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HAZOP Study and Risk Assessment in Three-Phase Separator Oil and Gas Exploration Farm - East Java, Indonesia

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ABSTRACT

Background: Security and safety of a process operation is the main goal. Industrial processes require adequate levels of security so that the sustainability of the production process runs smoothly and does not endanger the worker. Hazard and operability study (HAZOP) is an audit activity to ensure potential hazards that may occur in a plant. The failure of a component separator operation would lead to potential hazards that can threaten the lives of workers and employees, material losses, environmental damage and the ultimate drag on the company's reputation. Hazards of chemicals are processed in the separator will be exposed in the event of failure of the process. In the system can be divided into three points, namely the study of input points separator, vessel systems, and output separator. From the block assessed based on data maintenance, process the data in order to know the likelihood and consequences and the risk matrix is built. Assessment process and assessment of hazard operability study PV-9900 separator guideword generated for the process variables temperature and pressure. At the end of this part of the study and make a recommendation in the form of emergency response plan (ERP).

KEYWORDS: Keyword 1 : HAZOP, Keyword 2 : Likelihood, Keyword 3 : Consequences, Keyword 4 : Risk Matrix Keyword 5 : ERP

INTRODUCTION

Security and safety is something that is important and a major state in the world of work, especially when jobs are executed at high risk for the safety of workers and the environment. Danger (hazard) which can lead to endangerment of safety of life and the environment can occur on things unpredictable even underestimated. According to the OHSAS 18001: 2007, the danger (hazard) is all sources, situation or activity that has the potential to cause injury (accident) and occupational diseases. Therefore it is necessary to audit the work

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environment in order to predict the hazard that can occur and the subsequent risk management planning (risk management) for the handling of such hazards. Dhillon, B.S., [2].

PT. Joint Operating Body PERTAMINA - Petrochina is a joint venture entity of PT. Pertamina (Persero) is a State-Owned Enterprises (SOEs), Indonesia with PT. Petrochina- Indonesia, Ltd. PT. JOB (Joint Operating Body) Pertamina-Petrochina including upstream company in terms of oil and gas exploration (oil and gas) with drilling activity, separation of crude oil and distribution for advanced process to partner companies PT. Joint Operating Body Pertamina - Petrochina. In the implementation of these activities, PT. Joint Operating Body Pertamina-Petrochina manages materials classified as hazardous. Danger may occur due to the nature and content of various chemicals contained in crude oil which is the result of the drilling, one of the elements is H2S, is a substance that is most prone to fire and gas leakage H2S as toxic gas. Skrtic, Lana [20].

The potential hazard could cause accidents; the purpose of the research guaranteed for the safety of the workers with the most severe consequence is death. Potential work accidents are caused by the toxic properties of H2S gas and crude oil properties itself flammable. Potential accidents that can involve citizens more widely around the plant. That is because the H2S gas is carried by the wind and the volume of crude oil very much, quite capable of burning plant area of PT. JOB Pertamina-Petrochina and the surrounding environment. Danger may occur due to system failure or hardware security and control system at the plant. Small failures that occurred could have a domino effect if there is no emergency to evaluate and improve the system failure. From such exposure, this is the background for such research activities (HAZOP), Robert W. Johnson, [17]. And the assessment of risk management (Risk Management) for the protection of potential hazards and the preparation of emergency response plan (ERP) for the implementation of mitigation on PT. JOB Pertamina-Petrochina. With these evaluations can then unknown source of the problems of potential hazards that can then be built safeguards to reduce the level of risk and accidents that will occur in the PV-9900 unit. Musyafa, A., and Zulfiana, E., [11].

2. Methodology:

2.1 Plant Separator:

Separator is equipment that is commonly used in industry. The function of separator is to separate certain liquids with other liquids with different density or boiling point or separating a mixture of materials in order to obtain its constituent materials by breaking down the materials that have different phases. The working principle of this equipment separates the gas and liquid are first performed by crashing production drilling results into the inlet diverter that material outlining the system liquid and gas from the well. Furthermore, legally physics of gas will rise to the top position and liquid separator will drop. Temilade Ladokun and Farhad N., [21]. Liquid separation technique using the difference principle density, while the density of water is heavier bring down to the separator and crude oil that has a density lighter water rises to the surface. The bottom of the separator has two rooms separated by a weir. Weir will keep the water would not move to another room, while the oil is above the water will pass through the weir heights and flows into the second chamber so that the results of the three-phase separator is processed is the separation of gas, oil and water. Three substances material separation from the drilling results will be forwarded to the advanced process. For products forwarded to scrubber and flare gas, oil products to be forwarded to a stripper, and to be forwarded to the water gas water boot. The following three-phase separator shown specification PV-9900 is shown in Table 1. [5].

Table 1: Specifications Three-Phase Separator , PV-9900

Tag Number	Spesifikasi	
PV-9900	Size	144” ID x 30’-0” T/T
	Design Pressure	286 PSIG @ 250 °F
	Operating Pressure	125 PSIG @ 180 °F
	Corrosion Allowance	0.0125 INS
	Materials	A-516 GR 70
	Capacity	5000 OPD/50000 BWPD / 40 MM

2.2 HAZOP Study:

Hazard and Operability Study (HAZOP) is a structured engineering study to evaluate and assess the risk management system. HAZOP study is useful as a technique for identifying a potential danger in the process. Musyafa.A, *et al*. [12]. HAZOP is a theory that assumes that risk is caused by deviation of the design or operating purposes. Identification of deviation of design or operating purposes is facilitated by using the 'guidewords' as systematic list of perspective deviation. This approach is unique from HAZOP methodologies that help stimulate the imagination while exploring a potential deviation. HAZOP is suitable to be deployed to assess the hazards in facilities, equipment, and processes. HAZOP able to assess the system from a variety of perspectives. Fletcher, Lyn E., [4].

- Design: The ability to assess the system design to achieve the desired specifications and safety standards.

- Identify weaknesses in the system: the physical and operational environment, assess the environment to ensure the system in the right situation.
- Procedural and operational control system: estimating control engineering (automation), sequensial operation, control procedures (human interaction), etc. And assess the various operational modes - start-up, standby, normal operation, steady and unsteady states, normal shutdown, emergency shutdown, etc.

2.3 Risk:

Risk is the likelihood combination possibilities and consequences that occur according to the following equation 2.1.

Risk = (Consequence) x (Likelihood) (1)

MTTF is the mean value of the instrument have failed in a certain period of time. Every day plant- III sulfuric acid fully operational within 24 hours. Likelihood is calculated by equation (2).

Likelihood = (1/MTTF) x 43800 jam (2)

By the standards of the Australian / New Zealand (AS / NZS 4360: 2004), the consequences can be determined based on the level of a few tables consequences criteria as shown in Table 2. Ebeling, Charles E.,(1997).

Table 2: Table Consequences, (The Standard Australia / New Zealand (AS / NZS 4360: 2004)

Level	*Guideword*	*Description*
1	*Insignificant*	The system operates and safe, there was a slight disturbance does not mean
2	*Minor*	The system continues to operate and secure, interference resulted in a slight decrease in performance or, impaired system performance
3	*Moderate*	The system can operate, failure may result in the machine loses its main function and / can cause product failure
4	*Major*	The system cannot operate. Failure can cause a lot of physical damage and system, can cause product failure, and / does not meet regulatory requirements Safety
5	*Catastrophic*	System operation is not feasible, the severity of which is very high if the failure affects a secure system, in violation of regulations Safety

Frequency is evaluated based on the number of the occurrence of hazards. Frequency can also be evaluated based on historical data or from the same component failures that have occurred on the component failure rate based on the data. By the standards of the Australian / New Zealand (AS / NZS 4360: 2004), the level of likelihood can be determined based on criteria such as shown in Table 3.

Table 3: Likelihood *base* on The Standard Australia/ New Zealand (AS/NZS 4360:2004)

Level	Guide word	Description
A	Almost certain	Risks occurring more than 5 times in 5 years
B	Likely	Risk of more than 4-5 times in 5 years
C	Moderate	Risk of more than 3 or less than 4 in 5 years
D	Unlikely	Risk of 2-3 times in 5 years
E	Rare	Risks rarely, appear / occur less than two times in 5 years

By Equation (2.1), is the result of multiplying the value of risk likelihood and consequences, so that subsequently obtained a risk matrix criteria as shown in Table 4. Montgomery, Douglas C. [9].

Table 4: Risk Matrix (The Standard Australia/ New Zealand (AS/NZS 4360:2004)

Likelihood	*Consequences*				
	Insignificant	Minor	Moderate	Major	Catastrophic
	1	2	3	4	5
A (Almost certain)	**H**	**H**	**E**	**E**	**E**
B (Likely)	**M**	**H**	**H**	**E**	**E**
C (Moderate)	**L**	**M**	**H**	**E**	**E**
D (Unlikely)	**L**	**L**	**M**	**H**	**E**
E (Rare)	**L**	**L**	**M**	**H**	**H**

Where :

E = *Extreme risk*

H = *High risk*
M = *Moderate risk*
L = *Low risk*

2.4 Risk Management:

Risk management is part of the process management phases. The purpose of risk management to minimize losses and increase the chance or opportunity. Basically, risk management is the prevention of the occurrence or accident keugian. Tahapan of the first risk management process is to determine the content that is to be analyzed, which includes data collection strategies, risk management methods, as well as the determination criterion. The next stage risk identification that includes risks that will occur from the hazards are analyzed and how these risks can occur. For the risk analysis stage, estimate the likelihood and consequences, can further known risk criteria based on the result of the combination of likelihood and consequences. The next evaluation of risk, whether the risk is acceptable or not, if not then continued efforts to reduce the risk of handling. In the implementation of these measures, always do the communication and consultation between the members and do monitor and review. Musyafa, A. *et al* [13].

2.5 Evaluation of Risk Management:

In this discussion outlined evaluation measures for risk management and hazard operability study. The object of research here three phase separator to function as crude oil separator results from drilling wells into three products namely oil, water, and gas. The study began with a literature study on matters related to the separator, among others: risk management and hazard and operability study will be implemented safety standards such as IEC 61508. The next phase maintenance collect data, process data and other supporting data. Phase berkut perform data processing. seek control charts, tables mebuat cause and consequences, likelihood tables, as well as the risk matrix table. Data processing analysis and tabulated hazard and operability (HAZOP). HAZOP validated against a table that has been built. If the results are not valid it must be repeated on a data processing step. At the stage of data processing as well prepared emergency response plan (ERP). Assumed if the one-step preparation of risk management is further assumed to be an explosion at the plant Separator PV-9900. Then steps need to be prepared to anticipate these events. Jeerawongsuntorn. *et al*. [6], Poulose, [16]. The flow chart of research shown in Figure 1.

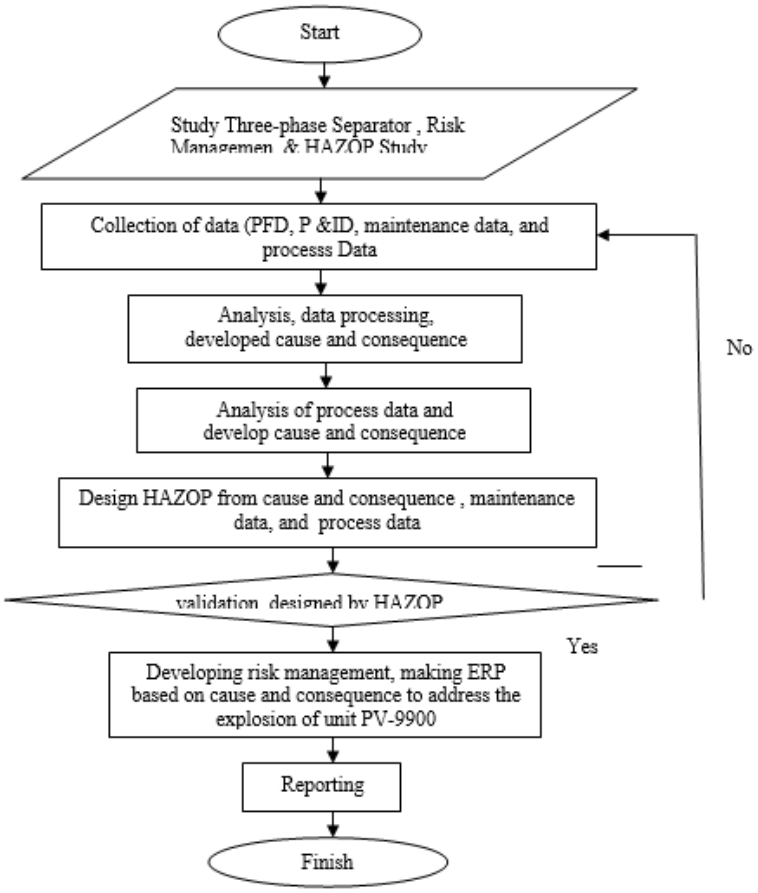

Fig. 1: Flowchart of the Research

Results:

3.1 Process and Input /Output:

Study points (nodes) that are determined to be investigated is input separator (separator input), vessel (vessel), the output separator (separator output). Data sought further plant that will produce an average value vairabel operation, deviation, likelihood and severity. Maintenance of data sampled over 5 years starting in September 2009 - August 2014. The process data is used as study materials sampled during the two months of November 2014 - December 2014 next. Based on these data hereafter devised control chart and calculations are discussed and form the basis of creating a table HAZOP. Musyafa, A., and Kristianingsih, L., [11]

3.2 Guideword and Deviation:

In the separator system as a whole made guideword as shown by Table 5.

Table 5: Guideword Three Phase Separator system PV-9900

No.	Component	Guideword	Deviation
1.	Pressure Indicator (PI-9910)	High	Higher Pressure
		Low	Lower Pressure
2.	Pressure Indicator Control (PIT-9932)	High	Higher Pressure
3.	Pressure Indicator (PI-9944)	Low	Lower Pressure
4.	Flow Indicator (FI-9941)	More	More Flow
		Less	Less Flow
5.	Temperature Indicator (TI-9944)	High	Higher Temp.
		Low	Lower Temp.
6.	Pressure Indicator (PI-9932)	As Well As	As Well As Pressure
7.	Pressure Indicator Control (PIT-9932)	High	Higher Pressure
8.	Pressure Indicator (PI-9944)	Low	Lower Pressure
9.	Flow Indicator (FI-9941)	More	More Flow
		Less	Less Flow
10.	Temperature Indicator (TI-9944)	High	Higher Temp.
		Low	Lower Temp.
11.	Pressure Indicator (PI-9932)	As Well As	As Well As Pressure

Based on Table 4.1, it can be observed that the system of three-phase separator guideword PV-9900 consists of; high and low pressure, and temperature, as well as more, less, and as well as to the flow rate. From the guideword then made a table hazard operability study and its recommendations for addressing the threat that is likely to occur. [7].

3.3 Likelihood:

Likelihood value is determined based on the data that is recorded on the maintenance instrument division of PT. JOB PPEJ-Tuban. Likelihood obtained by dividing Operating time for 5 years in hours and Mean Time to Failure (MTTF) in an hour anyway. The MTTF is obtained with an average seek time of a status instrument to undergo restoration, recalibration and damage equipment. Having obtained the likelihood at each node, the next step to formulate any node that is an integral three-phase separator system PV-9900. The following results are calculated based on the likelihood that the data collected from all three phase separator system PV-9900.Adapun Likelihood criteria shown in Table 6.

Table 6: Criteria Likelihood entire three-phase separator system PV-9900

Instrument	MTTF (Jam)	*Likelihood*	Kriteria *Likelihood*
SDV-9904	16936	2.59	E
OLT-9934	25416	1,72	E
LIC 9935	19404	2.26	D
PSV-9931	21888	2,001	D
PSV-9932	21888	2,001	D
TT-9939	21888	2,001	D
PCV-9947A	14584	3,003	C
BDV-9961	21888	2,001	D
TT-9969	21888	2,001	D

Further step is to formulate that each node becomes a sub-system of the three-phase separator PV-9900. From Table 4.2, it can be observed that the likelihood for the entire system has a dominant likelihood criteria is at the D criteria, the criteria for the position of E, D, and C. Thus the emergence of these systems have a range of system failure with rare criteria - moderate. This shows that the system cukupsering failure. However, the level of its appearance is still within reasonable limits and still be tolerated.

3.4 Consequences:

Consequences analysis was conducted to determine the approximate severity (severity) and possible effects caused by the deviation of the average operating variables. From the data created process control chart that shows some degree of control achieved by the data limit. Based on the level of control limit calculation is then adjusted to a category consequences.

Formulation consequences on the overall three-phase separator system PV-9900 is done by combining the consequences on each node. On criteria such consequences can be observed that the three-phase separator system PV-9900 has consequences criteria 1 and 3 were nearly balanced. Criteria 1 and 3 indicates that the consequences insignificant and moderate, it indicates that when there is a failure in the separator, it will berakibatkan to the most severe conditions, especially the failure of the system that caused the engine to lose its function and lead to product failure. John N. Dyer, *et al*. [8].

Table 7: Criteria consequences three-phase separator system PV-9900

No.	Instrumen	Kriteria Consequences AS/NZS
1.	SDV-9904 (PI-9910)	1
2.	Temperature Indicator (TI-9963)	3
3.	Oil Level Transmitter (OLT-9934)	3
4.	InterfaceLevel Transmitter (ILT-992)	1
5.	Pressure Indicator Control (PIT-9932)	1
6.	Pressure Indicator (PI-9944)	1
7.	Flow Indicator (FI-9941)	3
8.	Temperature Indicator (TI-9944)	3
9.	Pressure Indicator (PI-9932)	1

4 .Result:

4.1 Risk Matrix:

Analysis of risk matrix aims to map the risks that can occur in a system with data sources likelihood and consequences. As shown by Table 8.shown risk matrix.

Table 8: Risk Matrix three-phase separator PV-9900

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
	1	2	3	4	5
A (Almost certain)					
B (Likely)					
C (Moderate)	PV-9900		PV-9900		
D (Unlikely)	PV-9900		PV-9900		
E (Rare)	PV-9900		PV-9900		

Risk matrix system is a combination of risk matrix each node. The combined number of risk level of each node to the low risk category amounted to 5, in the category of moderate risk amounted to 3, and in the high risk category amounted to 1, and the risk for the category = 0. If likelihood and consequences on every node coupled the importance of the risk matrix as Reviewed shown by table 8. Of the risk matrix can be observed that the three-phase separator PV-9900 occupies an area of risk in the range of low risk to high risk. High level of risk that may occur in the three-phase separator to be assessed hazard operability study to improve the ability to prevent danger. Silvana.D.Costa. *et al*. [19].

4.2 Risk Management:

Based on the risk analysis has been done, the explosion is a potential hazard may occur due to excessive pressure. It is due to the input node of the whole separator, and putput separator has a variable pressure that may exceed the threshold value. When an explosion is the most dangerous thing H2S gas leakage which radiate into the surrounding environment. H2S gas can easily be spread quickly because of the presence of wind. Therefore necessary emergency response plan (ERP) when the situation occurs. Here is a map of the spread of H2S according to the wind direction is often the case (of the local weather data) and maps of the center of activity at the center point area (CPA). Shown in Figure 2. Ronny D.N., *et al*. [18]

Fig. 2: Map of the center of activity (CPA) and in the spread of H2S

4.3 Recommendation:

From the analysis made on and needs to be done to support the safety of workers in the unit CPA: Because of the office side of the south CPA and safe briefing areas (SBA) parts of the south, including areas affected by the distribution of H2S gas when separator exploded then it is recommended that, for these two places are provided mask the same amount or slightly more than the number of workers. Providing and setting up a bus or other transport equipment quickly to relocate workers who gathered in the southern part of the SBA, this is due SBA southern part including areas affected by the distribution of H2S and need immediate redeployment of workers who had gathered at the site

4.4 Emergency Response Plan (ERP):

Beradasarkan analysis, when an explosion is a potential hazard that occurs in the three-phase separator PV-9900. The condition is caused by a high pressure separator which in turn drive a wedge components. If this was not well anticipated. Then the explosions may occur and could potentially lead to a domino effect that occurs following an explosion. There are several countermeasures if it happens that early prevention and advanced countermeasures.

4.5 Early Countermeasures:

In the initial response, there are several actions that should be performed by the operator, when the three-phase separator PV-9900 having a blast and the subsequent alarm namely:

- Do not Panic.
- Stop all activity and extinguish all sources of energy.
- Turn off the car and get off when were on the vehicle.
- Please find and wear masks to minimize the impact of inhalation of H2S gas.
- A quick walk do not run toward safe briefing area (SBA) north for all workers in the control room
- and towards safe briefing area (SBA) for workers in the southern part of the southern part of the
- CPA's office.
- Please pass routes that have been provided as in Figure 4.2.
- Ignoring other workers who had fallen or fainted when the precarious state and focus towards safe
- briefing areas (SBA).
- Counting and ascertain the number and personal data of workers gathered at the safe briefing area (SBA).

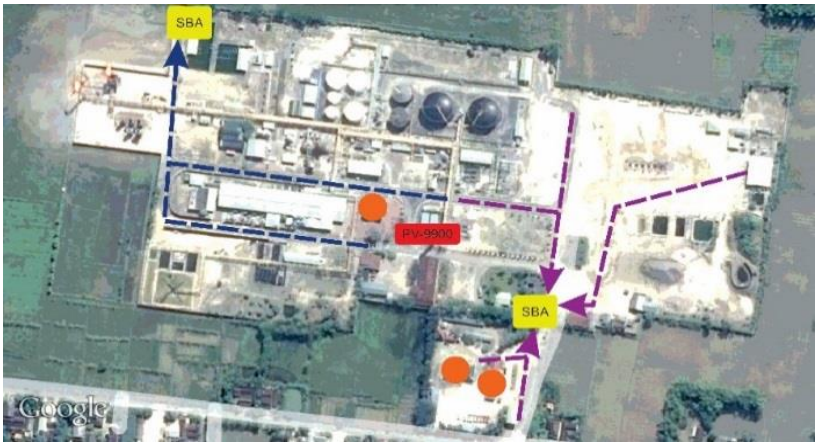

Fig. 3: Evacuation route to the safe briefing area (SBA)

In Figure 3. are recommended evacuation routes to reach safe briefing area (SBA) nearby. In the eastern region are encouraged to follow the purple route to the nearest SBA SBA is south and west to the area are encouraged to follow these SBA blue towards the north. At the service is set up so that workers and employees can reach the nearest SBA

4.6 Advanced Countermeasures:

In penangulangan was undertaken after or simultaneously with the initial response to the steps as follows:

- Paramedics immediately combed the field with first aid equipment on the accident (P3K) which has provided with an ambulance ride to find workers who have gathered in the briefing safe area (SBA) and evacuate to safe briefing area (SBA).
- field commander rushed to muster points CPA, wear protective gear and coordinate with emergency response team (ERT) and conducted an analysis of the problems that occur and determine the equipment and personnel necessary to control the situation.
- deputy field commander soon master menu point CPA, wear protective gear and coordinate with field commander. As well as done some preliminary investigations on the problem and take appropriate action in addressing the problems.
- Tim emergency response team (ERT) to the muster point and wear protective gear, and assist deputy field commanders to investigate problems, coordinate and execute the instructions of deputy field commander.

Conclusion:

Based on research that has been done can be concluded as follows: Assessment hazard operability study showed that of the data maintenance and process data that has been processed obtained HAZOP which mangacu on guideword and can further assessed risk in the low category = 5, the risk in the category of moderate = 3, in the category of high risk = 1, and the risk for the category Catastropic = 0. to improve system security needs to be improved intensity of inspection and maintenance as it has made recommendations HAZOP and implement emergency response plan, so that the security and safety of workers and employees can be guaranteed when there is a failure as a result of PV-9900 separator explosion.

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