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The Influence of Inventory Service Level and Equipment Criticality on Equipment Uptime Through MRO Inventory as an Intervening Variable (Case Study At PT. ABC)

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ABSTRACT: The oil and gas production field of PT ABC located in Central Java has been operating for 10 years with a gas production capacity of 70 MMSCFD, making it one of the largest gas production fields in Indonesia. However, in the past 4 years, there have been fluctuations in production and a decrease in equipment uptime due to breakdowns in the production facility equipment. The results of the problem analysis indicate that the cause of the decrease in equipment uptime is the constraint on the availability of equipment spare parts in MRO (Maintenance, Repair, and Operation) activities, thus it is necessary to identify the factors that can influence equipment uptime. The purpose of this research is to determine (1) the effect of inventory service level on MRO inventory at PT. ABC; (2) the effect of equipment criticality on MRO inventory at PT. ABC; (3) the effect of MRO inventory on equipment uptime; (4) the effect of inventory service level on equipment uptime through MRO inventory at PT. ABC; and (5) the effect of equipment criticality on equipment uptime through MRO inventory at PT. ABC. The research method is quantitative, using secondary data obtained from PT. ABC's reports. Data analysis uses the Structural Equation Model (SEM) operated with SmartPLS software. The results of this study indicate that (1) inventory service level has a significantly positive effect on MRO inventory. A higher service level at PT. ABC indicates a greater likelihood of promptly meeting the material/spare parts needs of the MRO inventory; (2) equipment criticality has a significantly positive impact on the MRO inventory. The implementation of criticality assessment using the SECE method at PT. ABC can focus MRO inventory management on the most important spare parts to minimize equipment downtime and carrying costs; (3) MRO inventory has a significantly positive impact on equipment uptime. The optimal performance of MRO inventory can overcome material shortage constraints; (4) inventory service level has a significantly positive impact on equipment uptime through MRO inventory. A high service level has a greater likelihood of meeting spare parts needs in the MRO inventory, ensuring that MRO activities are not disrupted and can improve equipment uptime; and (5) equipment criticality has a significant positive impact on equipment uptime through MRO inventory. Prioritizing maintenance and parts management with equipment criticality assessment can improve MRO inventory performance and equipment uptime.

KEYWORDS: Inventory Service Level, Equipment Criticality, Equipment Uptime, MRO Inventory

INTRODUCTION

In the oil and gas industry, shutdown is a critical measure that can affect the operation and production of a company (Hameed et al., 2015; Kusmono et al., 2024; Seif et al., 2020; Tang et al., 2016; Zhu, Liyanage, & Jeeves, 2020; Zhu, Liyanage, Panesar, et al., 2020). It can be divided into two types: planned and unplanned shutdowns. Planned shutdown refers to the maintenance of the production facilities to prevent activities such as maintenance and other activities, while unplanned shutdown refers to the failure of all or some equipment during the shutdown (SKK Migas, 2022). The Facilities department, which manages the production facilities in the area between choke valve/post-Christmas Tree and export point is one of the main sources of shutdowns. The downtime caused by breakdowns in the facilities area can lead to downtime or a short period of shutdown. Downtime caused by failures in lifting oil and gas can increase the potential for production shortages (SKK Migas, 2024). The Gas Gross Production Profile for PT ABC from 2014-2035 shows that during the fourth quarter, there was a significant fluctuation in production and uptime due to breakdowns in production facilities.

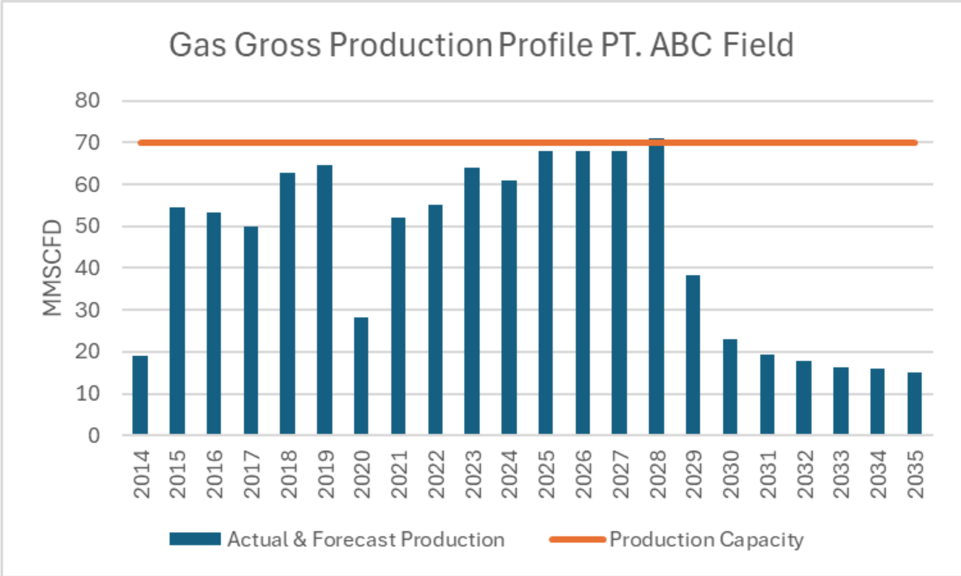

Figure 1. Gas Gross Production Profile Plant PT ABC from 2014 – 2035

Source: Production Report PT ABC (2024)

This can be identified using the Pareto diagram, which is used to identify factors affecting uptime. Two basis data are used: time and condition. Time is used to determine the mean time to repair (MTTR) and shutdown frequency of the event shutdown caused by production facility failure.

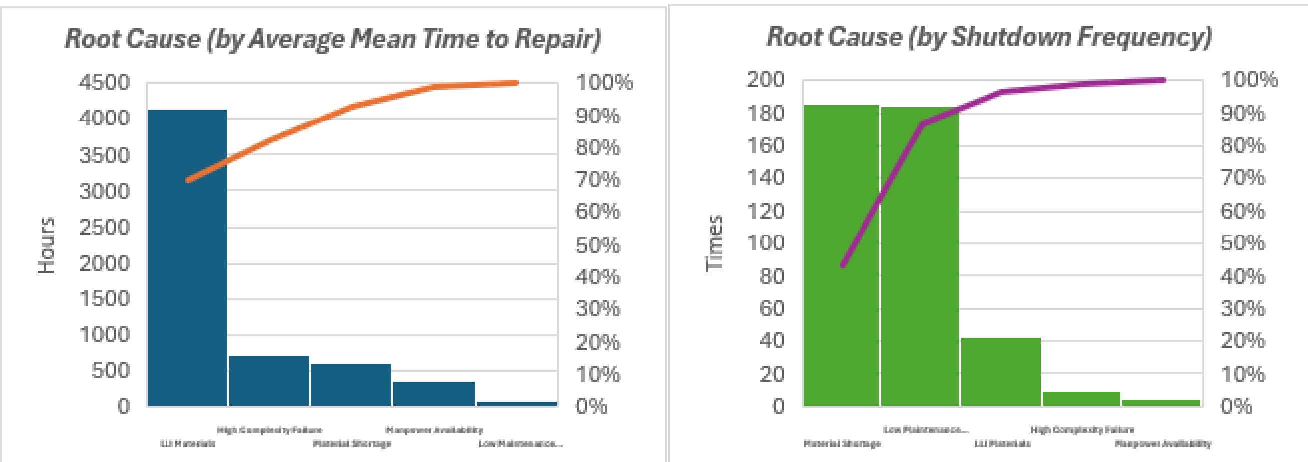

Figure 2. Pareto Diagram Root Cause of Uptime Decrease in Lapangan PT ABC 2020-2024

Source: Monthly Report Maintenance PT ABC, 2024

The root cause of uptime issues can be attributed to several factors, including poor planning and management of spare parts in Maintenance, Repair, and Operation (MRO) inventory. MRO inventory has a large number of items and is often overstocked, leading to understock or overstock (Khusna & Nugraha, 2018). To address this issue, it is essential to establish a balance between planning and management of spare parts (Sueur & Dale, 1998). Faisal dan Mahmoud (2003) found that isk-based maintenance is an important approach to prevent shutdowns, which can help companies prioritize risk-based maintenance strategies to minimize risks. By using this system, companies can maintain high performance levels, maintain efficient service levels, and reduce the risk associated with downtime. The company should also ensure the service level provided and align it with the quality control criteria for the supply chain (Fidlerová et al., 2014; Setiawan & Ernawati, 2023; Sueur & Dale, 1998). Some studies have been used as references to study the optimal factors of MRO inventory. Ali et al. (2020) studied the improvement of the MRO inventory management system in oil and gas companies to increase service levels and reduce average inventory investment. Bayu Wisnu, et al. (2024) conducted a comprehensive analysis of the LPO issue at PT Pertamina EP Donggi Matindok Field using FMEA, identifying discontinued spare parts as a root cause. Guajardo, Ronnqvist, et.al. (2015), dan Sudjatmiko, et.al. (2018) focused on demand forecasting and equipment criticality ranking to determine the ideal safety stock level for MRO inventory. The issues arising related to MRO inventory in the field of PT ABC oil and gas company and the research gap in previous studies necessitate further research on ways to improve uptime through the optimization of MRO inventory, by increasing inventory service levels and assessing equipment criticality rankings for determining safety stock of spare parts materials.

LITERATURE REVIEW

Operational management involves decision-making related to the production or service being offered, the necessary resources, and the use of technology. Fahmi (2016) explains that management is an illiterate discipline that uses knowledge and skills to manage and control human resources to achieve desired outcomes. Assauri (2016) defines management as a management activity within an organization focused on the production process of goods or services. Jay Heizer and Barry Render (2015) define management as the process of activities that create value from goods and services, converting input into output. The main focus of management is on managing the production process without focusing on production planning or production management. The main components of management include planning the production system, managing production resources, managing production inventory, and managing quality control. The production information system is also crucial in understanding the relationship between production and the market.

Constraint management is a concept in operations and project management that focuses on identifying and addressing critical aspects that affect performance or productivity of a system or process. Eliyahu Goldratt's Theory of Constraint provides a framework for understanding and addressing these aspects to enhance efficiency and effectiveness in any business or organization. The first principle of constraint management is that every system or process has a set of constraints that can be addressed to achieve its goals. This can be physical, such as a limited amount of resources or capacity, or based on constraints, such as organizational structure or stakeholder relationships (Blackstone, 2001). By identifying and solving these constraints, organizations can improve their capacity, increase efficiency, and achieve better results. Process constraint management involves identifying constraints, understanding how to effectively use constraints, coordinating between constraints and systems, improving constraints, and identifying potential constraints. The Theory of Constraints has been applied in various industries, from manufacturing to large corporations (Marton & Paulová, 2010). It is often combined with tools and concepts from production management, such as linear programming, material requirements planning, and lean manufacturing (Gupta, 2003; Şimşit et al., 2014).

Uptime refers to the time when a system functions and is available for efficient use, which is a crucial indicator of operational efficiency and plant performance. The formula for uptime is: Uptime = Total Time – Shutdown Time. Uptime that is maintained can reduce production activities and lift oil and gas, thereby reducing the potential for production shortages. This is the difference between the maximum production capacity that can be achieved at a given time and the capacity that can be achieved during a planned or unplanned shutdown in the Integrated Operation System of production system (SKK Migas, 2022).

Inventory management is crucial in managing production processes and achieving company goals. Effective inventory management minimizes costs, time spent on production, and inventory levels that are necessary for optimal production activities (KP & Nayak, 2017). It also helps minimize expenses related to inventory management, such as stock out, service level, and labor costs (Yang & Niu, 2009). Ramping inventory management can help reduce costs and increase production efficiency. Efficient inventory management is essential in managing operational organization operations (MRO), particularly in the areas of procurement, improvement, and operation (MRO). Many organizations face challenges in efficiently managing MRO inventory. The main issue is stockout, which affects the supply chain and production efficiency. To address this, effective inventory management strategies and technological advancements, such as inventory management software and digital inventory management systems, are crucial. Wireman (2008) highlights the importance of implementing a systematic approach to inventory management, focusing on the use of inventory categorization based on quality and usage frequency. This approach helps organizations optimize inventory levels and ensures that inventory levels remain constant and consistent (Ali et al., 2020). The Q,r model, also known as the fixed order quantity model, is a strategy used to optimize inventory investment and service levels. By considering factors like cost, lead time, and service level, the model minimizes total inventory investment while maintaining service levels (Robinson, 1993). In conclusion, inventory management plays a significant role in managing production processes and achieving company goals. By implementing effective inventory management strategies, organizations can minimize costs, improve efficiency, and enhance their overall performance (Priniotakis & Argyropoulos, 2018).

Ronen (1983) emphasized the importance of inventory management in ensuring efficient stock management and effective inventory service levels. He highlighted that inventory service level, which reflects the potential risks, can lead to a slow response to new orders or avoidable delays. Ronen also highlighted the influence of variable project timelines on service level.

Therefore, he suggested analysing historical data, improvement/improvement of processes, and other variables to ensure accurate planning and adherence to inventory service levels.

Graedel et al., Rosita & Rada, Kuo, Shimada et al., and EY India stem from the criticality of industrial equipment that helps conduct comprehensive analysis and detailed data analysis to accurately assess the reliability of each piece of equipment. Accurate assessment and categorization of equipment criticality involve understanding the potential impact of equipment failure on production, safety, and the environment. This requires a deep understanding of the various factors that contribute to the reliability and overall performance of each piece of equipment. The equipment criticality ranking process is not just a technical exercise and involves input from various stakeholders, including maintenance personnel, engineering teams, and production managers. Their expertise and insights are invaluable in ensuring a holistic assessment of equipment criticality (Graedel et al., 2011). Safety and Environmental Critical Element (SECE) is a comprehensive methodology to ensure the safety and environmental integrity of industrial processes (Kuo, 2011). Process Safety Management (2023) conveys that a systematic approach identifies and assesses critical elements to prevent and mitigate potential hazards associated with the operation of industrial facilities. The SECE method involves a thorough analysis of all aspects of the industrial process, including equipment, procedures, and human factors, to identify potential hazards and assess their impact on safety and the environment. EY India (2023) comes from a strength that has garnered significant attention in the industrial sector with high hazard levels, where the consequences of failure can be catastrophic. Continuous improvement is a key component of the SECE method, which allows organizations to adapt to new technologies, regulations, and industry best practices while maintaining a strong focus on safety and environmental management.

MRO inventory plays a crucial role in the oil and gas industry, as the productivity and availability of machinery heavily depend on the accessibility of spare parts and necessary materials (Ali et al., 2020). The increasing demand for maintenance, repair, and overhaul services for equipment, which is estimated to reach over $61 billion by 2017, highlights the importance of effectively managing MRO inventory to ensure a high service level (ElSaid et al., 2018). Specifically, a study on an oil and gas company found that by optimizing the ordering policy, the company was able to achieve a higher service level while reducing inventory investment. The study shows that the relationship between service level and optimal MRO inventory is complex, as it is influenced by factors such as product damage, random failures, and demand uncertainty (Li et al., 2018). Previous research also revealed that inventory service level has a significant positive impact on MRO inventory, as found in studies conducted by Ali et al. (2020), Kusuma & Hasibuan (2022), and Siponen et al. (2019).

H1 : Inventory service level has a significantly positive impact on MRO inventory at PT. ABC.

Efficient MRO inventory management is crucial in the oil and gas industry, as equipment failure can lead to production loss and emergency repairs. Brok (1987) emphasizes the importance of developing strategies for managing spare part inventory to minimize investment. Criticality analysis is a key aspect of inventory control, focusing on equipment components' criticality ranking, lead-time, and downtime costs. Akanni & Alonge (2015) and Ali et al. (2020) have explored the use of criticality analysis to prioritize maintenance and management, improving service levels while reducing overall inventory investment. Hmida et al. (2013) propose a multi-criteria inventory policy that combines inventory classification with preventive maintenance programs. Rizal & Mulyono (2019), Pradini & Kusumawati (2024), and Singh & Ganguly (2020) have also found that equipment criticality positively impacts MRO inventory, highlighting the need for a comprehensive approach to inventory management.

H2 : Equipment criticality has a significantly positive impact on MRO inventory at PT. ABC.

MRO inventory plays an important role in maintaining asset productivity and increasing uptime (Ali et al., 2020; Ganapathy et al., 2021). Planned uptime can have a significant financial impact (Ganapathy et al., 2021). The oil and gas industry invests heavily in asset integrity management programs, but another factor to consider is the occurrence of shutdowns due to equipment failures caused by material shortages. Referring to the theory of constraints, by identifying uptime-related issues caused by the increase due to maximum MRO inventory and implementing the right solutions to address the constraints that limit a system's performance. By developing efficient maintenance strategies and optimizing MRO inventory, oil and gas companies can enhance overall system availability, increase unexpected uptime, and reduce operating costs (Ali et al., 2020; Ganapathy et al., 2021; Nordal & El-Thalji, 2021). Previous research has also revealed that MRO inventory has a significant positive impact on equipment uptime, as found in the studies by Rizal & Mulyono (2019), Pradini & Kusumawati (2024), and Singh & Ganguly (2020).

H3 : MRO inventory has a significant positive impact on equipment uptime at PT. ABC.

Optimal MRO inventory is achieved when the quantity of spare parts available in the inventory is ideal according to the maintenance and repair needs of the equipment, in order to minimize carrying cost, stock-out cost, and downtime cost. A high service level generally requires more inventory storage, which leads to increased inventory holding costs. The relationship between service level and optimal MRO inventory is quite complex. Service level is the likelihood of having the necessary spare parts available for maintenance and equipment repair work. A higher service level indicates a greater likelihood of meeting demand promptly without delays. The oil and gas industry invests heavily in asset integrity management programs, but another factor to consider is the occurrence of shutdowns due to equipment failures caused by material shortages. Referring to the theory of constraints, by identifying uptime-related issues that have increased due to MRO Inventory and implementing the right solutions to address the constraints that limit a system's performance. By developing efficient maintenance strategies and optimizing MRO inventory, oil and gas companies can enhance overall system availability, prevent unexpected shutdowns, and reduce operating costs (Ali et al., 2020; Ganapathy et al., 2021; Nordal & El-Thalji, 2021). Previous research findings also revealed that inventory service level has a significantly positive impact on equipment uptime through MRO inventory, as found in the studies by Siponen et al. (2019) and Pradini & Kusumawati (2024).

H4 : Inventory service level significantly negatively affects equipment uptime through MRO inventory at PT. ABC.

One approach is the use of criticality analysis to prioritize the maintenance and management of equipment components. By identifying the most critical assets, the company can focus its inventory management efforts on the most important components to maintain production uptime (Akanni & Alonge, 2015). A study on inventory management in the oil and gas industry found that by applying a more sophisticated approach to criticality analysis, the company was able to improve service levels while simultaneously reducing overall inventory investment (Ali et al., 2020). Workflows and specific methods for implementing criticality-based inventory management in the oil and gas industry have been explored in various research studies. These studies have highlighted the importance of considering not only equipment criticality ranking but also the broader implications for health, safety, and the environment in the event of equipment failure. MRO inventory plays a crucial role in maintaining asset productivity and maximizing uptime (Ali et al., 2020; Ganapathy et al., 2021). Planned uptime can have a significant financial impact (Ganapathy et al., 2021). By developing efficient maintenance strategies and optimizing MRO inventory, oil and gas companies can enhance overall system availability, prevent unexpected shutdowns, and reduce operating costs (Ali et al., 2020; Ganapathy et al., 2021; Nordal & El-Thalji, 2021). Previous research findings also revealed that equipment criticality has a significantly positive impact on equipment uptime through MRO inventory, as found in the studies by Rizal & Mulyono (2019) and Singh & Ganguly (2020).

H5 : Equipment criticality has a significant negative impact on equipment uptime through MRO inventory at PT. ABC.

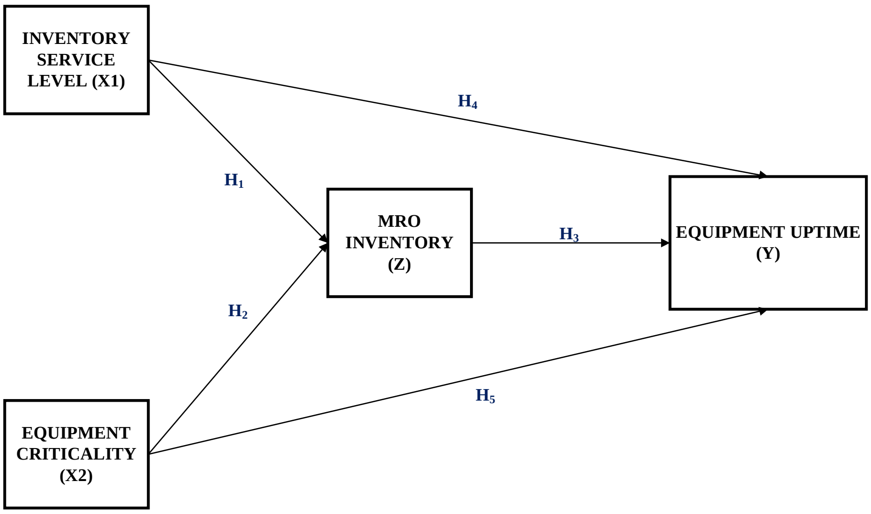

Figure 3. Research Model

RESEARCH METHOD

This type of research is explanatory research, which focuses on the position and relationship between the variables being studied (Sugiyono, 2018). According to Priyono (2016), explanatory research aims to connect different patterns that are interrelated and produce cause-and-effect relationship patterns. This research applies the scope of the study related to the research location in Central Java. Meanwhile, the object of this research is PT. ABC. The type of data used in this research is quantitative data, which consists of numbers or non-numeric data converted into numbers. In this study, the quantitative data used are secondary data obtained from PT ABC's reports related to the variables being investigated, namely Inventory Service Level (X1), Equipment Criticality (X2), MRO Inventory (Z), and Equipment Uptime (Y).

Structural Equation Model (SEM), the analytical tool used in this research, is operated through SmartPLS software. PLS is an analysis method that is considered robust and known as soft modelling because it does not require the assumptions of ordinary least squares (OLS) regression, such as the necessity of multivariate normal distribution in the data and the absence of multicollinearity among exogenous variables. Moreover, even though the available sample size is not large, this method can still be used (Ghozali & Latan, 2015). Philosophically, PLS is used to create predictive theories. According to the PLS model, every measure of explained variance is variance. PLS can address uncertainty issues and provide a clear definition of score components because this method estimates latent variables as a combination of their indicators (Ghozali, 2006). The theory known as weight estimation aims to produce the latent variable score components by optimizing the inner model, or structural model, which shows the relationships between variables, and the outer model, or measurement model, which connects indicators with their structure. The goal is to reduce the residual variance and the dependent variable. The parameter estimation model, which is the output of PLS, consists of three groups. Weight estimation is used to calculate the scores of latent variables. Path estimate shows the relationship between the latent variable and its indicator block. As well as the location of parameters or regression constant values and average values for the indicators. The decision regarding whether the indicator variable is significant or not can be determined by comparing the p-value with the predetermined significance level (α). Conventionally, the value of α is usually set at 5% (0.05). If the t-statistic value is greater than +1.96, then the variable is considered significant; conversely, if it is smaller, then it is not significant. Similarly, if the p-value ≤ 0.05, the indicator variable is considered significant, whereas if the p-value ≥ 0.05, the indicator variable is considered not significant.

RESULTS

Descriptive statistical analysis is a test used to explain the variables being examined in the research to facilitate researchers in obtaining information from the existing data (Sarwono, 2006). The results of the descriptive statistical analysis in Table 1 include information on the mean, maximum and minimum values, as well as the standard deviation, with the results as follows.

Table 1. Descriptive Statistical Analysis

Variables	Minimum	Maximum	Mean	Standard Deviation
Inventory Service Level	.66696	.78672	.73418	.05794
Equipment Criticality	0	1	.40	.548
MRO Inventory	46.50	99.75	65.7000	26.55148
Equipment Uptime	2598.26400	11042.62200	5700.30252	3531.11027

Source: Research Data, 2025

In Table 1, it is known that the Inventory Service Level (X1) variable has a minimum value of 0.666 during the Q1 2017 period and a maximum value of 0.786 during the Q4 2024 period. Additionally, the average (mean) value of the Inventory Service Level (X1) variable is 0.734 with a standard deviation of 0.057. The results show that the standard deviation is lower than the average, which means that the data distribution for the Inventory Service Level (X1) variable has a low level of variation. Equipment Criticality variable (X2) shows the lowest value of 0 in the first quarter of 2017, and the highest value of 1 in the second quarter of 2023. The average value of this variable is 0.40 with a standard deviation of 0.548. The higher standard deviation than the average reflects a significant level of data variation in the Equipment Criticality (X2) variable. For MRO Inventory (Z) variable, the minimum recorded value was 46.50 in the first quarter of 2018, while the maximum value reached 99.75 in the fourth quarter of 2025. The average value of this variable is 65.70 with a standard deviation of 26.551. Because the standard deviation is smaller than the average, this indicates that the data on the MRO Inventory (Z) variable has a relatively low level of dispersion. Meanwhile, the Equipment Uptime variable (Y) has a minimum value of 2.598 occurring in the second quarter of 2019, and a maximum value of 11.042 in the first quarter of 2023. The average value of this variable is 5.700 with a standard deviation of 3.532. The standard deviation value being smaller than the average indicates that the data variation in the Equipment Uptime variable (Y) is relatively low.

Convergent validity is evaluated through the outer loading values on the outer model. The outer model diagram presented below shows the outer loading values of each indicator, which reflect the total contribution of each variable analysed in this study.

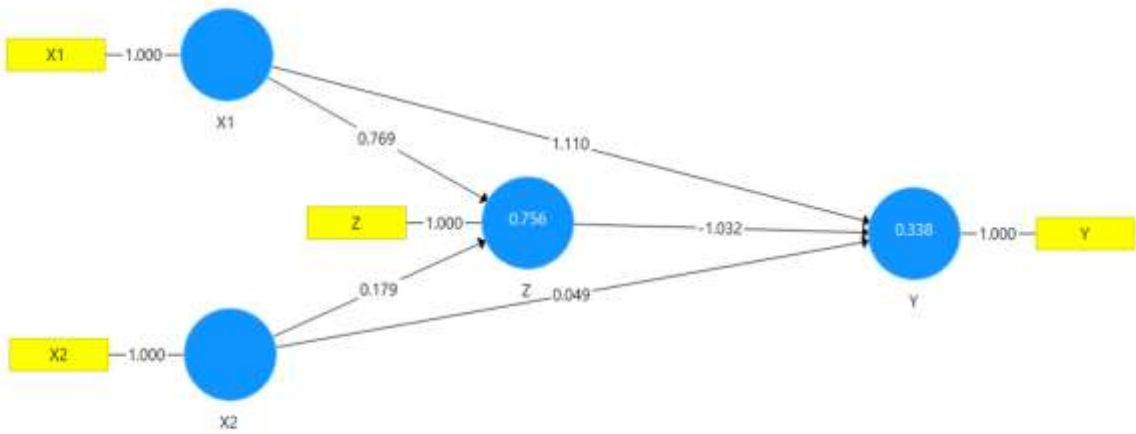

Figure 4. Outer Model Results
Source: SmartPLS Output (2025)

Reflective indicators are considered to have high value if they show a correlation of more than 0.70 with the measured construct. The evaluation of convergent validity in the measurement model with reflective indicators is conducted by assessing the correlation between the scores of each item or component and the construct score processed through the PLS method.

Table 2. Outer Loadings

Variables	**Inventory Service Level (X1)**	**Equipment Criticality (X2)**	**MRO Inventory (Z)**	**Equipment Uptime (Y)**
Inventory Service Level (X1)	1,000			
Equipment Criticality (X2)		1,000		
MRO Inventory (Z)			1,000	
Equipment Uptime (Y)				1,000

Source: SmartPLS Output (2025)

Table 3. Construct Reliability and Validity Results

Variables	***Cronbach's Alpha***	***rho_A***	***Composite Reliability***	***Average Variance Extracted (AVE)***
Inventory Service Level (X1)	1,000	1,000	1,000	1,000
Equipment Criticality (X2)	1,000	1,000	1,000	1,000
MRO Inventory (Z)	1,000	1,000	1,000	1,000
Equipment Uptime (Y)	1,000	1,000	1,000	1,000

Source: SmartPLS Output (2025)

Table 4. Discriminant Validity Result

Variables	**Inventory Service Level (X1)**	**Equipment Criticality (X2)**	**MRO Inventory (Z)**	**Equipment Uptime (Y)**
Inventory Service Level (X1)	1,000			
Equipment Criticality (X2)	0,481	1,000		
MRO Inventory (Z)	0,251	0,016	1,000	
Equipment Uptime (Y)	0,855	0,549	-0,056	1,000

Source: SmartPLS Output (2025)

Inner model analysis, or structural model, involves several steps, including the assessment of R-Square (R^2), f-Square (f^2), and Q-Square (Q^2) calculation results. The results of the inner model testing can be seen in Figure 5.

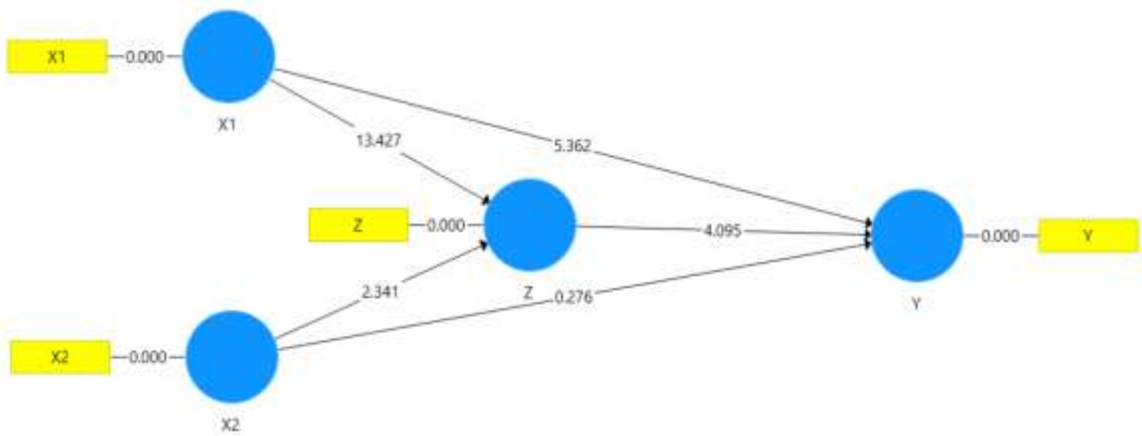

Figure 5. Inner Model
Source: SmartPLS Output (2025)

According to the explanation of the image regarding the internal model shown in Figure 5, there are two exogenous variables, namely Inventory Service Level (X1) and Equipment Criticality (X2), as well as two endogenous variables, namely MRO Inventory (Z) and Equipment Uptime (Y). In the first step of the Inner Model evaluation analysis, the output value from the R-Square calculation is used to compute each endogenous variable. Next, this R-Square value is used to calculate the extent of the influence of exogenous variables on endogenous variables in this study. The results of the R-Square value analysis conducted with SmartPLS are shown as follows.

Table 5. R-Square

Variables	**R Square**
Equipment Uptime (Y)	0,338
MRO Inventory (Z)	0,756

Source: SmartPLS Output (2025)

After calculating the R-Square value, the next step is to calculate the output value on the f-Square with the following results.

Table 6. F-Square

Variables	**Inventory Service Level (X1)**	**Equipment Criticality (X2)**	**Uptime Peralatan (Y)**	**MRO Inventory (Z)**
Inventory Service Level (X1)			0,500	1,861
Equipment Criticality (X2)			0,002	0,101
Equipment Uptime (Y)				
MRO Inventory (Z)			0,393	

Source: Research Data, 2025

The Q-Square value is used to evaluate the extent to which the observation results produced by a quality research model. The Q-Square value can be obtained by observing the Construct Cross-validated Redundancy value in the Blindfolding results.

Table 7. Q-Square value

Variables	**R Square**
Equipment Uptime (Y)	0,290
MRO Inventory (Z)	0,759

Source: SmartPLS Output (2025)

The next step in this research analysis is hypothesis testing. The purpose of this hypothesis testing is to identify the influence between the research variables, which is conducted using the Bootstrapping method on this model, and then analyze the t-statistics values and their significance levels against the P-values in the Path Coefficient table. The results of the Path Coefficient calculations to test the first to the third hypotheses in this study are presented in the table below.

Table 8. Path Coefficient

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P-Values
X1 -> Z (H1)	0,769	0,774	0,057	13,427	0,000
X2 -> Z (H2)	0,179	0,170	0,076	2,341	0,020
Z -> Y (H3)	-1,032	-1,050	0,252	4,095	0,000
X1 -> Y	1,110	1,149	0,207	5,362	0,000
X2 -> Y	0,049	0,021	0,176	0,276	0,783

Source: SmartPLS Output (2025)

Based on the output calculation results in Table 8, in the direct influence test of this research, it was found that T-Statistics must be > 1.96 and P-Values must be < 0.05. From the results of the hypothesis testing regarding the direct effect, it can be concluded that: (1) Inventory Service Level (X1) has a significant positive effect on MRO Inventory (Z); (2) Equipment Criticality (X2) has a significantly positive effect on MRO Inventory (Z); (3) MRO Inventory (Z) has a significantly positive effect on Equipment Uptime (Y); (4) Inventory Service Level (X1) has a significantly positive effect on Equipment Uptime (Y); (5) Equipment Criticality (X2) does not affect Equipment Uptime (Y).

The indirect effect test is conducted to identify the influence of the independent variable on the dependent variable through the intervening variable. "An intervening variable is a variable that affects the relationship between the independent variable and the dependent variable through indirect influence" (Sugiyono, 2018), and is often referred to as a mediating variable. The indirect relationship referred to is that the intervening variable can act as a mediator in the relationship between the two variables being studied. In this study, an analysis was conducted to determine whether the intervening variable in the form of MRO Inventory (Z) can function as a mediator for the variables Inventory Service Level (X1) and Equipment Criticality (X2) on Equipment Uptime (Y), by considering the T-Statistic value and P Values or significance level on the Specific Indirect Effect using the Bootstrapping method as follows.

Table 9. Specific Indirect Effect

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (|O/STDEV|)	P-Values
X1 -> Z -> Y (H4)	-0,794	-0,814	0,209	3,803	0,000
X2 -> Z -> Y (H5)	-0,185	-0,178	0,093	1,993	0,047

Source: SmartPLS Output (2025)

In the Specific Indirect Effect table, the criteria that must be met are that the calculated T-statistics value must be <1.96, which is the criterion limit, and the P-values must have an output <0.05, which is the significance limit. Based on Table 3.9, it can be determined regarding the indirect effect as follows: (1) Inventory Service Level (X1) has a significant positive impact on Equipment Uptime (Y) through MRO Inventory (Z); (2) Equipment Criticality (X2) has a significant positive impact on Equipment Uptime (Y) through MRO Inventory (Z).

Based on the data testing results presented above, this research yields several findings.

The influence of Inventory Service Level (X1) on MRO Inventory (Z)

The influence of the Inventory Service Level variable (X1) on the MRO Inventory variable (Z) shows a T-Statistics value of 13.427 with a positive (+) value and P-Values of 0.000. Referring to those values, it can be said that the T-Statistics value is > 1.96 and the P-Values < 0.05. Thus, it can be said that Inventory Service Level (X1) has a significantly positive effect on MRO Inventory (Z). In other words, the higher the Inventory Service Level (X1), the higher the MRO Inventory (Z) will be. The results of the first hypothesis test, which states that Inventory Service Level has a significant positive effect on MRO Inventory, are in line with previous research findings by Ali et al. (2020); Kusuma & Hasibuan (2022); and Siponen et al. (2019), which also revealed that inventory service level has a significant positive effect on MRO inventory. In other words, a high inventory service level at PT. ABC will ultimately result in an increase in MRO inventory. The availability of spare parts needed for maintenance and repair work can improve the performance of MRO inventory at PT. ABC. A higher service level at PT. ABC indicates a greater likelihood of promptly meeting the demand for materials/spare parts. The optimal MRO inventory at PT. ABC is achieved because the number of spare parts available in the inventory is ideal according to the needs of maintenance and repair work to minimize carrying cost, stock-out cost, and downtime cost. MRO inventory at PT. ABC plays a crucial role in the oil and gas industry, as the productivity and availability of machinery heavily depend on the accessibility of spare parts and necessary materials. The increasing demand for maintenance, repair, and overhaul services for equipment highlights the importance of effectively managing MRO inventory to ensure a high service level. These findings confirm that at PT. ABC, an oil and gas company, by optimizing the ordering policy, the company was able to achieve a higher service level while simultaneously reducing inventory investment.

The influence of Equipment Criticality (X2) on MRO Inventory (Z)

The influence of the Equipment Criticality variable (X2) on the MRO Inventory variable (Z) shows a T-Statistics value of 2.341 with a positive (+) value and P-Values of 0.020. Referring to those values, it can be said that the T-Statistics value is > 1.96 and the P-Values are < 0.05. Therefore, it can be said that Equipment Criticality (X2) has a significant positive effect on MRO Inventory (Z), in other words, the higher the Equipment Criticality (X2), the higher the MRO Inventory (Z).

The results of the second hypothesis test, which states that Equipment Criticality has a significant positive effect on MRO Inventory, are in line with the findings of previous research conducted by Rizal & Mulyono (2019); Pradini & Kusumawati (2024); Singh & Ganguly (2020). In other words, high Equipment Criticality at PT. ABC will ultimately lead to an increase in MRO Inventory. Effective MRO inventory management PT. ABC is very important in the oil and gas industry because downtime associated with equipment failure can be very detrimental, both in terms of production loss and the need for emergency repairs. As a result, oil and gas companies need to pay significant attention to developing strategies for managing spare part inventory to ensure the availability of spare parts for high-criticality equipment. One important aspect of MRO inventory control is the classification of inventory items based on item criticality, which takes into account several factors including the criticality ranking of the equipment, lead-time, and downtime cost from failures that occur due to the unavailability of critical items. One approach is the use of criticality analysis to prioritize the maintenance and management of equipment components. By implementing criticality assessment using the SECE method, PT. ABC can focus inventory management efforts on the most important components to maintain production time and minimize carrying costs of materials and spare parts. Additionally, by implementing other methods such as risk-based inspection and predictive maintenance to assess the likelihood and consequences of equipment failure, then aligning appropriate inventory control strategies. This study found that by applying a more sophisticated approach to criticality analysis, PT. ABC was able to improve service levels while simultaneously reducing overall inventory investment. This was achieved through the use of continuous review policies for the most critical items and periodic review policies for non-critical items. The workflow and specific methods for implementing criticality-based inventory management in the oil and gas industry in this study on PT. ABC highlight the importance of considering not only equipment criticality ranking but also the broader implications for health, safety, and the environment in the event of equipment failure.

The Influence of MRO Inventory (Z) on Equipment Uptime (Y)

The influence of the MRO Inventory variable (Z) on Equipment Uptime (Y) shows a T-Statistics value of 4.095 with a positive (+) value and a P-Value of 0.000. Referring to those values, it can be said that the T-Statistics value is > 1.96 and the P-Values are < 0.05. Thus, it can be said that MRO Inventory (Z) has a significantly positive effect on Equipment Uptime (Y). In other words, the higher the MRO Inventory (Z), the higher the Equipment Uptime (Y).

The results of the third hypothesis test, which states that MRO inventory has a significantly positive effect on equipment uptime, are in line with the findings of previous studies conducted by Rizal & Mulyono (2019); Pradini & Kusumawati (2024); Singh & Ganguly (2020). In other words, a high MRO inventory at PT. ABC will ultimately lead to an increase in equipment uptime. MRO inventory plays an important role in maintaining asset productivity and increasing uptime at PT. ABC. High uptime can have a significant financial impact on PT. ABC. The oil and gas industry invests heavily in asset integrity management programs, but another factor to consider is the occurrence of shutdowns due to equipment failures caused by material shortages. Referring to the theory of constraints, by identifying the increase in uptime caused by the optimal performance of MRO Inventory and implementing the right solutions to address the constraints that limit the performance of a system at PT. ABC. By developing efficient maintenance strategies and optimizing MRO inventory, PT. ABC, as an oil and gas company, can enhance overall system availability, increase plant uptime, and minimize operating costs.

The influence of Inventory Service Level (X1) on Equipment Uptime (Y) through MRO Inventory (Z)

The influence of the Inventory Service Level variable (X1) on Equipment Uptime (Y) through MRO Inventory (Z) shows a T-Statistics value of 3.803 with a positive (+) value and P-Values of 0.000. Referring to those values, it can be said that the T-Statistics value is > 1.96 and the P-Values are < 0.05. Thus, it can be said that the Inventory Service Level (X1) has a significant positive effect on Equipment Uptime (Y) through MRO Inventory (Z). In other words, the higher the Inventory Service Level (X1) and MRO Inventory (Z), the higher the Equipment Uptime (Y) will be. The results of the fourth hypothesis test, which states that Inventory Service Level has a significant positive effect on Equipment Uptime through MRO inventory, are in line with the findings of previous studies conducted by Siponen et al., (2019) and Pradini & Kusumawati (2024). In other words, the high Inventory Service Level and MRO inventory at PT. ABC will ultimately lead to an increase in equipment Uptime. MRO inventory at PT. ABC plays an important role in the oil and gas industry, as the productivity and availability of machinery heavily depend on the accessibility of necessary spare parts and materials. Optimal MRO inventory is achieved when the number of spare parts available in the inventory is ideal according to the maintenance and repair needs of the equipment, in order to minimize carrying cost, stock-out cost, and downtime cost. A high service level generally requires more inventory storage, which leads to increased inventory storage costs. The relationship between service level and optimal MRO inventory is quite complex. Service level is the likelihood of the availability of spare parts needed for maintenance and repair work on equipment. A higher service level indicates a greater likelihood of meeting the demand for materials/spare parts promptly without delay. PT. ABC, which has invested in an asset integrity management program, has observed shutdowns due to equipment failures caused by material shortages. Referring to the theory of constraints, by identifying issues related to uptime that have increased due to MRO Inventory and implementing appropriate solutions to address the constraints that limit a system's performance. By developing efficient maintenance strategies and optimizing MRO inventory, PT. ABC can improve overall system availability, prevent unexpected shutdowns, and reduce operating costs.

The influence of Equipment Criticality (X2) on Equipment Uptime (Y) through MRO Inventory (Z)

The influence of the Equipment Criticality variable (X2) on Equipment Uptime (Y) through MRO Inventory (Z) shows a T-Statistics value of 1.993 with a positive (+) value and a P-Value of 0.047. Referring to those values, it can be said that the T-Statistics value is > 1.96 and the P-Values are < 0.05. Thus, it can be said that Equipment Criticality (X2) has a significantly positive effect on Equipment Uptime (Y) through MRO Inventory (Z). In other words, the higher the Equipment Criticality (X2) and MRO Inventory (Z), the higher the Equipment Uptime (Y). The results of the fifth hypothesis test, which states that Equipment Criticality has a significant positive effect on Equipment Uptime through MRO inventory, are in line with previous research conducted by Rizal & Mulyono (2019) and Singh & Ganguly (2020). In other words, high Equipment Criticality and MRO inventory at PT. ABC will ultimately lead to an increase in equipment Uptime. The use of criticality analysis to prioritize the maintenance and management of equipment components at PT. ABC. By identifying the most critical assets, PT. ABC can focus its inventory management efforts on the most important components to maintain production uptime. This finding revealed that by applying a more sophisticated approach to criticality analysis, the company was able to improve service levels while simultaneously reducing overall inventory investment. Workflows and specific methods for implementing criticality-based inventory management in the oil and gas industry have been explored in various research studies. This research highlights the importance of considering not only equipment criticality ranking but also the broader implications for health, safety, and the environment in the event of equipment failure. MRO inventory plays a crucial role in maintaining asset productivity and maximizing uptime at PT. ABC. High uptime can have a significant financial impact because production operations remain uninterrupted. By developing efficient maintenance strategies and optimizing MRO inventory, PT. ABC as an oil and gas company can improve overall system availability, prevent unexpected shutdowns, and reduce operating costs.

CONCLUSIONS

Based on the results of this study, the following conclusions can be drawn:

1. Inventory service level can positively and significantly influence MRO Inventory. The findings of this positive and significant influence are based on the results of testing the direct effect with a T-Statistics value of 13.427 with a positive (+) value and P-Values of 0.000. Therefore, it can be said that the higher the Inventory Service Level, the higher the MRO Inventory.
2. Equipment Criticality can positively and significantly influence MRO Inventory. The findings of this positive and significant influence are based on the results of testing the direct effect with a T-Statistics value of 2.341 with a positive (+) value and P-Values of 0.020. Thus, it can be said that the higher the Equipment Criticality, the higher the MRO Inventory.
3. MRO Inventory is capable of positively and significantly affecting Equipment Uptime. The findings of this positive and significant influence are based on the results of testing the direct effect with a T-Statistics value of 4.095 with a positive (+) value and P-Values of 0.000. Therefore, it can be said that the higher the MRO Inventory, the higher the Equipment Uptime.
4. The Inventory Service Level can positively and significantly influence Equipment Uptime through MRO Inventory. The findings of this positive and significant influence are based on the results of testing the direct effect with a T-Statistics value of 3.803

with a positive (+) value and P-Values of 0.000. Thus, it can be said that the higher the Inventory Service Level and MRO Inventory, the higher the Equipment Uptime will be.

5. Equipment Criticality can positively and significantly affect Equipment Uptime through MRO Inventory. The findings of this positive and significant influence are based on the results of testing the direct effect with a T-Statistics value of 1.993 with a positive (+) value and P-Values of 0.047. Therefore, it can be said that the higher the Equipment Criticality and MRO Inventory, the higher the Equipment Uptime.

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