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Analysis of Corrosion Risks Safety Barriers Performance and Pipeline Safety Level Determination for Offshore Gas Pipeline Well A, PT. XYZ

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Abstract

Various important aspects of the operational activities of the oil and gas industry must receive attention, in an effort to create a safe environment and operation for both workers and the surrounding community. This aspect relates not only to installations and workers, but the process of transport and distribution of oil and gas through pipes also. Failure on the offshore gas pipelines can cause some risks that can be harmful to humans and the environment around the pipeline in case of leakage or even an explosion. The failure may be due to several factors, including leakage of the lining of pipelines due corrosion risks. Various studies and case reports indicate the level of accidents or fires and leaking offshore gas pipeline is still going on. An analysis of safety barriers corrosion risks offshore gas pipeline was conducted to determine the performance levels of pipeline safety barriers with a case study on an offshore gas pipeline wells A, PT. XYZ. In doing analysis, three parameters were used, namely functionality, reliability and robustness. This research was conducted with descriptive analytic design using secondary data that has available in the company. This study illustrates the performance of the pipeline safety barriers, refers to the pipeline level of risk, and ultimately a pipeline safety level will be obtained as reference in the operation.

Keywords: offshore, pipeline, safety barriers, risk, corrosion, pipeline safety level

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1. Introduction

Related to the statistics of offshore transmission pipeline accidents in the United States, according to data released by the US Department of Transportation in the Pipeline and Hazardous Materials Safety Administration period 1996–2015, there were 342 incidents resulting in a loss of property of US $ 392,759,720 [1]. Taking into account the data,

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an analysis of the performance of safety barriers for corrosion piping system risk is required in order to manage and minimize the risk of major accident or fatal accident.

PT. XYZ is a multinational company engaged in oil and gas exploration and exploitation. Based on the Pipeline Risk Assessment that has been done, and then known the risk of corrosion both internal and external is to have high potential (high risk) to cause damage to the pipeline. Some efforts to protect the pipeline facility well A from potential damage related corrosion risks have been determined, including to install internal coating and cathodic protection [15].

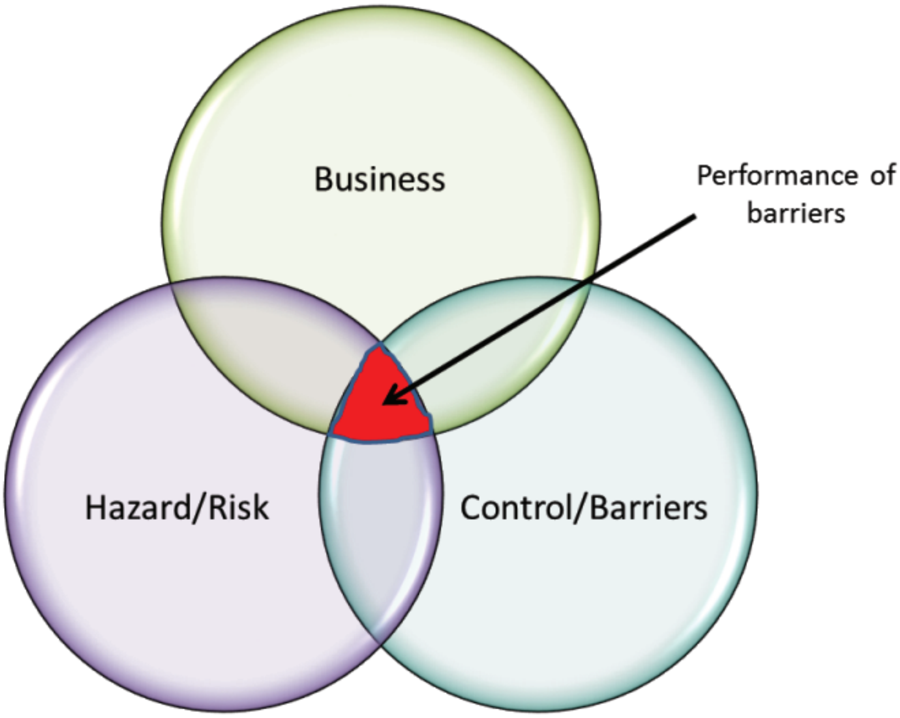

Figure 1: Research background.

The general objective of this research is to analyze the performance of corrosion risk safety barriers, as a reference in the determination of pipeline safety level of offshore gas pipelines well A, PT XYZ. The scope of this research is to analyze performance of safety barriers of corrosion risk of offshore gas pipeline facility by using descriptive analytic method, using Functionality, Reliability, and Robustness criteria. The safety barriers to be analyzed are preventive safety barriers, are internal anti-corrosion coating and installation of cathodic protection.

2. Theoretical Review

Risk management is a continuous and continuous management process with the aim of identifying, analyzing, and assessing potential hazards in a system or related to an activity, and to identify and to introduce measures to control risk, to eliminate or decrease potential Harm to humans, the environment, or other assets [2]. Definition Pipeline Risk Management is one of the systems used to manage the strategy of a pipeline system by considering the potential risks that exist, with the aim that the pipeline system can flow the fluid to the customer in accordance with a predefined capacity nomination [3].

The most common pipe anomalies found are corrosion (Metal Loss) [4]. Corrosion is defined as a breakdown of a material that is usually a metal material by reaction with the environment. Corrosion consists of the following factors:

1. Anode
2. Cathode
3. The metallic path connecting the cathode and anode
4. Electrolytes

The types of corrosion that occur in pipes are as follows:

1. Internal Corrosion

   Internal corrosion occurs because the material transported or piped by water, oil or gas can cause a corrosive environment on the inside of the pipe. Control of pipe internal corrosion is to use chemicals such as bactericides inhibitors and pigging at certain intervals is an effective technique in preventing corrosion and eliminating water and sewage in pipes.

2. External Corrosion

   The external corrosion of the offshore pipeline is strongly influenced by the characteristics of seawater. Local corrosion is evaluated using depth and length measurements to determine the remaining strength of steel. Control of external corrosion in pipes is with the use of cathodic protection.

Refer to Occupational Safety of Oil and Gas Distribution Pipes, what is meant by pipes is pipes oil and/or natural gas which include well flow pipes, oil transmission pipes, gas pipes, main pipes and service pipes [5]. In relation to pipelines deployed at sea shall comply with the following requirements:

1. In case the depth of the seabed is less than 13 meters then the pipe must be planted at least 2 (two) meters below the sea bed and is equipped with ballast system so that the pipe is not displaced or moved or refuted with the pipe.

2. In the case of the depth of the seabed 13 (thirteen) meters or more then the pipe can be placed on the seabed, as well as equipped with ballast system for the pipe not displaced or moved.

The Pipeline Integrity Management System (PIMS), is a method that can integrate to inspection planning and conserving maintenance strategies based on risk as its basic method [6]. Safety barriers may be defined as a means or equipment, both physical and non-physical, designed and made intentionally, in an attempt to prevent, overcome or reduce unwanted events or accidents [7].

Safety barriers are associated with hazards, energy sources or sequence of events. This is supported by a statement from PSA [8] that "it shall be known what the barriers have been established and which function they are meant to fulfill." This means that barriers must be well defined or formalized and linked to certain hazards. Then Hollnagel [9] states that in colloquial terms barriers are more synonymous with barrier function. Sklet [10] provides an illustration of safety barriers in relation to the process of occurrence of an accident occurrence.

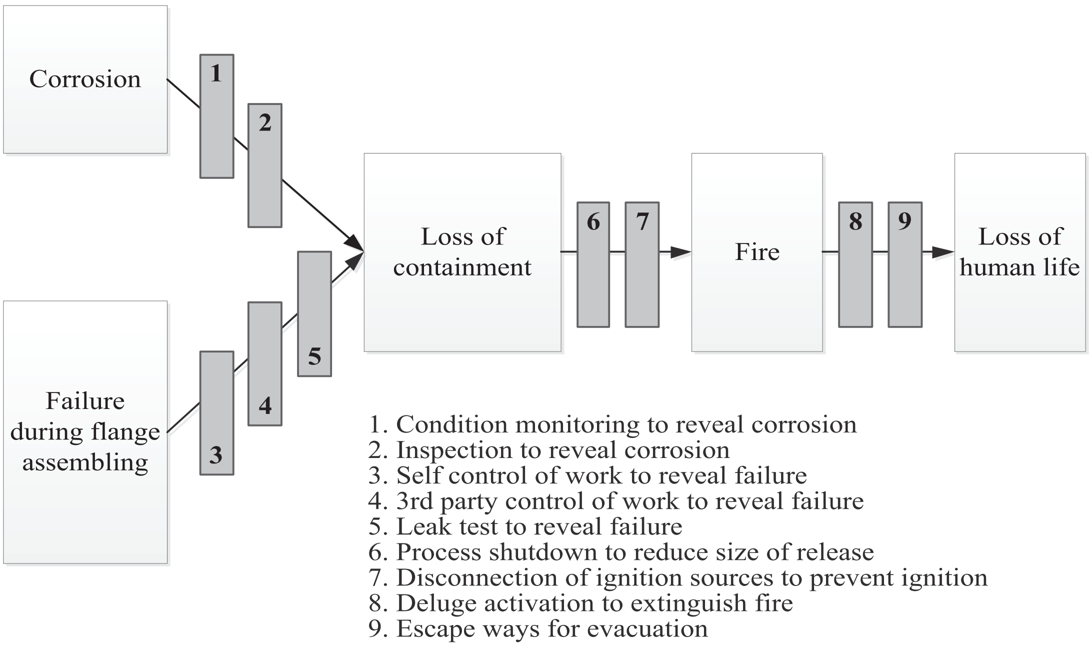

Figure 2: Illustration of barriers influencing a process accident. Source: Sklet [10].

Table 1: Theoretical review safety barriers.

Literature	Description
Sklet [10]	Physical and/or non-physical facilities planned to prevent, control, or reduce unwanted events or accidents.
OED [7]	A fence or something intentionally erected to prevent a person from accessing a place.
PSA [8]	*Safety barriers are linked to hazards, energy sources or sequence of events.*
Hollnagel [9]	*Barriers are more synonymous with barrier functions.*

After a review of several studies and taking into consideration the condition of PT XYZ is not currently installed, the authors make a summary which then becomes the basis of selection criteria that will be used.

Based on the Table 2, the criteria used in conducting this research are as follows:

1. Functionality

   An ability of the safety barriers to perform certain functions, as designed and made for them, based on technical aspects, environmental and operational conditions.

2. Reliability

   Reliability is the chance of pipeline can operate well without failure in certain condition and time. Reliability is the opposite of probability of failure (PoF). Reliability can also be defined as the ability to perform functions in accordance with the actual function with the response time required or in accordance with the demand in the initial design.

3. Robustness

   Robustness can be defined as a form of ability and safety barrier resistance to the level of potential hazard or risk, with the criteria of having a function as defined and having a low Probability of Failure (PoF) or having a high level of reliability (R). Robustness cannot stand alone and is closely related to previous criteria of Functionality and Reliability.

3. Research Method

Analyzing the performance of existing safety barriers using predetermined criteria, referring to Method developed by Sklet [10], namely functionality, reliability and robustness. The basic concept is shown in Figure 3.

Table 2: Summary performance of safety barriers criteria.

Criteria	Author(s)	Descriptions
Functionality	Sklet [10]	Ability to perform certain functions based on technical aspects, environmental conditions, and operational aspects
	Rollenhagen [11]	The barriers are there and how they work
	PSA/RNNS [8]	The effect of a barriers possessed against the sequence of accidents, if they are functioning properly based on the design aspect.
	Neogy et al. [12]	Mention that the effectiveness level of a barriers is related to the level of suitability and comprehensive barriers protect against exposure to certain bahays.
	Taylor [13]	Mentioning that the adequacy level of a barriers is able to prevent accidents based on the base design, in accordance with applicable standards and regulations, the capacity should not be exceeded, and if barriers are inadequate, additional barriers must be provided.
	Hollnagel [9]	Efficiency or adequacy: how efficiently barriers are expected in achieving their goals.
	Andersen et al. [14]	The effectiveness of safety barriers is the ability to perform safety functions in duration, non-degraded mode and under specified conditions.
Reliability	PSA/RNNS [8]	Ability to function in accordance with demand.
	Neogy et al. [12]	Associated with the ability to withstand failure.
	Hollnagel [9]	Will the barrier fulfill its purpose when needed?
	Rollenhagel [11]	The ability of a means to function on demand.
	Taylor [13]	All necessary signals must be detected when a barrier activation is required. Active barriers must be fail-safe, and either self-testing or tested regularly. Passive barriers should be checked regularly.
	Sklet [10]	Ability to perform function in accordance with the actual function with the response time required or in accordance with request.
Robustness	PSA/RNNS [8]	Ability to function during a sequence of events or under the effect of an accident load is given
	Hollnagel [9]	The reliability and resilience of barriers, that is, how well it can withstand the variability of environmental conditions.
	Taylor [13]	Ability to withstand extreme events, such as fire, flood, etc. Barriers will not be disabled by activation of other barriers. The two barriers will not be affected by the common (single) cause.
	Sklet [10]	Ability to withstand accidental loads and functions as mentioned during the sequence of events.

Scoring system or weighting is given to all criteria to analyze the performance of safety barriers. The basic concept of scoring is that in analyzing the performance of

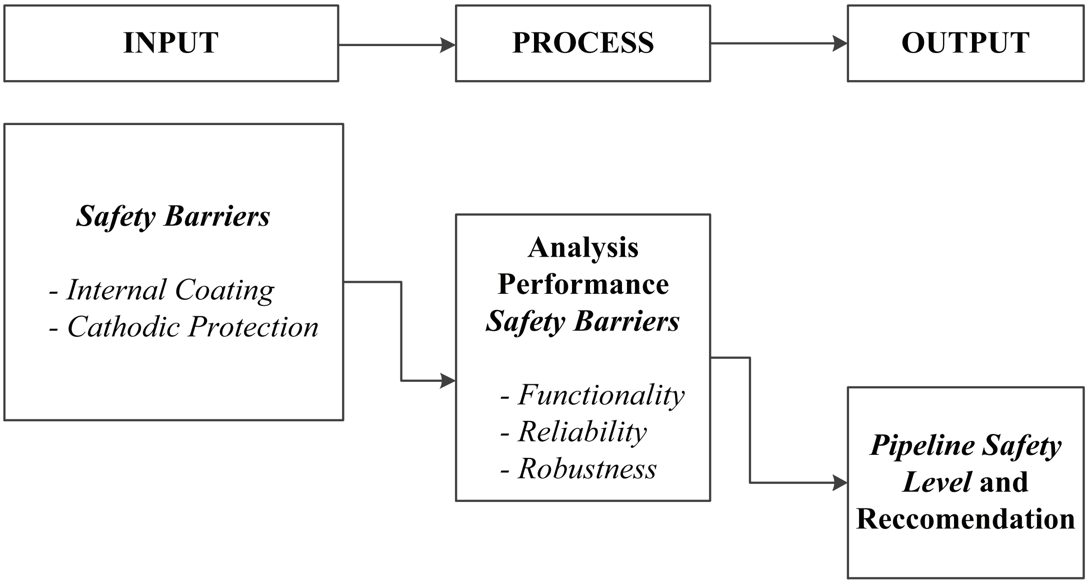

Figure 3: Conceptual framework.

safety barriers of corrosion risk, based on expert judgment and best practice in Oil and Gas Industry, the main thing is how strength or how strong is safety barriers in this case internal coating and cathodic protection against corrosion risk gas pipeline under the sea. The score given to the reliability criteria is 50 percent.

A criterion of functionality is then given a score of 30 percent. Robustness can be analyzed by looking at the reliability and functionality of safety barriers. Robustness cannot stand on its own and is dependent on the criteria of reliability and functionality. The given weight or score is 20 percent. Based on this and with consideration of risk type, magnitude of risk and managerial technical aspects, each safety barrier is given 50 percent weight for internal coating (IC) and 50 percent for cathodic protection (CP).

4. Functionality (30%)

The calculation is to multiply the weight of each safety barrier by the percentage of weight, referring to equation 1. The functionality criterion for internal coating is calculated based on the corrosion allowance (CA) specified, while for cathodic protection is by calculating the current demand and its current output. This provision is described in the following flow diagram of the research functionality criteria.

It will be said that the functionality criteria for both safety barriers are internal coating and cathodic protection is accepted and vice versa cannot be accepted if the functionality criteria of one or both safety barriers are not met.

$$Functionality = (IC \times 50\%) + (CP \times 50\%) \quad (1)$$

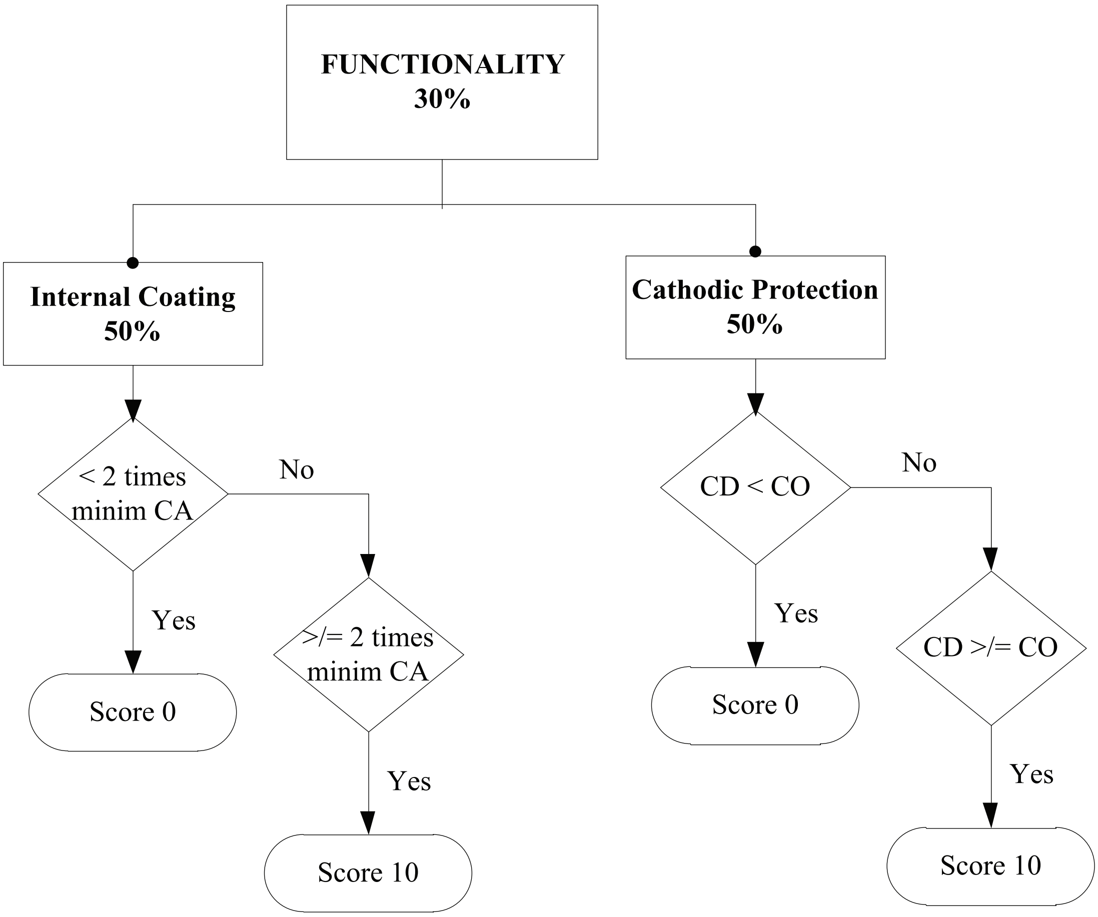

Figure 4: Functionality criteria research flow chart.

4.1. Reliability (50%)

Calculated based on the weight of each safety barriers multiplied by the weight of each safety barrier, using the following equation.

$$Reliability = (IC \times 50\%) + (CP \times 50\%) \quad (2)$$

Internal coating (IC) reliability is calculated based on its thickness (T) and density (D), while cathodic protection (CP) is calculated based on the amount of anode weight (JBA) and the minimum distance of anode mount (JMPA). It is said to be accepted if the reliability of both safety barriers are met and vice versa is said cannot be accepted if the reliability criteria of one or both safety barriers are not met.

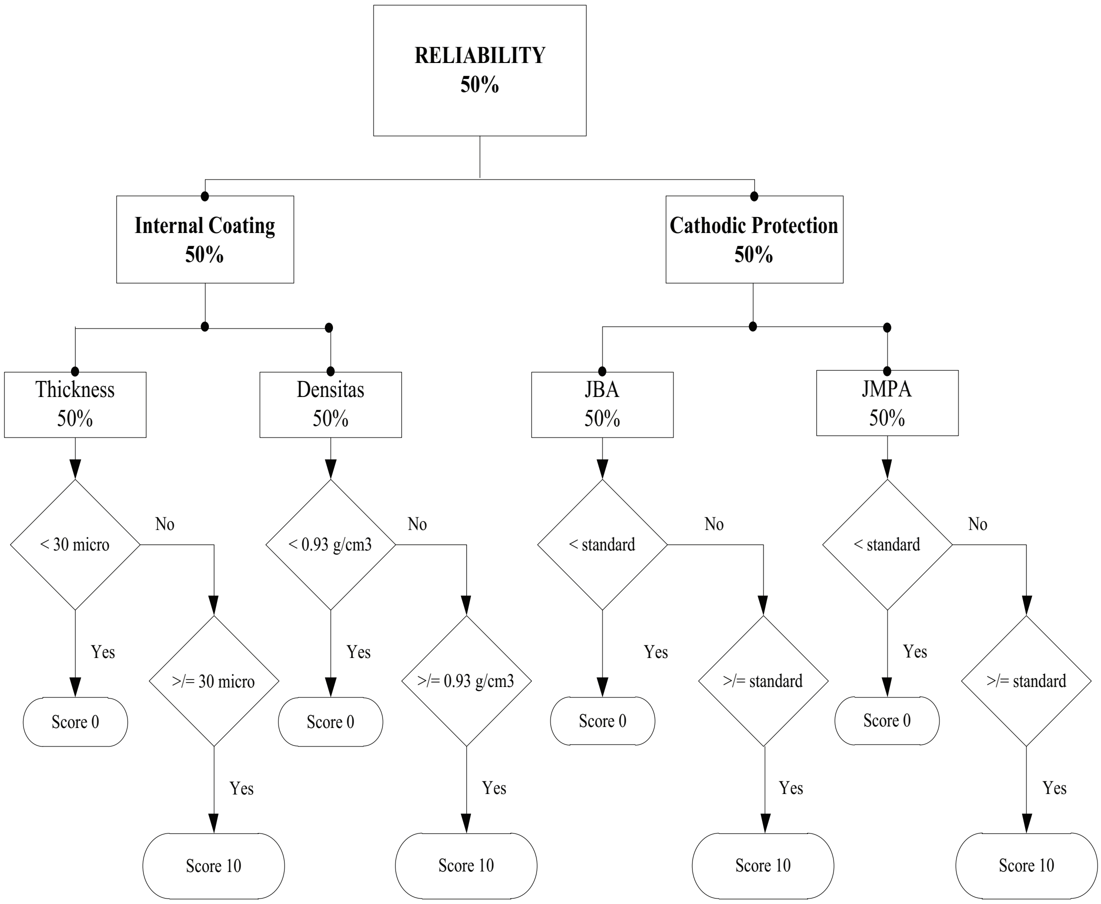

Figure 5: Reliability criteria research flow chart.

4.2. Robustness (20%)

Robustness is a combination between functionality and reliability. Then, these robustness criteria can be accepted if both functionality and reliability criteria are met and vice versa are not accepted if one or both functionality and/or reliability criteria are not met. The following is the equation formula and flow chart used to analyze safety barriers performance of corrosion risk criteria robustness.

$$Robustness = (\text{IC} \times 50\%) + (\text{CP} \times 50\%). \quad (3)$$

In the determination of Pipeline Safety Level will use 3 levels, namely Acceptable, ALARP Region and Non-acceptable. The scoring system is used in the determination of pipeline safety level, that is, using Gutman scale. There are 3 (three) parameters used in this research, so the value of I (interval) is 10: 3 = 3.33.

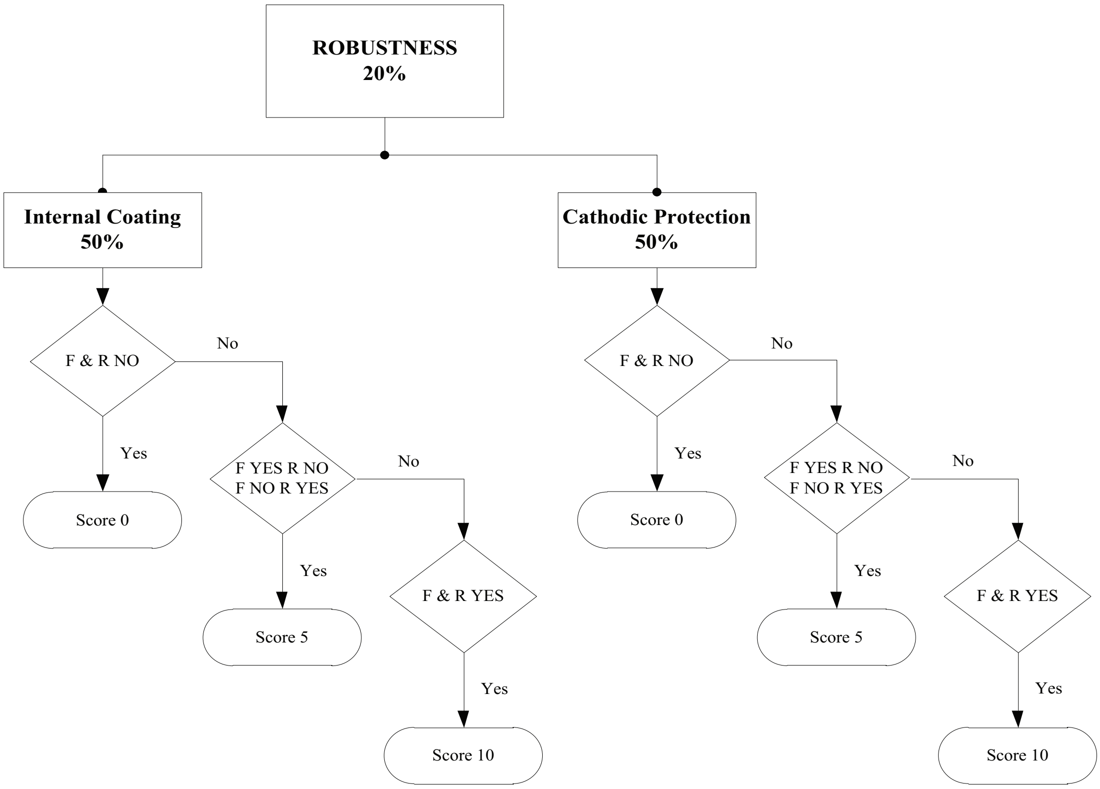

Figure 6: Robustness criteria research flow chart.

1. **Acceptable**: more than or equal to 6.67
2. **ALARP Region**: more than or equal to 3.33 and less than 6.67
3. **Non-acceptable**: less than 3.33

4.3. Pipeline safety level

$$\{(\textit{Functionality} \times 30\%) + (\textit{Reliability} \times 50\%)\} + (\textit{Robustness} \times 20\%). \qquad (4)$$

5. Results and Discussion

The results of the overall safety barriers performance analysis are shown in the following table.

In the determination of Pipeline Safety Level, from the calculation get the score for pipeline safety level is equal to 10 and it is concluded that the pipeline safety level entered in the acceptable level.

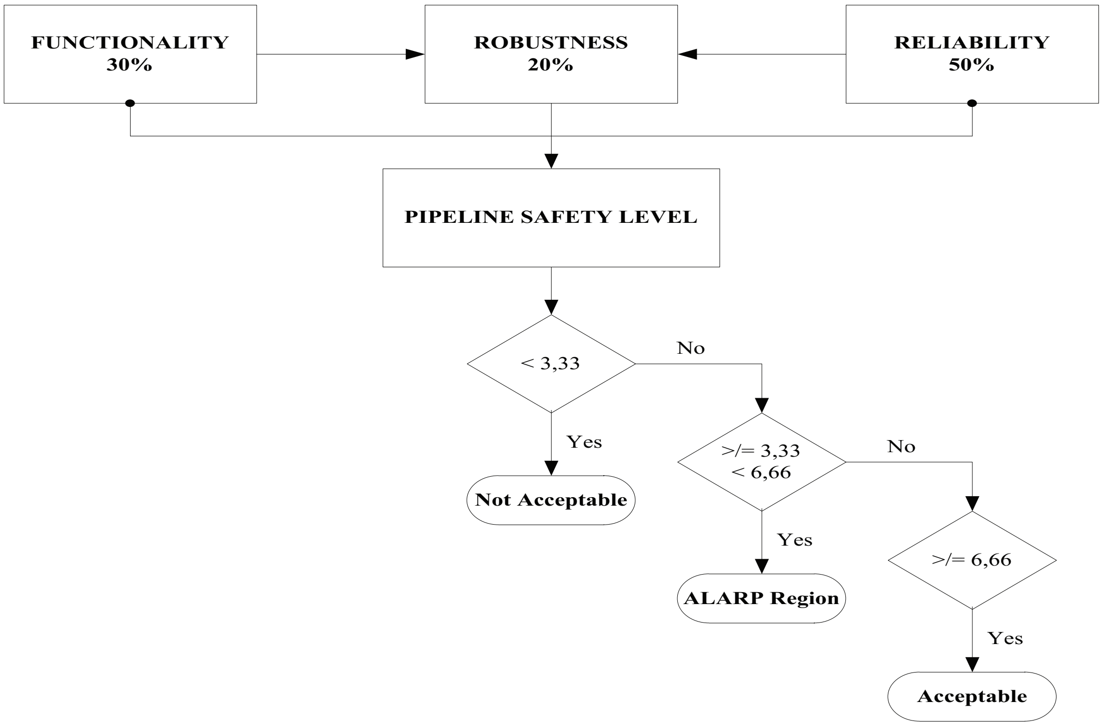

Figure 7: Pipeline safety level research flow chart.

Table 3: Analysis result of *Safety Barriers Performance*.

	Criteria		
	Functionality (F)	**Reliability (R)**	**Robustness**
Internal Coating			
Score	10	10	10
Remark	CA = 3 mm	T = 30 micrometer D = 0.9 g/cm^3	Criteria F and R accepted
Cathodic Protection			
Score	10	10	10
Remark	CD > CO	JBA and JMPA as standard	Criteria F and R accepted
Final Result			
Score	**10**	**10**	**10**
Remark	**Accepted**	**Accepted**	**Accepted**

6. Conclusion

It is stated that all criteria specified can be accepted, so it can be concluded that safety barrier performance of corrosion risk of offshore gas pipeline well A is very good. Pipeline safety level results from the calculation obtained score of 10 and classified as acceptable level.

7. Suggestions

1. Conducting supervision attached to the stage of fabrication and installation.
2. Measurement of all established requirements including Corrosion Allowance (CA), Coating Thickness (T), Coating Density (D) and Current Output (CO), Current Demand (CD), Number of Weight Anode (JBA), Proximity Distance (JMPA) of Cathodic Protection Anode at offshore gas pipeline well A during fabrication and installation stage.
3. Formulate and establish regular inspection procedures, programs and schedules for pipeline corrosion either through inspection of inside and outside pipelines, pipe inspection and cathodic protection inspection.
4. Once the pipe is installed, conduct a periodic inspection program on the overall pipe conditions.

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