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Risk Analysis on Leakage Failures of Pipelines Using Hybrid Risk Analysis Method

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ABSTRACT

In this final project has been conducted a study on risk analysis on subsea pipeline leakage by using hybrid risk analysis method. The study begins by determining the scope of the analysis using fault tree analysis which can be determined the main event of the leakage failure of subsea pipeline until the basic event. After determining the scope of the analysis then proceeded to calculate the frequency of each event using the quantitative method. In this calculation is known the frequency of basic event through data from scientific paper programming and scientific research and then calculated the frequency result of top event using Boolean Equation until we get the frequency of failure due to leakage pipelines for 0.0141213. After knowing how big the probability of failure, followed by determining how much impact or consequence of the failure. The consequences of failure are determined based on their impact on safety, environment, and business. In the determination of the impact with the qualitative method using questionnaires interviews to some respondents. After obtaining the result of questionnaire interview then calculated the mean of the questionnaire result to determine how big impact of the failure is based on safety, environment, and business. After knowing how big the probability and consequences of the failure, then determine the position of the risk zone on the risk matrix that refers to DNV RP-G101. After knowing the position of the risk zone, it can be determined how to control risk based on cause-effect.

Keywords: *pipelines, hybrid risk analysis, probability, consequence, quantitatives, qualitatives, risk matrix*

1. INTRODUCTION

Pipes is a technology to transfer fluids such as oil, gas, or water in large quantities and distances in onshore or offshore areas. Because the area that through by the pipelines are very diverse, like from the sea, lowlands, and in the soil.

In the offshore pipeline industry one of the challenges faced related to the risks that exist from the threat of each asset that occurs due to technical problems until human error. In subsea pipeline leaks, many factors can cause the risks.

In subsea pipeline leaks, there are several processes to be undertaken until subsea pipelines can be install in offshore facilities. Some subsea pipeline leakage processes are basically as follows;

a. Pipelines Inspection
   In this process, the pipe bars from the factory will be checked and recorded of the pipe itself and then be given the identity of the pipe bars ranging from pipe number, heat number, and so on. All the data will be recorded so that tracking of the pipeline is easier to do.
b. Pipelines Welding
   Subsea pipeline welding is used to connect one pipe rod with another pipe rod. In this process the pipe will be welded to be connected by using heavy equipment and required experts in the process.
c. *Non-Destructive Test*
   Non-Destructive Test is an underwater pipeline test that has been connected with welding. In this process the pipe will be tested to know whether there is any defect in the welding process. NDT can be done by shooting X-rays or gamma rays. From these results will be known where the presence of welding

disability. If the disability has not been fixed then NDT must be re-done until it passes the test.

d. *Coating*
In subsea pipeline structures, coatings or protective films are used as the first protective barrier to prevent corrosion. Coatings on subsea pipes are used to protect the subsea pipes from their environment to be physically more effective at separating pipe steels from their potentially corrosive environment. Coating can be used by painting the pipe or by using concrete material.

e. Cathodic Protection
Cathodic protection is a method of protecting metal from corrosion by sacrificing the anode. Basically corrosion occurs due to chemical reactions. Cathodic protection also needs to be checked periodically whether the anode is still able to withstand the rate of corrosion.

2. MATERIALS AND METHODS

The flow of research work on this final project is done based on the following stages. The first stage is a literature study that refers to previous studies, journals, valid codes, and so on. The literature study used in this final project based on a study of risk analysis using Hybrid Risk Analysis on subsea pipeline leaks.

2.1 Data Collection

Data collection based on existing data in the field and also results from several journals. The data used are:

- Pipelines data.
- Frequency data on basic event.
- Environment data.

2.2 Determine the Scope of the Analysis

This should be believed to be the initial focus on risk determination. There are three things to note, which is to determine exactly what to evaluate, what type of risk analysis is used, and to propose the expected results. In determining this scope by using the Fault Tree Analysis method.

2.3 Determine the Probability of the Risk

In this step is expected to be able to translate the frequency of the fault tree analysis from top events to basic events. For quantitative method, determination of events used by risk management perspective. This step will be searched for the probability of an event.

2.4 Determine the Consequence of the Risk

In this step is expected to be able to determine the consequences of an event based on safety, environment, and business. The approach used is qualitatives method by using interview questionnaire.

2.5 Determine the Position of the Risk Matrix Zone

The usefulness of this risk matrix will help to determine which zone is necessary for risk control. The process of making risk matrices using various scenarios that may occur and determine the zone that can still be in tolerance until the zone can not be tolerated.

2.6 Risk Control

In this risk control, it is used to prevent, detect, and mitigate threats and improve the system.

3. RESULTS AND DISCUSSION

3.1 Fault Tree Analysis

In the process of determining the scope of the analysis. Fault tree analysis becomes the choice of determining an event from cause to effect. Fault tree analysis begins by determining the event to be dissected down to the most basic event and the cause of an event (top event). In the process here, the top event of the Final Task is "Failure that occurs on the leakage of subsea pipelines." Which is then revealed to be the main event and continue to be reduced to a basic event.

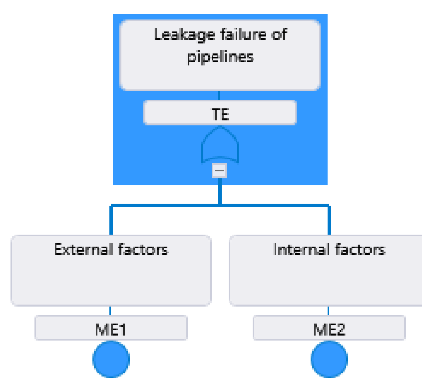

Figure 3.1 Top Event Leakage failure of pipelines

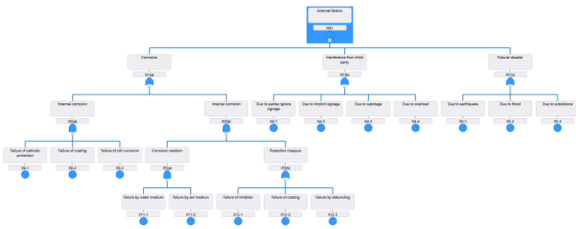

Figure 3.2 Main Event External Factors

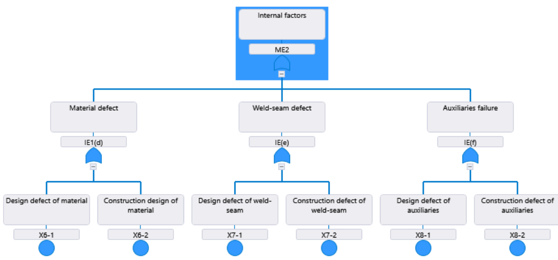

Figure 3.3 Main Event Internal Factors

3.2 Determine the Probability of the Risk using Quantitative Method

In this process, the frequency of the basic event by data to the frequency of top event can be known. To know how much frequency of the event using Boolean Equation. Boolean Equation is used to determine the frequency of occurrence with the first specified logic event AND or OR then raised to know the frequency of events above the basic event. Here the frequency of the main event and top event.

Table 3.1 Frequency Main Event and Top Event

No	Event	Probality
1	Underwater pipeline leakage due to external factors	0.00780
2	Underwater pipeline leakage due to internal factors	0.00631
3	Underwater pipeline leakage	0.01412

3.3 Determine the Consequences of The Risk

In this process to determine the consequences of an event determined on safety, environment, and business using interviews to 5 experts judment. Expert Judgment taken from EPC company that is PT. Perusahaan Gas Negara (PT PGN). At this company is taken more or less 5 people who are considered able to become expert judgment with the capacity of educational level, work experience, and occupied current positions are adjusted to this Final Project.

Table 3.2 Consequence of Failure

No	Event	Impact	Value
1	External factor	Safety	4.4
		Environment	4.4
		Business	4.6
2	Internal factor	Safety	1.8
		Environment	2.4
		Business	2.2
3	Underwater pipeline leakage	Safety	4.6
		Environment	4.6
		Business	4.4

3.4 Determine the Position of the Risk Matrix Zone

Once we know how big the probability and consequences of an event. We can put it into the risk matrix. The risk matrix used using codes corresponds to DNV RP-G101. In this case, for the probability of using the quantitative approach while for the consequences of using the qualitative approach. Once we know the probability of failure and the consequences of failure we can find out where is the position of the risk.

MATRIKS RESIKO
DNV RPG101

Frequency \ Concequency	A	B	C	D	E
>0.01	Yellow	Red	Red	Red	Red
1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
<0.00001	Green	Green	Green	Yellow	Yellow

Figure 3.4 Risk Matrix DNV RP-G101

Because probabilities and consequences are known as in the table below:

Table 3.3 Probability and Consequency

No	Event	Probability	Consequences		
			Safety	Environment	Business
1	External factor	8.E-03	4.4	4.4	4.6
2	Internal factor	6.E-03	1.8	2.4	2.2
3	Underwa ter pipeline leakage	1.E-02	4.6	4.6	4.4

So from these results can determine in which zone the risk. For the risks that are in the green zone, it can be said that the risk can still be tolerated, for those in the yellow zone is said to be a risk that needs to be wary of. For those entering the red zone it is said that the risk is already intolerable and risk control must be taken immediately.

Table 3.4 The zone position of the risk in risk matrix

Kegagalan Faktor Eksternal ditinjau dari Safety

		Concequency				
		Insignificant	Slight	Major Injury	Single Fatality	Multiple Fatality
Frequency	>0.01	Yellow	Red	Red	Red	Red
	1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
	1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
	1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
	<0.00001	Green	Green	Green	Yellow	Yellow

Kegagalan Faktor Eksternal ditinjau dari Environment

		Concequency				
		Insignificant	Slight	Local Effect	Major Effect	Massive Effect
Frequency	>0.01	Yellow	Red	Red	Red	Red
	1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
	1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
	1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
	<0.00001	Green	Green	Green	Yellow	Yellow

Kegagalan Faktor Eksternal ditinjau dari Business

		Concequency				
		Insignificant	Slight	Local Damage	Major Damage	Extensive Damage
Frequency	>0.01	Yellow	Red	Red	Red	Red
	1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
	1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
	1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
	<0.00001	Green	Green	Green	Yellow	Yellow

Kegagalan Faktor Internal ditinjau dari Safety

		Concequency				
		Insignificant	Slight	Major Injury	Single Fatality	Multiple Fatality
Frequency	>0.01	Yellow	Red	Red	Red	Red
	1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
	1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
	1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
	<0.00001	Green	Green	Green	Yellow	Yellow

Kegagalan Faktor Internal ditinjau dari Environment

		Concequency				
		Insignificant	Slight	Local Effect	Major Effect	Massive Effect
Frequency	>0.01	Yellow	Red	Red	Red	Red
	1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
	1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
	1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
	<0.00001	Green	Green	Green	Yellow	Yellow

Kegagalan Faktor Internal ditinjau dari Business

		Concequency				
		Insignificant	Slight	Local Damage	Major Damage	Extensive Damage
Frequency	>0.01	Yellow	Red	Red	Red	Red
	1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
	1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
	1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
	<0.00001	Green	Green	Green	Yellow	Yellow

Kebocoran Pipa Bawah Laut ditinjau dari Safety

		Concequency				
		Insignificant	Slight	Major Injury	Single Fatality	Multiple Fatality
Frequency	>0.01	Yellow	Red	Red	Red	Red
	1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
	1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
	1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
	<0.00001	Green	Green	Green	Yellow	Yellow

Kebocoran Pipa Bawah Laut ditinjau dari Environment

Frequency	Concequency: Insignificant	Slight	Local Effect	Major Effect	Massive Effect
>0.01	Yellow	Red	Red	Red	Red
1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
<0.00001	Green	Green	Green	Yellow	Yellow

Kebocoran Pipa Bawah Laut ditinjau dari Business

Frequency	Concequency: Insignificant	Slight	Local Damage	Major Damage	Extensive Damage
>0.01	Yellow	Red	Red	Red	Red
1.00E-03 s/d 1.00E-02	Yellow	Yellow	Red	Red	Red
1.00E-04 s/d 1.00E-03	Green	Yellow	Yellow	Red	Red
1.00E-05 s/d 1.00E-04	Green	Green	Yellow	Yellow	Red
<0.00001	Green	Green	Green	Yellow	Yellow

For the risks that are in the green zone, it can be said that the risk can still be tolerated, for those in the yellow zone is said to be a risk that needs to be wary of. For those entering the red zone it is said that the risk is already intolerable and risk control must be taken immediately.

3.5 Risk Control

For risk control on the analysis of subsea pipeline leakage risk, it is focused on the risks that are in the yellow and red zone. For the risk that is in the green zone can still be tolerated. The following risks are in the yellow and red zone.

Table 3.5 Risk that need to control

No	Risk	Probability	Consequence
1	External factor failure related to safety	High	Single fatality
2	External factor failure related to environment	High	Major effect
3	External factor failure related to business	High	Major damage
4	Internal factor failure related to safety	High	Insignificant
5	Internal factor failure related to environment	High	Slight
6	Internal factor failure related to business	High	Slight
7	Underwater pipeline leakage related to safety	Failure expected	Single fatality
8	Underwater pipeline leakage related to environment	Failure expected	Major effect
9	Underwater pipeline leakage related to business	Failure expected	Major damage

From the table, can be found whether the probability and or consequences that cause the occurrence of risks that must be controlled.

a. Internal factor failures are viewed from safety, environment, and business at this risk, the probability of occurrence is large, and the impacts on safety, environment and business are too great. To control such risks is required to improve the level of safety, environment, and business. And also do not forget to suppress the level of probability.

b. Internal factor failures are viewed from safety, environment, and business at this risk, the probability of occurrence is great, but the impacts on safety, environment and business are not so great. To control the risk is required to reduce the probability of the incident.

c. Underwater pipeline leakage is viewed from safety, environment, and business at this risk, the probability of occurrence is very high and the impact is enormous. To control this risk is expected to reduce the level of probability and reduce the level of consequences on safety, environment, and business.

4. CONCLUSIONS

In this Final Project found 2 main event, from the top event leakage underwater pipeline that made the incident to determine the probability and consequences of an event. For failure external factors have a high probability. While the consequences on the safety single fatality is in the red position, the environment major effect is in the red position, the major damage business is in the red position. On failure internal factors have a high probability. Internal factor failures have consequences for business insignificant to be in yellow, environment is slight in yellow, and business is slight in yellow position. Top events or failures due to subsea pipeline leaks have the expected failure probability. The failure of submarine pipeline construction has consequences on safety single fatality is in the red position, the major environmental effect is in the red position, and the major damage business is in the red position.

After knowing the position of the risk zone in the matrix, then proceed with the solution of the second problem formulation that is controlling the risk. At each risk entering the yellow and red zones should be controlled on the probability of risk and or on the consequences of those risks.

Of these risks, at the risk of entering the yellow and red zones the way to risk control is as follows:

- Internal factor failures are viewed from safety, environment, and business at this risk, the probability of occurrence is large, and the impacts on safety, environment and business are too great. To control such risks is required to improve the level of safety, environment, and business. And also do not forget to suppress the level of probability.
- Internal factor failures are viewed from safety, environment, and business at this risk, the probability of occurrence is great, but the impacts on safety, environment and business are not so great. To control the risk is required to reduce the probability of the incident.
- Underwater pipeline leakage is viewed from safety, environment, and business at this risk, the probability of occurrence is very high and the impact is enormous. To control this risk is expected to reduce the level of probability and reduce the level of consequences on safety, environment, and business.

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