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Study of HAZOPs in the Screening Unit of the Industrial Gas Wastewater Treatment Plant

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A B S T R A C T

The filtration is the final stage of industrial gas wastewater treatment for clean water generation. Filtration is an operation of separating solid and liquid materials by filter medium. In filtration process the driving force such as pressure difference by gravitation or rotary power cause the feed to flow. The process parameters in the filtration process need to be monitored and controlled because deviation or abnormality of the process parameters will cause operating failures. This condition requires a more in-depth identification so that the risks of operating failures can be minimized. HAZOPs is a method to identify hazard that caused by deviation of parameters using guide words. Steps of the research consisted of early survey, literature study, and filling the HAZOPs worksheet such as determine study node, deviation, parameter, guideword, risk evaluation, and risk control. The results of the study show that there were four potential deviations from three parameters which were flow, pressure, and temperature. Risk values analysed were medium and low. Recommendation of the system are adding alarm, valve, changing filter regularly, and scheduling the routine maintenance.

Introduction

The absorption process is one part of the production process in a natural gas processing plant. One process that utilizes the absorption process is the dehydration process, which aims to avoid the hazards associated with pipeline transportation and wet gas processing. However, this process is not free from problems, including corrosion, water condensation, and blockages formed by ice or gas hydrate [1]. Water vapor can also increase the corrosivity of natural gas, especially when the gas is acidic [2]. One way to prevent hydrates from occurring is to reduce or even eliminate the water content in natural gas. Therefore, it is necessary to process water absorption by an absorbent that is considered quite effective. Glycol is an excellent absorbent for water because the hydroxyl groups in glycol form bonds similar to water molecules [3]. The absorption process using a type of glycol, namely TEG (Triethylene Glycol), is one way to prevent the formation of hydrates and corrosion [4]. Most natural gas producers use Tryethylene Glycol (TEG) to remove water from natural gas streams because TEG is quickly regenerated.

TEG, which contains a lot of water vapor, is called rich glycol which is further processed again (glycol regeneration). Rich glycol is heated in the reboiler, so the water vapor evaporates, and the TEG remains in the liquid phase. The TEG that has been cleaned of water vapor will be reused. This process has a side product, namely water vapor. Water vapor contains impurities and has a strong odor. So far, to overcome the water vapor is utilizing combustion. The combustion process has the potential for fire & unplanned shutdown, wastes fuel, and causes air pollution. To overcome this, the water vapor will condense and go through the wastewater treatment process to become clean water that can be reused for sanitation purposes. The final stage in the wastewater treatment process is the filtering process with sludge filters and carbon filters to produce clean water.

Filtration is the process of separating solids from fluids. In the domestic sewage treatment process, the purpose of filtration is to remove suspended and colloidal particles by filtering them with filter media [5]. Wastewater passes through 3 stages of filtration, including:

a) Sludge filter (F301): at this stage, a sack is used as a filtering medium so that the sludge is retained in the sack and clean water can pass through to the next stage
b) Water filter (F302): at this stage, a cartridge filter is used so that impurities that have a small size can be retained and clean water can pass
c) Carbon filter (F303): Carbon works by absorption or adsorption. When any material passes through the activated carbon, the material contained in it will be absorbed on the carbon surface so that impurities in the water can be removed.

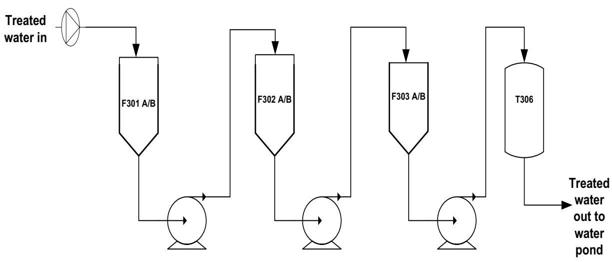

Figure 1. Filtration Process PFD

The following is an overview of the PFD of the process described above. The processing stage has just been made. Therefore, it is necessary to identify the hazard using a HAZOPs study suitable for the process industry. Hazard and Operability Study (HAZOPs) is a qualitative technique to identify potential hazards that will occur using a series of guide words.

HAZOPs can be used practically for various stages of the process. In addition, it can also be used for new equipment or equipment that has been previously installed and can be used all the time. In addition to identifying the machine and components to be analysed, this method can also be used to determine procedures and instructions for an operation so that failures originating from the human factor can be identified.

HAZOPs are used to determine deviations in existing process parameters so that control can be carried out to minimize the impact that occurs [6]. The HAZOPs method's purpose is to systematically review a process or operation in a system and determine whether irregularities can push the system towards unwanted accidents or not [7]. The work on HAZOPs uses a series of guiding words to identify deviations that have occurred and what consequences they will have [8]. The following are the advantages of the HAZOPs method: very helpful for analysing non-quantifiable hazards.

- Analysis of hazards and operational problems of systems or processes is carried out in a systematic, detailed, and comprehensive manner
- Generate preventive actions or prevention of risk events and control measures for the consequences of risk events
- Can be applied to various systems, processes, and procedures
- Producing the written recording and documentation that had been passed the feasibility test [8].

METHOD

This study focuses on occupational safety and health risk analysis in industrial gas processing wastewater treatment plants. Risk analysis uses the HAZOPs study to determine the scope, deviation, keywords, and controls carried out.

In general, the stages carried out in this study include:

1. Preliminary survey aims to find general information about the filtering process in the wastewater treatment and 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.

While the stages for working on HAZOPs can be seen in Figure 2. In Figure 2, it can be seen that the initial stage of work was to carry out a P&ID analysis related to the steps in the screening process carried out by the gas industry, then collect data related to operations, equipment, and maintenance data. Based on the data, it is known that some deviations occur in determining the probability value (Table 1) and the consequences (Table 2) according to Australian/New Zealand standards [9]. Determining the value of risk can be seen in Table 3. If the risk is still acceptable, the next step is to prepare the HAZOPs worksheet. If the risk is unacceptable, it is necessary to analyse additional risks before assessing the HAZOPs worksheet. The final stage is to analyse the results of the HAZOPs worksheet.

It is very important to determine nodes in the HAZOPs method by dividing the facility into process systems and subsystems [10]. 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. The preparation of HAZOPs was also carried out by brainstorming between the drafting team and company experts [11]. Risk assessment is 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 Likelihood Level can be seen in Table 2 which is adapted from the Australian/New Zealand standard [AS/NZS 4360:2004].

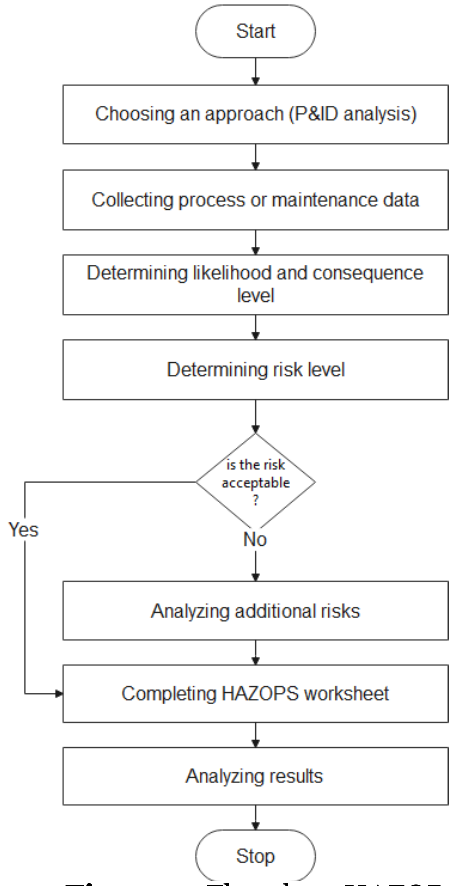

Figure 2. Flowchart HAZOPs

Table 1. Consequence Level

Level	Descriptor	Description
1	Insignificant	The system operates & is safe, there are a few insignificant disturbances
2	Minor	The system remains operational & safe, disturbances result in a slight decrease in performance or system performance is disrupted
3	Moderate	The system can operate, failure can cause the machine to lose its main function and / 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 / 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. Likelihood Level

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 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: low, medium, high, and very high, as shown in Table 3. The risk level is obtained from Table 3 by multiplying the likelihood value by the consequences.

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

RESULT AND DISCUSSION

Filtering is a mixture separation operation between solids and liquids by passing solid, and liquid feeds through a filter medium. For all screening processes, the feed flows due to a propulsive force in the form of a pressure difference, for example, due to gravity or torque. Generally, filtering is done when the amount of solids in suspension is smaller than the liquid [12].

Wastewater that has received a settling process enters the sludge filter tank (F-301 A/B). At this stage, sludge filtering (large-sized particles) occurs then the wastewater that is free from sludge is pumped into the water filter (F-302 A/B) and proceeds to the carbon filter (F-303 A/B) then channeled towards the treated water tank. The treated liquid waste stream will then be accommodated in the control tub as the final test before being used again [14]. Potential hazards can be assessed in the system by filling in the HAZOPs worksheet in Table 4.

Table 4. Worksheet HAZOPS

Deviation	***Cause***	***Consequence***
Less Flow	1. P-302 A/B pump failure 2. There is a leak or crack in the pipe	1. The is no water in *sludge filter* F-301 2. There is no water in *water filer* F-302 A/B 3. The is no water in the *carbon filter*
More Flow	1. Pump failure	1. Water rises beyond tank capacity 2. It can cause flooding 3. More water can harm the pump
More Pressure	1. Pump failure 2. Backflow occurs in the pump, if the pressure at the discharge of the pump increases.	1. Increase temperature 2. Can damage the pump
High Temperature	1. The weather is hot or there is a fire outside the machine	1. Increased pressure and temperature can cause damage to the pump

Table 5. Penilaian Risiko

Deviation	***C***	***L***	***R***	***Reccomendation***
Less Flow	4	E	L	*1.* Use *safety valve* 2. Conduct regular inspection and repair
More Flow	3	D	M	1. Regular check 2. Install a high flow alarm on the pipe 3. Install a high-water alarm 4. Replace the filter regularly
More Pressure	4	D	M	1. Add pressure *relief valve*
High Temperature	4	E	L	1. Install a high temperature alarm .

HAZOPs studies carried out at the filtering unit of industrial gas wastewater treatment plants show 4 types of deviation that can occur, including less flow, more flow, more pressure, and high temperature. Each of these deviations can cause the risk of failure and malfunction of the wastewater treatment system. The risk of failure is also capable of causing a decrease in the quality of the gas produced at the factory.

Therefore, it is necessary to carry out the risk assessment shown in Table 5.

The risk assessment on the filtering unit of the industrial gas wastewater treatment plant shows that there are 2 moderate risks and 2 low risks. In preparing these HAZOPs, recommendations for proper control are also given, or deciding what actions are needed to control hazards or operability problems [13]. Therefore, although the four risks are acceptable, control is still needed by adding alarms, valves, routine filter replacement, 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 3.

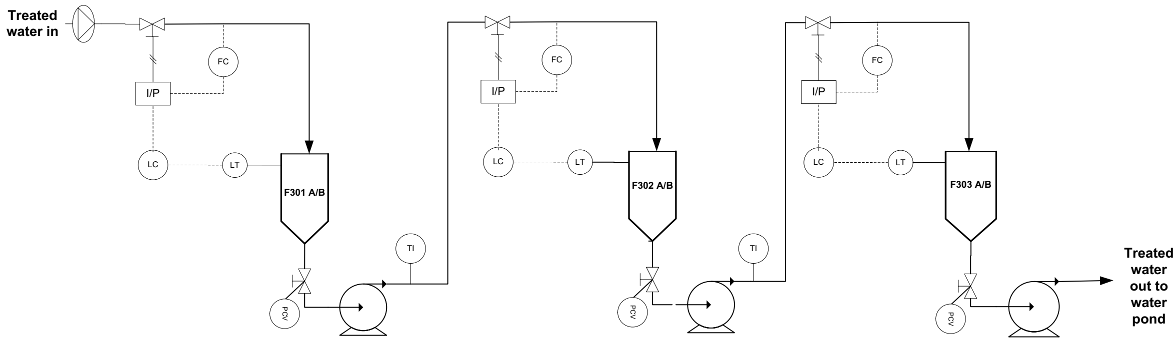

Figure 3. P&ID Proses Penyaringan

In Figure 3, several safety devices and controllers have been installed in the screening process unit. In the F301 A/B (sludge filter unit) and F302 A/B (water filter unit), a safety valve is installed in the form of a pressure relief valve (PSV) so that if there is overpressure, the pump valve will open to remove excess pressure caused by residual gas that is still present in the condensation stage so that the deviations that occur in the process can be controlled. Safety Valve, or Pressure Safety Valve (PSV), is an automatic pressure relief device driven by static pressure upstream of a valve with full opening or popping characteristics. Safety valves are used primarily for gas or vapor fluids [14].

In addition, the F301 A/B, F302 A/B, and F303A/B also have a flow controller (FC) that can adjust the flow rate so that overflow does not occur. The indicators installed are the temperature indicator (TI) which functions to determine the temperature of the liquid passing through the pipe, and the level indicator (LI), which acts to determine the liquid level, so that excess contents do not occur in the tank. Installation of control instrumentation in the process ensures the process stability of a circle and suppresses external disturbances [14].

All safeguards that have been installed must be written down on the HAZOPs worksheet. Safeguards are efforts to protect, namely the existence of preventive equipment that prevents the causes or measures to protect against the consequences of losses. Safeguards also provide information to operators about deviations that have occurred and also to minimize the effects [15].

Conclusion

This research was conducted at a wastewater treatment plant in the gas processing industry. Some of the processes in the WWTP are condensation, settling, and filtering processes. But this article will only be about filtering units. Filtration is an attempt to separate a mixture of solids and liquids. Some of the equipment in the filtering unit includes pumps, water filters, and carbon filters. HAZOPs study was conducted on the process flow and resulted in 2 low-risk and 2 medium-risk. Additional controls that can be carried out on the unit are the addition of alarms, valves, regular filter replacement, and routine maintenance scheduling.

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