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Dynamic Rbi with Central Difference Method Approach in Calculation of Uniform Corrosion Rate: A Casestudy on Gas Pipelines

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Abstract

The oil and gas industry generally uses a piping system to drain fluids. Even though the pipes used have been well designed, the use of pipes as a means of fluid transportation still provides the possibility of failure that can occur at any time, one of which is due to uniform corrosion. The use of standard Risk Based Inspection (RBI) according to the API RBI 581 document has been widely used to anticipate potential failures to pipe components. The use of standard RBI can reduce the risk of failure significantly. Because the standard RBI considers the component risk value to be constant, it causes an error in the component status assessment. It is unfortunate happen, if an industry fails due to an error in the inspection results, causing financial losses. This research will design dynamic RBI using thickness data of 12 PT.X inspection points in 5 inspection time intervals. The results showed that the dynamic RBI design that was compiled could provide real-time component condition status, capture fluctuations in the corrosion rate that occurred, and provide an accurate description of the actual component condition. RBI design makes inspection and maintenance planning more precise by reducing the frequency of redundant inspections and the possibility of inspection planning errors.

Keyword : *Dynamic RBI, Gas Pipeline, Risk Analysis, Uniform Corrosion, Piping Systems*

INTRODUCTION

The pipe is a means to flow fluids in the form of oil, gas, or water in large quantities and over long distances. A pipe has the possibility of failure, or risk can occur at any time. The consequence of failure of a damaged gas pipe can cause a fire and explosion, which will threaten the safety of workers and the environment. 185 accidents involving natural gas have been reported, pipeline accidents accounted for 127, and the most frequent accidents were caused by mechanical damage to pipelines [1]. Whereas in 2008, according to the CCAP (Canadian Association of Petroleum Producers) pipeline technical commission, there were at least 31 incidents in gas transportation. Meanwhile, the European failure data reveals that the failure rate on pipes is 2.1×10^{-4} (for small pipe diameters) and 7.1×10^{-4} (for large pipe diameters), where the failure rate is greater than the acceptable standard, namely around 10^{-6} per km/year. Due to the high level of possible corrosion in oil and gas piping systems, piping system networks are money-burning assets because these pipes will continue and always require replacement, maintenance, and workers who always supervise the safety of these components [2]. The data obtained indicate that developing a risk analysis assessment framework for a functional pipeline component is necessary [3] [4] [5] [6] [7].

The standard Risk Based Inspection (RBI) method has been widely applied in risk analysis in recent years. This method determines an inspection plan (which components must be inspected, when, and what method is appropriate for inspections). In the RBI concept, the risk results from the probability of failure (PoF) multiplied by the consequence of failure (CoF), where PoF is the probability of a failure occurring within a certain period, and CoF is the consequence if a component fails. Based on industry guidelines for RBI, three possible scenarios may occur due to predictions made using the standard RBI method in determining the age of equipment, namely [8]:

1. The estimated risk value exceeds the accepted risk value and occurs just before the time of the first RBI inspection.
2. The value of the estimated risk exceeds the accepted risk and occurs between inspection intervals.
3. The value of the risk that occurs remains below the risk that is accepted within the specified inspection time interval.

Based on the three possibilities above, the results of failure prediction and time for checking from the use of the standard RBI method still provide the possibility of prediction errors when a component will fail. This is very detrimental if a failure of a component cannot be predicted precisely because it will cause losses from production, component replacement, environmental damage, and worker safety.

The system applied to the standard RBI is to consider the level of damage remaining the same for years based on one inspection data so that it can provide a sense of uncertainty and inaccurate estimates, which can potentially experience unexpected failures. Therefore we need a system that can predict and track risk profile changes in real-time to ensure components operate safely(Bhatia et al., 2019), answering this, the concept of dynamic RBI is suitable to be applied.

Dynamic RBI is defined as a risk profile that provides the status of the risk of an equipment failure at a particular time and can be updated when new information is available on the equipment. Dynamic RBI performs calculations based on indicators of the degradation mechanism applied to the system, enabling operators to monitor component risk profiles in real time.

The concept of dynamic RBI is the answer to a system that can monitor component conditions in real time. Degradation rates can change drastically due to specific combinations of degradation indicator fluctuations. Dynamic RBI can capture these changes, which is impossible with standard RBI.

LITERATURE REVIEW

In general, corrosion can be defined as the forced destruction of a substance, such as a metal, due to its interaction with the surrounding environment. Corrosion is a natural decay process that cannot be prevented but can only be controlled. Corrosion is a common problem faced by various industries, including the oil and gas industry. Corrosion has a significant influence on the sustainability of component conditions. In the oil and gas industry, nearly 25% of failures occur due to corrosion degradation, while > 50% of corrosion causes are a mechanism of sweet and sour corrosion [10]. Both of these mechanisms cause internal corrosion in the oil and gas industry, generally caused by carbon dioxide (CO_2) and hydrogen sulfide (H_2S) compounds, which can also be exacerbated due to microbiological activities. Corrosion can occur if four elements make up the electrochemical cell, including the presence of an anode which is the place where the oxidation reaction occurs $M \rightarrow M^+ + e$, the cathode is the place where the reduction reaction occurs (consumption of electrons occurs at the cathode), there is a metallic pathway where the current flows from the anode to the cathode, and lastly, there is a solution (electrolyte) where a corrosive solution can carry electric current, contains ions [11].

Corrosion in the oil and gas industry occurs when metal materials come into contact with a humid environment. When a metal material is exposed to a corrosive solution, the metal atoms in the anode will undergo oxidation so that they lose electrons. Then these electrons will go to the cathode, which will then be absorbed through a reduction process. The cathode and anode are connected through the electrolyte medium. Ion exchange will occur to balance the positive and negative charges. Positively charged ions are released into the electrolyte solution, which will later bind to other groups of atoms that are given a negative charge [12]

The existence of electrolyte isolation between the inner and outer walls of the pipe and the specific shape of each part of the pipe causes corrosion to occur and develop internally and externally with different causes and mechanisms. CCAP (Canadian Association of Petroleum Producers) states that corrosion is the leading cause of failure in natural gas pipelines. Based on data collected in 2008 alone internal corrosion has accounted for 26% of the 31 failures that occurred in the gas industry [2]. Based on the type of corrosion, the steps for corrosion mitigation will be different, taking the example of the cathodic protection method, which is only effective for external corrosion mitigation. In contrast, for internal corrosion, the method cannot be applied.

In the piping system of the oil and gas industry, the content of sulfuric acid (H2S) and carbon dioxide (CO2) is the primary cause of failure resulting in uniform corrosion [13]. In this study, the phenomenon of pipe degradation will be focused on the phenomenon of uniform corrosion in the piping system. Uniform corrosion is assumed to occur on the entire surface of the pipe, which is in direct contact with fluids containing corrosive substances from CO2 and H2S gases contained in fluids in the oil industry and gas [9] [3].

Risk Based Inspection (RBI) is a method used in determining an inspection plan for equipment (determining which equipment needs to be inspected, when, and what method is appropriate to use) based on the risk level of equipment. Meanwhile, dynamic RBI is defined as a risk profile that provides status for the risk of a component within a specific time that can be updated when new data becomes available [8]. Dynamic risk is derived based on risk indicators of degradation mechanisms, enabling operators to monitor component risk profiles in real time. Because the risk profile is shown in real time, this method can be more effective for inspection planning because it can provide more accurate component conditions. **Figure 1** compares the standard RBI with the actual component conditions. It can be seen that the standard RBI is unable to capture fluctuations in the risk values that occur until the risk values have passed the risk tolerance threshold.

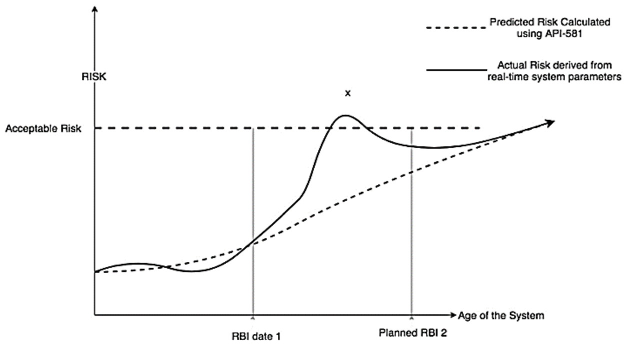

FIGURE 1. Illustrated comparison of the use of standard RBI with actual component conditions [8]

The corrosion rate is an important variable resulting from the relationship between degradation indicators and components. The corrosion rate can be derived based on data on decreasing mass or decreasing thickness over time. In this study, the finite difference derivative method consisted of forward difference, widely used in solving ordinary differential equations. The backward difference method determines the derivative if future data is unavailable, while the middle difference is the average of the forward and different methods. Backward so that the middle difference method uses past and future data. In this study, the median difference method will be used to determine the first derivative of the data [14]. In addition, the data owned follows the requirements for using this method. Namely, past and future data can be included in the middle difference equation.

METHODS

The material from this study uses pipe thickness data PT. X using the ultrasonic testing method. While the tools used are R-Studio software as a place to design algorithms and Igor software to perform data interpolation and visualization.

Retrieval of Pipe Thickness Data

The pipe thickness data used data from PT.X, which was taken by a UI Metallurgical and Materials Engineering student while carrying out a Practical Lecture (KP). The data for the pipe company PT.X has a diameter specification of 22 cm, made from carbon steel with the API X52 standard, with a total length of 975 meters. The data take from 12 inspection points with the types of pipe sections, including cylinders, T-shape pipes (Tees), and elbow pipes.

Corrosion Rate Modeling

Before calculating the corrosion rate in the piping system, modeling and simplification are carried out so that the calculation process can be carried out. Because there are 12 inspection points where there are three pipe shapes, as previously described, the difference in the shape of this pipe causes a difference in thickness measurements for each shape. From the 12 inspection points, all pipes have different initial thickness sizes. A scalable model of thinning that occurs is used to facilitate calculations, where each thinning will have units of percentage reduction in thickness/year. In addition, only pipe thickness data is used at the 180^0 position for all inspection points so that the calculations are consistent.

Calculation of The Corrosion Rate Using The Center Difference Method

Because the pipe thickness data that own is a set of data points, the corrosion rate can be determined by looking for derivatives in each of these data. The finite difference method was used to find the derivative value. As explained in the previous section, in this study, the middle difference method chooses because this method has a better level of accuracy compared to the other two finite difference methods.

Dynamic RBI Risk Calculation

Risk calculations can be calculated after the components PoF and CoF calculation values for each inspection time. In the dynamic RBI concept, the PoF value is dynamic. It is constantly changing due to fluctuations in system parameters and degradation indicators, while the CoF value obtained is considered a static value. The calculation of the CoF value will focus on finance. The results of the risk values are used to rank the components risk level for each inspection time, and the risk level obtained is used as a consideration for making decisions on planning the next inspection or maintenance.

Standard RBI Comparison Analysis with Dynamic RBI

After obtaining the results from the dynamic RBI risk calculation, a comparison was made with the existing standard RBI to evaluate the advantages and disadvantages of dynamic RBI in this study. The comparison will focus on the differences in the results obtained, the accuracy of the results, and whether dynamic RBI can be used as a risk management method to provide a more accurate component status.

RESULTS

Dynamic Rbi Risk Assessment

Pipe thickness data that has been interpolated and modeled is used in calculating the probability of failure and the financial consequences of failure adjusted to the operating conditions of PT. X.

Pof Value Determination

Based on the methodology described above, through the interpolation and model formulation stages, the corrosion rate value calculates using the center difference derivative method. The corrosion rate value was obtained for each inspection time. The calculation results show in **Table 1.**

TABLE 1. The value of the corrosion rate for each inspection time for PT. X

	September	October	November	December	January
Average (%/year)	0.00634176	0.006949	0.00153833	0.00645138	0.012671813
S. Deviasi (%/year)	0.00479982	0.006731	0.00572344	0.00616811	0.013370108

The corrosion rate value calculates for input data in calculating the Art value in an algorithm designed using R-Studio software. Art is the fractional value of the component wall thickness loss since the last inspection or the component's service start date. Corrosion rate values for each month have been considered to represent the percentage reduction in thickness of the PT. X for 12 inspection points with various shapes inside, such as T-shaped pipes (tees), cylinders, and elbows with different thicknesses. The difference in thickness has been overcome by using scaled pipe thickness modeling so that the corrosion rate value obtained has units of percent thickness lost per year.

The Art value for each inspection time interval converts into a damage factor value, $Df_{(t),}$ conversion of this value uses the conversion table that is in part 2 calculation of the value of the probability of failure table 5.11 thinning damage factor conversion (API RP 581, 2016). After the value of the damage factor using equation 1. The value of the probability of failure can be calculated, where total *gff* is an assumption of the possible frequency of component failures based on the size of the leak holes that may occur provided in the document API RP 581 part 2, table 3.1, suggested Component Generic Failure Frequencies. The FMS value is a system management factor, using the average value of the possible values generated against the system management audit from PT.X with a value equal to 1. The results of calculating the PoF value and its calculation components shown in **Table 2**.

$$Pf(t) = gff_{\text{total}} . Df_{(t)} . F_{MS} \qquad (1)$$

TABLE 2. Calculation results of dynamic RBI PoF values

No	Month	Art	$Df_{(t)}$	*gff*	PoF
1	September	0.222982	1.459634	3.06×10^{-5}	4.47×10^{-5}
2	October	0.325184	4.511016	3.06×10^{-5}	1.38×10^{-4}
3	November	0.069647	1	3.06×10^{-5}	3.06×10^{-5}
4	December	0.282538	2.650766	3.06×10^{-5}	8.11×10^{-5}
5	January	0.579195	160.0682	3.06×10^{-5}	4.90×10^{-3}

Cof Value Determination

The calculation of the consequences of failure in this study uses the level 1 method in the calculation recommended by the RBI RP 581 document, where the selection of this method is based because it is a simplified calculation and the type of fluid flowed by PT. X list in the level 1 consequence analysis fluid list in section 3, table 4.1 List of Representative Fluids Available for Level 1 Consequence Analysis [15]. Calculating the CoF from the company's operating data concerning the RBI document. **Table 3** shows the stages in the process of calculating the value of the consequences starting from calculating the possible leakage rate to the final stage, namely the financial consequences that will occur as a result of component failure.

TABLE 3. CoF value calculation process

No	CoF component	Calculation components
1	Theoretical Leakage Rate	Fluid properties, leak size area, transition pressure, heat capacity ratio, constants in table 3.B.2.1 part 3 of API RBI 581 document.
2	Estimation of Total Dispensable Fluids	Fluid mass in evaluation component, additional mass that may escape.
3	Leak Type	The time required to release a quantity of fluid 4536 kg, for each size of the leak.
4	Estimation of Detection and Isolation systems	Assumptions and adjustments to PT.X data with table 4.5 section 3 of the API RP 581 document.
5	Leakage Rate For Consequence Analysis	Adjusted reduction factor values from table 4.6 section 3 of API document RP 581, and theoretical leakage rates.
6	Consequence Areas of Flammable and Explosive Materials	Leakage rate consequences, mitigation factor values, tables 4.8M and 4.9M section 3 API RBI 581 document, mitigation reduction factor values.
7	Financial Consequences	$FC = FC_{cmd} + FC_{affa} + FC_{prod} + FC_{inj} + FC_{environ}$

The calculation results for each stage of the summarized failure probability calculation are in **Table 4** and **Table 5**. The calculation of the consequences of failure is carried out based on four possible measures according to the recommendations of RBI RP 581. After the components of the calculation of the consequences of failure are obtained, the calculation phase of the financial consequences is adding up every possible financial consequence, namely the cost of repair and replacement of components(FC_{cmd}), cost of damage to components around the area affected by failure (FC_{affa}), costs related to lost production quantities and business interruptions due to replacement of damaged components (FC_{prod}), costs of potential accidents due to component failure (FC_{inj}), environmental cleaning costs due to component failure ($FC_{environ}$). In this research, the value of the financial consequences of cleaning the environment does not consider because the fluid flowed by PT. X has a boiling point below the average point, so the material will quickly evaporate and disappear if a leak occurs. So for each component's financial consequences, the results of the calculations shown in **Table 6** with a total of 1,023,894.651 USD which is the value of the total financial consequences.

TABLE 4. CoF component calculation results

No	Leakage Size	Theoretical Leakage Rate	mass add, n kg	mass avail, n kg	Type Leakage	Detection & Isolation System	raten (kg/s)
1	Small	7,809x10^{-3}	1.4056	7,922.2	Continuous	Category B for detection and isolation systems, there are detectors and system shutdown options	0.0066
2	Medium	1.23x10^{-1}	22,139	7,943	Continuous		0.1045
3	Large	1.9835	357.03	8227.9	Continuous		1,686
4	Broken	7,856	1414,2	9,335	Continuous		6,678

TABLE 5. The result of the calculation of the consequences of the component failure area

No	Leakage Size	(m^2)	(m^2)
1	Small	0.0474	0.1321
2	Medium	0.7108	1.8727
3	Large	10.8480	27.0333
4	Broken	42.4263	102.8242

TABLE 6. The results of the calculation of financial consequences

No	Financial Component	Value (USD)
1	FC_{cmd}	26.4052
2	FC_{affa}	27,286.76
3	FC_{prod}	207,539.57
4	FC_{inj}	789,041.91
5	$FC_{environ}$	-
	Total (FC)	**1,023,894.651**

Analysisi of Dynamic RBI Risk Score

At this stage, a risk value calculation will determine the component's risk level in a time function. As previously explained, the risk calculation can calculate by combining the value of the probability of failure with the value of the consequences of financial failure. This failure probability value in the dynamic RBI concept is considered a function of time because the data used in the calculation is obtained based on continuous observation of the degradation factor that occurs in the components in contrast to the consequences of failure, which are constant values or are not affected by time. This failure probability value will continue to increase over time because the depletion degradation mechanism will continue to occur with the age of the component.

Risk calculations can be carried out using data from the calculation of the probability of failure and the consequences of failure in terms of financial results that have been done previously. Generally, in presenting the results of risk calculations in standard RBI, a risk matrix is used, which represents the relationship between the probability of failure and the consequences of failure. In the risk matrix, at least four definitions of risk indicate the level of risk of the components. The risk matrix is shown in **Figure 2.** In this figure, the failure probability category is determined by the value of the damage factor, D_f. In contrast, the failure consequence category is determined by the previously calculated financial consequence value. These two categories can be determined using **Table 7.**

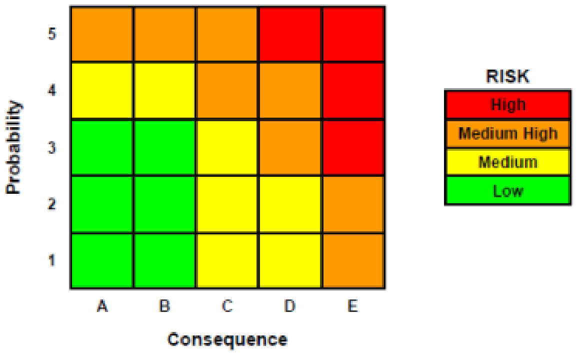

FIGURE 2. Risk matrix for presenting data from risk calculation results [15]

TABLE 7. Failure probability and failure consequence categories [15]

Probability category		Consequence Category	
Category	*Range*	Category	*Range*(USD)
1	$D_f \leq 2$	A	$FC \leq 10{,}000$
2	$2 < D_f \leq 20$	B	$10{,}000 < FC \leq 100{,}000$
3	$20 < D_f \leq 100$	C	$100{,}000 < FC \leq 1{,}000{,}000$
4	$100 < D_f \leq 1{,}000$	D	$1{,}000{,}000 < FC \leq 10{,}000{,}000$
5	$D_f \geq 1000$	E	$FC \geq 10{,}000{,}000$

The D_f value obtained in the previous PoF calculation process in Table 2 is converted to get the category of the probability of failure. Likewise, for the value of the total financial consequences obtained, a conversion is carried out to obtain the category of consequences of failure. The category results representation in **Table 8**.

TABLE 8. Results of failure probability categories and failure consequences

Month	PoF value	FC value (USD)	Category Probability of failure	Failure Consequences Category
September	4.47×10^{-5}	1,023,894.651	1	D
October	1.38×10^{-4}	1,023,894.651	2	D
November	3.06×10^{-5}	1,023,894.651	1	D
December	8.11×10^{-5}	1,023,894.651	2	D
January	4.90×10^{-3}	1,023,894.651	4	D

Based on **Table 8**, it can be seen that the failure probability category values obtained are different each month. This follows the proposed dynamic RBI concept. The difference in this probability category is most likely due to differences in environmental influences from the components each month, which affect the uniform corrosion degradation mechanism causing fluctuations in the corrosion rate. As for the category of failure consequences themselves, each month has the same category because the concept of the CoF in dynamic RBI is still the same as the standard RBI concept, where these consequences indicate the potential losses that will occur when a component fails.

The fluctuations in the values obtained are shown in **Figure 3.** Both the PoF value and the PoF value category fluctuate every month. This fluctuation every month is the important data generated by the dynamic

RBI method, in contrast to the standard RBI, which will only show a constant value based on the last inspection data. This data fluctuation is important because, with this data, we can know the component condition in real time and more accurately. In figure 3, the fluctuations between September and December can be considered minor and not potentially dangerous. However, the slightest fluctuation will affect the condition of the components and, in the near or long term, will have the potential to damage the components. This is not considered and not presented in the standard RBI concept that widely uses today, standard RBI, which tends to assume a constant risk value at any time in the long term and will have an error due to fluctuations that are ignored. This error value will get bigger and tend to result in a wrong prediction of the condition of the component, where the component will fail before the maintenance time.

Based on the dynamic RBI data obtained, it can be seen that there was a significant spike in January. Compared to other months, the value for this month has a huge difference, so in January, it is necessary to pay more attention to the components by studying what causes them. Underlies this spike in the value of the probability of failure. The existence of fluctuations in the value of the probability of failure and significant spikes that are read by the dynamic RBI provides increased confidence and accuracy of the actual condition of the components.

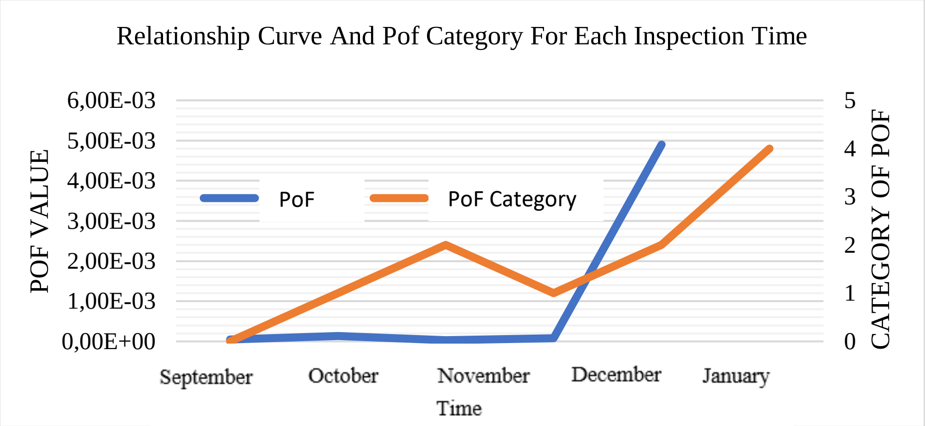

FIGURE 3. PoF value relationship curve and PoF Category for each inspection time

The value categories obtained in table 8 are also presented in the risk matrix shown in **Figure 4.** The figure shows a mapping of the risk level of the PT pipe components. X, it can be seen that there is a difference in the level of risk each month. As previously explained, the difference in the level of risk, although it can be said to be relatively small, is also important to pay attention to because this fluctuation over time will cause a significant error in the calculation of the standard RBI. Suppose for a long time. A check does not carry out on the actual condition of the component. In that case, it will provide an opportunity for error from the standard RBI prediction so that failure may occur before the maintenance time on the component.

Table 9 shows the results of calculating the risk value from a financial perspective in USD units. **Figure 5** shows the curve of the relationship between the probability of failure and the risk value that has been calculated. In this curve, there is a linear relationship between the two components where the risk value of a component will increase as the value of the probability of failure increases.

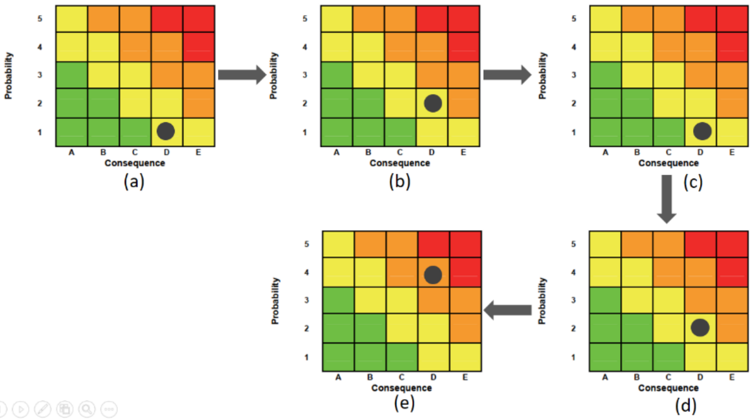

FIGURE 4. Mapping the risk level of PT.X pipe thickness data for each time of inspection, a) September, b) October, c) November, d) December and e) January (next year)

Table 9. The results of the calculation of the risk value of PT pipe data. X

No	Time	PoF value	FC Rate (USD)	Risk Value (USD)
1	September	4.47E-05	1,023,894.651	45.7680909
2	October	1.38E-04	1,023,894.651	141.2974618
3	November	3.06E-05	1,023,894.651	31.33117632
4	December	8.11E-05	1,023,894.651	83.0378562
5	January	4.90E-03	1,023,894.651	5017.08379

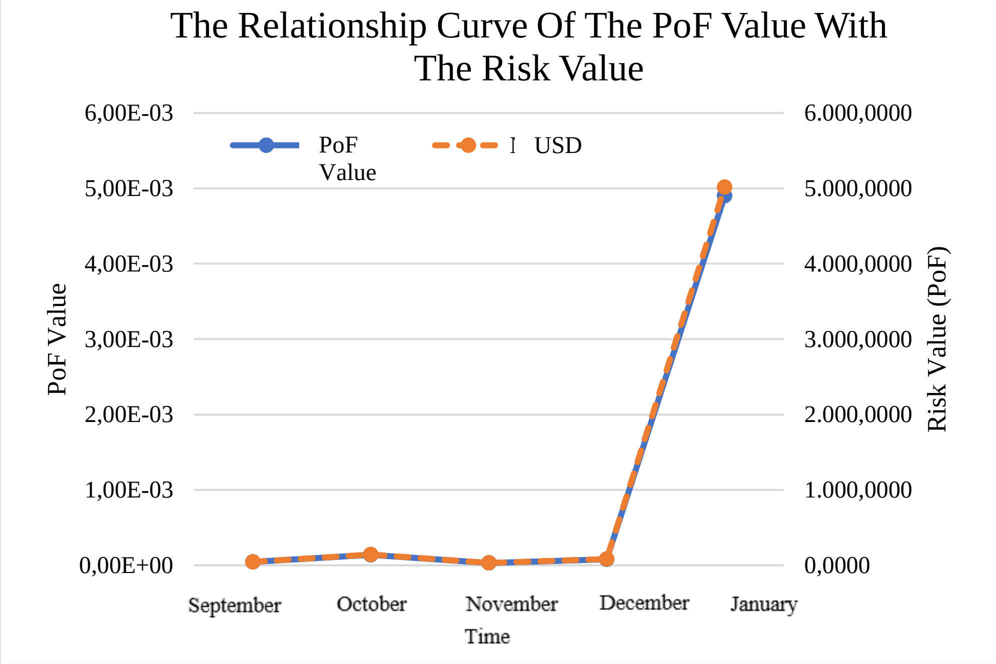

FIGURE 5. The relationship curve of the PoF value with the Risk value for each inspection time

Based on the results of the dynamic RBI calculations, it is proven that there are fluctuations in the risk value in a short time. These fluctuations are most likely caused by the relationship between the degradation factors that occur in actual conditions. These degradation factors will influence each other so that the value of the degradation rate can only be considered constant for a short time because it will cause significant errors in the results of predictions and plan maintenance. In optimizing the risk value used to make inspection planning decisions and determining the actual condition of a component, an accurate method and value are needed to represent the actual risk value of the component. The use of the dynamic RBI method is proven to provide more accurate results compared to the use of the linear method, which is commonly used with an extended inspection period and assumes the risk value of the components is constant over time.

Maintenance Analysis And Comparison of Dynamic RBI With Standard RBI

Corrosion rate fluctuations and failure probabilities are generally difficult to capture when using standard RBI. Using standard RBI will assume that the corrosion rate has a constant value based on the last inspection data, such as research conducted by [16] in his research entitled "Optimizing the Estimation of Failure Risk in the Uniform Corrosion Rate Function Using the Monte Carlo Method". In this study, the risk value calculation and inspection planning were carried out based on the last inspection data so that the failure probability value was obtained using the linear method in category 3. In contrast, the consequence category was at a value of "D". The data then map on the maintenance risk matrix, and the following maintenance schedule was obtained for two years. **Figure 6** shows a comparison between the use of dynamic RBI and standard RBI carried out [16]. In the standard RBI for each inspection time, the failure probability value is considered constant,

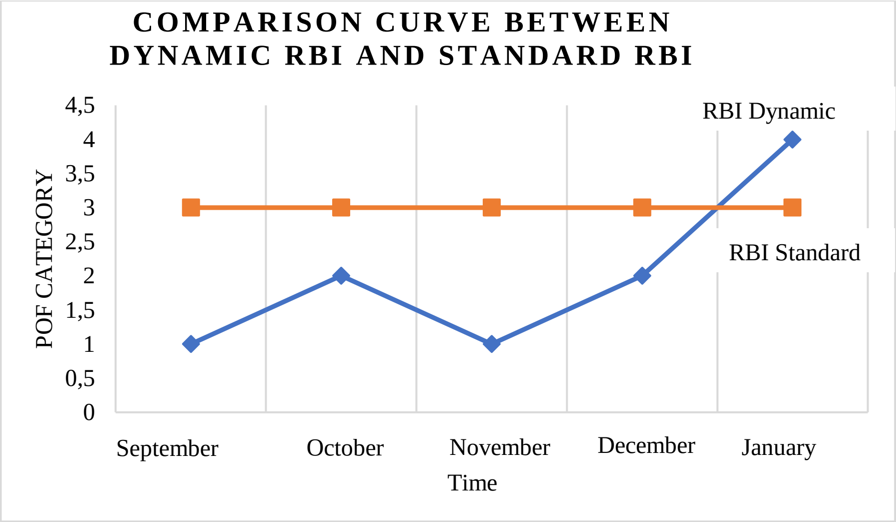

FIGURE 6. PoF category comparison curve between dynamic RBI and standard RBI at each inspection time.

In addition, using standard RBI creates an opportunity for error. It is even greater if the assumed risk value is constant at long intervals because real-time conditions of the components are not obtained, which in actual conditions continue to fluctuate with the age of the components. Therefore, this dynamic RBI is recommended for use in the oil and gas industry because, in real-time, the condition of components/piping systems can be known.

The results of this dynamic RBI will result in a better component safety system in real-time, with component conditions that can be monitored based on the obtained curve. As long as the components continue to operate and monitoring is carried out continuously, the curve will continue to move closer to the critical value set by the industry. If it is almost close to the critical value and signs of damage have been found in the field, inspection planning can be carried out in time close to this condition. Inspection planning that is too long will minimize using dynamic RBI so that costs incurred due to inspections that are too early or costs incurred due to incorrect prediction of failure time can minimize.

CONCLUSION

1. The design of the dynamic RBI in the gas pipe case study has been successfully formulated using the center difference method approach in calculating the corrosion rate. PT.X pipe thickness data with inspection intervals per month was interpolated using Igor software with the cubic spline method. With the help of R-Studio software, simulations are carried out with the design of the dynamic RBI algorithm that has been compiled so that the results are obtained in the form of risk values for each inspection time, namely in September, October, November, December, and January.
2. The risk values obtained from PT.X gas pipeline inspection data are in the medium range (4 inspection times) and medium-high (1 inspection time). Based on these results, it can be seen that there are fluctuations in the risk value, which are most likely caused by degradation factors that experience interactions with their environment.
3. The difference between the dynamic RBI and standard RBI methods is seen in the risk values obtained. The use of standard RBI will only provide one risk value as a result of the standard RBI concept, which assumes the risk value of a component will be constant based on the last inspection data carried out. In contrast to using RBI, according to the results obtained, the risk value for each inspection time interval has a different value and level of risk. From these results, the risk of a component cannot be considered a constant value. For each inspection time, the risk value for each inspection interval is 45.7680909 USD in September, 141.2974618 USD in October, 31.33117632 USD in November, 83.0378562 USD in December, and 5017.08379 USD in January.

   The dynamic RBI design that has been made is proven to capture fluctuations in the corrosion rate that occurs in the gas pipeline of PT.X. Corrosion rate fluctuations that occur every month are the cause of increasing error values in inspection results using the standard RBI method. The results of this dynamic RBI result in a better component safety system, in real-time component conditions can be monitored based on the obtained corrosion rate fluctuation curve. With this condition, inspection planning that is too early or inspection planning that is too long will be minimized using dynamic RBI so that costs incurred due to inspections that are too early or costs incurred due to incorrect prediction of failure time can be reduced.

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