Risk Assessment of Gas Pipeline using Risk based Inpection and Fault Tree Analysis

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Abstract: During the operational period on the gas pipeline network there are many potential damage that can result in pipeline failure. The pipeline operators need to perform risk analysis by identifying the damage, determining probability parameters, the consequences of pipeline failures and performing risk calculations so as to know the pipeline network risk profile and the impact for the people, the environment, assets, and reputation of the company. More effective inspections can reduce the risk level by reducing the frequency of future failures, through corrective and preventive action. In general, the purpose of this method is to screen all equipment in an operating unit of a facility to identify areas of high risk, calculate the risk value of all equipment in the operating unit of the product calculation of probability of failure and consequence of failure, determine the priority of equipment requiring inspection based on the calculation of risk, develop an appropriate and effective inspection program and manage the risk due to failure of an equipment and determine the mitigation method to reduce the risk. This study aims to conduct risk assessment that can be used further to minimize the failure that occurs in gas pipeline. The method used is risk-based inspection (RBI) to plan risk-based inspections by comparing probabilities and consequences, arranged in a risk matrix to obtain the level of risk. And the root cause of failure is investigated by using fault tree analysis (FTA) method which to identify the causes of failure in depth, identify weaknesses in a system, assess and propose for reliability or security, to identify the impact of human error, prioritize failure contributors, to identify effective upgrades to the system, to gauge the probability of failure and to optimize the test and maintenance so that the prevention solution can be found. Potential risks that cause the failure are congenital defects, less routine maintenance, operating frequency, easy to dust, material age, difficult to reach the places and less reliable operators. So the cause of the damage is human, equipment maintenance and environment.

1 INTRODUCTION

PT X is a gas transporter company which is a consortium between a state-owned company and a foreign company in operating distribution pipes in DKI Jakarta area. The pipeline drains gas for domestic industry needs. The onshore pipeline for the domestic industry began operations in 1988. The pipe which has a diameter of 16" is an API 5L-X52 pipe with a certain thickness that is adjusted to the ROW (Right of Way) location class. During 14 years of the operational period there were many potential damages which could result the failure of pipeline. One of the pipe failure that occurred at the end of 2010, the pipe has broken. A pipe rupture occurs in one of the pipe segments located in Riau area which results the supply of gas to an oil company stopped. This incident became great attention of the Indonesian government, because with the rupture pipeline the national oil supply was stalled which resulted in huge losses to the state, pipeline operators company, or gas users.

The repair process that was carried out due to the failure of pipeline caused the operation of the pipeline and gas supply to consumers stopped for several days. This has become the main concern of management and the government to further improve the integrity of the pipeline in pipeline operation. In addition to the cessation of gas supply to customers, failure in the gas pipeline transportation system, both onshore and offshore, results in several risks that endanger humans and the surrounding environment in the event of a leak or explosion. These failures can be caused by several factors, including damage to the lining of the pipeline (coating), duct pipe (denting), leakage (leaking),

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ruptured pipelines, or due to external interference (third party activity) which can lead to pipe failure.

With that background, the application of risk management and data / information management that is applied in Risk Based Inspection (RBI) is expected to be used as a system in developing efficient and effective strategies in the operation of pipelines to transport natural gas to customers.

Several studies and discussions have been conducted to discuss risk management both in the pipeline, platform and on systems that generally have a high operational risk for gas companies.

Regarding the risk calculation method has been discussed which presents an integrated quantitative risk analysis method in the gas pipeline network (Han Z.Y & Weng W.G, 2010). The method consists of probability assessment, consequence analysis, and accident risk evaluation. In addition comparative risk assessments are carried out using qualitative and quantitative methods. In the qualitative method, index selection is based on statistical analysis of the database of accidents that have occurred with the calculation of weight according to the theory of reliability engineering and the gray correlation theory (Han Z.Y & Weng W.G, 2011) While the quantitative risk assessment method, the possibility, and consequences of different accidents are analyzed and integrated.

The importance of pipelines that operate and integrated well, a special strategy is needed so that the pipeline network can operate properly and safely. Risk analysis conducted in the RBI and also the FTA discussed in this thesis is expected to help pipe operators in determining the right method so that the pipeline can operate properly and safely through inspection, maintenance, and repair activities (repairs if needed) which is carried out regularly in accordance with certain rules and time periods based on risk analysis (Tan Zhaoyang, Li Jianfeng, Wu Zongzhi, 2011). In order for more optimal implementation, it is necessary to integrate well between the operating area of the pipe segment with one another, whether from data, information, or implementation schedule based on proper risk priority analysis. The application of RBI and also FTA can provide reliability and maintainability to pipeline operations through proper inspection strategies and maintenance procedures that can minimize risks and provide added value and profit to the pipe operator both in terms of availability and pipe productivity..

This research was conducted to analyze the risks in the gas pipeline. The field study was conducted in one of the gas companies by collecting data, measuring wall thickness on the gas pipeline API 5L X-52 using a T-Gauge V, where the measuring instrument has been calibrated. Data of damage that has occurred previously was also collected as supporting data. Preparing measurement objects where there are 2 gas pipeline objects, GG Macan - Citraland – Batas DKI line with a length of 7514 meters. Gas pipeline measurements are carried out at the time of dismantling. Then the measurement results data is collected, making a risk assessment by calculating the probability of damage and consequences of damage, identifying the cause of the damage, then determining the appropriate inspection step based on the results of the calculation of the risk. The RBI method used in this study is semi-quantitative based on the risk matrix. And also the FTA method to find out the root cause of the damage in detail. Once that is obtained, an analysis process is carried out to get a careful inspection plan recommendation.

2 METHODOLOGY

Pipeline Risk Management is one of the systems used to regulate the strategy of a pipeline network system by looking at the potential risks that exist so that the pipeline system can still flow fluid to customers according to the specified capacity nomination (Kent M.W, 2004). Every pipeline operator or company that has a pipeline does not want a work accident (zero incident target) as long as the pipeline operates. Conducting pipeline integrity management by looking at potential risks is the main objective and all pipeline operators. This method continues to be developed sustainably by and for pipe operators by providing the necessary information and then implementing it in an integrated manner through practical programs that have proven effective in the oil and gas industry. The practical program is conditioned and applies to all pipelines both onshore and offshore, depending on the information data available. This method has been refined into 5 steps, and their detailed explanation is given below.

Step 1: Hazard Identification. Pipe integrity is mechanically determined by the type and size of defects / defects or the presence of anomalies in the pipe. Understanding the mechanism and behavior of defects is very important to make the right plan to reduce the level of pipe failure and improve the safety of pipeline operations.

Step 2: Fault Tree Analysis. This method is carried out with a top down approach, which begins

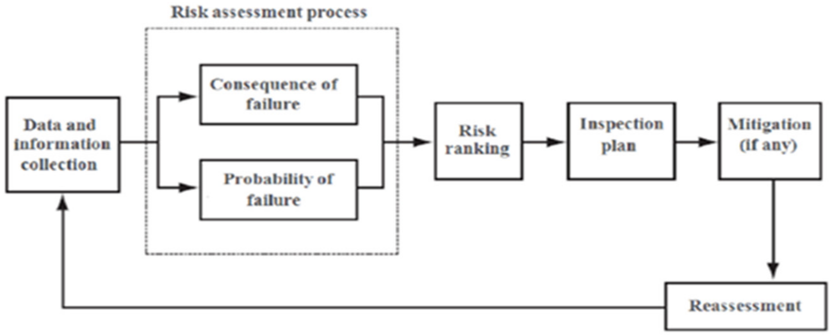

Figure 1: Risk Based Inspection Process.

with the failure or loss assumption of the top event then details the causes of a top event until a root cause failure (B. Vesely, 2002). FTA is a technique to identify failures of a system. FTA is function oriented or better known as "top down approach" because this analysis starts from the top level and passes it down. FTA is a technique for connecting several series of events that produce another event (Sunaryo, M. Aditya Hamka, 2017).

Step 3: Risk Analysis. The risk is the probability of an event that can cause loss or failure or potential failure. Whereas in general the danger is described as a characteristic and a group that will cause potential losses (Tan Zhaoyang, Li Jianfeng, Wu Zongzhi, 2011) It is very important to make a difference between danger and risk, because basically risks can change without changing danger. So the point is that risk can be reduced by identifying and minimizing existing risks.

Step 4: Risk Based Inspection. Risk Based Inspection is a method that uses levels risk as a basis for prioritizing and regulating an inspection activity. The potential advantage of this RBI method is that it can increase the operating time and work of a process facility where at the same time there is an increase or at least maintenance at the same level of risk (American Petroleum Institute, 2000) . The purpose is to determine the possibility of an incident occurring the probability and the impact of the consequence also to identify defects or defects that can cause large-scale accidents before they occur.

Step 5: Corrosion Rate Determination. Calculation of corrosion rate for pipes using API 570, the formula for determining the corrosion rate is determined by Eq. 1.

$$\textbf{Corrosion rate} = \frac{t_{prvious-}\, t_{actual}}{time\ between\ t_{prvious\ and}\, t_{actual}} \quad (1)$$

Where : t_{actual} = thickness at current inspection (inch)

$t_{previous}$ = thickness on previous inspections (inch)

The data needed to calculate the corrosion rate is the thickness measured at previous inspections, the thickness measured at the current inspection, and age inspection (K. Elaya Perumal, 2014). This corrosion rate serves to determine the remaining life of pipe. The remaining life can be interpreted as the tolerance of equipment to the type damage. This remaining life will determine the interval time for next inspection. The formula of remaining life is determined by Eq. 2.

$$\textbf{Remaining life} = \frac{t_{actual-}\, t_{required}}{corrosion\ rate} \quad (2)$$

Where : t_{actual} = thickness at current inspection (inch)

$t_{required}$ = minimum thickness that should be owned by the pipe

Step 6: Calculation of ar/t. Ar/t calculation (damage factor parameter) functions in determining factors thinning damage. Determination of ar/t is obtained from time (a), corrosion rate (r), and also thickness (t). This calculation is equivalent to the fraction of the wall loss due to thinning. The formula for a /t calculation is determined using the Eq. 3.s

$$\textbf{ar/t} = \frac{Equipment\ service\ x\ corrosion\ rate\ (inch\frac{h}{years})}{original\ thickness}$$

3 RESULTS AND DISCUSSION

All data taken from PT. PGAS Solution in Jakarta. PT. PGAS Solution provides limited data due to classified confidential data from a company, so based on the data obtained can use an analysis in the form of semi-quantitative analysis. The type of inspection carried out during inspection is in the form of visual inspection. This visual inspection is an external inspection that is inspecting from outside of the pipeline. Because the results are in the form of thickness data, this inspection uses a measuring instrument, the T-Gauge V which is used to measure the thickness of gas pipeline. Results of comparison of each sample can be seen in Fig. 2 and Fig. 3.

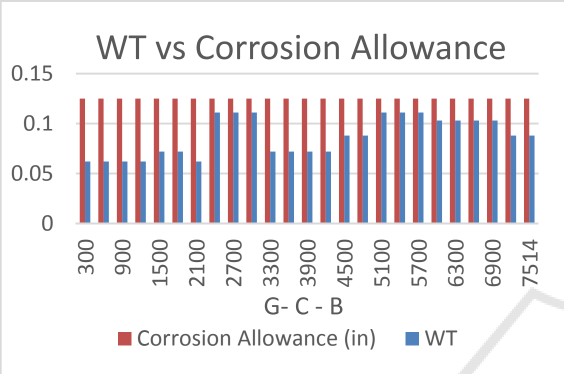

Figure 2: WT vs Corrosion Allowance.

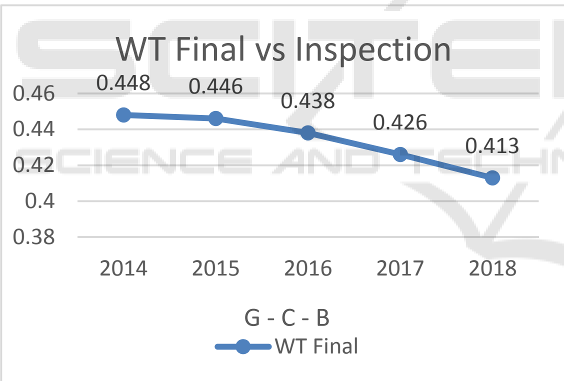

Figure 3: WT vs Year Inpection.

The inspection interval carried out is every 300 meters where in each measurement 4 measurement points are carried out every 90 degrees. Based on the pipe installation process in 1998 with a pipe thickness of 0.5, in 2018 showed a different average pipe thickness. The average pipe thickness is 0.413. The thickness of the pipe tends to decrease due to thinning due to corrosion or commonly called damage mechanism and also the thinning of material

FTA aims to identify the causes of failure in depth, identify weaknesses in a system, assess and propose for reliability or security, to identify the impact of human error, prioritize failure contributors, to identify effective upgrades to the system, to gauge the probability of failure and to optimize the test and maintenance. Failures that have the highest risk level are analyzed to identify the root causes of the problem based on the activity and causes of other aspects that may be involved

RISK ASSESSMENT MATRIX				
SEVERITY / PROBABILITY	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	High	High	Serious	Medium
Probable (B)	High	High	Serious	Medium
Occasional (C)	High	Serious	Medium	Low
Remote (D)	Serious	Medium	Medium	Low
Improbable (E)	Medium	Medium	Medium	Low
Eliminated (F)	Eliminated			

Figure 5: Risk Matrix Analysis.

The analysis aims to reduce the possibility of a risk where useful for controlling risk and minimizing costs for controlling costs issued because of the risk that might occur in the future. For effective inspection and efficiently the inspection should be based on the level of risk of the equipment.

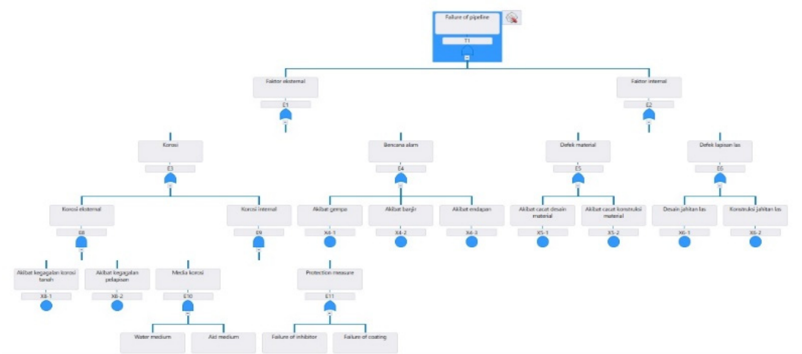

Figure 4: Fault Tree Analysis.

Based on the specified risk rating and also the calculation of the remaining life an equipment can be prepared an inspection plan. Frequency of an inspection carried out no longer than half the remaining period of use of the device. This matter because if a piece of equipment has reached the remaining half of its life, then the device has needed more intensive attention and further analysis to decide whether the equipment can still be used in the operating system or not.

The effectiveness of each inspection carried out within the time specified is characteristics for each damage mechanism. The highest amount of effectiveness will be used to determine the damage factor. If several inspections are carried out and have value low effectiveness over a specified time period. An effective method is by referring to the visual inspection and the addition of an analysis using an ultrasonic device to measure the thickness of the pipeline.

To determine the right inspection method is to see the mechanism of damage that occurs. In this analysis, the damage in the form of thinning, namely thinning of the wall thickness due to localized corrosion.

Some methods that can be used are visual examination, ultrasonic straight beam, eddy current, flux leakage, radiography and dimensional measurement. These methods are the most effective method used for this type of thinning damage. Not all of the above methods are used in their application, this involves costs if all methods are used.

4 CONCLUSION

Gas pipelines are one of the most potentially high-risk job sites that can cause workplace accidents to minimize the possibility of damage occurring using the RBI method and the Fault Tree Analysis method. RBI to plan risk-based inspections by comparing probabilities and consequences, arranged in a risk matrix to obtain the level of risk. And the root cause of failure is investigated by using FTA failure analysis diagram method.

Potential risks that cause the failure of congenital defects, less routine maintenance, operating frequency, easy to dust, material age, difficult to reach places and less reliable operators. Hazard identification was used to identify the hazards that have highest risk level, and FTA was used to search for the root causes of those hazards

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