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Research Paper

Systematic hazard analysis of flare system nodes in Chemical process safety

Hayder A. Alhameedi [1,2], ***Athmar A. Alzubaidi*** [3], ***Joseph D. Smith*** [2], ***Doug Allen*** [4] ***Saud Aldawood*** [5], ***and Paul Ani*** [2]

[1] *Chemical Engineering Department, College of Engineering, University of AL-Qadisiyah, Al Diwaniyah 58001, Iraq.*
[2] *Linda and Bipin Doshi Department of Chemical and Biochemical Engineering, Missouri University of Science and Technology, Rolla, MO 65409-1230. USA.*
[3] *Accounting and Banking Sciences Department, University of AL-Farabi, Baghdad 10022, Iraq.*
[4] *Chief Engineer at Zeeco, Inc., Broken Arrow, OK 74014, USA.*
[5] *Nuclear Technologies Institute, King Abdulaziz City for Science and Technology, Riyadh 11442, Kingdom of Saudi Arabia.*

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ABSTRACT

Multidimensional consequences may arise from an accident in the flare system of any chemical or petrochemical plant due to the improperly managed flare system, which can lead to the presence of the toxic and flammable gases. The Hazard and Operability Study (HAZOP) is a systematic method used to assess and identify risks that can occur during operation, ensuring risk reduction and the safety of using equipment or units. This study aims to apply the HAZOP technique to identify the hazards associated with the gas flaring process in an air-assisted flare. The air-assisted flare system was subdivided into four sections (nodes), which were analyzed separately. These nodes included the gas supply line, air supply line, pilot flame line, and flare unit. A total of 11 potential high-risk factors related to gas flaring were identified and measured to eliminate or mitigate these risks, which were recommended to reduce the negative effects on human health, the environment, and the economy.

1. Introduction

Given the rise in industrial accidents, safety and risk management have become paramount in the workplace, particularly in the chemical and petrochemical industries [1]. The majority of accidents are the result of a chain of events ultimately caused by human error. Employers must ensure a safe working environment, free of recognized hazards that could cause or are likely to cause death or serious bodily harm to employees. Therefore, before operating or conducting any experiment on the unit, it is crucial to identify and assess the hazards and operational problems. Various techniques can be used to achieve these objectives, such as checklists, what-if situation analysis, LOPA (Layer of Protection Analysis), Dow and Mond indexes, Fault-tree and HAZOP (hazard and operability) [2]. Among these techniques, the HAZOP technique is considered the most effective method for risk assessment because of the highly structured analysis that results from conducting HAZOP [3, 4]. Also, HAZOP is a qualitative method that covers a wide range of processes and includes safety and operability. However, HAZOP requires a detailed plant plan, and it is time-consuming. Several studies have used the HAZOP method to assess risk in various aspects, such as pyro-processing facility [5], separation system in offshore platform [6], industrial wastewater treatment unit that producing biohydrogen [7, 8], sulfur furnace unit [9], fuel storage terminal [10], fixed bed reactor for MTBE synthesis [11], oil production units [12], biodiesel production plant [13], styrene butadiene rubber (SSBR) plant [14], chemical plants [15]. Flare systems in refineries and chemical plants are used to dispose of unwanted flammable and toxic gases by burning them in the open environment, a practice necessitated by the relief operations of different equipment [16–18]. Failure in flaring operations or equipment can cause disasters for the entire plant and have multidimensional consequences for human health, plant equipment, and the environment [19, 20]. As a result, it is very important for flare systems to work reliably and efficiently and to stop things that could cause process deviations. Accordingly, the main objective of this paper is to use the HAZOP technique to assess and identify risk possibilities from air-assisted flare operations. It also aims to reduce the number of dangerous accidents that could affect human safety or the environment. This study seeks to aid researchers working with flare systems in identifying and assessing risks related to the flaring process.

2. Methodology

This section provides a brief technical description of the flare system with its subdivisions.

2.1 Flare system description

The last line of defense against any malfunctioning events in chemical and petrochemical plants is the flare system. The flare system is designed to handle the flared gases released during sudden shutdown or upset events. The process and instrumentation diagram (P&ID) for the flaring system is shown in Fig. 1. The flaring system is divided into four main sections (nodes), each with a specific function and purpose. These sections include the fuel line, the assist-air line, the pilot line, and the flare equipment. The fuel line includes the gas cylinder, needle valve, one-way valve, solenoid valve, and mass flow controller. Nitrogen gas is used to purge the remaining gas from the pipelines.

*Corresponding Author.
E-mail address: hayder.alhameedi@qu.edu.iq ; Tel: (+964) 786-585 5060 (Hayder Alhameedi)

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Nomenclature			
HAZOP	Hazard and Operability Study	*I*	Indicator
LOPA	Layer of Protection Analysis	*TT*	Temperature transmitter
P&ID	Process and instrumentation diagram	*F*	Flow
V	Valve	*L*	Line
T	Temperature	*TK*	Tank
P	Pressure		

The nitrogen gas line, consisting of a nitrogen tank, pressure gauge, needle valve, flow meter, and shutoff valve, is connected to the fuel line just after the one-way valve. The mass flow controller is connected to a computer to adjust the fuel flow rate [21]. Node 2, the air node, comprises the building compressor, pressure regulator, filter, needle valve, flow meter, pressure gauge, and air distributor. The third node in the system is the flare equipment, which includes a water seal, flare stack, emission probe, flare tip, air distributor, hood, DCS-401, and AIT-401. Pilot flame gas is used to provide the required ignition source for the flared gas, including a one-gallon propane gas cylinder, needle valve, on/off valve, temperature probes, temperature readers, and flow control. Two pilots were used in the experiment to ensure the pilot flame's existence during the experiment runtime, preventing the release of unburned hydrocarbons.

2.2 HAZOP methodology

HAZOP studies systematically guide the review of any process, focusing on deviations, their causes, and the resulting consequences and recommending actions to mitigate them. HAZOP applies to existing plants undergoing major redesigns as well as to new plants. HAZOP requires a detailed plant description, P&ID, and operating and startup/shutdown procedures. As a first step, the P&ID is broken down into different sections with defined boundaries to ensure the analysis of each section in the process. In this study, the flare system was divided into four main nodes, as shown in Fig. 1. The second step is to identify the process deviation for each node, which is a combination of guide word and parameter, such as high temperature, high pressure, low level, misdirected flow, no/low flow, etc. as shown in Table 1. The next step is to identify the causes that could lead to each process deviation. Then, they identify the consequences of each process deviation without considering any safeguard. Identifying the available safeguards in the system that can prevent the process deviation, such as alarms, trips, and controls These safeguards may also be able to eliminate the sources of the process deviation. making recommendations to follow in case the safeguard fails to prevent the process deviation. These recommendations must be able to reduce the process deviation caused or reduce the consequences of the process deviation. Follow the same procedure (steps 2 to 6) for all other nodes. These steps are presented in Fig. 2.

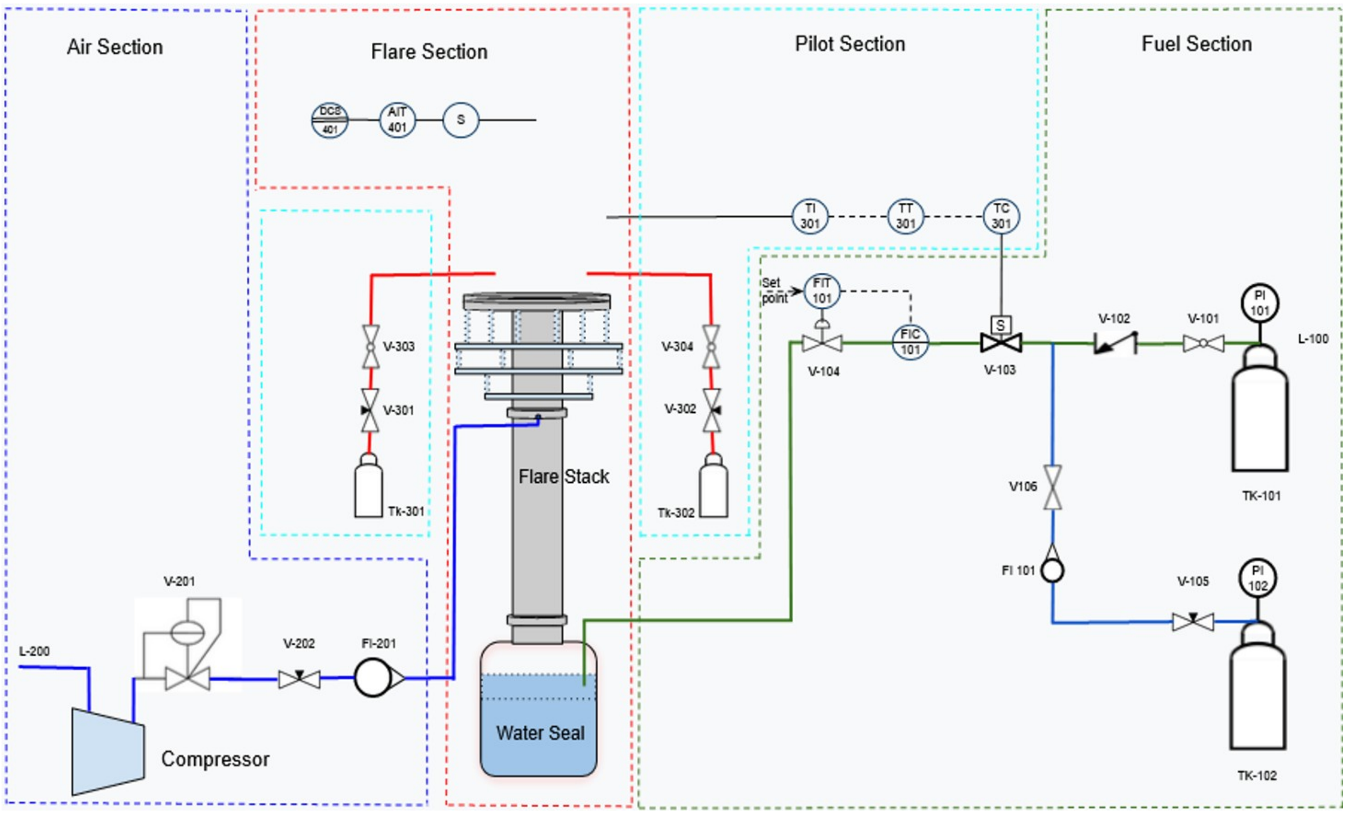

Figure 1. Simplified process and instrumentation diagram for flaring process.

2.3 Risk matrix

Risk is comprised of two components: the probability of harm's occurrence and the consequence of that harm [22]. By analyzing these components, the level of risk can be assessed for the identified hazard based on the risk matrix as shown in Table 2. In this matrix, the risk is ranked according to the priority of action, from highest priority to lowest operability. With a very low priority risk level (green zone), no risk mitigation is required. However, with higher risk levels (yellow, orange, or red zones in the risk matrix), risk mitigation is required down to the low priority risk level (green zone). The consequences of the identified hazard are ranked from 0 to 4 according to the severity that could occur, as shown in Table 3. This table provides the consequence range with respect to safety consequence criteria, in which the consequence rank of 0 means insignificant severity and 4 means catastrophic severity, which can result in causing one or more fatalities. The likelihood is shown in Table 4, in which the probability is ranked based on the occurrence frequency of the event, which can range from once per 10,000 years (likelihood rank 1) to once per year (likelihood rank 5).

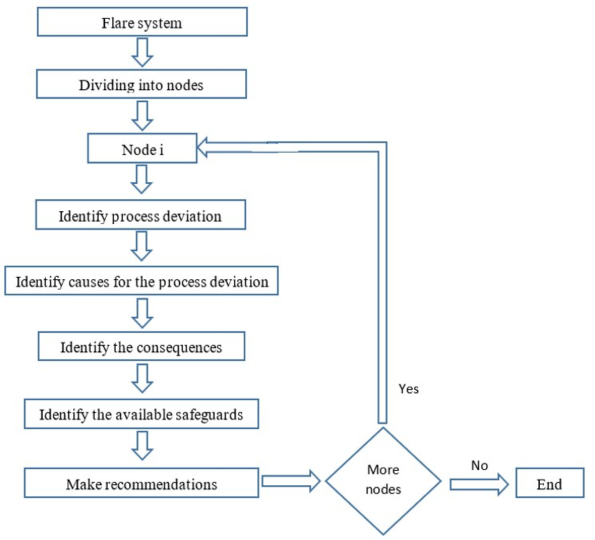

Figure 2. HAZOP Procedure Flowchart for Air-Assisted Flare System Risk Analysis.

Table 1. Process deviation matrix (guideword/parameter matrix).

Parameter/ Variable	Guide word				
	More	Less	None	Reverse	Other Than
Flow	High Flow	Low Flow	No Flow	Back Flow	Loss of Containment
Pressure	High Pressure	Low Pressure	Vacuum	—	—
Temperature	High Temperature	Low Temperature	Cryogenic	—	—
Level	High Level	Low Level	No Level	—	Loss of Containment
Composition or State	Additional Phase	Loss of Phase	—	Change of State	Wrong Material
Reaction	High RxN Rate	Low RxN Rate	No Reaction	Reverse Reaction	Wrong Reaction

Table 2. Risk Matrix for Evaluating Operability and Priority Based on Likelihood and Consequences.

		Consequences				
		0	1	2	3	4
Likelihood	5	Operability	Low priority	Medium priority	High priority	High priority
	4	Operability	Very Low priority	Low priority	Medium priority	High priority
	3	Operability	Very Low priority	Very Low priority	Low priority	Medium priority
	2	Operability	Very Low priority	Very Low priority	Very Low priority	Low priority
	1	Operability	Very Low priority	Very Low priority	Very Low priority	Very Low priority
	0	Operability	Operability	Operability	Operability	Operability

3. HAZOP analysis results

The aim of this analysis is to reduce or eliminate the risk related to the flaring process by using the HAZOP technique to investigate the hazards in the flare system and reduce the chances of a possible accident in the future. Basically, the flare unit has a function of burning relief gases that collect from different equipment inside the chemical plant. Table **??** presents the HAZOP analysis conducted on node 1. This table includes the node identification, equipment, and lines within this node, design intention, process deviation, possible causes and consequences, engineering controls, and recommendations. The first element was the flow, which was analyzed into two categories: high and no/low flow. The high flow could occur because of the failure of valve V-103 due to the faulty signal from TI-301. It could also occur because of the full opening of valve V-104 due to operator error. In this circumstance, more fuel will enter the flare equipment, which can cause an unexpected flare flame size. However, valve V-104 is controlled by a computer, and the prior operating system was always closed, so there is no gas flow through the gas line until the operator allows the gas flow through this section to the flare section.

Table 3. Safety consequence classification criteria for risk assessment.

Consequence range	Safety consequence criteria	
0	insignificant	-
1	Minor	First aid, Minor Environmental Release, bodily injury (BI) and property damage $(PD) < \$\ 25,000$.
2	Moderate	Reportable Chemical Release, Recordable Injury, $PD\&BI < \$\ 100,000$, minor fire.
3	Major	Long Term Insurance (LTI), $PD\&BI < \$\ 250,000$, major fire, off-site release with public consequences.
4	Catastrophic	One or more onsite or offsite fatalities, $BI\&PD > \$\ 250,000$.

Table 4. Likelihood range based on event frequency.

Likelihood Range	Event Frequency	Impact Frequency
1	Once per 10000 years	$< 10^{-5}$
2	Once per 1000 years	10^{-4} to $10^{-5}/year$
3	Once per 100 years	10^{-3} to $10^{-4}/year$
4	Once per 10 years	10^{-2} to $10^{-3}/year$
5	Once per year	$> 10^{-2}/year$

The recommendations were to operate the flare system in an open environment with plenty of ventilation and with two or more operators to reduce the risk of having a large size of flame due to the high gas flow. On the other hand, if there is no or low gas flow to the flare system, the flame above the flare tip will be extinguished, which requires shutting down the whole system. Loss of containment process deviation is considered in this HAZOP analysis, which could happen because of the pipeline rupture, tank rupture, and/or a leak in fitting. This deviation causes a release of the flammable gas (propane) into the surroundings, which poses a potential hazard of explosion. However, the pipelines are made from stainless steel, which is rated to operate at 200 psig. To eliminate the process deviation of loss of containment, the pipe must be checked for any rupture or crack. The fittings are also required to be checked with soapy water for any leaks prior to running the experiment. The pressure could also be low or high in this node. The reasons for these deviations may be the plugging of the fuel line to the water seal or the depletion of the fuel in the gas cylinder. High pressure has no effect on the process because the highest pressure in this line is the gas cylinder pressure, which has a value of 175 psig. High temperature can affect the hood that is used to collect the combustion sample for each run. To avoid impact of the high temperature of the flame on the hood, it was recommended that the period of each test not exceed five minutes and that the hood be allowed to be cooled prior to running another experiment. Improper facility siting can cause hazards to the environment and the operators. Therefore, running the experiment inside the lab is considered an improper test site because of the lab sprinklers and its small size, which can damage the other lab equipment. It was recommended that the pre-start team must review and agree to the operating site prior to testing to avoid the hazards that accompany the operation of the system inside the lab. Therefore, all tests were conducted in an open environment. It was also recommended that proper training for anyone operating a system is needed prior to conducting an experiment. The HAZOP analysis results that were conducted on nodes 2, 3, and 4 are presented in the appendix at the end of this manuscript. These tables used the HAZOP sheet to implement the assessment of hazards and the required mitigation with respect to each hazard.

4. Conclusion

A risk assessment of the flaring process has been conducted by using the HAZOP method. A safe and reliable flaring process having a crucial importance for the safety of the whole plant equipment and the workers. Based on the conducted HAZOP study of an air-assisted flare, the following conclusions were drawn:

- It was found that eleven process deviations are required to mitigate or eliminate them by using safeguards or following recommendations.
- Improper facility siting is associated with the highest risk of process deviation that can impact operators and the lab. Therefore, conducting flare experiments of industrial size requires a wide area of plenty of ventilation or an open area.
- The impact of pressure deviation on the flaring process has a low impact on the operators and the environment.
- The high flow rate of the gas can increase the flame size above the flare tip, and the low flow rate of gas causes extinguishing of the flame, which requires a shutdown of the whole experiment.
- Examining the pipes, the fittings, and the equipment prior to any test can

Authors' contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX

The purpose of this appendix is to provide the reader with the required HAZOP information related to nodes 1, 2, 3, and 4 of the flare system used in this paper, as shown in Fig. 1.

Table A1. HAZOP analysis for node 1 (Fuel section).

	Node No.	Node 1, Fuel line						
	Equipment and Lines:	L-100, TK-101, TK-102, PI-101, PI-102, V-101, V-102, V-103, V-104, V-105, V-106, FIT-101, FIC-101, FI-101						
	Design Intention:	Line to transport propane from the gas cylinder to the water seal in the flare equipment.						
		Level A:	0	**Level D:**	6			
		Level B:	1	**Level O:**	4			
		Level C:	3					
Item No.	**Process Deviation**	**Possible Cause**	**Possible Consequences**	**Engineering and Administrative Controls**	**L**	**C**	**R**	**Recommendations / Comments**
1.01a	High flow	A valve, V-103, fails from a faulty signal from TI-301.	More fuel enters the flare equipment.	The computer-controlled valve V-104 ensures gas flow to the flare until the operator permits it to be opened.	4	2	**C**	Operate the flare system in an open area with plenty of ventilation.
1.01b	High flow	The valve, V-104, opens because of operator error.	An expected flame size above the flare tip.	Develop and follow the start-up, shutdown, and standard operation procedure (SOP)	5	1	**C**	No operation is allowed by only one person, and you must always have a second person.
1.020	No/low flow	Valve V-103 stays close	The flame will be extinguished above the flare tip.	Follow the shutdown procedure.	4	0	**O**	Have someone with an operator for troubleshooting.
1.050	Loss of containment	Pipe rupture, tank rupture, and leak in fitting	Flammable gas exposed to the surroundings	The pipelines (stainless steel) are rated to operate at 200 psi. Shut down if pipe is ruptured.	4	1	**D**	Before running the system, ensure to thoroughly clean the fitting with soapy water, as the likelihood of this issue is extremely low.
1.060	High pressure	Plug the line to the water seal.	Since the highest pressure in this line will be the tank pressure ~175 psig.	Pipelines and hoses are designed to operate at 200 psi and should be shut down if they are ruptured.	1	1	**D**	Use reverse osmosis (RO) water instead of tap water.
1.070	Low Pressure	Deplete the fuel source.	The pressure is depended on the pressure of gas tank.	Check the cylinder pressure or volume before conducting any experiment.	5	0	**O**	Refill the gas cylinder.
1.140	Steps out of order	Operator error	The pressure in the cylinder and the pipelines will be the same. See loss of containment if the valve is not open.	Follow the well-written SOPs and use the precaution list.	3	1	**D**	Training is mandatory for all individuals operating the flare system, regardless of the sequence of gas flow and pilot flame without air.
1.170	Composition	The distributor delivers a propane tank with impurities in it.	Clog line by condensation of heavy hydrocarbons	Inspect the Certificate of Analysis (COA) from the vendor.	3	0	**O**	Ask the vendor for a COA on propane (consider different vendors of propane).
1.180	Startup	See steps out of order (1.140)	System malfunction	Follow SOPs for a startup.	3	1	**D**	
1.190	Shutdown	See steps out of order (1.140)	Potential flammable gas inside flare stack.	Follow SOPs for emergency shutdown/purge steps.	3	1	**D**	Write/implement SOP for an emergency shutdown.
1.200	Emergency	Power loss, controller failure	System shutdown, no flow when power loss for mass flow controller and solenoid valve.	Follow SOPs for emergency shutdown conditions.	5	1	**C**	Write/implement SOP for an emergency shutdown.
1.210	Contaminants or Impurities	see 1.17			3	0	**O**	
1.270	Maintenance	Non-design operation without proper cleaning or repair	Leaks at connections (valves), plugged lines, mal-distributed flow resulting in poor flame	Follow the SOP for routine system maintenance.	4	1	**D**	Prepare and implement a maintenance SOP.
1.280	Facility siting	Improper test site (i.e., lab = sprinkler; back porch = behind lab.	Potential activation of the sprinkler system or damage to the lab.	Pre-startup review to confirm there are no siting issues.	5	2	**B**	Make sure the pre-startup team reviews and agrees to the site prior to testing. HAZOP will accomplish this recommended task.

Table A2. HAZOP analysis for node 2 (Air section).

Node No.		Node 2, Air line						
Equipment and Lines:		L-200, Compressor, V-201, V-202, FI-201						
Design Intention:		Line to transport air from the building compressor to the air slot jet.						
		Level A:	0	**Level D:**	7			
		Level B:	0	**Level O:**	3			
		Level C:	2					
Item No.	Deviation	Cause	Consequences	Engineering and Administrative Controls	L	C	R	Recommendations/ Comments
2.010	High flow	Compressor operation at non-design condition	High air flow to flare distributor through rubber lines (near atmospheric pressure)	Switch to shut down if flow is too high.	3	1	D	Check maximum line pressure for rubber lines leading to flare tip air distributor.
2.020	No/low flow	N/A						
2.030	Misdirected Flow	N/A						
2.040	Reverse Flow	N/A						
2.050	Loss of containment	N/A						
2.060	High pressure	Failure of Compressor Pressure regulator or hand valve V-202 closed while compressor operating.	Improper operation of compressor (excessive air)	Part of startup is to check/ensure all lines/valves open for air flow to flare tip.	1	1	D	
2.070	Low Pressure	N/A						
2.080	Vacuum	N/A						
2.090	High temperature	Large flare flame with high radiation to compressor/flow lines	Compressor failure	Use radiation shields or operate the compressor away from the flare tip/flame.	3	1	D	Ensure the rental or borrowed compressor is located far away from the flare flame or provide some radiation shielding for the compressor.
2.100	Low temperature	N/A						
2.110	Incomplete Reaction	N/A						
2.120	No Reaction	N/A						
2.130	Reactants added in wrong order	N/A						
2.140	Steps out of order	Operator error: operate compressor before you open valve 201.	dead head the compressor (overheat compressor)	Closely follow the start-up SOP.	5	1	C	Recommend proper training for anyone operating the system.
2.150	High level	N/A						
2.160	No/low level	N/A						
2.170	Composition	N/A						
2.180	Startup	loss of pressure (air flow)	flare does not operate properly	Follow the startup's SOP.	2	0	O	
2.190	Shutdown	loss of pressure (air flow)	flame not as vigorous	Follow the shutdown procedure.	2	0	O	
2.200	Emergency	loss of power	compressor shutdown/ loss of air flow	see 2.19	2	0	O	
2.210	Contaminants or Impurities	Dirty air/oil not changed often enough.	Compressor damage; "junk" in distributor at flare tip	Follow SOP for maintenance.	2	1	D	
2.220	Material of Construction	N/A						
2.230	Sampling	N/A						
2.240	Corrosion/ erosion	N/A						
2.250	Effluent	N/A						
2.260	Service Failure	see 2.21			2	1	D	
2.270	Maintenance	see 2.21			2	1	D	
2.280	Facility Siting	see 1.09			3	1	D	
2.290	Human Factors	see 1.14, 1.06			5	1	C	

Table A3. HAZOP analysis for node 3 (Pilot section).

Node No.		Node 3, Pilot line						
Equipment and Lines:		L-300, Tk-301, Tk-302, V-301, V-302, V-303, V-304, TI-301, TT-301, TC-301						
Design Intention:		Line to pump fuel from gas cylinder to the pilot to provide the required ignition source for the flared gases.						
		Level A:	0	**Level D:**	**0**			
		Level B:	0	**Level O:**	**12**			
		Level C:	0					
Item No.	Process Deviation	Cause	Consequences	Engineering and Administrative Controls	L	C	R	Recommendations
3.010	High flow	V-303 is fully open and inadvertently open V-301 completely open OR V-304 completely open and inadvertently open V-302 completely.	Large pilot flame	Flare operators adjust V-301 and V-302 to obtain the desired flame shape and length.	3	0	**O**	
3.020	No/low flow	The pilot gas tanks (TK-301 and TK-302) are empty.	Pilot flame extinguishes-temperature sensors detect no flame condition (T< 300C).	Operating and Shutdown SOPs	5	0	**O**	Conduct shut down procedure when pilot goes out
3.050	Loss of containment	Leaky valves or fittings	Flammable vapor exposed to surroundings	Leak test after tank swap out prior to operation (follow startup SOP).	5	0	**O**	Revised startup SOP to reflect when to do a leak test
3.060	High pressure	N/A		The pilot tip is exposed to the atmosphere.				
3.070	Low Pressure	see 3.02			5	0	**O**	
3.090	High temperature	N/A						
3.100	Low temperature	see 3.02					**O**	
3.140	Steps out of order	opening V-301 before V-302	Poor control of pilot gas flow and pilot flame size/shape	Startup/shutdown SOP	5	0	**O**	Recommend proper training for anyone operating system.
3.180	Startup	see 3.14			5	0	**O**	
3.190	Shutdown	see 3.14			5	0	**O**	
3.200	Emergency	see 3.14			5	0	**O**	
3.260	Service Failure	see 3.02			5	0	O	
3.270	Maintenance	see 3.02			5	0	O	
3.290	Human Factors	see 3.14			5	0	O	

Table A4. HAZOP analysis for node 3 (Pilot section).

Node No.	Node 4, Flare equipment							
Equipment and Lines:	Water seal, Flare Stack, Emission Probe, flare tip, air distributer, Hood, DCS-401, AIT-401							
Design Intention:	To burn fuel gases in open environment efficiently and safely and record gases composition of plume.							
		Level A:	0	**Level D:**	6			
		Level B:	1	**Level O:**	3			
		Level C:	4					
Item No.	Deviation	Cause	Consequences	Engineering and Administrative Controls	L	C	R	Recommendations
4.01a	High flow (flare gas)	See 1.01a and 1.01b.	Flare flame too large	Follow operating SOP and if needed shutdown SOP	4	2	**C**	Follow SOP.
4.01b	High flow (air)	See 2.01.	Flare grows too small.	Follow operating SOP and if needed shutdown SOP	3	1	**D**	Follow SOP.
4.020	No/low flow	See 1.02 and 2.02.	Flame extinguishes.	Operating/shutdown SOPs	3	1	**D**	Follow SOP.
4.030	Loss of containment	Leaks in connections	Gas escapes into the atmosphere, potentially ignited by the flare flame or pilot at the flare tip, causing the liquid seal to be lost.	Check the pipe connections prior to each run (start SOP).	5	0	**O**	Follow the startup/operate/shutdown SOP.
4.040	High pressure	See 1.07 and 2.07.			1	1	**D**	
4.050	Low Pressure	See 1.07			5	0	**O**	
4.060	Vacuum	Plugged line to water seal and cryogenic gas fed to water seal	A vacuum form in the liquid seal, stopping gas flow to the flare flame.	SOP	1	0	**O**	
4.070	High temperature	Increased gas flow	The temperature is too high for the surrounding materials.	Shut down if the flare flame is too large.	4	2	C	The system should be run for less than 5 minutes, ensuring sufficient time for cooling between runs.
4.080	Low temperature	No cause of interest						
4.090	Incomplete Reaction	Inadequate gas/air ratio	Unburned fuel and hydrocarbons emission	Monitor flame and plume composition	5	1	C	Use the adequate gas/fuel ratio.
4.100	No Reaction	See incomplete reaction						
4.110	Reactants added in wrong order	N/A						
4.120	Steps out of order	Operator error	The heat builds up in the hood.	Follow well-written SOPs and use a precaution list.	3	1	D	
4.130	High level	The water inside the water seal at high level	Small drops of water will be carried by the gas to the flame region.	The water seal should be maintained at the desired level and a mist eliminator should be used to prevent gas leakage.	1	0	D	The water level in the water seal is required to be checked prior any experiment.
4.140	No/low level	No water or low-level water inside the water seal	This may cause a flame back flashback.	Ensure the water level in the water seal at the desired level prior any experiment.	1	0	D	
4.150	Composition	See incomplete reaction						
4.150	Startup	N/A		Follow operating manual				
4.160	Shutdown	N/A		Follow operating manual				
4.170	Emergency	Loss of power	The fan stops and the heat builds up in the hood.	Follow SOP's for emergency shutdown condition.	5	1	C	
4.180	Maintenance	Leaks in stack-tip and stack-water seal connections	See loss of containments					
4.190	Facility Siting	See 1.28.			5	2	B	
4.200	Human Factors	N/A						

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