Iranian Journal of Oil & Gas Science and Technology, Vol. 11 (2022), No. 2, pp. 28-37
http://ijogst.put.ac.ir

Risk Assessment and Risk Management of Kermanshah Province Gas Company Using HAZOP Method

Zahra Heydari[1], Vahid Rahmani[2], Ali Akbar Heydari[3], Mohsen Motavassel[4*]

[1]M.S. Student, Put-Gas Company, Sistan and Balochestan, Iran
[2] M.S. Student, Razi University-Gas Company, Kermanshah, Iran
[3] M.S. Student, Sistan and Balochestan-Gas Company, Sistan and Balochestan, Iran
[4]Assistant Professor, Department of Chemical Engineering, Petroleum University of Technology, Abadan, Iran

Highlights

- The safety of pipeline is one of the priorities of gas companies, government and consumers.
- In this study performance of Hazard and operability (HAZOP) method for asses of hazards and risks, for all process
- This research was conducted by a team of 3 experts and identified the process hazards by means of quid words
- 282 risks were identified and only 03 risk is unacceptable e and 111 are Conditional that must be eliminated without delay, the others are acceptable that the risk must be eliminated but it is not an emergency.

Received: April 02, 2021; *revised: February 03*, 2022; *accepted: February 18, 2022*

Abstract

Every day's large amount of gas is consumed which is transported through pipelines. Due to irreparable consequences of gas related accident and their heavy financial losses; therefore, despite the company mission in the field such as: Increase the gas supply coverage, increase customer satisfaction, predict emergency response plan, etc. the safety of pipeline is one of the priorities of gas companies, government and consumers. Hazard is part of every human endeavor, so hazard identification and risk management is very important. As some of event may not be exactly predictable, the study of risk is very important. The risk management is a determinative step of the health, safety and environmental management system (HSEMS). In this study performance of Hazard and operability (HAZOP) analysis for asses of hazards and risks, for all process, that present in Kermanshah Province Gas Company was evaluated. There are different risk analysis techniques such as FMEA, JSA, HAZID and so on. As the HAZOP is Process Hazard Analysis that not only identifies system hazards, but also determines their probability of occurrence by the effects of any deviations from design conditions and it gives us the accurate results, it's used for risk assessment in this project. This research was conducted by a team of 3 experts and identified the process hazards by means of quid words. At the end of this study in Kermanshah Province Gas Company's about 282 risks were identified and only 03 risk are unacceptable e and 111 are Conditional that must be eliminated without delay, the others are acceptable that the risk must be eliminated but it is not an emergency.

Keywords: Evaluation, Gas company, Hazop, Risk, Risk Assessment.

How to cite this article
Heydari, Z., Rahmani, V, Heydari, A.A, Motavassel, M, Risk Assessment and Risk Management of Kermanshah Province Gas Company Using HAZOP Method, Iran J. Oil Gas Sci. Technol., Vol. 11, No. 1, p.28-37, 2022.
DOI: 10.22050/IJOGST.2022.292733.1604

*Corresponding author:
Email: motavasel@put.ac.ir

1. Introduction

Risk is a combination of the probability of occurrence or exposure to a dangerous event and the severity of injury or illness that can occur due to the occurrence or exposure to that reality (Sotic et al., 2015). The purpose of risk assessment and hazard identification is to provide an input for making key decisions that not including only risks but also includes financial profit or loss (Kaplan et al.,). Classification of the risks helps us to consider them at an interlocked structure as well as for easier planning for their management (Crocker et al., hand book). There are various methods of hazards identification and risk assessment. HAZOP study is one of the most common methods of risk assessment in the oil, gas and petrochemical industries. This method can be used at different times of the process life cycle such as process design and operational life. Advantage of HAZOP method are:

1.Possibility to assess the consequences of a failure of personnel and finding of the mistake of personnel would have a considerable consequence.

2.This method allows to find new dangerous situation and condition

3.Doing this study can increase the efficiency of the operation equipment, it helps to find the unplanned breaks and damage of equipment and etc.

4.By applying this method, we can understand the process exactly.

Dis advantage of Hazop study are:

1.This process need long time.

2.This method need to careful study of the process and accurate knowledge of emergency situations.

3.It needs an expert team and experienced leader (Kotek et al., 2012)

This method is performed by an expert team of different science. They can detect possible deviations from the design, construction, modification and other factors that cause the events. HAZOP study is performed by evaluating and process reviewing and process engineering designs. Risk factors and equipment errors as well as operational problems with related consequences are identified in HAZOP study. The parameters and guide word (Quid words and their description was summarized in Table1) are used for evaluating all possible failure. The system to be studied is divided to separate nodes for ease of investigation. For each node, parameters, guide words and process deviations are considered. For each deviation and failure, the causative agents, the consequences and the existing protective layers are determined. After examining the protective layers, if the amount of risk is unacceptable, suggestions are made to reduce the risk of hazards (ISHTEYAQUE et al., 2019, John Gould et al., hand book).

The main purposes of HAZOP study are: (National petrochemical company, 2009)

- Identify hazardous point in the process cycle and the role of process equipment in creating the causes of accident.
- Identify existing protective layers to prevent an accident or reduce its consequences.
- Recognize the consequences of deviating from process parameters and classify them at risk levels.
- Provide the necessary actions to promote protection systems.

HAZOP study is used for the analyses of many kinds of industry; Gas exploration field located in pakistan(ISHTEYAQUE et. al 2019), Gas refinery units (Askarian et. al2015), batch chemical plants (Srinivasan et, al 1998), continuous chemical processes (Dunj et. al 2011), Petroleum,

Petrochemical and Chemical Industries (Nolan et. al 1994), Steam Power Plant (Musyafa et. al2012).

Table1
Quid words used in HAZOP

description	quid words
Complete deviation from design	No/None
The increase/decrease of any relevant physical property	More (High)/ Less (Low)
More components present in the system	As Well As
component missing ,	Part of
A parameter occurs in the opposite direction	Reverse
Complete substitution	Other Than

The main objective of this work is to analyze of the Kermanshah Province Gas Company, analyze the existing condition and process safety requirement to ensure the minimum possible risk in various process operation and suggest some corrective action to reduce the risk and prevent the accident. Kermanshah providence Gas Company operates in the field of gas distribution. In addition to household consumers, most of the gas consumption in this province is spent on industrial uses, including power plants, petrochemicals, refineries and other industries. This company receives the gas and delivers it to consumers after pressure reduction. This company has about 45 CGS and 212 TBS, according to the risks of gas facilities, identifying and evaluating process risks in this company is very essential.

2 Methodology

In This article we use HAZOP method to risk assessment and management on Kermanshah Province Gas Company, the research steps are summarized as below:

1. Define all assumption about the unit during the study process.
2. Define the operational method in this case study.
3. Specify the nods.
4. Explain general designs and operational conditions in nods.
5. Mention process parameters for each nod.
6. Select the process parameter and mention the parameter initial design.
7. Applying deviations with parameters and defining failure scenarios. (Table1 summarized the quid words used in HAZOP and table 2 explain an example of possible deviations for different parameters).
8. Identify all factors that cause deviations from design mod.
9. Identify all possible consequences of deviations regardless of barrier.
10. Determine the available barrier for each of consequences.
11. Determine the probability and severity for each of the consequences.
12. Determine the risk level.
13. Find the corrective action to eliminate or reduce the unacceptable risks.
14. Repeat the above steps for other keywords, process parameters and study groups.
15. Prioritize the defined actions for implementation

16. Recalculate all RPN numbers.

One of the most important part of HAZOP study is to determine the risks and their interpretation. In calculating the risk number, the following items have been considered:

1.Probability of occurrence of each event

2.Possible consequences and their severity

3.Risk number

Table2

An example of possible deviations for different parameters

Deviation	parameter
No flow, High flow, Low flow, Reverse flow	Flow (rate)
Too much, too little	Flow (amount)
High pressure, Low pressure	Pressure
High temperature, Low temperature	Temperature
High level, Low level, No level	Level
Too much mixing, not enough mixing, Loss of agitation, Reverse mixing	Mixing
Component missing, High concentration, Low concentration	Composition
Impurities present, Catalyst deactivated/inhibited	Purity
Too long, too short, too late, too soon	Time
Omit a step, Steps reversed, Extra step	Sequence
High pH, Low pH	pH
High viscosity, Low viscosity	Viscosity
High heat value, Low heat value	Heat Value
Extra phase, Phase missing	Phases
Additional source, Additional destination, Wrong source, Wrong destination	Location
No reaction, too little reaction, too much reaction, Reaction too slow, Reaction too fast	Reaction

The level of probability and intensity are determined according to the complexity and value of the organization; this level is specified in the risk matrix.

The risk assessment process includes determining the probable cause of an accident, consequences and existing controls. In order to analyze the risk, we determined the existing controls, the cause of the accident, possible events and also the risk situation. (Freeman et.al, 1992, Jordi et.al, 2010).

According to the obtain numbers and comparison with the defined criterion, the type of risk is determined. The risk matrix, which is determined according to the levels of probability and levels of consequences, is shown in table3. This matrix and table 4 were the basis for risk ranking.

Table 3
risk matrix

Increase probability						consequence				severity
Level6	**Level5**	**Level4**	**Level3**	**Level2**	**Level1**	**reputation**	**environment**	**asset**	**people**	
						No impact	No effect	No damage	Slight injury	(1)
			Acceptable			Slight impact	Slight effect	Slight damage	Minor injury	(2)
		ALARP				Minor impact	Minor effect	Minor damage	Major injury	(3)
						Significant effect	Moderate effect	Local damage	disability	(4)
UN acceptable						National effect	Major effect	Major damage	One fatality	(5)
						International effect	Massive effect	Massive damage	More than one fatality	(6)

Table 4
Risk decision criteria

Recommendation	color	Risk degree	Risk rank
Risk should be assessed as soon as possible	red	High	unacceptable
Risk must be eliminated without delay	yellow	Medium	conditional
Risk must be eliminated but it is not an emergency	blue	low	acceptable

3. Result and discussion

In this section the risks of Kermanshah Province Gas Company are assessed. So, the three aspects of health, safety and environmental risks are considered using HAZOP method. Study nods are selected according to the team's knowledge of the process study, based on the sequence of operation and process importance. For HAZOP studies, Kermanshah Province Gas Company facilities are divided in to three categories: CGS (city gate station), TBS (Town Border Station) and combined. Table 5, and 6 show the nodes of each category. Based on the detail shown in the table 5 provided by HAZOP team about 4 nodes were recognized for CGS and CGS-TBS and according to the table6, one node is defined for TBS stations.

Table5
CGS and CGS-TBS nods

Nodes	Type	Design Conditions/Parameters
Filter separator	Pipeline tank filter	Temperature, pressure, flow, level, start up, Operation, Maintenance

Nodes	Type	Design Conditions/Parameters
heater	pipeline	Temperature, pressure, flow, level, start up, Operation, Maintenance
	heater	
	filter	Composition
	coil	
Pressure reduction equipment	pipeline	Temperature, pressure, flow, level, start up, Operation, Maintenance
	regulator	
	Pressure shut-off valve	
	Gas flow meter	
odorizer	pipeline	Temperature, pressure, flow, level, Operation, Maintenance
	Tank	
	Mitering pump	

Table6
TBS nods

Nodes	Type	Design Conditions / Parameters
Pressure reduction equipment and filtration	Pipeline	Temperature, pressure, flow, level, start up, Operation, Maintenance
	Regulator	
	Pressure shut-off valve	
	Dry gas filter	

Deviations are the combination of quid words and parameters. After identifying the deviations, their potential effects are analyzed. If the effects are serious and important, the causes of these deviations should be identified. If these causes can be eliminated or reduced, corrective actions should be considered for it. Corrective action should be to eliminate or reduce the cause or their severity (Rossing et.al,2010, Ramazan et.al,2007). After detailed study about 11 deviations and 14 possible causes were identified for CGS and CGS-TBS that about 5 were related to Node 1, about 9 were related to Node 2, about 9 were related to Node 3 and about 9 were related to Node 4. After Risk calculation, 14 risks were identified. Out of which only 01 risk is unacceptable and 03 are conditional that should be eliminated without delay, the others are acceptable. In the TBS analysis about 11 deviations and 14 possible causes were identified. After Risk calculation, 14 risks were identified. Out of which only 01 risk is unacceptable and 03 are conditional that should be eliminated without delay, the others are acceptable. Due to the high volume of worksheets, two worksheets of CGS and TBS nods are summarized as examples in table7.

Table7
Summarize HAZOP worksheet to analyze the existing Safeguards on filter separator of CGS or CGS-TBS

cause	consequences	Existing controls	Risk Matrix			Suggested recommendations	New Risk Matrix		
			S	L	RR		S	L	RR

high **.1** consumption downstream	The possibility of liquid and solid particles being carried by the gas out of the filter and turbulence downstream. Also increase wear	The operator can notice by observing a flow increasing	3	4	CO	Standby filter should be considered for stations that do not have a stand by filter	2	2	AC
		Limits for some consumers at peak consumption if pressure drop is observed				Implement a capacity balancing program for CGS to reduce noise pollutions			
	Damage to internal filter equipment or lines, especially filter elements	The operator can notice by observing a flow increasing	2	5	CO	Add separator filter on stations without separator filter	1	2	AC
	Failure to achieve the desired temperature at the heater outlet and increase the likelihood of hydrate formation	Limits for some consumers at peak consumption if pressure drop is observed	2	3	AC				
	Increased vibration in pipelines and damage to equipment holders	Limits for some consumers at peak consumption if pressure drop is observed	1	3	AC				
		Maintenance schedule							
	Increased noise pollution	Use suitable personal protective equipment	1	3	AC				
		Noise measurement							
	Probes corrosion of ultrasonic measuring systems	Existence of probe breakdown alarms	2	3	AC				
		Adhere to the maintenance plan based on the manufactures' recommendation s							

Pipeline rupture in filter downstream	Gas leakage and the possibility of fire and explosion	Existence of LBV system and pressure shut of valve	3	3	CO
		Annual thickness measurement			
	Increased vibration in pipelines and damage to equipment holders	Maintenance schedule	1	3	AC

In safety studies in order to better analysis, the reputation, environment, asset and people consequence is considering. Recommendation prepared by HAZOP study team should be comprehensive, feasible and include equipment specification. The main suggestions made in the HAZOP study for CGS case include the following:

Consider appropriate filter, balance the capacity to reduce noise pollution, consider an internal leak detection schedule, check the safety interlock on the separator filter to prevent the door from opening before the gas is completely drained, consider regular schedule for DPI (differential pressure indicator) maintenance and calibration, install the safety valve on the separator filter and emphasize its serviceability throughout the operation. Study the installation of flame detector in suitable place of the station, training and emphasis on the importance of safety requirements during the filter installation, sampling of water inside the heater to measure the concentration of ethylene glycol (it is added to prevent freezing) in water, emphasis on implementing maintenance constructions and considering training schedule to implement it. HAZOP studies are not considered complete until the recommendations are fully reviewed and evaluated.

4. Conclusions

The HAZOP analysis is one of the best method for the identification and management of hazard existing in the gas industry during design and operational phase. In this study HAZOP team identified all deviations in each node for all detected nodes; however the HAZOP team concluded that about 282 risks were identified and only 03 risk are unacceptable e and 111 are Conditional that must be eliminated without delay , the others are acceptable that the risk must be eliminated but it is not an emergency, in the filter separator study node, the filter lid may not be completely closed at start-up and sudden opening of the filter lid may cause operator damage and this risk is unacceptable for the company. The team suggested that the possibility of changing the filter lid from quick opening closure to solar type should be considered. It is also recommended to install filter drain and setup quid line near the filter separator.

The following items have been identified as subjects for further research activities:

- Modeling high risk cases using software such as phast. etc.
- Apply the hazop study for other providence gas company.

5. Acknowledgment

The authors would like to thank the Kermanshah Province Gas Company for their support in Data gathering and analysis.

References

Sotic, A, Rajic, R., the review of the definition of risk, Online Journal of Applied Knowledge Management, Vol.3, No. 3, P. 17–26, 2015.

Kaplan, S., John Garrick, B., on the quantitate definition of risk, Journal of risk analysis, Vol. 1, 1980.

Crocker, K., and Snow, A., The theory of risk classification, hand book, JEL: D82, G22.

Kotek, L, Tabas, M., Hazop study with qualitative risk analysis for prioritization of corrective and preventive actions, Journal of Procedia engineering, Vol.42, 2012.

ISHTEYAQUE, S., JABEEN, S., ABRO, S. H., GHANI, A. A., SIKANDAR, S., SAIM, Q., Hazard and Operability Study of Gas Exploration Field Located in Pakistan, Journal of Sindh university research, Vol. 51, No. 2, P. 189-194, 2019.

Askarian, A., Jafari, M., J., Omidi, L., Miri Lavasani, M., R., Taghavi, L., Ashori, A., Hazard Identification and Risk Assessment in Two Gas Refinery Units, Journal of Health Scope, Vol. 7, No. 1, 2018.

Srinivasan R, Venkatasubramanian V. Automating HAZOP analysis of batch chemical plants. Journal of Chem Eng, Vol. 22, No. 9, P. 1345-55, 1998.

Dunjó, J., Fthenakis, V., Darbra, R.M., Vílchez, J.A., Arnaldos, J. Conducting HAZOPs in continuous chemical processes: Part II. A new model for estimating HAZOP time and a standardized approach for examining nodes. Journal of Process Safety Environ, Vol. 89, No. 4, P. 224–233, 2011.

Gould, J., review of hazard identification techniques, an agency of the Health and Safety Executive.

National petrochemical company, HSE-MS setup guides, HAZOP guides, 2009.

Nolan, D., P., Application of HAZOP and What-if Safety Reviews to the Petroleum, Petrochemical and Chemical Industries, Noyes Publications, New Jersey, 1994.

Musyafa, A, Hardika, A, Hazard and Operability study in Boiler System of the Steam Power Plant, IEESE International Journal of Science and Technology (IJSTE), Vol. 1, No. 3, P. 1-10, 2012.

Freeman, R. A., R. Lee, T. P. McNamara, Plan HAZOP studies with an expert system, Chemical

Engineering Progress, Vol. 88, No. 8, P. 28–32, 1992.

Jordi D., V. Fthenakisb, J. Arnaldos, Hazard and operability (HAZOP) analysis. A literature review, Journal of Hazardous Materials, Vol. 173, P. 19–32, 2010.

Rossing, N. L., M. Lind, N. Jensen, S. B. Jørgensen, A Goal-based methodology for HAZOP analysis, International Journal of Nuclear Safety and Simulation, Vol. 1, No. 2, P. 134-142, 2010.

Ramzan, N., F. Compart, and W. Witt, Methodology for the generation and evaluation of safety

system alternatives based on extended HAZOP. Process, journal of safety Progress, Vol. 26, No.1, P. 35–42, 2007.