The development of a risk-based maintenance flowchart to select the correct methodology to develop maintenance strategies of oil and gas equipment

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Abstract. There are hundreds, even thousands of equipment that are installed on an Oil and Gas Plant. The equipment can be static equipment, rotating machinery, or protective devices. Each type of equipment has a unique failure mechanism and failure mode. Maintenance tasks should be performed to prevent these failures from being happened. The maintenance task should be developed based on the methodology, which will capture the failure mechanism yet to prevent it from being more severe. Before March 2018, the Indonesian government has adopted a time-based maintenance policy for all static equipment operated by oil and gas companies operating in the Republic of Indonesia's territory. Every three years, the static equipment that works must be inspected and recertified. In March 2018, the Minister of Energy and Mineral Resources issued regulation No. 18, which allows the use of risk analysis methods to determine maintenance strategies, known as risk-based maintenance, for all equipment operated by oil and gas companies operating in Indonesia. This paper will develop an initial flowchart to select the correct methodology to develop maintenance based upon the dominant failure mode. A case study to demonstrate the flowchart has also been performed in an Onshore Receiving Facility (ORF).

Keywords. Equipment Criticality Analysis (ECA), Reliability Centered Maintenance (RCM), Risk-Based Inspection (RBI), Risk-Based Maintenance (RBM), Safety Integrity Level (SIL).

1. Introduction

There are hundreds, even thousands of equipment that are installed on an Oil and Gas Plant. Maintenance activities should be performed to prevent failure mechanisms and failure mode being happened. In Oil and Gas practice, there are codes and government regulations as well to have Oil and Gas Companies to perform mandatory maintenance in order the plants are permitted to continue to operate.

Traditional inspection codes for the static equipment are based on prescriptive or time-based requirements. The recommendations require the operator to perform the inspection at a specific time interval regardless of the condition of the equipment. Examples of such offers can be found in American Petroleum Institute (API) inspection codes [1][2][3]. These codes focus only on the probability of failure, and the failure consequence of the equipment is not to be considered. Having these codes implemented, sometimes it is found that the equipment is still fit for service between two inspection intervals.
However, among hundreds or thousands of equipment operated in oil and gas plants, those will not have the same likelihood to fail at the same rate. Also, the consequence caused by every failed equipment does not have the same severity level. There is a concept to represent both the probability of failure and its consequence into a single representation called risk.

API initiated to include the consequence of the failure and the probability of failure of the static equipment in 2000. This concept can be found in API Risk-Based Inspection document guidance [4]. This document has been superseded by the latest document [5] in 2016.

Risk can be defined as a measure of possible loss or injury and is expressed as the combination of the incident probability and its consequences. Risk can be described as the multiplication of the probability of failure (PoF) and the consequence of failure (CoF), as can be seen in Equation 1.

\[ Risk = PoF \times CoF \] (1)

In most processing facilities, a large percent of the total risk for a processing unit will be concentrated in a relatively small percentage of the equipment items. These potential high-risk components may require greater attention through a revised inspection plan. The cost of the increased inspection effort may be offset by reducing excessive inspection efforts in the areas identified as having lower risk. Figure 1 shows the typical risk of equipment distribution in a processing facility.

Figure 1. Typical risk of equipment distribution in a processing facility.

Until 2018, the Indonesian government has adopted a time-based maintenance policy for all static equipment operated by the oil and gas companies operating in the Republic of Indonesia's territory. Every three years, static equipment that operates must be inspected and recertified so that it can be operated legally. In March 2018, the Minister of Energy and Mineral Resources issued regulation No. 18, which allows the use of risk analysis methods to determine maintenance strategies, known as risk-based maintenance, for all equipment operated by oil and gas companies operating in Indonesia. For this reason, it is necessary to develop a framework to guide the selection of appropriate analysis methods to determine maintenance strategies for various equipment used in the oil and gas industry. Different methodologies relating to RBM are reviewed, and the implementation sequence is also studied.

2. Risk-based maintenance (RBM)

Maintenance is defined as a combination of all technical, administrative, and managerial actions during the life cycle of an item intended to retain it or restore it to a state in which it can perform the required function [6]. Practically, all companies which operate oil and gas processing plant already have a maintenance strategy to maintain the assets. The maintenance strategies applied generally adopt applicable rules, regulations, and codes relevant to the type of equipment. The maintenance strategies sometimes are also based on manual equipment or recommendations from vendors. The maintenance strategy approach in this way is generally known as the minimum maintenance approach and less attention to the risks that will occur if the equipment fails.
Risk-Based Maintenance (RBM) is a methodology to develop maintenance tasks based on the assets’ risk profile. The methods used to create maintenance tasks depend on the equipment failure mode. The failure mode is the effect by which a failure is observed on the failed item [6].

Equipment is a maintenance object. There are hundreds or even thousands of equipment operating in the oil and gas plant. Not all equipment has the same level of risk. High-risk equipment requires more attention compared to low-risk equipment. Therefore, the first step in implementing the RBM is to conduct screening to select medium and high-risk equipment which will be analyzed in detail. Detail analysis aims to develop a maintenance task that is technically feasible and worth doing.

2.1. Equipment Criticality Analysis (ECA)

The terminology of equipment criticality analysis (ECA) refers to the initial screening of equipment based on its critical level. ECA is a risk-based screening process to prioritize which equipment should be analyzed further using the appropriate methodology to determine maintenance tasks that are technically feasible and worth doing. Technically feasible is governed by the technical characteristics of the task and of the failure which it is meant to prevent. Whether it is worth doing is governed by how well it deals with the consequences of failure [7].

There are several methods developed to determine the critical level of equipment. The classical reliability textbook discussed this issue under the topic of component importance [8]. The theoretical discussion on how to determine the criticality of the component based on the location of the component in the system as well as the reliability value of the component. The criticality of the component is determined by its component importance. Component importance can be determined by Birnbaum's measure, criticality importance, Vesely – Vussell's measure, or Improvement potential.

The risk matrix is also widely used to determine the criticality level of equipment. The dimensions of a risk matrix depend on the number of probability and consequence ratings. A risk matrix with dimensions of 3 x 3 means that the risk matrix has 3 rating probabilities and 3 rating consequences. In oil and gas industry practice, DNV recommends conducting a screening process for static equipment before analyzing risk-based inspection [9]. This document has been superseded by the latest document [10] in 2017. The screening process is carried out using a 2x2 risk matrix, as shown in Figure 2. The matrix classifies risk into three levels: low risk, medium risk, and high risk.

![Figure 2. DNV risk screening tool](image)

Norsok recommends a more general criticality analysis process for systems, subsystems, and equipment in the oil and gas processing industry [6]. The critical level is determined based on the level of redundancy and the consequences if the system, subsystem, or equipment fails.

The protocol of the scoring system and risk matrix to determine criticality equipment before RBI analysis can be found in [11]. The protocols were developed based on [10]. ECA categorizes the static mechanical equipment into C1, C2, or C3, which refer to high, medium, or low criticality equipment, respectively. Both probability and consequence are determined by the scoring protocol. The scores will determine the probability level and consequence level. The risk, which represents the criticality of the equipment, is determined by combining the probability level and consequence level.
Efforts to improve the determination of criticality equipment have been carried out. Improvements are made by adding multiple criteria that contribute to the probability of failure and the consequences of failure. Improvements are also made to probability modeling.

A fuzzy inference system (FIS) is the actual mapping process from a given input to an output using fuzzy logic. The FIS application in determining the criticality of equipment can be found in [12]. The application of FIS has been used to rank the criticality of rotating machinery and the instrumentation in the oil and gas processing plant. The equipment criticality can be determined by ranking its functional failure risk (FFR) [12]. The FIS was adopted due to it can minimize the determination of suboptimal priorities from Functional Failure Risk (FFR).

Bayesian networks are a type of probabilistic graphical model that uses Bayesian inference for probability computations. Bayesian networks aim to model conditional dependence, and therefore causation, by representing conditional dependence by edges in a directed graph. Bayesian network applications in determining the criticality of equipment can be found in [13]. The conducted study investigates the safety and operational issues of the constant bottom-hole pressure drilling technique which is used in managed pressure drilling compared to conventional overbalanced drilling. The study first uses bow-tie models to map safety challenges and operating pressure regimes in constant bottom-hole pressure drilling techniques. Due to the difficulties in modeling dependencies and updating the belief on the operational data, the bow-ties are mapped into Bayesian networks. The Bayesian networks are thoroughly analyzed to assess the safety-critical elements of constant bottom-hole pressure drilling techniques and their safe operating pressure regime.

Analytic Hierarchy Process (AHP) is a multicriteria model that provides a methodology for comparing alternatives by structuring criteria into a hierarchy, providing for pair-wise comparisons of criteria at the lowest level of the hierarchy to be entered by the user, and synthesizing the results into a single numerical value. The application of AHP to determine the criticality of equipment can be found in [14]. Four criteria are considered for criticality analysis. They are the effect on the failure of equipment on power generation, environment and safety, frequency of failure, and Maintenance Cost.

The Fine–Kinney method is a comprehensive method for quantitative evaluations to aid in controlling hazards. In this risk assessment method, the risk value is calculated by considering the parameters of the consequence of an accident (C), the exposure or frequency of occurrence of a hazard event that could lead to an accident (E), and the probability of a hazardous event (P). The classical Fine–Kinney method has a limitation in that it assigns equal weight to these three parameters. The improvement of this method incorporating AHP has been developed and it has been implemented to determine the criticality of the equipment. This can be found in [15].

2.2. Risk-based inspection (RBI)
Static equipment operated at an oil and gas processing facility has a dominant failure mode of a loss of containment. The typical cause of this failure mode is the metal loss caused by corrosion. The inspection of static equipment is a form of a maintenance task that is commonly carried out to monitor the thickness and corrosion rate that might occur in the static equipment.

In oil and gas industry practice, API released an RBI recommended practice. This recommended practice provides quantitative procedures to establish an inspection using risk-based methods for pressurized fixed equipment, including pressure vessels, piping, tankage, pressure relief devices (PRDs), and heat exchanger tube bundles [5]. API also releases the other document to guide the development of RBI programs on fixed equipment in refining, petrochemical, chemical process plants, and oil and gas production facilities [16]. The intent is for [16] to introduce the principles and present minimum general guidelines for RBI, while document [5] provides quantitative calculation methods to determine an inspection plan.

DNVGL also published RBI recommended practice for oil and gas industry practice [10]. This recommended practice aims to describe a method for establishing and maintaining an RBI plan for offshore pressure systems. It provides guidelines and recommendations which can be used to customize methods & working procedures that support the inspection planning process.
There was a study to implement this RBI methodology [17] with the piping as the object of the RBI study. In refineries and processing plants, the enormous amount of piping is more complicated in distribution than other types of equipment. In general, compared with different types of equipment in these industries, more difficulty in inspection planning is encountered. To lessen the piping risk level, more and more companies have adopted and applied risk-based inspection (RBI) methodology, leading to risk reduction and cost benefits.

A study to incorporate AHP into RBI analysis has been performed by [18]. RBI methodology was proposed to evaluate the maintenance strategy in the industrial process, which was constructed in one of the units of Fujian Oil Refinery ISOMAX unit. All equipment in this unit was evaluated and categorized into five risk zones based on the RBI result, which covered five levels. Also, an application of the analytical hierarchy process (AHP) to select the most practicable maintenance strategy for equipment which was in each risk rating scale, was described.

Another study has also been conducted to couple RBI methodology and Multi-Objective Genetic Algorithm (MOGA) for defining efficient inspection programs in terms of inspection costs and risk level, which also comply with restrictions imposed by international standards and/or local government regulations [19].

2.3. Safety integrity level (SIL)

There are equipment and instrument in oil and gas processing facilities having protective functions or safety functions. The Safety Instrumented Systems (SIS) are the systems responsible for the operating safety and ensuring the emergency stop within limits considered safe whenever the operation exceeds such limits. The main objective is to avoid accidents inside and outside plants, such as fires, explosions, equipment damages, protection of production and property, and, more than that, avoiding life risk or personal health damages and catastrophic impacts to the community. Therefore, the failure mode of this kind of device is the loss of protection.

Safety integrity is defined as 'the likelihood of a safety-related system satisfactorily performing the required safety functions under all the stated conditions, within a stated period of time, and a safety integrity level (SIL) as a discrete level (one of 4) for specifying the safety integrity requirements of safety functions The Safety Integrity Level (SIL) is a statistical representation of the integrity of the SIS when a process demand occurs. Testing the SIS is the only way to ensure the protective device keeps functioning. The frequency of the test depends on the safety integrity level.

There is a standard [20] that provides a basic functional safety standard applicable to all industries. It defines functional safety as: "part of the overall safety relating to the EUC (Equipment Under Control) and the EUC control system which depends on the correct functioning of the Electrical/Electronic/Programmable Electronic (E/E/PE) safety-related systems, other technology safety-related systems, and external risk reduction facilities."

The evaluation of SIS will reveal whether the risk controlled by the protective device in oil and gas processing plants comply with the standard or not. One of the proposed methods to evaluate SIS is using a genetic algorithm as it can be found in [21]. Another method to verify the integrity level of SIS is by using a reliability block diagram and Montecarlo simulation [22]. The verification was done following the requirements of IEC 61508.

A study to simplify and more efficient methodology for the safety assessment of electromechanical SIS in compliance with the Standards IEC 61508 and IEC 61511 can be found in [23]. The proposed technique is based on an alternative implementation of the Reliability Block Diagram (RBD) approach for the performance analysis of the Safety Instrumented System.

2.4. Reliability-centered maintenance (RCM)

For the equipment having failure modes other than loss of containment and loss of protection, there is a methodology to capture different failure modes, analyze them, and recommend maintenance tasks. Such a procedure is reliability-centered maintenance (RCM). Early works of RCM before the formal RCM standard was released can be found in [24].
RCM is a process to ensure that systems continue to do what their user require in their present operating context. It is generally used to achieve improvements in fields such as the establishment of safe minimum levels of maintenance [7]. The technical standard to perform the RCM process can be found in [25][26]. If it is performed correctly, RCM will recommend a maintenance task that is technically feasible and worth doing.

RCM indicates that reliability is the main point of reference for the planning, but the consequences of failures are also assessed. However, uncertainties and risks are to a limited extent addressed by the RCM method. A methodology to incorporate risk as an extension of the RCM analysis was proposed by [27]. The methodology is called reliability and risk centered maintenance (RRCM).

An integration of identification critical components before the implementation of RCM is presented in [28]. A modification of the RCM table to incorporate risk priority numbers before select technically feasible and worth doing maintenance tasks can be found in [29]. The purpose of the modification is to optimize the maintenance task. Another method to optimize RCM planning is to use a genetic algorithm. A multi-objective model is proposed to solve the mathematical problem of optimizing the reliability-centered maintenance planning of an electric power distribution system (EPDS). The main goal is to minimize the preventive maintenance costs while maximizing the index of the reliability of the whole system [30].

Figure 3. Proposed RBM flowchart to choose maintenance tasks analysis methodology based upon failure mode of the equipment.

3. Proposed RBM flowchart

Maintenance tasks developed from maintenance strategy should be able technically feasible and worth doing to prevent equipment failure being occurred. The maintenance task at least consists of two issues, i.e., what task to do to prevent failure mode being happened and when the task will be executed. Determining what task to do and when to do it requires the understanding of failure modes associated with it and the cause and the mechanism of failure. There are methodologies to deal with these issues.

RBI is a methodology deal with the loss of containment failure mode of static equipment, SIS and SIL methodology deal with the loss of protection of protective device while other methodology to analyze different failure modes are provided by RCM. There are hundreds of even thousands of equipment operate in oil and gas processing plants. Therefore, it is recommended to perform ECA to prioritize the equipment, which can be categorized as having medium and high risk. The results of the ECA can be categorized into high risk, medium risk, or low risk. C1, C2, and C3 refer to the high, medium, and low-risk equipment categories, respectively. Depend on the failure mode of the
equipment, equipment with C1 and C2 category will be analyzed further using RBI, SIL, or RCM. The result of the analysis will determine technically feasible and worth doing maintenance tasks of the equipment based upon its failure mode. For equipment with the C3 category, a planned corrective maintenance strategy will be appropriate for it. Figure 3 shows the proposed RBM flowchart to choose maintenance tasks analysis methodology based upon the failure mode of the equipment.

4. Case study
A case study regarding the use of the RBM flowchart is presented below in the early implementation of RBM. An onshore receiving facility (ORF) operating in the East Java Province of the Republic of Indonesia has been selected for the case study. The study is still in an early stage of RBM implementation. Therefore, the objective of the case study is to group the equipment based upon its dominant failure mode. Once it is identified, an appropriate methodology to develop a maintenance strategy is recommended.

4.1. System description
Figure 4 shows an overview of the onshore receiving facility being studied. The acid gas from the wellhead is processed in the wellhead platform (WHP). The acid gas is feed to the manifold before it is separated in the liquid-gas separator. The separated fluids are then sent to the floating production storage and offloading (FPSO). The acid gas is processed to become sweet gas in the FPSO and send it back to WHP before it is sent to the ORF.

![Figure 4. The overview of the onshore receiving facility.](image)

Figure 5 shows the schematic flow diagram of the ORF. The sweet gas from the WHP flows through a subsea pipeline before it is fed into a separator V-001. The separated gas is led to the customer through sales gas metering package M-001. Some of the separated gas is also led to the fuel gas system that is used for the internal utilization of ORF. The separated liquid from V-001 is sent to the liquid burner system and flare system.

Fuel gas scrubber V-002 and fuel gas separator S-001 will process gas from V-001 to become dry gas and send it to fuel gas superheater E-001. This process ensures that there are no liquid contents in the dry gas before it is contained in the instrument gas receiver (V-003). The operation of the ORF is also supported by utility systems such as closed drain and flare system, open-drain system, oily water treatment system, liquid burner system, diesel system, freshwater system, and fire water system.

4.2. The physical asset hierarchy
The first step in conducting this study is to identify the asset hierarchy of the ORF. For the study, the hierarchy of the asset is arranged based upon asset hierarchy as it is recommended in [31]. The source information for the asset hierarchy comes from the company asset register, process flow diagram (PFD) and piping and instrument diagram (P&ID) of the ORF, and other relevant information.

The hierarchy of physical assets can be arranged technically. The technical hierarchy describes the technical structure of the installation by giving functional locations unique identifiers. The technical hierarchy provides an overview of equipment units that belong together technically and shows the physical relationship between main equipment, instruments, valves, etc.

As per standard [31], the physical assets hierarchy is divided into nine levels starting from industry type until part level. The hierarchy starting from the top until the lowest level is as following: industry – business category – installation – plant/unit – section/system – equipment unit – subunit – component / maintainable item – part. An example of the taxonomy of the physical assets can be seen in Table 1.
Figure 5. Schematic flow diagram of the ORF.
Table 1. The taxonomy of physical assets [31].

| Main Category | Taxonomy Level | Taxonomy Hierarchy | Definition |
|---------------|----------------|--------------------|------------|
| Use / Location data | 1 | Industry | Type of main industry |
| | 2 | Business category | Type of business or processing stream |
| | 3 | Installation category | Type of facility |
| | 4 | Plant/unit category | Type of plant/unit |
| | 5 | Section/System | Main section/system of the plant |
| Equipment subdivision | 6 | Equipment class/unit | Class of similar equipment units. Each equipment class contains comparable equipment units |
| | 7 | Subunit | A subsystem necessary for the equipment unit to function |
| | 8 | Component/Maintainable item | The group of parts of the equipment unit that are commonly maintained (repaired/restored) as a whole |
| | 9 | Part | A single piece of equipment |

For this study, the hierarchy of the physical assets will be broken down until level 8. At this level, the initial maintenance strategy will be determined for the component/maintainable item based on the developed RBM flowchart.

4.3. The study results

The application of the proposed RBM flowchart is initiated by registering all assets based on the hierarchy. The hierarchy of the physical assets will be broken down until level 8. Data in level 1 to level 5 informs the type of industry, business category, installation category, and the plant where the data located. Table 2 shows the list of information at level 5 or the list of systems available in ORF. Level 6 to level 8 describes the equipment information starting from its class/unit until its component. The maintenance strategies might be applied to any equipment at these levels.

Table 2. The list of systems in the ORF.

| No. | Name of system |
|-----|----------------|
| 1   | Close drain system |
| 2   | Diesel system |
| 3   | Electrical distribution system |
| 4   | Flare system |
| 5   | Freshwater system |
| 6   | Fuel system |
| 7   | Instrument gas system |
| 8   | Enclosed liquid burner package |
| 9   | Custody meter package system |
| 10  | Oily water treatment system |
| 11  | Open drain system |
| 12  | Piping system |
| 13  | Gas pig receiver system |
| 14  | Fire protection system |
| 15  | Gas inlet separator system |
| 16  | Telecommunication |
| 17  | Workshop |
From the process flow diagram (PFD) and piping & instrument diagram (P&ID), it can be identified that the ORF plant consists of 17 systems, 98 equipment class/unit, 137 subunits, and 3490 components / maintainable items. Therefore, there will be massive and complex data in registering the physical hierarchy of the assets. The complexity and integrity of the data will be the issue in handling massive data. The integrity of the data should be stable. A database program will record and manage the hierarchy of the assets as per standard [31]. Figure 6 shows the hierarchy level relationship data in a database program.

![Figure 6. Data relationship.](image)

All data has been processed and stored in the database. Figure 7 shows the ORF's physical asset hierarchy screenshot starting from level 4 to level 8. There are 17 subsystems identified at level 5, as in Table 2. Level 6 groups the equipment in a class or unit. There are 98 equipment classes at this level. In some cases, it is preferable to develop maintenance strategies at this level.

![Figure 7. The screenshot of ORF's physical asset hierarchy.](image)

There is a drain transfer pump as an example at level 6. In this case, it is preferable to develop maintenance strategies for this equipment at this level. The pump has dominant failure modes other than loss of containment and loss of protection. Therefore, the maintenance strategies should be developed based on the RCM methodology. Of 98 equipment classes at level 6, 93 of them have been recommended to adopt the RBM methodology to evaluate or improve the maintenance strategies. The use of the proposed flowchart leads to the following recommendations. The RBI, SIL, and RCM methodology will be applied to 13, 29, and 51 equipment, respectively.
Level 7 or subunit is a sublevel necessary for the equipment unit to function. Each equipment unit has different subunits from other equipment units. For example, the pump might consist of power transmission, power unit, control and monitoring system, piping system, and lubrication system. It is rare to develop a maintenance strategy at this level since every subunit might have some components. It is more appropriate to create maintenance strategies at the component level.

Level 8 or component is the group of equipment units that are commonly maintained (repaired/restored). There are 3490 components identified in the ORF. RBM methodology flowchart is applied to all components to obtain an appropriate methodology to develop an effective maintenance strategy. The RBI, SIL, and RCM methodology will be used for 326, 1113, and 2051 components, respectively. Figure 8 shows the distribution of the applied RBM methodology for the assets both at equipment classes (level 6) and at the component level (level 8). Figure 8 summarizes assets grouping based on RBM type both at equipment class (level 6) and component level (level 8).

![Figure 8. Asset grouping based upon RBM type.](image)

Figure 8. Asset grouping based upon RBM type.

a. RBI analysis result of 50-DC-6425-31492X  
b. Detail inspection plan

![Figure 9. RBI analysis result and detail inspection plan.](image)
To demonstrate the application of the proposed RBM flowchart, let's take a drain transfer pump at the equipment class as an example. The pump is recommended to adopt the RCM methodology to develop or to improve its maintenance strategy. In the drain transfer pump, the pump has a piping system subunit (level 7) that consists of many pipings (level 8). The pipings have a dominant failure mode of loss of containment. Therefore, the RBI methodology is recommended to develop the inspection plan. For example, ORF-01-50-DC-6425-31492X is the tag number of piping under the piping system to support the pump. This piping's RBI analysis showed that this piping's risk category is low at the RBI date. An inspection plan has also been developed based on RBI's analysis result. Figure 9 shows the summary of the RBI analysis and detailed inspection plan of the pipe.

5. Discussion and future works
A case study on the application of the proposed RBM flowchart has been completed. The object of the case study is an onshore receiving facility. However, the case study showed that the result of the RBI analysis of the sample component is low risk. The analyst might skip the RBI analysis recommendation for this sample only if the analyst knew that the pipe had been screened before. The method to filter the component and categorize it based on its criticality is known as equipment criticality analysis (ECA).

Further study and the development of ECA methodology will be performed. The ECA study will be focused on the development of ECA protocols for the equipment operated in the oil and gas industries. The method developed must be practical but supported by a strong scientific background. The various ECA methods will be assessed its applicability level in the field, considering that this framework will be implemented for practical industrial purposes.

6. Conclusion
An RBM framework for onshore receiving facility equipment has been developed, and a case study has been performed. The case study proved that the appropriate methodology to develop an effective maintenance strategy is based on the equipment's dominant failure mode. The proposed methods are RBI, SIL, and RCM.

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