Implementation of the Hazard and Operability Study (HAZOPS) Method in the Sedimentation Unit of the Gas Industry Wastewater Treatment Plant

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Abstract
The gas industry generally uses Triethylene Glycol (TEG) to extract the water content in natural gas. TEG that has been used can be reused by means of regeneration. . This process has a side product, namely water vapor. The water vapor produced from the regeneration process can be used for sanitation purposes by changing the phase to liquid (water). Water produced from regeneration must go through the stages of wastewater treatment before being used because it contains impurities. One of the stages of wastewater treatment is settling which includes flocculation and coagulation. The sedimentation process is one of the sources of danger in wastewater treatment. Sources of danger in the deposition process can come from added chemicals, mixing processes that occur due to reactions between chemicals and the use of agitators which, if not appropriate, can cause process failure or danger to workers. Hazard identification techniques are needed in the deposition process to prevent process failures or work accidents. In this research, hazard identification was carried out using HAZOPs. The risk assessment of the settling unit in the gas industry wastewater treatment plant shows that there are 2 medium risks and 2 low risks namely low flow rate and high rotational speed.

***Keywords*:** *Sedimentation, HAZOPs, Flocculant, Coagulant*.

Abstrak
Industri gas umumnya menggunakan Triethylene Glycol (TEG) untuk mengambil kandungan air pada gas alam. TEG yang ditelah digunakan bisa digunakan kembali dengan cara melakukan regenerasi. Proses ini mempunyai produk samping yaitu uap air/ vapor. Uap air yang dihasilkan dari proses regenerasi bisa dimanfaatkan untuk keperluan sanitasi dengan cara mengubah fase menjadi liquid (air). Air yang

dihasilkan dari regenerasi harus melalui tahapan pengolahan air limbah terlebih dahulu sebelum digunakan karena memiliki kandungan pengotor. Salah satu tahapan pengolahan air limbah yaitu pengendapan yang mencakup flokulasi dan koagulasi. Proses pengendapan merupakan salah satu sumber bahaya di pengolahan air limbah. Sumber bahaya pada proses pengendapan dapat berasal dari bahan kimia yang ditambahkan, proses pencampuran yang terjadi karena ada reaksi antar bahan kimia dan penggunaan agitator yang apabila tidak sesuai dapat menimbukan kegagalan proses atau bahaya bagi para pekerja. Teknik identifikasi bahaya diperlukan pada proses pengendapan untuk mencegah terjadinya kegagalan proses ataupun kecelakaan kerja. Pada penelitian ini dilakukan identifikasi bahaya dengan menggunakan HAZOPs. Penilaian risiko pada unit pengendapan di instalasi pengolahan air limbah industri gas menunjukkan bahwa terdapat dua tingkat risiko sedang yaitu kecepatan dan tekanan tinggi dan dua risiko rendah yaitu laju alir rendah dan kecepatan putar tinggi.

Kata Kunci: *Pengendapan, HAZOPs, Flokulan, Koagulan*.

1. Introduction

This increasingly large population growth means that daily living needs are also increasing so that the number of industries emerging is also increasing. As the number of industries increases, the potential for pollution and damage to the environment also increases. If it continues to be ignored and no handling is carried out, it will cause disruption to the balance of the ecosystem around the industry. Efforts to handle this require basic steps and actions and principles starting from the planning stage, in order to prevent large losses for the company (Tarwaka et al, 2004). Currently, there are many government regulations that regulate environmental pollution problems due to industrial activities. One of them is Law No. 23 of 1997 concerning environmental management by every company in carrying out its business activities and the consequences that must be borne if they pollute the environment. (Simamora & Kurniati, 2007)

The gas industry is one of the companies that produces waste in its production process. The gas industry generally uses TEG (Triethylene Glycol) to extract the water content in natural gas. TEG that has been used can be reused by means of regeneration. TEG which contains a lot of water vapor called rich glycol is then heated in a reboiler so that the water vapor evaporates and the TEG in the liquid phase is ready to be used again. This process has a side product, namely water vapor. The water vapor produced from the regeneration process can be used for sanitation purposes by changing the phase to liquid (water).

Water produced from regeneration must go through the stages of wastewater treatment before being used because it contains impurities. One of the stages of wastewater treatment is settling which includes flocculation and coagulation. At this stage, coagulation and flocculation processes will occur. Coagulation is the stage of water treatment where solid matter which has a very small size will float above then colloids combine and change shape into flocs which have a larger size because chemical agents have been added. Flocculation is the removal of turbidity in water by making small sized particles turn into large sized particles. The force on each molecule that is obtained from stirring is one of the elements that has an impact on the rate of manufacture of floc particles (Susanto, 2008).

In the sedimentation tank (B303) coagulation and flocculation processes occur by adding chemicals. In this deposition process there are several types of chemicals added to assist the process and agitators that can help form flocs. The sedimentation process is one of the sources of danger in wastewater treatment. The source of danger in the deposition process can come from added chemicals, the mixing process that occurs due to reactions between chemicals and the use of agitators which, if not appropriate, can cause process failure or danger to workers.

The aim of this research is to identify potential environmental risks in the liquid waste processing process so that the causes of these potential risks can be identified. Once the causes of potential environmental risks are known, prevention of the most dangerous potential environmental risks can be carried out. So it is hoped that liquid waste disposed of into the environment will comply with existing quality standards and not disturb environmental balance.

Hazard identification techniques are needed in the deposition process to prevent process failures or work accidents. In this research, hazard identification was carried out using HAZOPs. Hazard and Operability Study (HAZOP) is a qualitative technique to identify potential hazards that will occur using a series of guide words.

HAZOPs can be easily utilized for various process steps. In addition, it can be used for actual equipment or equipment that has been previously installed and operates at any time. Its application is also more widely used, apart from identifying the machine and/or components to be observed, this technique can also be used to determine the stages and jobdesk of an operation, so that hazards caused by the human factor can be identified. The use of HAZOPs is also to obtain data on non-conformances that arise, so that controls can be implemented to minimize risk (Mey, 2014). The HAZOPS technique aims to systematically analyze the system in a process or operation unit, and to provide information on the probability of a failure occurring which could pose a hazard (Pujiono, 2019). HAZOPs are done by making several words that can guide the detection of existing non-conformances and how big the consequences are (Hari, 2014).

2. Method

This study focuses on risk analysis on occupational safety and health aspects in the deposition unit. Risk analysis uses the HAZOPs study with the stages of determining the scope, deviation, keywords, and controls carried out. The variables use for thi research are flow, pressure and rotating speed. Figure 1 is a flowchart of HAZOPs. In the early stages of the research, P&ID analysis was carried out regarding the stages of the screening process carried out by the gas industry, then collecting data related to processes, equipment and maintenance data.

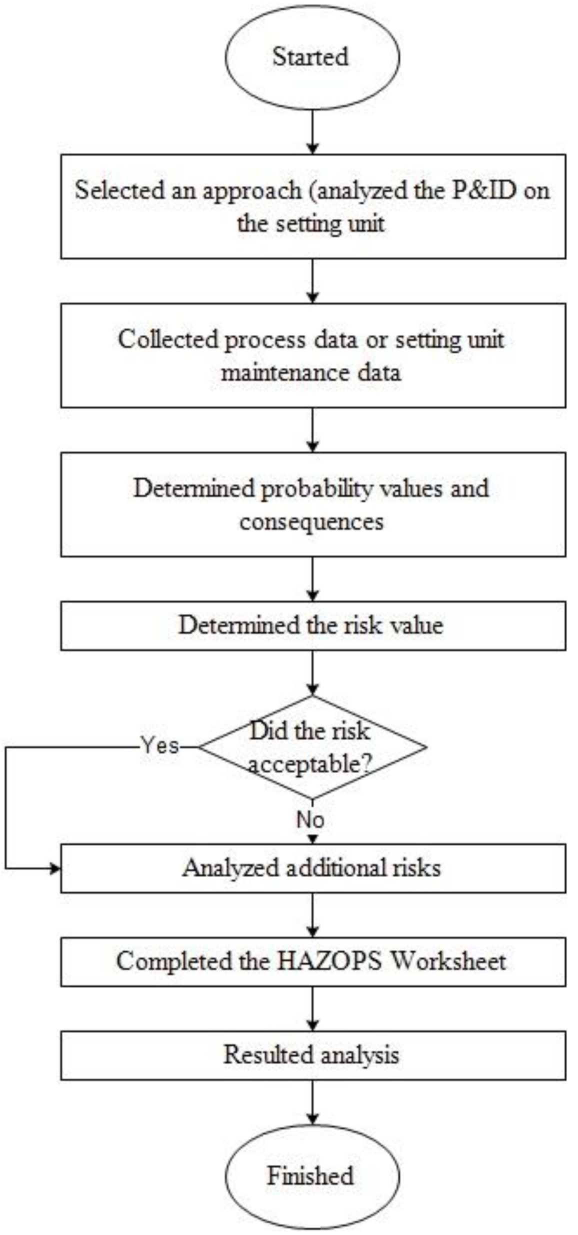

Figure 1. HAZOPs Flowchart

All data that has been obtained is then processed so that it is known that some deviations occur in the process to determine the probability value (can be seen in Table 1) and the consequences (can be seen in Table 2) according to Australian/New Zealand standards while determining the risk value can be seen in Table 3 If the risk is still acceptable, the next step is to prepare a HAZOPs worksheet. If the risk is unacceptable, it is necessary to analyze additional risks before conducting an assessment of the HAZOPs worksheet. The final stage is to analyze the results of the HAZOPS worksheet. The stages carried out in this research include:

1. Preliminary survey, aims to find out in general about the filtering process in wastewater treatment, gas processing industry.
2. Literature study, aims to collect material and theory for the study of HAZOPs
3. Completion of the HAZOPs worksheet, in the form of filling in study nodes, deviations, parameters, guide words, risk assessment, and risk control.

Determination of nodes is done by dividing the facility into process systems and subsystems (Jeffrey, 2006). Guidewords are words that are easy to use for qualitative or quantitative design and as a guide and simulation of the brainstorming process to identify process hazards. HAZOPs preparation was also carried out by brainstorming between the drafting team and also with company experts (Rausand, 2004). Risk assessment is carried out based on the multiplication between the consequences and likelihood. Consequences and likelihood levels were determined qualitatively by comparing expert opinions.

Consequences assessment uses a scale of 1-5 as shown in Table 1 while the level of likelihood can be seen in Table 2 which is adapted from the Australian/New Zealand standard (AS/NZS 4360:2004).

Table 1. Level of Consequence

Level	Descriptor	Description
1	Insignificant	The system operates & safe, there are a few insignificant disturbances
2	Minor	The system remains operational & safe, disturbances result in a slight decrease in performance or disrupted system performance
3	Moderate	The system can operate, failure can cause the machine to lose its main function and or can cause product failure
4	Major	System cannot operate. Failure can cause a lot of damage to assets and systems can lead to product failure and or not meeting the requirements of work safety regulations
5	Catastrophic	The system is not feasible to operate, the severity is very high if the failure affects a safe system in violation of work safety regulations

Table 2. Level of Likelihood

Level	Description	Description
A	Almost certain	The risk occurs more than 5 times in 5 years
B	Likely	The risk occurs 4-5 times in 5 years
C	Moderate	The risk of occurring more than 3 or less than 4 in 5 years
D	Unlikely	The risk occurs 2-3 times in 5 years
E	Rare	Risk rarely appears / occurs less than 2 times in 5 years

Risk assessment is carried out based on the multiplication between the consequences and likelihood by using the risk matrix on the Australian/New Zealand standard. (AS/NZS

4360:2004). This risk matrix divides risk into four levels, namely low, medium, high and very high as summarized in Table 3.

Table 3. Risk Matrix

Likelihood	Consequences				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Medium	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	Medium
Rare	Low	Low	Low	Low	Medium

3. Result and Discussion

The settling process is a process of releasing solids from liquids so that they separate into clear liquids and sludge. The deposition process uses gravity to leave the suspension so that a clear precipitate and solution occurs (Joseph, 2020). The precipitation process went well because it was assisted by the addition of 3 types of chemicals and agitatitang process.

The sedimentation process is carried out by pumping the settled water using a feed pump (P-301A) to the reactor (B-303). Three types of chemicals each placed in a chemical measuring tank (T-308, T309 and T310) entered the B303 reactor. Potential hazards can be studied in the system by filling in the HAZOPs worksheet in Table 4.

Table 4. Worksheet HAZOPS

Deviation	***Cause***	***Consequence***
Less Flow	1. Pump Failure 2. There are leak pr crack in the chemical or waste water inlet pipe	1. There is no water entering the B-303 reactor 2. The amount/concentration of chemicals decreased as a result of the P303 A/B and P304 A/B pumps being damaged
More Flow	1. The Feed flowrate is too large and corrosive	1. Cause overflow 2. Reaktor B303 damaged by corrosives
More Pressure	1. Vapor that comes from the rest of the condensation process cannot get out 2. High speed rotating in B303	1. Increased Pressure Reaktor B303 damaged by overpressure
More Rotating Speed	1. The speed of M310 mixer uncontrolled	1. A vortex occurs in the deposition process so that the impurities cannot dissolve

The HAZOPs study that has been carried out at the filtering unit of the gas industry wastewater treatment plant shows that there are four types of deviation that can occur, including less flow, more flow, more pressure, and high rotating speed. Each of these deviations can cause the risk of failure and malfunction of the settling unit. The risk of failure is also capable of causing failure in the deposition process. This is in accordance with research by Nurul Hardianti (2017) who identified failure factors in the waste processing process consisting of changing waste discharge, homogenization less evenly distributed due to the influence of the mixer and overflow occurs due to high pressure. Therefore it is necessary to carry out a risk assessment which will be shown in Table 5.

Table 5. Risk Assessment

Deviation	***C***	***L***	***R***	***Recommendation***
Less Flow	4	E	L	*1.* Use *safety valve* 2. Conduct periodic inspections and repairs
More Flow	3	D	M	1. Conduct periodic inspections and repairs 2. Setting flow controller 3. Setting level indikator
More Pressure	4	D	M	1. Setting pressure *relief valve*
More Rotating Speed	4	E	L	1. Installation of the rpm measurement sensor on the M301 stirrer 2. Periodic performance checks

Note: L (likelihood of hazard occurring), C (intensity of consequence should the hazard occur) and R (overall risk rating). E and D (see Table 2). L and M (see Table 3)

The risk assessment of the settling unit in the gas industry wastewater treatment plant shows that there are 2 medium risks and 2 low risks. In preparing these HAZOPs, appropriate control recommendations are also given, or deciding what actions are needed to control hazards or operability problems (Mey, 2014). Therefore, even though the four risks are still acceptable, control is still needed in the form of adding alarms, valves, and routine maintenance scheduling so that the production process can run smoothly and safely. The following is the P&ID according to the recommendations that have been given as shown in Figure 2.

In Figure 2 several safety devices and controllers have been installed in the settling process unit. B303 (Reactor tank) is installed with safety in the form of a pressure safety valve (PSV) so that if there is overpressure in the pump the valve will open to remove excess pressure so that deviations that occur in the process can be controlled. In addition, the T308, T309 and T310 also have a flow controller (FC) that can adjust the flow rate so that overflow does not occur. The indicator installed is level indicator (LI) which function to determine the temperature of the liquid passing through the pipe and the height of the liquid so that there is no excess content in the tank. The main element of the pressure relief system is the pressure relief device (SV/PSV/PRV/BDV). The type of instrumentation equipment for measurement generally consists of 4 process quantities, namely pressure measurement, temperature measurement, flow measurement and liquid surface measurement. (Murie, 2021).

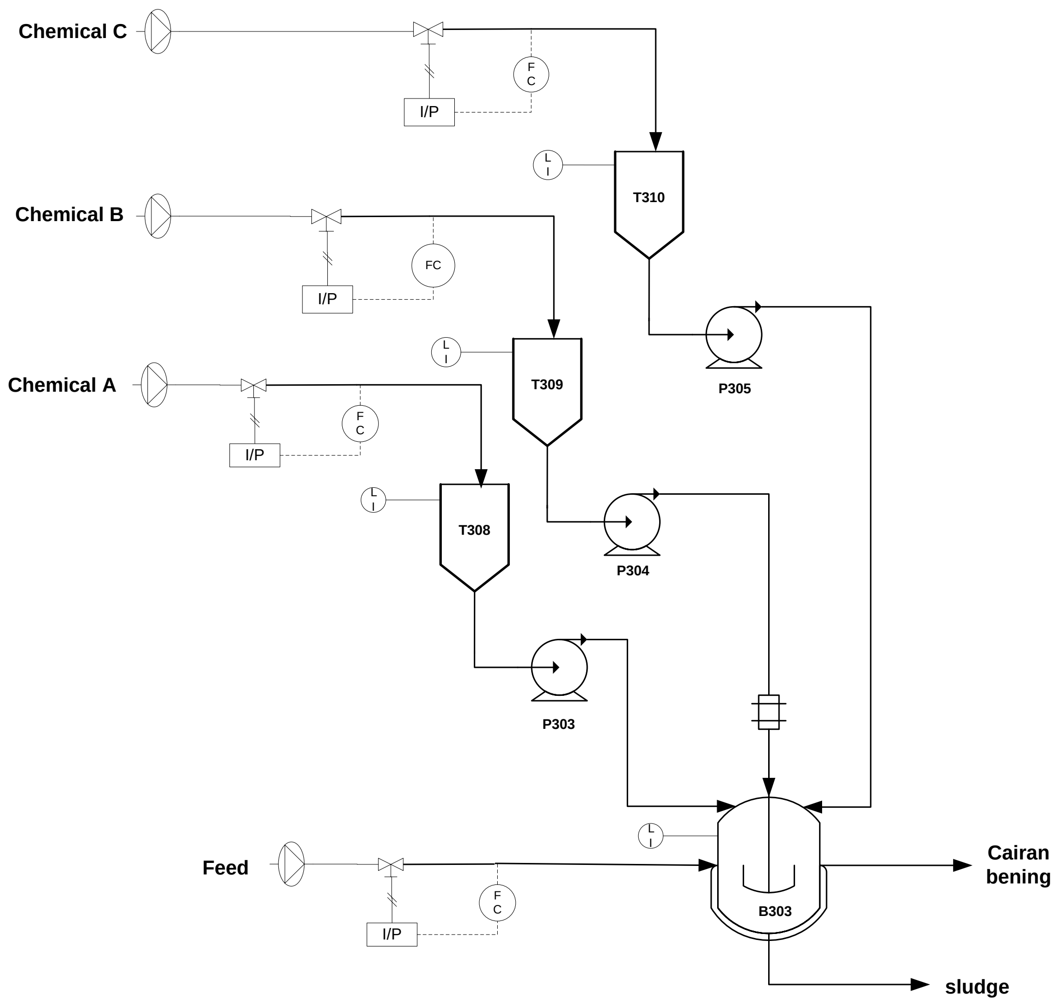

Figure 2. P&ID Sedimentation Process

4. Conclusion

The risk assessment of the settling unit in the gas industrial waste water treatment plant shows that there are 2 moderate risks, namely the occurrence of over flowrate and over pressure and then there are also 2 low risks, namely the occurrence of low flowrate and more rotating speed in accordance with research by Nurul Hardianti (2017) who identified failure factors in the waste processing process consisting of waste flowrate, the influence of the mixer and large pressure which causes overflow.

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