*Mantik Journal, 8 (1) (2024), ISSN 2685-4236 (Online)*

Published by: Institute of Computer Science (IOCS)

Jurnal Mantik

Journal homepage: www.iocscience.org/ejournal/index.php/mantik

# Comparison of inventory management methods: reliability centered spares (RCS), ABC analysis and fixed timed period

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ARTICLE INFO

*Article history:*

Received Mar 05, 2024
Revised Mar 08, 2024
Accepted Mar 14, 2024

*Keywords:*

ABC analysis;
Fixed time period;
Inventory analysis;
Lead time;
Reliability centered spares;
*Stock level.*

ABSTRACT

Spare parts inventory management is very important for PT XYZ, which is one of the largest fertilizer producers in Indonesia. The cost of spare parts, especially for air compressors, constitutes a significant portion of the production cycle cost. This study aims to determine the optimal spare parts inventory value at PT XYZ by comparing the ABC analysis, fixed-time period, and reliability-centered spares (RCS) methods. The results showed that the fixed-time period method has a positive impact on company profits of Rp. 1,648,391,080 and offers better control of Class A spare parts inventory. The ABC analysis method also helps prevent inventory shortages that could disrupt company operations. However, the RCS method cannot be compared because the probability value must be determined by the company itself. In this study, demand fluctuations, lead time, reorder points, and inventory levels are also crucial considerations in determining the value of spare parts inventory. By using the fixed-time period method, PT XYZ can achieve greater profits and effectively control its spare parts inventory.



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## 1. INTRODUCTION

Spare parts inventory management is an important aspect of equipment maintenance and repair activities (Zhu et al., 2020). Maintaining an adequate stock of spare parts can help businesses reduce equipment downtime and improve operational efficiency(Gallego-García et al., 2021). However, inventory holding costs must also be considered when managing spare parts inventory (Odedairo, 2021) Effective spare parts inventory management involves balancing the cost of holding inventory against the risk of equipment downtime and the associated costs. This requires businesses to carefully analyze their spare parts inventory and choose the appropriate inventory management method to optimize their inventory levels. The cost of spare parts at PT XYZ, which is engaged in the fertilizer industry, accounts for a significant portion of the production cycle costs, especially for critical equipment such as air compressors (Patel et al., 2022). The annual value of spare parts consumed by rotating machines, with a service life of about 30 years, reaches nearly 2.5% of the initial purchase price. Spare parts often face expiration issues, leading to their disposal at relatively low values (Zhang et al., 2021).

The success or failure of an organization depends on the performance of its inventory management. Companies often face a culture of storing large quantities of spare parts to maintain availability, resulting in low inventory turnover values. This condition indicates high operating costs and can even reflect poorly on top managers and investors (Bošnjaković, n.d.).

Several studies have been conducted to identify effective methods of managing spare parts inventory. However, existing studies have certain limitations, such as focusing on only one company or not considering important factors such as demand fluctuations and delivery times (Pinçe et al., 2021). As a result, it is difficult to generalize the results of these studies to all types of businesses.

However, some studies have shown significant benefits in using certain methods. (Angelina et al., 2020) the reliability-centered spares (RCS) method has proven effective in optimizing spare parts inventory. This method considers the failure rate of critical components to determine the optimal spare parts requirement (Alamri & Mo, 2022). In addition, min-max stock analysis is used to determine the minimum and maximum number of critical parts. Nevertheless, no method is suitable for all businesses. Each business has different needs, and factors such as demand fluctuations, delivery times, reorder points, and inventory levels must be considered in choosing the right method.

Of course, achieving optimal inventory is essential in inventory management. With the right inventory level, companies can reduce inventory costs, increase profits, and satisfy customer (Tookanlou & Wong, 2020) s. Therefore, companies must develop flexible and responsive inventory management strategies to deal with rapid market changes.

Methods such as ABC analysis, which categorizes items by value, and the fixed time period (FTP) method, which determines the time interval for reviewing and replenishing inventory, can be useful guidelines in managing spare parts inventory. However, these methods should be customized to the specific needs of the business, and factors such as lead time, reorder point, and storage costs should be considered (Gunasekaran & Ngai, 2005). By considering these various factors, companies can determine the optimal value of spare parts inventory to maintain the smooth operation of their business.

(Lee et al., 2024) noted that demand fluctuation or demand variability is the uncertainty in the amount of demand for goods or services in a certain period. (Zhang et al., 2021) pointed out that research focusing only on one company cannot be generalized to different industries. Thus, factors affecting spare parts inventory management in different industries need consideration. (Dey & Seok, 2024) stated that demand fluctuation can affect the amount of inventory that must be stored, thereby affecting the effectiveness of spare parts inventory management. Therefore, demand fluctuations and delivery time factors, such as the long delivery time required for critical parts necessitating more inventory to keep business operations running (Stranieri et al., 2024), need consideration in spare parts inventory management research.

(Risyahadi & Putri, 2019) considered only the use of the FTP method in spare parts inventory control without comparing it with other methods that may be more effective in certain situations. Therefore, the most effective inventory control method needs exploration in spare parts inventory management research. (Angelina et al., 2020) stated that the reliability-centered spares (RCS) method can calculate the optimal critical spare requirement by considering the failure rate of critical components. Thus, the failure rate of critical components also requires consideration in spare parts inventory management research.

Research by (Angelina et al., 2020) also employed min-max stock analysis to determine the minimum and maximum number of critical parts. Therefore, min-max stock analysis needs consideration in spare parts inventory management research. (Angelina et al., 2020) stated that the RCS method shows that the spare parts inventory policy for all critical components of the machine for the next year is to store a certain number of components but does not consider lead time, reorder point, and stock level.

Therefore, these factors also require consideration in spare parts inventory management research.

Although various studies have been conducted on spare parts inventory management, there is no one-size-fits-all approach suitable for all businesses. Some studies focus on a specific company or industry, making their results difficult to generalize. Additionally, many studies do not consider factors such as demand fluctuations, delivery times, reorder points, and stock levels that can affect the required inventory amount. However, certain methods, like the reliability-centered spares (RCS) method, have been shown to be effective in optimizing spare parts inventory for smooth business operations. It can be concluded that there is no universal and universally effective inventory management method for all businesses, and an effective approach must consider various factors affecting spare parts inventory to meet specific business needs. It is hoped that PT. XYZ can use one of these methods to determine the optimal spare parts inventory value by considering delivery time, demand fluctuations, reorder points, and stock levels.

## 2. RESEARCH METHOD

### 2.1 Research Design

(Hanum et al., 2020) This approach will help readers gain a more complete understanding of the problems faced in spare parts inventory management and can offer suggestions regarding factors to consider in choosing the optimal inventory management method. The data collected is quantitative, in the form of spare part inventory data, using secondary data. In this study, secondary data comprises air compressor spare part inventory data from PT. XYZ, one of the largest fertilizer manufacturing companies in Indonesia.

### 2.2 Measurement

Product grouping using the ABC Class-Based method is carried out to determine the level of importance of each product by grouping products into three classes, namely A, B, and C (Muhammad et al., 2023). The steps taken in classifying based on the ABC method are as follows: Make a list of products, the number of requests, and the price of each product, calculate the total turnover of each product, sort the products from the largest to the smallest total turnover to facilitate the division into classes A, B, and C. Class A represents fast-moving products that contribute around 60%-80% of turnover, while class C represents the slowest-moving products, accounting for 5%-15% of turnover.

One of the inventory control models described by (Heizer et al., n.d.) is the fixed period system or fixed time period, where orders to replen ish inventory are placed at the end of the period. At that time, the amount of inventory on hand is calculated. What is ordered is only the amount needed to increase inventory to the specified target amount. (Haeussler et al., 2020)The fixed period system operates under several assumptions; the only relevant costs are ordering costs and holding costs, the period between ordering and delivery of products (lead time) is known and constant, each item is independent of the others.

(Wen et al., 2024) stated that components can be classified into two groups: repairable and non-repairable components. (Yamada et al., 2022) provided the formula for calculating repairable components.

(Chakravarthy & Rao, 2021) described inventory as an idle resource awaiting further processing. (Aprilianti & Ishak, 2023) explained that the Economic Order Quantity (EOQ) is the quantity of inventory ordered at one time that minimizes annual inventory costs. The formula for calculating the EOQ.

## 3. RESULTS AND DISCUSSIONS

### 3.1. ABC Analysis

With data collected, this section explores the data to uncover findings for the research goals. These findings will then be carefully analyzed.

Table 1. Grouping of Goods with ABC Analysis Based on the Number of Items and Costs

| No | Category | Number of Items | Cost (Rupiah) | Item Presentation (%) | Cost Percentage (%) |
|---|---|---|---|---|---|
| 1 | A | 10 | 4.649.958.632 | 79 | 80 |
| 2 | B | 8 | 890.652.400 | 15 | 15 |
| 3 | C | 20 | 357.607.326 | 6 | 5 |
| | | | 5.898.218.358 | | |

According to the ABC analysis presented in Table 1, it is observed that 10 items at PT XYZ fall into category A, accounting for 79 percent of the total number of items at a cost of Rp 4,649,958,632, which equals 80 percent of the total inventory fund absorption. Meanwhile, category B comprises 8 items or 15 percent of the total, with a cost absorption of Rp 890,652,400 or 15 percent, and category C includes 20 items, which is 6 percent of the total, with a cost absorption of Rp 357,607,326 or 5 percent.

Components in category A require more stringent inventory control compared to categories B and C to avoid high-cost burdens, large idle funds, and increased storage costs, given its significance in the production process. By identifying and managing category C, which has a lower impact on inventory costs, PT. XYZ can potentially achieve savings of Rp 357,607,326, equivalent to 5 percent.

The study further compares its findings with previous research. This research shows that effective management of category C items can result in cost savings of 5%. This reaffirms previous research showing that proper management of low-cost items can contribute to overall cost efficiency.

### 3.2. Fixed Time Period (FTP)

ABC analysis emphasizes groups or types of materials that have a relatively high or expensive use value (Adenike, 2020). Inventory control in category A will certainly differ from the control of categories B and C. Especially for category A at PT XYZ, the control of goods will be prioritized due to their higher value. Therefore, by implementing this ABC classification, the company can focus on controlling the inventory of items that are of great value and fall into category A. This is important because disorderly control of category A items can potentially cause significant losses to the company if not managed properly (Adenike, 2020)

The Fixed Time Period method assumes that inventory is counted at predetermined intervals, which may lead to the inventory count dropping to zero after an order is issued. This condition can go unnoticed until the next period, while new orders still take time to arrive. It is very likely that a stock shortage will occur through the review period, T, and the order lead time, L. Safety stock must protect against material shortages during the review period or the order lead time until the order is received. The formula used to determine the number of items ordered is:

$$q = \bar{d}\,(T+L) + z\sigma_{T+L} - I$$

Which:

- $q$ = Quantity of goods to be ordered
- $T$ = Evaluation period (year)
- $L$ = Order period/lead time
- $\bar{d}$ = Average consumption daily, month, year

$z\sigma_{T+L}$ = Standard deviation of demand during evaluation period T and lead time
LI = Total existing stock plus those on order and Safety stock

for the fixed time period model as follows:
*safety stock* = $z\sigma_{T+L}$

Table 2. Moving spare part data

| No | Description | Qty/ unit | Price/unit (Rupiah) | Class | Data Moving (Year) 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Average Usage/year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Journal Bearing (Suct Side) | 1 | Rp. 876.367.923 | A | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0,43 |
| 2 | Journal Bearing (Disc Side) | 1 | Rp. 876.367.923 | A | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0,43 |
| 3 | Labyrinth Ring (Shaft Seal) | 8 | Rp. 91.232.000 | A | 0 | 8 | 0 | 0 | 0 | 0 | 8 | 2,29 |
| 4 | Thrust Bearing Pad assy. (active & inactive) | 1 | Rp. 532.671.810 | A | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0,29 |
| 5 | Labyrinth Ring (7th - 10th) | 3 | Rp. 144.830.800 | A | 0 | 4 | 0 | 0 | 0 | 0 | 4 | 1,14 |
| 6 | Labyrinth Ring (Shaft) | 4 | Rp. 91.232.000 | A | 0 | 8 | 0 | 0 | 0 | 0 | 8 | 2,29 |
| 7 | Labyrinth Ring (Shaft Seal) | 4 | Rp. 91.232.000 | A | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0,29 |
| 8 | Labyrinth Ring (Shaft Seal) | 2 | Rp. 91.232.000 | A | 0 | 8 | 0 | 0 | 0 | 0 | 8 | 2,29 |
| 9 | Leaf Spring (Shaft End Side) | 14 | Rp. 11.358.384 | A | 0 | 14 | 0 | 0 | 0 | 0 | 14 | 4 |
| 10 | Labyrinth Ring (5th Impeller) | 1 | Rp. 128.865.200 | A | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0,29 |

The calculation shown in Table 2 above is for spare part number 1, namely the journal bearing (suction side). The table shows data on moving spare parts classified as A, which will then be calculated. After calculating the average use of spare parts per year, the standard deviation is determined, followed by the calculation of safety stock, the number of items to be ordered (q), and the calculation of average inventory. As an example of calculations in this paper, the calculation steps will be explained starting with the standard deviation on the journal bearing (suction side) spare part, which is 0.49. The average lead time for this compressor spare part is 8 months, or 0.66 years. Since each year is independent and σd is constant, then:

$$\sigma_{T+L} = \sqrt{(T + L)\sigma d^2}$$
$$= \sqrt{(1 + 0{,}66)(0{,}49)^2}$$
$$= \sqrt{(1{,}66)(0{,}24)} = 0{,}63 \ (\textit{safety stock})$$

$$q = \bar{d}\,(T + L) + z\sigma_{T+L} - I$$
$$= 0{,}43(1+0{,}66)+0{,}63 - 1$$
$$= 1{,}334 - 1$$
$$= 0{,}34$$

Average inventory = $q/2$ + $SS$ = 0,34/2 + 0,63 = 0,8 units

After calculating safety stock and the number of items ordered, the calculation for each spare part is obtained as follows:

Table 3. Data spare part for calculation of the FTP method

| No | Description | Qty/ unit (stock) | Price/unit (Rupiah) | Cumulative amount (Rupiah) | Class | Moving Data (year) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| 1 | Journal Bearing (Suct Side) | 1 | Rp 876,367,923 | Rp 876,367,923 | A | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 2 | Journal Bearing (Disc Side) | 1 | Rp 876,367,923 | Rp 876,367,923 | A | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 3 | Labyrint Ring (Shaft Seal) | 8 | Rp 91,232,000 | Rp 729,856,000 | A | 0 | 8 | 0 | 0 | 0 | 0 | 8 |
| 4 | Thrust Bearing Pad assy. (active & inactive) | 1 | Rp 532,671,810 | Rp 532,671,810 | A | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 5 | Labyrint Ring (7th - 10th) | 3 | Rp 144,830,800 | Rp 434,492,400 | A | 0 | 4 | 0 | 0 | 0 | 0 | 4 |
| 6 | Labyrint Ring (Shaft) | 8 | Rp 91,232,000 | Rp 729,856,000 | A | 0 | 8 | 0 | 0 | 0 | 0 | 8 |
| 7 | Labyrint Ring (Shaft Seal) | 4 | Rp 91,232,000 | Rp 364,928,000 | A | 0 | 4 | 0 | 0 | 0 | 0 | 4 |
| 8 | Labyrint Ring (Shaft Seal) | 8 | Rp 91,232,000 | Rp 729,856,000 | A | 0 | 8 | 0 | 0 | 0 | 0 | 8 |
| 9 | Leaf Spring (Shaft End Side) | 14 | Rp 11,358,384 | Rp 159,017,376 | A | 0 | 14 | 0 | 0 | 0 | 0 | 14 |
| 10 | Labyrint Ring (5th Impeller) | 1 | Rp 128,865,200 | Rp 128,865,200 | A | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | | Total | | Rp 5,562,278,632 | | | | | | | | |

Table 4. Calculation results of the FTP method using MS. Excel

| No | Description | Average Usage/year | Standard deviation | Safety stock | q | Average Inventory | Average Inventory * spare part/unit price |
|---|---|---|---|---|---|---|---|
| 1 | Journal Bearing (Suct Side) | 0.43 | 0.49 | 0.64 | 0.35 | 0.81 | Rp 712,746,786.88 |
| 2 | Journal Bearing (Disc Side) | 0.43 | 0.49 | 0.64 | 0.35 | 0.81 | Rp 712,746,786.88 |
| 3 | Labyrint Ring (Shaft Seal) | 2.29 | 3.61 | 4.66 | 0.46 | 4.89 | Rp 445,689,395.76 |
| 4 | Thrust Bearing Pad assy. (active & inactive) | 0.29 | 0.45 | 0.58 | 0.06 | 0.61 | Rp 326,936,046.74 |
| 5 | Labyrint Ring (7th - 10th) | 1.14 | 1.81 | 2.33 | 1.22 | 2.94 | Rp 425,580,310.07 |
| 6 | Labyrint Ring (Shaft) | 2.29 | 3.61 | 4.66 | 0.46 | 4.89 | Rp 445,689,395.76 |
| 7 | Labyrint Ring (Shaft | 1.14285714 | 1.81 | 2.33 | 0.23 | 2.44 | Rp 222,682,435.25 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Seal) | | | | | | | |
| 8 | Labyrint Ring (Shaft Seal) | 2.29 | 3.61 | 4.66 | 0.46 | 4.89 | Rp | 445,689,395.76 |
| 9 | Leaf Spring (Shaft End Side) | 4 | 6.32 | 8.15 | 0.79 | 8.54 | Rp | 97,033,871.16 |
| 10 | Labyrint Ring (5th Impeller) | 0.29 | 0.45 | 0.58 | 0.06 | 0.61 | Rp | 79,093,126.87 |
| | | | | | | | Rp | 3,913,887,551.15 |
| | | | Total profit using the FTP method = | | | | Rp | 1,648,391,080.85 |

First collect spare part data as shown in Table 3 and then Table 4 which presents the results of calculations using the FTP method for 10 spare part units, it is found that the application of the Fixed Time Period method in controlling class A spare part inventory has a significant positive impact on company profits. The results obtained show that without using the FTP method, the company incurs costs of Rp. 5,562,278,632, compared to the total value using the FTP method of Rp. 3,913,887,551. Thus, by utilizing the FTP method, the company managed to achieve a total profit of Rp. 1,648,391,080. Furthermore, the proper and efficient management of 10 units of class A spare parts demonstrates the effectiveness of the FTP method in reducing storage costs, preventing inventory shortages, and ensuring the smooth operation of the company.

The application of the FTP method demonstrates its effectiveness in optimizing inventory control for Class A parts. By calculating the right order quantities and corresponding safety stock levels, the company can minimize storage costs while ensuring adequate stock availability. These findings are consistent with the literature that suggests that periodic review systems such as FTP can be advantageous for managing high-value inventory items with fluctuating demand patterns (Risyahadi & Putri, 2019).

### 3.3. Reliability Centered Spares (RCS)

a. Selection of Critical Sub Systems and Components

Qualitative measurement using the Reliability Centered Spares (RCS) method is carried out based on the condition of the air compression subsystem and all of its constituent components to determine which are considered critical (Mirzaei et al., 2023). The components in the air compression subsystem are analyzed based on five main RCS questions with their respective weights: effect of unavailability of spares 35%, consequences of unavailability of spares 35%, anticipation of unavailability of spares 20%, and component price 10%. The product of these factors is the Criticality Index (CI) value, indicating the component's level of criticality. According to the CI calculations on the RCS worksheet, four components were identified with high criticality: the rotor, journal bearing (suction), journal bearing (discharge), and thrust bearing. Before proceeding with the component and part needs calculation, they are first classified as repairable or non-repairable, as the calculation formula differs between the two, with repairable components including a scrap rate variable.

b. Spares Calculation

Components identified as critical can be categorized based on their reparability after damage. This study classified journal bearings as critical yet repairable components.

MTBF is known = 17352

$$\lambda 1t = \frac{1}{MTBF} t = \frac{AxNxMxT}{MTBF} = 0{,}9958$$

To simplify the calculation of components, Table 5 is used as shown below.

Table 5. Journal Bearing Probability Calculation

| i | P(i:$\lambda_1$= 0.9958 | P(i:$\lambda_2$= 0.7178 |
|---|---|---|
| 0 | 0.3694277 | 0.487803 |
| 1 | 0.73730 | 0.837969 |
| 2 | 0.881704 | 1 |

After obtaining the probability of journal bearing components, the next component requirement calculation can be seen in Table 5. An example of an iteration of calculating the need for journal bearing components is as follows:

Table 6. Journal Bearing Component Requirement Calculation Results

| n-1 | P | P% |
|---|---|---|
| 0 | 0.18020 79 | 18.0 2% |
| 1 | 0.5985 | 59.8 5% |
| 2 | 0.8817 | 88.1 7% |
| 3 | 0.98700 34 | 98.7 0% |

From the results of the calculation in Table 6, it is known that the number of spare parts or spares for journal bearing components to fulfill 95% of the inventory for 12 months is 3 components.

### 3.4 Calculation of Critical Component Inventory Policy and Cost

Based on these calculations, the optimal EOQ, or ordering lot, for journal bearing components is 3 components per order. The required safety stock is 4 components, and the reorder point is triggered when the component parts in stock at the warehouse drop to only 7 units. The total cost incurred for the inventory of journal bearing components amounts to Rp. 2,304,551,317.52.

Recent research conducted at PT XYZ has produced significant findings regarding inventory control using ABC Analysis and the Fixed Time Period (FTP) method. The research emphasizes the importance of effectively managing high-value category A inventory at PT XYZ. By applying ABC Analysis, companies can allocate resources to control items that have a major impact on inventory costs. This is in line with previous research that indicates the need for tighter control of high-value items to prevent financial losses.

This research also highlights the combined use of ABC Analysis and FTP methods, showing how this integration can improve the effectiveness of inventory management at PT XYZ. This is in contrast to previous research that often focuses on only one inventory control method. This new perspective emphasizes the value of using multiple strategies for inventory management.

## 4. CONCLUSION

Based on the data analysis and discussion that has been carried out, the conclusions are as follows: The application of the Fixed Time Period (FTP) method to Class A spare part inventory has a positive impact on company profits. The significant gain of Rp. 1,648,391,080 indicates that the use of this method can reduce costs associated with inventory, such as storage costs and inventory shortage costs. Additionally, better control over the number of Class A spare parts can prevent inventory shortages that may disrupt the smooth operation of the company. With the application of the Reliability Centered Spares (RCS) method, influenced by the probability value (P) from not stocking (0) to the maximum stock with a value of P > 95%, the calculation result is 3 stocks of journal bearing material. The total cost for 3 stock material journal bearings is Rp. 2,304,551,317.52. Therefore, it can be concluded that in applying the RCS method, company management at PT XYZ is recommended to set the probability value (P) or service level that the company desires.

The application of the Fixed Time Period (FTP) method to class A spare parts inventory has a positive impact on company profits. This method can reduce inventory-related costs, such as storage costs and inventory shortage costs. The use of the Reliability Centered Spares (RCS) method by considering the probability value (P) from no inventory (0) to maximum inventory with a value of P> 95% can result in an optimal inventory calculation. However, this method requires determining the probability value (P) or service level that the company wants. Comparison of ABC and Fixed Time Period analysis methods is feasible for comparative studies. The RCS method cannot be compared because of the probability value (P) or service level that must be determined by the company, resulting in inventory values that differ from the quantity and management costs of the three methods.

In practice, company management at PT XYZ is advised to set the probability value (P) or service level that the company wants when applying the RCS method. This will affect the value of inventory that the company will manage in supporting daily operational activities.

In theory, the results of this study provide further understanding of spare parts inventory control and methods that can be used to optimize inventory management. The implications of this research can be a reference for companies in developing effective and efficient inventory control strategies.

Based on the data analysis and discussion that has been conducted, we make the following suggestions: For future research, it is recommended to conduct studies using the RCS method by including variable availability in determining the value of inventory. The application of ABC analysis, Fixed Time Period, and RCS method calculations in this journal can be applied to different spare part equipment (other than compressor spare parts). PT. XYZ can consider using the RCS method in inventory management by determining the service level value against the stock-out level so that production continuity can be maintained.

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