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Review article

The identification and analysis of risks in Hydrogen unit of refinery using HAZOP and LOPA techniques

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ABSTRACT

Process industries have always been exposed to fire, explosion and release of chemical materials. To identify and evaluate risk in process industries including oil and gas, there are various methods in which *hazard* and operability study (HAZOP) is one of the most common methods. To do this, at first all organizational duties and unit activities are identified. Then, the study technique of operation and risk is used as an effective and sys thematic method to identify risk and operating problems and the relevant effects. The identified activities in risk assessment are applied. The results of evaluation of identified risks showed that 6 cases had hazard higher than 15 and it is not acceptable. In terms of risk intensity, the highest frequency of unacceptable risks (4 cases) is observed in “reformer heating chamber”. The analysis of consequence of hazards showed that for 6 hazardous points, independent layers of protection can reduce risk as 100% to target factor (10^{-5}) and safety integrity level is fulfilled completely.

1. Introduction

In the past, safety plans were controlling the accidents based on a philosophy. It means that safety engineering acts after an accident and attempts to perform required researches and define the causes of accident and use the results as a basis for prevention of similar events. By development of complex systems namely the warehouse of atomic head, this idea was developed that there are some methods for the analysis of events to identify the risk potential before an operation. Today, the system safety based on a planning is organized and it is like a process before the event based on control analysis method. The safety activities of system are divided into engineering and managerial activities.

Now, there are more than 70 qualitative and quantitative types of risk assessment all around the world. One of the methods is Preliminary Hazard Analysis (PHA) that was used for the first time in the early 50s in US to analyze the safety of liquid missiles. This method was enforced by aviation industries of this country and was named by Boing Company. After this application, this technique was developed to different industries including chemical, nuclear industries (Mohammadfam, 2007). The simple analysis method is a comparison with the aim of identification of risks and dangerous conditions leading to the damage of activity, utility or existing system (Nassir, et al., 2007; Alizadeh and Moshashaei, 2015; IEC/FDIS, 2009; Rasoulzadeh et al., 2015). Another method is Failure Modes and Effects Analysis (FMEA) method. This method was used for the first time in US army (Alizadeh et al., 2015). By LOPA method, the user can determine the general value of risk reduction and risk reduction provided by different protective layers (Khandan et al., 2015). If after the design of process of safety issues, risks are reduced, we can use one of the change methods in main system of process control, alarms, explain duties of the expert, installing emergency valves or providing safety systematic instructions and then we can calculate the general value of safety level. The analysis method of protective layers is used in different studies to evaluate the risk of systems. Process industries are exposed to fire, explosion and chemical materials release. Economic, human and environmental outcomes of these events are harmful. The Three Mile Island accident was a partial nuclear meltdown that occurred in reactor number 2 of Three Mile Island Nuclear Generating Station (TMI-2) in Pennsylvania. Three million radioactive gases were released outside the power plant (Dunjó et al., 2010). This was occurred due to negligence of the staffs and human mistake. Thus, it is necessary to consider the prevention of these events and assess their risks using the reduction of occurrence intensity. The analysis of protective layers by evaluation of the existing protective layers can prevent any defect of these layers. Based on the significance of hydrogen unit in refinery and important use of this method in improvement of safety integrity level, the present study is performed.

2. Theoretical basics

Human error identification techniques are used to predict human error in dynamic and complex systems. These techniques are provided in response to the evaluation of users errors leading to great disasters in chemical and nuclear industries (Chernobyl, Three Mile Island, Bopal, etc.). Now, these methods are developed and are used in different industries including petrochemical, air traffic control center, military industry and social technologies. These methods can be raised as quantitatively and qualitatively (Gowland, 2006). HEI is used in life cycle of a system. These techniques are used in identification and evaluation of human errors in design, construction, operation, maintenance of systems and job duties. The outputs of these methods are potential errors, error, defect and outcomes of a defect and control of defect methods. Some of the methods including HET, SHERPA are used to identify and classify the user errors. Some methods, including THEA and HEIST are used for identification and prediction of error in a comprehensive system. Some of the methods including HERT define numerical probability of an error (Ghasemi et al., 2010). Important indices are used in classification of the validity of method, sensitivity of the method in detection of valid errors, rapid and easy use. These techniques depend upon the judgment of the analyzer. It is possible that different analysts use a method to identify and evaluate error in a definite task and have different prediction and evaluation of its potential errors.

Systematic Human Error Reduction and Prediction Approach (SHERPA): SHERPA method was raised for the first time by Embrey (1986) as human error reduction technique to analyze the duties and present potential solutions for the identified errors. Stenton (2000) applied this technique in oil and gas industries. This technique was used to help people in process industries including nuclear plant, petrochemical, oil and gas extraction and energy distribution (Salmon and Walker, 2003). Occupational safety and health (OSH): The factors effective on health of employees or other workers (including temporary works and temporary employees), guests and visitors or any person at work place. The organization can control legal requirements, safety and health of people working far from the direct region or those exposed to workplace activities (Chongguang and Zhang, 2007).

Risk assessment: Risk assessment process based on a risk by considering adequate controls and decision making about the acceptability of risks or not. LOPA method: The analysis of protection layers by considering independent protection layers as a semi-quantitative method can identify the risks. This method is called semi-numerical as in this method, numbers are used and a numerical prediction of risks is generated (Mazlumi, 2013). Independent protection layers: The layers that are used to prevent turning risk to an accident in process industries (Mofidi, 2013).

3. Review of literature

Jahangiri (2007) in a study evaluated LOPA method and showed that this method was started with an unsuitable outcome as environmental, health, safety or economic outcome and then this outcome is estimated. Also, for each outcome, initial causes are defined. The results of application of this technique in chemical industries show that this technique is an effective tool to determine safety integrity level by process safety engineers and a few resources are required compared to other risk assessment techniques. Frest (2010) in a study identified and evaluated LOPA scenario and stated that identification of scenarios was one of the difference cases in LOPA. The experience of experts is a major factor in these items. This study presents an analysis of chemical process risk and it is a semi-quantitative measurement method for the outcomes leading to human damage. This trend is used to evaluate change management. The results of this study are realistic and in each step of risk assessment process, more details are provided for the method correction. In addition, the results of each state define the risks of each scenario. Nilson (2009) regarding the evaluation of the relationship between mortality and damages with process change risk analysis showed that the loss risk in working activity was acceptable and development plan and process change had no considerable effect on society risk.

4. Study findings

4.1. The results of identification of risk of hydrogen unit

For risk assessment in refinery hydrogen unit, at first all organizational duties and unit activities are identified. In this unit, the operation and activities are managed by control room and 43 people including control operators and yard operators and supervisors. We can say three are three types of organizational duties in these sub-units including 14 control operators, 21 yard operators and 8 supervisors. The duties of control operators are shown in Table. The yard operators have operational duty of these units.

Table 1
The results of studies of operability and hazard method in refinery hydrogen unit.

Code	Outcomes	Causes	Deviations	Operating node
A.1.1.1	System performance rate is reduced	Flow loss in riffle due to pressure reduction	lack/shortage/ increase of flow	Valve of natural gas entrance and operation section
A.2.1.1			The inverse or lost flow	
A.3.1.1	There is no risk for reactor but the catalyst is damaged	The failure or error of Shift Effluent Exchanger in much closing	High temperature of desulfurized feed	
A.3.2.1	As above	Transfer increased temperature to Shift Effluent Exchanger due to temperature increase or hot steam flow rate		

A.4.1.1	As above	The failure or error of Shift Effluent Exchanger in much opening	Low temperature of desulfurized feed
A.4.2.1	As above	Transfer decreased temperature to Shift Effluent Exchanger due to sediment, temperature decrease or hot steam flow rate	
A.5.1.1	Limitation for recovery of hydrogen steam and problem for compressor due to the pressure increase and reduction in accuracy of control of S/C rate and damage to equipment	Failure of PV-8001 or any factor as under the system control while opening	High pressure
A.5.2.1	Delay in preparation of desulfurization sector for launching	Failure of PV-8011 or any factor as under the system control while opening or closing (launching)	
A.6.1.1	Disconnection or reduction of feeding and reduction of production rate leading to the reduction of purity degree of product. At pessimistic state, the risk of damage to reformer pipes can increase temperature, stop production and increase disturbance for users	Failure of PV-8001 or any factor as under the system control while closing	Low pressure
A.6.2.1	Like the above item with high intensity	Disconnection of XV-8001 due to failure or error	
A.6.3.1	Like the above item with low intensity	Opening round caps of cleaning lines of reactors to flame due to failure or error	
A.6.4.1	In normal operation, disconnection or reduction of feeding and reduction of production rate and destruction of material	Failure of PV-8011 or any factor as under the system control while opening	
A.7.1.1	Reduction of life cycle of ZnO, COMOX catalysts and Toxicity risk of reformer catalysts	Increase of sulfur compound in HPU feed	Lack of good performance
A.7.2.1	Toxicity risk of reformer catalysts	The end of catalyst (ZnO)	
A.7.3.1	Reduction of hydrogen generation and toxicity of reformer catalysts	Reduction of recovery rate of H2/NG due to any cause	
A.7.4.1		Low quality of catalyst or its long life	

A.7.5.1	The increase of effluent temperature of hydrogenator and reduction of life cycle of COMOX catalyst	Purity reduction of H2 recovery due to the presence of CO2/CO		
A.7.6.1	Toxicity risk of reformer catalysts	Sedimentation on catalyst		
A.7.7.1		Catalyst track due to loading bad catalyst		
A.7.8.1	THe increase of effluent temperature of hydrogenerator and reduction of life cycle of COMOX of catalyst and worse, violation of acceptable temperature	Change in feed structure due to the presence of CO2/CO or Olefin		
A.8.1.1	In case of failure of PSV, the unit is stopped	PSV maintenance	Maintenance problems	
B.1.1.1	Reduction of production rate and at worst (below 40%) and damage to reformer pipes due to temperature increase, reduction of flow in the entire pipes, stop reduction and sever disturbance for users	Failure of FV-8006 or any other factor regulating opening and closing in control loop	Lack of shortage of desulfurized feed flow	Combined stage and reformer steam
B.1.1.2	Mechanical damage in convection pipes due to temperature increase			
B.2.1.1	Reduced rate of S/C leading to formation of cock in reformer. The damage to reformer pipes and utilities, reduction of H2 generation and product quality	Failure of FV-8007A or any other factor regulating opening and closing in control loop	Lack or shortage of High Pressure Steam(HPS)	
B.3.1.1	Gradual increase of cock formation and differential pressure in reformer, incomplete reaction, untransformed NG, increase of CO in reformer exit leading to the dysfunction of shift exchanger HT and losing material (cleaned Pressure swing adsorption	Failure of FV-8006 or any other factor regulating opening and closing in control loop	High flow of desulfurized feed	

B.4.1.1	Losing energy due to steam consumption and high fuel, increase of the temperature of crust of reformer pipes and damage to them	Failure of FV-8007A/B or any other factor regulating opening and closing in control loop	HPS high flow	
B.5.1.1	Probable damage to reformer pipes, catalyst, refractory, convection, riffle due to temperature increase	Generation of excess heat in reformer due to the failure in TIC-8035/TIC-8025 or failure in fuel,	High temperature	
B.5.2.1	The damage to wiring of convection	After-burning in reformer		
B.5.3.1	The damage to reformer effluent transfer lines due to temperature increase	Damage to refractory in exit transfer lines of reformer		
B.6.1.1	Reduced performance of reformer, bad reaction, reduction of production and purity of products and stop production and reaction	Generation of low heat in reformer due to the failure in TIC-8035/TIC-8025 or failure in fuel, unsuitable fuel-air ratio	Low temperature	
B.6.1.2	Reduction of heat transfer in convection and dysfunction in riffle			
B.6.1.1	Reduction of reaction rate, increase of pipes crust, increase of original pressure in reformer, disturbance for PSA and at worse stop production	Form cock, break catalyst (for water transfer in launching), candle, etc.	High difference pressure	
B.7.1.1	Reduced performance of reformer, bad reaction, reduction of production and purity of products and stop production and reaction	Catalyst toxicity due to sulfur compound, metal and chloride	Lack of good performance	
B.7.2.1	Catalyst destruction	The increase of catalyst age or reduction of its quality		
C.1.1.1	System performance rate is reduced	The main effect of flow, temperature and pressure in chamber	lack/shortage/ increase of flow	High pressure
C.2.1.1	System performance rate is reduced	Exiting safeguards, launch processes/stopping	The inverse or lost flow	
C.3.1.1	Probable damage to reformer pipes, catalyst, refractory, convection, riffle due to temperature increase	Generation of excess heat in reformer	High temperature	

C.3.1.2	Probability of damage to Induced draft fan due to high temperature		
C.3.2.1	The damage to wiring of convection	After-burning in reformer	
C.4.1.1	Reduced performance of reformer, bad reaction, reduction of production and purity of products and stop production and reaction	Generation of low heat in reformer due to the failure in TIC-8035/TIC-8025 or failure in fuel, unsuitable fuel-air ratio	Low temperature
C.4.1.2	Reduction of heat transfer in convection and dysfunction in riffle		
C.4.1.3	Risk of fall of temperature under dew point		
C.5.1.1	Increase of air rate/fuel (excess air) with the reduction of chambered temperature	Simultaneous opening of some temperature adjusting systems with various reasons	
C.6.1.1	Reduction of air rate/fuel (excess air), increase of unburned fuel and after-burning	Simultaneous closing of some temperature adjusting systems with various reasons	
C.7.1.1	Reduction of air rate/fuel (excess air), increase of unburned fuel	Failure in PV-8017 A/B or another factor in control loop regulating opening and closing	High pressure
C.7.1.2	At worst, pressure is higher than atmosphere pressure and leads to shortage of gas of chimney/steam of reformer and humane injury		
C.7.2.1	As above	Sudden increase of fire in launching (for any reason)	
C.7.3.1	Uncontrolled fire	Pipe fracture	
C.8.1.1	Increase of air rate/ fuel (excess air) with temperature reduction in chamber and low energy	Failure in PV-8017 A/B or another factor in control loop regulating opening and closing	Low pressure
C.8.1.2	At worst, Mechanical damage to reformer refractory		
C.8.2.1	As above	Turning off both recursive fans of service due to failure or error	
C.9.1.1	High steam and its waste in reformer leading to materials waste and damage to refractory	Wearing, destruction and high age of steam pipes	Pipes fracture in heater

D.1.1.1	Boiling probability and any problem in exchanger 3E-803 A, disturbance in reforming operation, at worst, damage to exchanger due to shaking and dry operation	Failure in PV-8061or another factor in control loop regulating opening and closing	High temperature of BFW in riffle	Steam drum in reformer furnace
D.1.1.2	As above	Stop exchanger activity for any reason		
D.2.1.1	Reduction of steam generation and energy loss due to the elimination of excess heat by cooler	Failure in PV-8061or another factor in control loop regulating opening and closing	Low temperature of BFW in riffle	
D.2.2.1	As above	Reduced temperature of gas chimney		
D.3.1.1	Sedimentation of pipes and spiral leading to thermal points generation	Bad cooler	High concentration of TDS	
E.1.1.1	Destruction of dumping system, equipment and lines	Failure in TV-8009 or another factor in controlling closing	High temperature of very hot steam	Generated steam
E.1.1.2	As above	Increase of reformer temperature		
E.2.1.1	Temperatures fall below the acceptable point and probable disturbance for external consumers	Failure in TV-8009 or another factor in controlling closing	Low temperature of very hot steam	
E.2.1.2	Probability of damage to gooseneck of pipes due to temperature increase	Sediment in very hot system due to accepting water		
E.2.1.3	As above	Reformer temperature reduction		
F.1.1.1	Increase of temperature in steam drum, damage to reformer, spiral, pipes and other equipment due to pressure increase	Failure in PV-8045or another factor in control loop regulating opening	High pressure	
F.1.1.2	As above	Final reduction of very hot steam consumption by reformer		
F.2.1.1	Adequate driving and difference in reaction with low pressure of steam	Failure in PV-8045or another factor in control loop regulating opening	Low pressure	
F.2.1.2	As above	Final reduction of very hot steam consumption by reformer		
F.2.1.3	As above	Temperature reduction in steam drum		
G.1.1.1	Loss of materials, probability of level and temperature increase	Opening blow down valve mostly due to failure or error	High flow	Blowdown system

G.2.1.1	Pessimistically, high filling and entrance of blow down and steam to aerator	Failure in LV-8005 or another factor in controlling opening	High level	
H.1.1.1	Reduction of transformation performance, remaining CO in gas process leading to problem in PSA. At worst, product purity and increase of CO in hydrogen recovery	Failure in LV-8053 or another factor in controlling opening	Low temperature of gas process in HT transformer	HT transformer
I.1.1.1	Increase of gas candle, reduction of hydrogen purity gas disturbing the users	The increase of age of absorbents	Lack of good performance	PSA
J.1.1.1	The required hydrogen is not provided to produce hydrogen leading to catalyst toxicity and their life reduction	Failure in FRV-800 or another factor in controlling opening	Lack/shortage of recovery hydrogen flow to desulfurization sector	Compressor of hydrogen recovery
K.1.1.1	The risk of damage of reformer of riffle pipes due to the temperature increase and preparation of launching reformer with delay	Failure or error in the system performance	Lack/shortage of nitrogen	Nitrogen flow
L.1.1.1	At worst, the increase of pressure in pipes and aerator due to pressure increase	Failure of operator of control	Abrasion/wearing	Aerator

- Coding method (left column) as:
- Latin alphabets show any operational node as A to L.
- The first number of the left side shows any deviation of an operational node.
- The second and third values show any cause and outcome in deviations.

4.2. The results of evaluation of risks of refinery hydrogen unit

This section of results applies the identified activities in risk assessment. Table 2 shows the results of HAZOP method in the study unit. Operating nodes in each of activities are with cause, effects and recommendations. The frequency of risks and their intensity in each operating node are identified in Figure 1. The results showed that the highest risk frequency were in nodes “natural gas entrance valve and operating sector” (21 cases), “reformer heating chamber” (18 cases) and “combined stage and reformer steam”(13 cases).

In terms of risk intensity, the highest frequency of unacceptable risks (4 cases) is observed in the node “reformer heating chamber”. In addition, the highest frequency of acceptable risks (9 cases) with alarm (11 cases) is in the node “natural gas entrance valve and operating sector”.

Table 2
The risk degree of executive activities in hydrogen unit.

Risk degree	Accident intensity	Accident probability	Code	Operating node
2	2	1	A.1.1.1	Valve of natural gas entrance and operation section
2	2	1	A.2.1.1	
4	2	2	A.3.1.1	
4	2	2	A.3.2.1	
2	2	1	A.4.1.1	
4	2	2	A.4.2.1	
4	2	2	A.5.1.1	
6	3	2	A.5.2.1	
12	4	3	A.6.1.1	
16	4	4	A.6.2.1	
12	4	3	A.6.3.1	
12	4	3	A.6.4.1	
9	3	3	A.7.1.1	
6	3	2	A.7.2.1	
6	3	2	A.7.3.1	
9	3	3	A.7.4.1	
9	3	3	A.7.5.1	
6	3	2	A.7.6.1	
4	2	2	A.7.7.1	
4	2	2	A.7.8.1	
12	4	3	A.8.1.1	
16	4	4	B.1.1.1	Combined stage and reformer steam
9	3	3	B.1.1.2	
12	4	3	B.2.1.1	
12	4	3	B.3.1.1	
9	3	3	B.4.1.1	
9	3	3	B.5.1.1	
6	2	3	B.5.2.1	
4	2	2	B.5.3.1	
16	4	4	B.6.1.1	
9	3	3	B.6.1.2	
12	3	4	B.6.1.1	
9	3	3	B.7.1.1	
3	1	3	B.7.2.1	
4	2	2	C.1.1.1	Reformer heating chamber
4	2	2	C.2.1.1	
6	2	3	C.3.1.1	
6	3	2	C.3.1.2	
2	1	2	C.3.2.1	
12	4	3	C.4.1.1	
2	1	2	C.4.1.2	
1	1	1	C.4.1.3	
6	2	3	C.5.1.1	
15	5	3	C.6.1.1	
8	4	2	C.7.1.1	
20	5	4	C.7.1.2	
20	5	4	C.7.2.1	

16	4	4	C.7.3.1	
9	3	3	C.8.1.1	
12	4	3	C.8.1.2	
12	4	3	C.8.2.1	
9	3	3	C.9.1.1	
16	4	4	E.1.1.1	
16	4	4	E.1.1.2	Steam drum in reformer furnace
6	2	3	E.2.1.1	
6	2	3	E.2.2.1	
9	3	3	E.3.1.1	
12	4	3	F.1.1.1	
12	4	3	F.1.1.2	
15	5	3	F.2.1.1	Generated steam
9	3	3	F.2.1.2	
9	3	3	F.2.1.3	
9	3	3	G.1.1.1	
9	3	3	G.1.1.2	
3	1	3	G.2.1.1	
3	1	3	G.2.1.2	
3	1	3	G.2.1.3	
6	2	3	H.1.1.1	Blowdown system
12	4	3	H.2.1.1	
15	3	5	I.1.1.1	
6	2	3	J.1.1.1	HT transformer
9	3	3	K.1.1.1	PSA
12	3	4	L.1.1.1	Compressor of hydrogen recovery

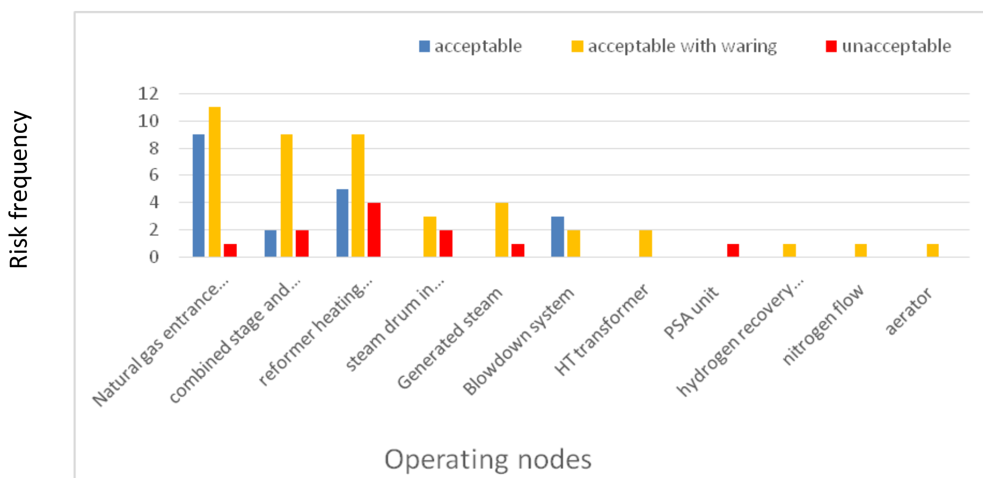

Fig. 1. Frequency of risks of identified operating nodes in hydrogen unit.

5. Discussion and conclusion

The condition of investigated scenarios and their reduced risk are shown as:

Scenario 1

This scenario “Disconnection or reduction of feeding and reduction of production rate with the pressure reduction in the node of natural gas entrance value” is created due to gas disconnection in XV-8001 regulator due to human failure and based on the estimation of corrective action “control system on FT-8006 A/B/C to show flow, alarming system and automatic lock” can act as an independent protection layer (IPL) with Probability of Failure on Demand (PFD) equal to1 $\times 10^{-2}$ can be used as a non-immediate action. This protection layer with some tools as counter can reduce the risk to 100% of ratio to target factor (10^{-5}). Thus, there is no need to provide and install excess protection layers and this layer as monitoring method and counter installation can provide occurrence of this scenario and the relevant outcome to the maximum state.

Scenario 2

This scenario “Reduction of production rate and damage to reformer pipes with the shortage of desulfurization flow” due to the failure of FV-8006 exchanger (or any other factor regulating opening and closing in control loop) is created and according to the estimation of corrective action group “control of S/C ratio, control system on FT-8006 A/B/C to show flow” can be used an independent protection (IPL) with Probability of Failure on Demand (PFD) equal to1 $\times 10^{-2}$ can be used as a non-immediate action. This protection layer with some tools as counter can reduce the risk to 100% of ratio to target factor (10^{-5}). Regarding this scenario, like the previous case, the protection layer with tools without any extra action can avoid occurrence of this scenario and the relevant outcome.

Scenario 3

This scenario “Reduction of reformer performance, bad reaction, reduction of production and products purity and stopping production at low temperature of reform steam” due to the low heat in reformer due to the failure of TIC-8035/TIC-8025 or problem in fuel system, bad ratio of fuel-air and according to the estimation of corrective action group “control system on FT-8006 A/B/C to show flow, alarming system and automatic lock can be used an independent protection (IPL) with Probability of Failure on Demand (PFD) equal to 1 $\times 10^{-2}$ can be used as a non-immediate action. This protection layer with some tools as counter can reduce the risk to 100% of ratio to target factor (10^{-5}).

Scenario 4

This scenario “Reduction of air rate/fuel (excess air), increase of unburned fuel and after burning with the reduction of heating chamber of reformer” due to simultaneous closing of some adjusting systems of air temperature for various reasons can be created” and according to the estimation of corrective action group “install temperature mark on each exit path, equip spiral of convection and gas chimney to alarm” can be used an independent protection (IPL) with Probability of Failure on Demand (PFD) equal to 1 $\times 10^{-2}$ can be used as a non-immediate action. This protection layer with some tools as counter can reduce the risk to 80% (10^{-4}) of ratio to target factor (10^{-5}). To reduce the outcomes of this scenario to achieve target factor, we should install more protection layers. To do this, based on the evaluation of industrial maps and collaboration with technical authority of sector, adding a yard operator for continuous monitoring or using a robot with electronic eyes in front of the chamber of adjusting system of air temperature to avoid simultaneous closing can be used and this scenario is reduced (Mohammad Fam and Kianfar, 2010).

Scenario 5

This scenario “shortage of gas from chimney/steam from reformer and risk of human injury with high pressure of heating chamber of reformer” due to failure in PV-8017 A/B (or any other factor regulating opening and closing in control loop) can be created and according to the estimation of corrective action group “control system on FT-8006 A/B/C to show flow, alarming system and automatic lock can be used an independent protection (IPL) with Probability of Failure on Demand (PFD) equal to1 $\times 10^{-2}$ can be used as a non-immediate action. This protection layer with some tools as counter can reduce the risk to 80% (10^{-4}) of ratio to target factor

(10^{-5}). Based on the significance of this scenario in terms of human safety and lack of efficiency of protection layers, it seems that regulation of internal lent of valves can avoid sudden pressure without much cost and can control reformer steam. Also, using automatic firefighting equipment and planning regarding emergency exit from hall can be effective on reduction of outcomes of this accident. With periodical repair and monitoring of flow control, can be considered as excess protection layers.

Scenario 6

This scenario "reduction of hydrogen purity gas with the lack of good performance of PSA system" due to the increase of age of absorbents can be created and according to the estimation of corrective action group "using safeguards AAH-8007A (CO), AAH-8007B (CO2) can be used with PFD equal to1 $\times 10^{-2}$ can be used as a non-immediate action. This protection layer with some tools as counter can reduce the risk to 100% of ratio to target factor (10^{-5}). Thus, it is required to design an exact schedule to achieve goals regarding corrective actions in the system to control accidents with high intensity in refinery hydrogen unit.

The results of corrective actions and reduced risk for scenarios showed that for 6 risky points (e.g. first, second, third, sixth, scenarios), adding independent layers of protection can reduce risk 100% (compared to target factor) and safety integrity level is provided. Regarding four other regions (e.g. fourth, fifth scenarios), risk is reduced as 80% by layers of protection. In a similar study by Jafari et al. (2015) in a refinery hydrogen unit, the results showed that based on time-consuming process of analysis of preferred protection layers, it seems that combining this method with a software tool can make the method efficient and increase the speed and accuracy. Indeed, implementation of a safety management system is an efficient way to allocate resources to safety. The combined models at average and high level of safety control help the combination of methods in achieving integrated safety level. The shortage of adequate control on probable risk of industrial activities can lead to human outcomes. Technical methods with managerial solutions are used to reduce risk. Thus, optimization of risk reduction with improvement of analyzed process and decision making about the selection of independent layers of protection after initial corrective actions should be performed as periodical. On the other hand, the increase of work ethic and reduction of work pressure on workers with safety training and occupational health with different jobs (Naghmi, 2010) can be effective on improving safety control of employees.

References

Alizadeh, S.S., Moshashaei, P., 2015. The Bowtie method in safety management system: A literature review. Sci. J. Rev., 4(9), 133-138.

Alizadeh, S.S., Sheikh Damanab, P., Rasoulzadeh, Y., Moshashaie, P., Varmazyar, S., 2015. Failure modes and effects analysis (FMEA) technique: A literature review. Sci. J. Rev., 4(1), 1-6.

Chongguang, W., Zhang Beike, M.X., 2007. The layers of protection analysis (LOPA) in process industry [J]. Automation in Petro-Chemical Industry. 1002; 40001.

Dunjó, J., Fthenakis, V., Vílchez, J.A., Arnaldos, J., 2010. Hazard and operability (HAZOP) analysis. A literature review. J. Hazard. Mater., 1020; 221(2), 29.

First, K., 2010. Scenario identification and evaluation for layers of protection analysis. J. Loss. Prev. Proc. Indust., 1020; 11(2), 208-25.

Ghasemi, M., Nasl Seraji, J., Zakerian, S.A., Azhdari, M.R., 2010. The ergonomic study (identification, prediction and control), human error in one of the rooms of petrochemical industry control using SHERPA method. J. Health. Res. Inst, 8(1), 41-52.

Gowland, R., 2006. The accidental risk assessment methodology for industries (ARAMIS) layer protection analysis (LOPA) methodology: A step forward towards convergent practices in risk assessment? J Hazard Mater., 130(3), 307-10.

Jafari, M., Lajevardi, S., Mohammad-Fam, I., 2015. Semi quantitative risk assessment of a hydrogen production unit. Int. J. Occup. Hygiene., 1028; 8(1), 202-5.

Khandan, M., Koohpaei, A., Jabari, M., Vosoughi, S., 2015. Risk assessment of chemical prosesses using layer of protection analysis (LOPA) method: Case study in a petrochemical unit's drum 1028.

Mazlumi, A., Kermani, A., Nasl Seraji, J., Ghasemzade, F., 2013. Identification and evaluation of human errors using SHERPA method in emergency physicians in Hazrat Amiralmomen in hospital of Semnan. J. Work. Med., 5(3), 67-78.

Mofidi, A., Jabari, M., Allahyardi, Mehrabni, M., Shahriari, F., 2013. The models and techniques of events analysis. Introduction of a new method to evaluate simple accidents. The sixth transnational conference of new progress in engineering science. Tenekabon, Higher education institute of Ayandegan.
Mohammad Fam, A., 2007. Safety analysis methods. Fanavaran publications. Tehran.
Mohammadfam, A., Kianfar, A., 2010. Application of the technique of hazard and operability in evaluation of safety, health and environmental risks (case study, oil warehouse of national company of oil products distribution). Sci. Environ. Technol., 12(1), 39-49.
Naghami, M., Tsutsumi, A., Tsuchiya, M., Morimoto, K., 2010. Job control and coworker support improve employee job performance. Indust. Health., 48(6), 845-851.
Nassir, P., Alizadeh, S.S., Golbabaei, F., Shahtaheri, S.J.A.D., 2007. Hazards identification and assessment in a production factory using Job Safety Analysis (JSA). J. Environ. Sci. Technol., 8(4).
Nilsson, K., 2009. Preliminary hazard analysis of the natural gas delivery pipeline between young and bomen in NSW, Palanger Risk Management Consulting, 45.
Rasoulzadeh, Y., Alizadeh, S.S., Valizadeh, S., 2015. Health, safety and ergonomically risk assessment of mechanicians using job safety analysis (JSA) technique in an Iran city. India. J. Sci. Technol., 8(28).
Salmon, P., Walker, N.A.S., 2003. Human factors design methods review. Human factors integration defence technology center, 16-19.

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