

The Evaluation of Safety Barriers Using the Method Lopa Case: Haoud Berkaoui in Sonatrach

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To cite this article:

Samia Hariz, Fares Telli. The Evaluation of Safety Barriers Using the Method Lopa Case: Haoud Berkaoui in Sonatrach. *International Journal of Environmental Monitoring and Analysis*. Vol. 7, No. 3, 2019, pp. 68-74. doi: 10.11648/j.ijema.20190703.12

Received: June 17, 2019; **Accepted:** July 18, 2019; **Published:** September 19, 2019

Abstract: Nowadays, the industrial world has developed awareness to risk and risk management especially to major risks with catastrophic consequences. Because of this; great efforts has been put to prevent and protect against these risks. The analysis and evaluation of risks are an essential steps to prevent the occurrence or to the reduce severity of the accidents, several methods are used to analyze and evaluate risk, they are divided into three categories qualitative, semi quantitative and quantitative. These methods differ in when, where and why to apply them, qualitative methods are generally easy to apply and fast in identifying the risks, quantitative methods are not as easy but provide a numerical value to the risk that helps in risk comparison in the case of evaluation or decision-making, and semi quantitative methods falls in between. In this framework the objective is to evaluate the performance of the safety barriers using layer of protection analysis (LOPA). It was applied on Haoud Berkaoui in Sonatrach one of the leading companies in oil and gas industry in Africa, we have chosen the new flared gas recovery project as the subject of our study as it is new and no previous work has been done on this subject, we have identified its most critical system and it was the separator V-160, this separator is crucial to the hole operating station, as it holds all the condensate at the end of the operation. We established a HAZOP study and we rely on it to realize LOPA that should be a step for organizations to move towards more semiquantitative and quantitative analysis. So we will try to realize this abstract method in the field. Hopefully this work can contribute to the company applied upon.

Keywords: The Safety Barriers, Companies of Oil and Gas, Lopa

1. Introduction

This paper intends to be a part of creating a safer workplace by developing of a model for application of Layer of Protection Analysis (LOPA) for a production system. The model's main objective is to evaluate a system's risk, compare it with risk acceptance criteria and to determine whether safety measures are sufficient and efficient, if the system safety requirements are not achieved, present protection layers have to be improved or additional protection layers have to be added.

The literature shows that security systems must be used strongly to achieve organizational goals. The main role of safety systems is highlighted more than ever for maintaining staff health, protecting the environment and improving the reputation of organizations. The proper functioning of the security system depends on the reliability and likelihood of

system failure, which determines the security of the integrated [1-3]. The LOPA method is potentially a way to proceed with the evaluation. Safety gates, the article by [4-7]. It is also found in another article that, Protective Layer Analysis (LOPA) can successfully respond to personnel protection issues and the preservation of the environment. This technique is a simplified process of quantitative risk assessment, which uses order of magnitude categories to determine the frequency of causes, the severity of the consequences and the failure probability of independent layers of protection to analyze and assess the risk of harm. Specific accident scenarios. The LOPA requires the application of qualitative risk assessment methods to identify accident scenarios, including root causes and appropriate safeguards. This can be fulfilled, for example, by HAZOP studies or hypothesis analysis [8-11].

The objective of our study project is to gain extensive

knowledge of how to allocate requirements of safety and make risk decisions using layer of protection analysis (LOPA). As a part of this the following aspects shall be covered: define and clarify all basic concepts of the recommended LOPA approach, identify and describe interfaces between LOPA and other risk analysis methods (especially HAZOP) and discuss pros and cons related to LOPA especially the limitations of LOPA [12-14].

Sonatrach is one of the major oil and gas companies in Africa and the world and a major contributor to world's economy, Haoud Berkaoui is part of their exploration and production division, the different fields, geographical situation and the different units. Sonatrach and Haoud Berkaoui in particular is a perfect site to apply the LOPA method discussed in following parts, knowing that the production in this site is 24/7 we understand how crucial this site is to the company, because of the nonstop production we need to assure the safety of the site 24/7 including both equipment and personnel safety [15].

2. Material and Methods

Layer of protection analysis (LOPA) is a semi quantitative tool for analyzing and assessing risk. In this part we describe the LOPA process, discuss the strengths and limitations of LOPA and describe the requirements for implementing LOPA in an organization. Layer of protection analysis (LOPA) is a simplified quantitative tool for analyzing and assessing risk. LOPA was developed by user organizations CCPS (Center for Chemical Process Safety) during the 1990s as a streamlined risk assessment tool, using conservative rules and order-of-magnitude that estimates frequency, probability, and consequence severity. When the method was shown to be an efficient mean to assess risk, several companies published papers describing the driving forces behind their efforts to develop the method, their experience with LOPA and examples of its use. In particular, the papers and discussion among the attendees at the Center for Chemical Process Safety (CCPS) International Conference

and Workshop on Risk Analysis in Process Safety in 1997 brought agreement that a book describing the LOPA method should be developed. This led to the publication of the Concept Book Layer of Protection Analysis: Simplified Process Risk Assessment (CCPS LOPA) in 2001. Since its inception, the LOPA methodology has continued to evolve, and some companies have utilized or supplemented the methodology with more advanced techniques [16-18]. where LOPA is typically used [19], [20]

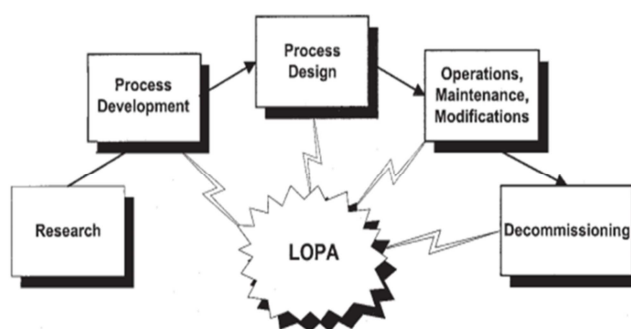


Figure 1. The process life cycle showing.



Figure 2. Key questions using a rational, objective, risk-based approach.

In LOPA, the individual protection layers proposed or provided are analyzed for their effectiveness. The combined effects of the protection layers are then compared against risk tolerance criteria. Characteristics of the answers provided by LOPA are listed below [21-24].

LOPA answers the key questions about the number and strength of protection layers by

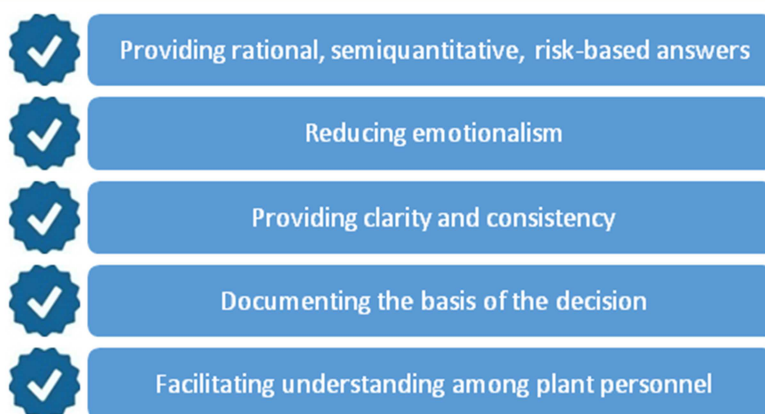


Figure 3. The LOPA answers.

2.1. Application of LOPA in the Haoud Berkaoui in Sonatrach

The identification and risk analysis by the LOPA method requires the presence of particular data and information about

the different risk evaluation parameters such as, the initiating events frequencies, mitigated consequences frequencies and also the probabilities of failure of the different protection layers [26].

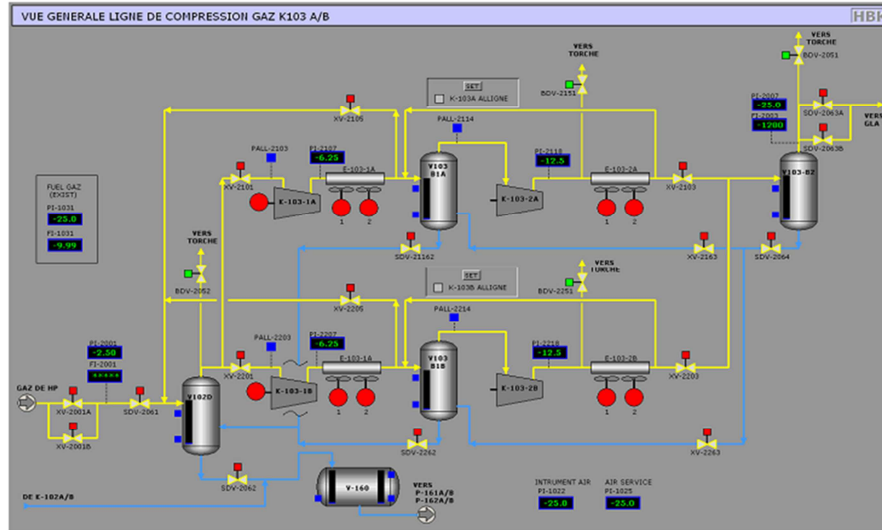


Figure 4. A graphic view of the first compression line.

These data are obtained generally from the history of the system being analyzed (Feedback). However, in case of the data absence or insufficiency, we resort to other sources like, data banks and expert judgment. Despite choosing these data while respecting its adaptation to the system under study, we choose the history or similarly operating systems data. In this case, we had to use the data banks due to the systems novelty and the absence of data history and similar systems. LOPA is a semi quantitative method and as every other risk analysis method it is not perfect, however it lets us give better risk judgments, usually better than the qualitative methods. Semi quantitative methods are applied from 10% to 12% of the time, in this work, we will try to put pen to paper and realize

this abstract method in the field. Hopefully this work can contribute to the company applied upon [23-25].

2.2. System Presentation

The RGA (in French Récupération des Gaz Associer/Torché) or Flared Gas Recovery is relatively a new project in Haoud Berkaoui. Established in 2008 with the goal to recover most condensate from the flared gas, this new installation helps the production center both economically by producing more and not literally burn the product, and environmentally by reducing the emissions.

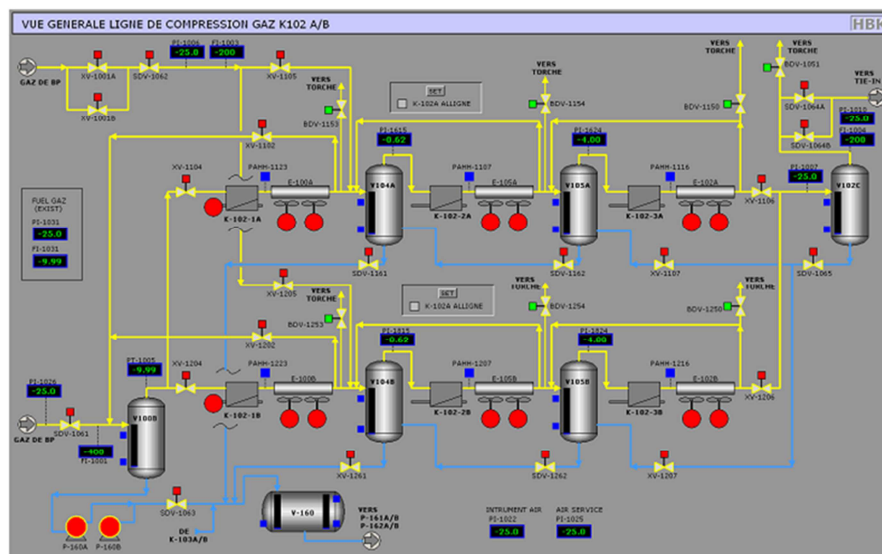


Figure 5. A graphic view of the second compression line.

This work is the first to put its equipment in a study. The gas is separated from oil in a three separation systems, with the different pressure levels. Each system (Base Pressure, Medium Pressure and High Pressure) sends to the RGA station which compresses the gas up to 35 bars.

The station of recovery, send and compression of flared

gas has two compression lines (1st BP+MP and 2nd HP). Each line has two compression trails a principal named A and a reserve named B.

For the following parts, we will explain what happens with part A and it applies to part B.

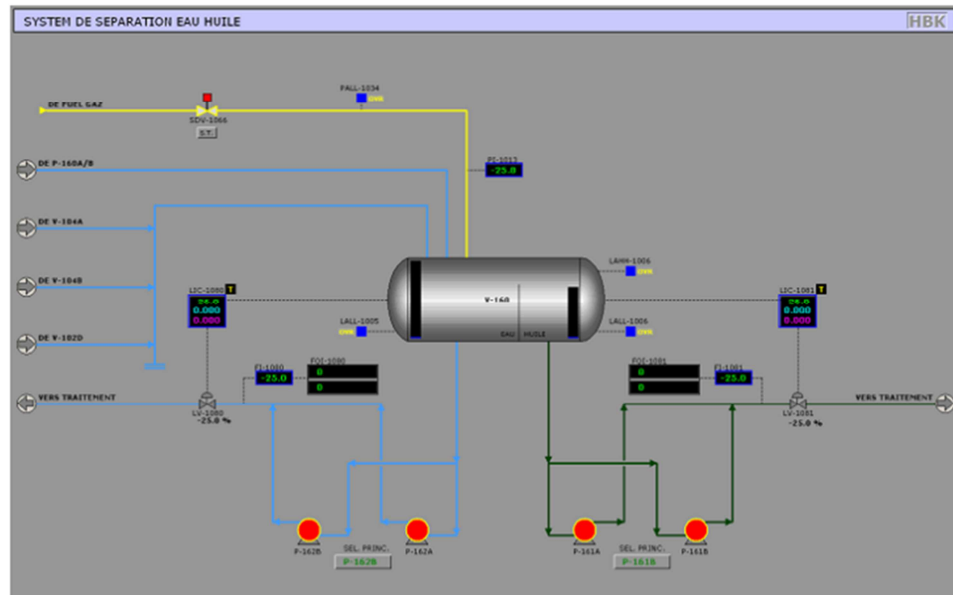


Figure 6. Water oil seperating system V-160.

The BP line gets to the separator V 100-B after that we get to the reciprocating compressor K 102 that has 3 compression stages named K 102-1 A, K 102-2 A, K 102-3 A each one followed by a dry cooler, the operation (see Figure 4) is the following:

- 1) The BP coming from V 100-B is compressed to 2 bars by K 102-1 A and reunites with the MP already exiting
- 2) They enter the separator 04-A then get compressed to 8.5 bar by K 102-2 A and sent into the third stage
- 3) They enter the separator V 105-A, and then compressed by K 102-3 A to 35 bars after that they enter the separator V 102-C.

The HP line enters the separator V 102-D then goes to the centrifugal compressor K 103 that has two compression stages K 103-1 A and K 103-2 A to arrive to the desired pressure 35 bars (Figure 5).

After each compression there is a dry cooler and a separator, all condensate are collected in the separator V 102-D. Note that all the condensate in V 100-B, V 104-A/B and V 102-D are all sent to the separator V-160 making it the most important piece of the puzzle, and that is the system under study (Figure 6).

3. Results and Discussion

3.1. LOPA Tables

This step is the essence of this work it combines both LOPA steps 5 and 6, the LOPA tables illustrate the cause-consequence pairs in each scenario, determines the scenario frequency and compare it to the risk tolerance criteria.

Table 1. LOPA table for scenario 1.

Scenario (SC 1): High level causes oil to enter the blowdown system		
Consequence		Oil enters blowdown system (G 2)
Initiating event		BPCS 1 failure BPCS 2 failure
Enabling event		/ /
Initiating event frequency		10 ⁻¹ /year 10 ⁻¹ /year
Independent protection layer	Human and alarms	10 ⁻¹ 10 ⁻¹
	High SIF	10 ⁻¹ 10 ⁻¹
Total PFD		10 ⁻² 10 ⁻²
Frequency of mitigated consequence		10 ⁻³ /year (P 2) 10 ⁻³ /year (P 2)
Risk tolerance criteria		
Risk tolerance criteria met?		Yes
Notes		Tolerable risk that is accepted but needs to be monitored

Table 2. LOPA table for scenario 2.

Scenario (SC 2): Low level causes water contamination			
Consequence			Water contaminated with oil (G 2)
Initiating event			BPCS 1 failure (continue operating)
Enabling event			/
Initiating event frequency			10^{-1} /year
Independent protection layer	Water SIF		10^{-1}
Total PFD			10^{-1}
Frequency of mitigated consequence			10^{-2} /year (P 3)
Risk tolerance criteria			
Risk tolerance criteria met?			Yes
Notes			Tolerable risk that is accepted but needs to be monitored

Table 3. LOPA table for scenario 3.

Scenario (SC 3): High gas pressure and explosion hazard				
Consequence		Explosion (G 3)		
Initiating event		PCV-1013 failure to close	Human and alarms	PSV-1003
Enabling event		/	/	/
Initiating event frequency		10^{-1} /year	10^{-1} /year	10^{-2} /year
Independent protection layer	PCV-1013	/	/	10^{-2}
	Human and alarms	10^{-1}	/	10^{-1}
	PSV-1003	10^{-2}	10^{-2}	/
Total PFD		10^{-3}	10^{-2}	10^{-3}
Frequency of mitigated consequence		10^{-4} /year (P 2)	10^{-3} /year (P 2)	10^{-5} /year (P 1)
Risk tolerance criteria				
Risk tolerance criteria met?		Yes		
Notes		Tolerable risk that is accepted but needs to be monitored		

Table 4. LOPA table for scenario 4.

Scenario (SC 4): Low pressure inside could lead to implosion			
Consequence		Implosion (G 3)	
Initiating event		PCV-1013 failure to open	Human and alarms
Enabling event		/	/
Initiating event frequency		10^{-1} /year	10^{-1} /year
Independent protection layer	PCV-1013	/	/
	Human and alarms	10^{-1}	/
	Gas SIF	10^{-2}	10^{-2}
Total PFD		10^{-3}	10^{-2}
Frequency of mitigated consequence		10^{-4} /year (P 2)	10^{-3} /year (P 2)
Risk tolerance criteria			
Risk tolerance criteria met?		Yes	
Notes		Tolerable risk that is accepted but needs to be monitored	

3.2. Interpretation

In the first scenario we have seen that a failure in one of the BPCSs can initiate a scenario however the two IPLs (human and alarms, high SIF) can interfere to reduce the frequency of the initiating event into a tolerable level thanks to their PFDs. The tolerance criteria for this scenario are achieved but monitoring is still needed.

The second scenario starts with the initiating event of BPCS 1 failure this means it is no longer considered as an IPL, leaving only the water SIF as the IPL for this scenario with a PFD equal to 10^{-1} , it can reduce the frequency into a tolerable level but still needs monitoring.

The third scenario has one of three possible initiating events either PCV-1013, human and alarms or PSV-1003 failing, we cannot accept any of them as IPL if they are part of the initiating event or it interferes with their action. As it's the case here, when there is a false high pressure alarm the operator will bypass the PCV-1013 thus making it ineffective.

Still the existing IPL PFDs are adequate in reducing the risk into a tolerable level, but still needs further observations.

In the fourth scenario the implosion can happen due to two different initiating events the first being a PCV-1013 failure to open which can be reduced by two IPLs human and alarms and the gas SIF making the risk in the tolerable zone. The second initiating event is human and alarms failure this event interferes with the action of the PCV-1013 thus eliminating it from being an IPL. Only one IPL exists in this case which is the gas SIF with the PFD 10^{-2} sufficient to reduce the risk into a tolerable zone; this risk needs further monitoring.

3.3. Recommendation

For the first and second scenario, the measures taken to avoid the consequences are adequate and the IPL are sufficient in preventing those consequences. However, improvement on high SIF and water SIF PFDs like adding redundant transmitters or improved PLCs, also making an independent indicator with human operator in the second

scenario can create a new IPL that can help reduce the risk into an acceptable level and provide more safety to the system.

For the third scenario, an explosion could happen if the PFDs of the IPLs are insufficient especially in case where the operator is the initiating event for this scenario a SIF for high pressure is needed to reduce the risk into the acceptable zone.

The fourth scenario starts with either PCV-1013 failing or human and alarms failing this could cause an implosion due to low pressure inside the separator. Our recommendation for this scenario is to raise the SIL level of the gas SIF by adding other transmitters or PLCs.

4. Conclusions

We have responded appropriately to the problematic of the representation and treatment of data uncertainties, most often by semi-quantitative methods of analysis and evaluation of industrial risks, the LOPA method is recognized as a simplified method and widely used in the oil industries.

We have tried to establish a more numerical risk value that is to say to go from a qualitative evaluation to a semi-quantitative evaluation using the LOPA, because it is a tool that uses an order of magnitude to assess risk and compare risk decision [27]. We also put into practice all the theoretical knowledge to try to make the transition from HAZOP to LOPA a real situation. We interpreted the results accurately and made our recommendations.

In conclusion we can say that this modest work can be considered as a first step in improving security barriers at the level of Algerian companies. Other important aspects can be the subject of future developments, according to a fuzzy or probabilistic model. The analysis of the effectiveness of the independent protection layers as a function of the frequencies of the reduced consequences is a subject that deserves to be addressed.

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