoid valve fail close 3.no flow of cooling water to vaporizer 4 due to pump failure	3	1.1 possible increase of temperature in water bath of vaporizer and decreases of water level resulting in damage of heater 1.2. decrease in flow rate of vapour propane 1.3 flame off in user end 2.1 possible flame off in burner in user end 2.2 Increase of pressure upstream of solenoid valve 3.1 no vaporization of liquid propane in vaporizer 4 resulting in flow of liquid propane to user leading to fire explosion	1.1 limit switch 1.2 level switch interlock to open solenoid valve 1.3 flow indication transmitter 1.4 Field instrument 2.1 remote operated valve interlock with indication alarm 2.2 flow indication transmitter 2.3 Pressure indication transmitter 2.4 safety relief valve 3.1 pump running indication 3.2 pressure gauge 3.3 field instrument	2	6	1. Review safeguard / interlocks for flame off at user end and also include re ignition sequence as of un burnt accumulation of propane 2.provide RTD indication on PLC and also add interlock to trip heater when high temperature 3. Provide solenoid valve at inlet PRS upstream of vaporizer and provide interlock to close solenoid valve in liquid trap.
FLOW	LOW FLOW	Low flow of cooling water to vaporization pump suction strainer choke	2	1. Decrease rate of vaporization liquid at user point 2. Possible dry run of pump leading to damage	1. Field instrument 2. pressure gauge	2	4	Provide solenoid valve at inlet PRS upstream of vaporizer and provide interlock to close solenoid valve in liquid trap

PRESSURE	HIGH PRESSURE	1. high pressure is blocked section between inlet and outlet isolation valve of with heater vaporizer 2. high pressure in vaporizer 4 propane line due to external fire	2	1.1 leak/ rupture from blocked section due to vaporization liquid propane 2.1 damage of equipment and release of propane to atmosphere leading to fire and explosion	1.1 PLC (HPS) indication used 2.1 pressure gauge 2.2 audio visual alarms	3	6	Provide TRV in the blocked section between inlet and outlet isolation valve
LEVEL	HIGH LEVEL	High level in vaporizer water bath due to solenoid valve open	1	Overflow of water leads to loss of utility		2	2	
	LOW LEVEL	Low level in vaporizer water bath due to solenoid valve close	2	Damages to heater if level goes low decrease in vaporization rate	Level switch is interlock to close liquid propane inlet valve	1	2	1. provide RTD indication on PLC and also add interlock to trip heater when high temperature 2. provide interlock to trip heater and propane feed to vaporizer on low level in water bath.
TEMPERATUE	HIGH	High temperature in water bath of vaporizer due to excessive heating by heater	2	1. increase of pressure and temperature of propane downstream of vaporizer 2. damage of pipeline / equipment leading to fire and explosion hazard if meet with an ignition source	1. pressure indication transmitter 2. temperature indication transmitter 3. PLC (HPS) is interlock with solenoid valve 4. alarms	2	2	provide RTD indication on PLC and also add interlock to trip heater when high temperature

	LOW	Low temperature in water bath of vaporizer due to heater failure	1	Decrease in vaporization rate and flow of liquid propane to user leading to unsafe condition in user side	Level switch is interlock to close liquid propane inlet valve and solenoid valve	2	2	1. Review safeguard / interlocks for flame off at user end and also include re ignition sequence as of un burnt accumulation of propane
UTILITY FAILURE	COOLING WATER FAILURE	Cooling water failure	2	1. decrease of level in vaporizer 1-3 water bath and damages to heater if level goes low decrease in vaporization rate 2. decrease of level in vaporizer water storage tank for damages to heater if level goes low decrease in vaporization rate	Level switch is interlock to close liquid propane inlet valve	3	6	
CORROTION\ EROSION	HIGH CORROSION	Corrosion / scaling in coil of vaporizer	2	1. decrease in efficiency of heater vaporizer 2. decrease in rate of vaporization of liquid propane in vaporizer resulting in flow of liquid propane to user leading to fire explosion		2	4	Periodic inspection of heater coils to be carried out for corrosion and scaling
LEAKAGE	MORE	Vaporizer leak	2	Release of propane into atmosphere leading to fire and explosion hazard	Audio visual alarm	2	4	
	MORE	Vaporizer 4 tube leak	2	Ingress of water into propane leading to carryover of liquid to user end resulting in fire and explosion in user side	Level switch	2	4	Provide solenoid valve at inlet PRS upstream of vaporizer and provide interlock to close solenoid valve in liquid trap

6. CONCLUSION

Propane is stored in the form of liquid in the bullet which has the capacity of 72tons and is used as gas. This study used the HAZOP and QRA techniques to Identify and analyze the propane-related operability hazards. vaporizer in TVSM, taking into account operational, technical, and conceptual aspects. Based on the findings, several preventative and mitigating actions have been implemented to lessen the severity of the consequences of accidents, therefore improving the safe environment.

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REFERENCES

[1] Chae, Heeyeop, Yeo Hong Yoon, and En Sup Yoon. "Safety analysis using an expert system in chemical processes." *Korean Journal of Chemical Engineering* 11.3 (1994): 153-161.

[2] Choi, Jae-Young, and Sang-Hoon Byeon. "HAZOP methodology based on the health, safety, and environment engineering." *International journal of environmental research and public health* 17.9 (2020): 3236.

[3] Li, Shuang, et al. "QRA-Grid: Quantitative risk analysis and grid-based pre-warning model for urban natural gas pipeline." *ISPRS International Journal of Geo-Information* 8.3 (2019): 122.

[4] Ibrahim, H. A., and H. S. Syed. "Hazard analysis of crude oil storage tank farm." *International Journal of Chem Tech Research* (2018): 300-308.

[5] Ezzat, Khaled Habib, et al. "Risk assessment for propane cooler in natural gas liquefaction plant." *Advances in Chemical Engineering and Science* 5.03 (2015): 270.

[6] Zou, Shuliang, et al. "Risk analysis of high level radioactive waste storage tank based on HAZOP." *Annals of Nuclear Energy* 119 (2018): 106-116.

[7] Benedetti-Marquez, E. B., et al. "Analysis of Operational Risks in the Storage of Liquid Ammonium Nitrate in a Petrochemical Plant, through the HAZOP Methodology." *Chem. Eng* 67 (2018): 883-888.

[8] Hariprasath, M., et al. “Risk Analysis (HAZOP Study) for a Hazardous Chemical Storage Plant.” *Advance in natural and applied science* (2017): 724-726

[9] Qureshi, A. R. "The role of hazard and operability study in risk analysis of major hazard plant." *Journal of loss prevention in the process industries* 1.2 (1988): 104-109.

[10] Khan, Faisal I., and S. A. Abbasi. "Risk analysis of a typical chemical industry using ORA procedure." *Journal of Loss Prevention in the Process Industries* 14.1 (2001): 43-59.

[11] IEC 61882:2001 Hazard and operability studies (HAZOP studies). Application guide.