Management of Surplus Project Spare Parts Using ABC Analysis in the Project Engineering Division of an Indonesian Cigarette Company

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ABSTRACT

This study discusses the management of leftover project components or ex-project spare parts in the Project Engineering division of PT. Dj. One of the causes of excess inventory is the Minimum Order Quantity (MOQ), which can potentially lead to inefficiencies if not managed systematically. One of the approaches used to improve inventory management is classification using the ABC analysis method. This method was chosen because it can group items based on their annual consumption value, making it easier for the company to prioritize high-value items that significantly impact operational costs. The objective of this study is to enhance warehouse management effectiveness, reduce waste in future projects, and optimize storage space utilization. In this study, data from 827 types of ex-project electrical spare parts were collected and analyzed based on their annual consumption values, then classified into three categories: A, B, and C. The classification results show that Category A consists of high-value items but in small quantities, thus requiring strict control. On the other hand, Category C consists of many low-value items that require minimal attention. The implementation of ABC analysis has proven effective in identifying priority items, improving inventory management efficiency, and supporting project readiness in the future.

1. INTRODUCTION

In the era of technological advancement and global competition, machinery plays a crucial role in producing consistent and high-quality products that can meet and satisfy consumer demands. PT. Dj is one of the largest cigarette companies in Indonesia, consistently prioritizing customer satisfaction. To achieve this goal, the company must be supported by various resources. In addition to human resources, PT. Dj is equipped with state-of-the-art cigarette manufacturing machines, supported by high-precision tobacco processing equipment capable of producing top-quality and consistent tobacco blends. Given the high demands and needs for advanced machinery at PT. Dj, a dedicated division called Primary Engineering was established. This division is responsible for fulfilling production capacity, implementing improvements, performing system upgrades, and conducting machine overhauls. Every machine, of course, requires parts as its essential components. According to Indrajit dkk [1] Spare parts are tools or materials that support the procurement of items needed for the equipment used in production processes. In any project, leftover parts are inevitable, one of the main causes being the procurement policy related to Minimum Order Quantity (MOQ), which is the minimum number of items a buyer must purchase from a supplier. In this study, parts left over from completed or closed projects are referred to as ex-project spare parts.

Spare parts management is a specialized case within inventory management, characterized by several unique aspects such as high item variability, risk of obsolescence, consumption closely linked to maintenance needs, and unpredictable demand patterns [2][3] also emphasized that spare parts storage is one of the most critical activities in spare parts logistics. Poor management of ex-project spare parts can lead to various losses, including:

1. Damage to parts due to prolonged storage and poor organization.

2. Long search times when locating specific parts.
3. Inefficient use of storage space due to improper arrangement.
4. Difficulty in controlling the condition and quantity of parts. Effective demand management and inventory control of spare parts—collectively referred to as spare parts management—play a central role in achieving target service levels while minimizing associated costs (Eaves and Kingsman, 2004).
5. Inability to utilize the parts to reduce investment needs in future projects.

Identification and classification are essential processes to ensure proper management of ex-project spare parts. At PT. Dj, the engineering project warehouse is used to store both spare parts intended for upcoming projects and ex-project parts, which are leftover components from completed projects. However, several challenges hinder the effectiveness of warehouse management. The core issue lies in how to identify and classify ex-project parts in the warehouse so they can be properly managed and contribute to operational efficiency. A warehouse serves as a temporary storage and retrieval area for inventory to support subsequent operational processes, distribution locations, or delivery to end consumers [4]. Figure 1 shows an example of ex-project spare parts that have not yet been properly managed.

Fig 1. Unclassified Ex-Project Spare Parts

Based on research and observations, there are 87646 ex-project spare parts until March 2025 stored across three warehouse locations that have not yet been properly classified and managed, as shown in Table 1 below.

Tabel 1. Spare Part Ex-Project Until March 2025

No.	Description	Period	Class Number	Unit	Location
1	Spare Part Ex-Project	Until March 2025	12	256	Warehouse A
2	Spare Part Ex-Project	Until March 2025	12	160	Warehouse B
3	Spare Part Ex-Project	Until March 2025	12	171	Warehouse C

This study is expected to provide significant benefits for PT. Dj in managing the engineering warehouse, particularly for ex-project spare parts. The research results are anticipated to support:

1. Operational effectiveness of the warehouse and project activities through the identification and classification of ex-project spare parts.
2. Proper management of ex-project spare parts is expected to reduce costs in future projects.
3. Minimizing the accumulation of leftover materials that may become damaged or deformed over time.

This study employs the ABC analysis (Analysis by Cost) as its research methodology, as it serves as a reliable basis for classifying ex-project spare parts and addressing the aforementioned issues. ABC analysis is one of the methods commonly used in inventory planning and control [5].

This study is considered urgent for several reasons:

1. The growing number of new projects has resulted in a buildup of ex-project spare parts, which in turn increases warehouse expenses.
2. As production capacity expands, more space is required, making it necessary to find ways to improve space efficiency, including the storage area for project spare parts.
3. Proper management of ex-project spare parts is one of management's initiatives to ensure accurate project costing and minimize the accumulation of unused or unmanaged spare parts.

2. THEORETICAL FRAMEWORK

2.1 Spare Parts Management

Spare parts management is a crucial component in supporting smooth operations, maintenance activities, and asset procurement within industrial environments [6]. Spare parts are components used to replace damaged items so that equipment can resume functioning as required. The presence of spare parts is vital due to their role in preventing production downtime and maintaining operational continuity. Other challenges include a limited number of suppliers and the lack of effective information systems to support spare parts management. Kennedy et al. [7] added that the decision between repairing or replacing equipment greatly influences spare parts management, especially when component reliability data is unavailable. The risk of obsolescence also increases when a particular spare part is no longer manufactured. An item is a spare part, component, device, subsystem, functional unit, equipment, or system that can be individually described and considere (BS EN 13306:2017) [8]

The unpredictable nature of spare parts demand—commonly referred to as intermittent demand—is also a major challenge. This type of demand, characterized by low volume, irregular frequency, and even periods with no demand, is difficult to forecast and complicates inventory planning. This situation creates a dilemma between overstocking (which ties up capital) and the risk of stockouts that can disrupt production [3][7].

To address these challenges, spare parts management must be carried out efficiently and systematically. One widely used approach is inventory classification systems, which help in prioritizing and supporting decision-making. Cavalieri et al. [3] recommended integrating spare parts management into Computerized Maintenance Management Systems (CMMS), as well as designing appropriate decision-making frameworks. One essential step within such a framework is the classification of spare parts.

2.2 ABC Analisys

Classification allows companies to manage a large variety of items more effectively, simplify control processes, and identify the most critical spare parts. According to Dekker et al. (1998), the main goal of classification is to ensure the availability of vital items that significantly affect production continuity. Lenard and Roy [3] also emphasized that material segmentation facilitates the evaluation of item groups, the application of constraints, and the adjustment of stock policies specific to each category.

One of the most widely used quantitative methods for spare parts classification is ABC analysis. This method is based on the Pareto principle, which states that 80% of the effects come from 20% of the causes. In inventory management, this means that approximately 80% of the total annual consumption value is typically contributed by about 20% of the total item types being managed. The ABC analysis is one of the most commonly used inventory management techniques where the classification of items is done in predefined categories: A (very important items), B (moderately important items), C (relatively unimportant items) [9]

ABC analysis classifies items into three categories based on their annual consumption value, as follows:

1. Category A – Represents approximately 10–20% of the total number of items but accounts for 70–80% of the total consumption value. Items in this category are high-value and have a significant impact on operational costs. Therefore, managing Category A items requires strict control, regular monitoring, and accurate procurement policies to avoid stockouts that could disrupt production processes.
2. Category B – Covers about 25–30% of the total items and contributes around 15–25% of the annual consumption value. Items in this category have moderate value and demand frequency. Management strategies for Category B are moderate, involving balanced oversight and control between cost efficiency and availability.
3. Category C – Represents roughly 50% of the total items but only contributes about 5% of the total consumption value. These are low-value items and are generally not critical to production continuity. Category C items can be managed with minimal supervision and less frequent replenishment, in order to avoid tying up capital inefficiently.

According to Ramanathan [10], ABC classification is typically based on two main parameters: annual demand and average unit price. Flores (1987) emphasized that this method is particularly useful for managing items with uniform characteristics. However, some researchers, such as Altay Guvenir and Erel [3], argued that the classical ABC approach is not always optimal in practice, especially under dynamic and complex conditions. To overcome these limitations, ABC analysis is often combined with other methods such as FSN (Fast-moving, Slow-moving, Non-moving) or multi-criteria approaches. FSN categorizes items based on their movement speed, making it useful for identifying obsolete or slow-moving items. This combined approach strengthens management decisions by considering multiple aspects, including both item value and demand behavior. Overall, spare parts classification using ABC analysis is an effective initial step in inventory management strategy. By focusing attention on items that significantly impact cost and operations, companies can optimize expenditures, avoid overstocking, and enhance readiness to meet future maintenance or project needs.

3. METHOD

3.1 Types and Methods of Data Collection

The research focuses on ex-project spare parts, which are leftover components from machine installations or spare parts from completed projects. The research object is the Project Engineering warehouse of PT. Dj, located in the western ring area of Kudus. The specific focus is on electrical ex-project spare parts. The data used in this study consists of two types:

1. Primary data, obtained from the classification of ex-project spare parts based on groupings and material classes. This includes detailed data on spare parts along with their prices.
2. Secondary data, obtained from existing records of ex-project spare parts documented by the logistics personnel. This includes historical purchase price data of the spare parts.

3.2 Research Methodology Steps

The steps carried out in this research are as follows:

1. Collecting all data related to ex-project spare parts.
2. Validating and processing the ex-project spare parts data.
3. Grouping the spare parts data based on their usability—distinguishing between usable parts (mechanical and electrical) and unusable parts. This research specifically focuses on electrical ex-project spare parts, which total 827 different types.
4. Classifying the spare parts based on material class, where the classification is determined according to the function and application of each spare part.
5. Collecting historical spare part purchase data to estimate the acquisition cost of each spare part.
6. Inputting price data into the classified ex-project spare parts list according to their material class.
7. Performing classification of ex-project spare parts using the ABC classification technique.

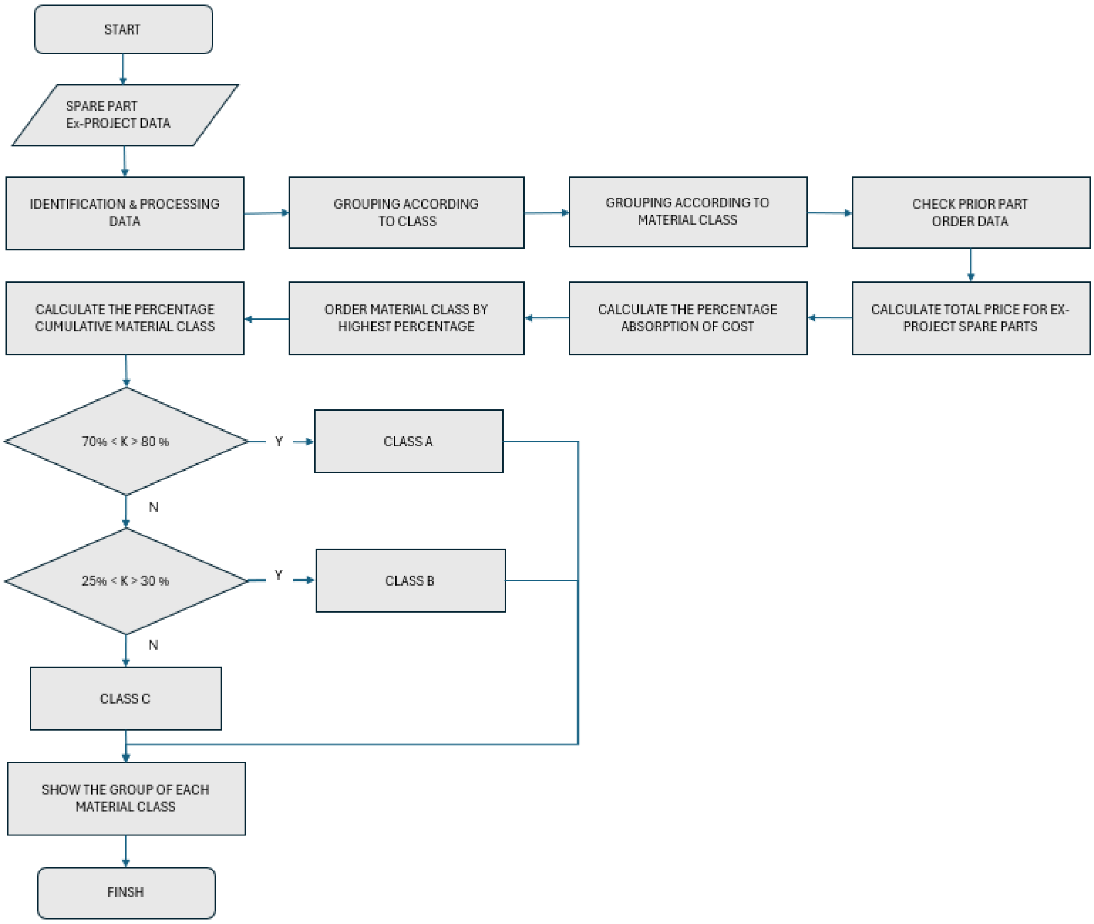

Fig 2. Research Process Flow

3.3 ABC Classification

The ABC classification technique used in this study divides the existing inventory into three categories based on annual dollar volume [11].

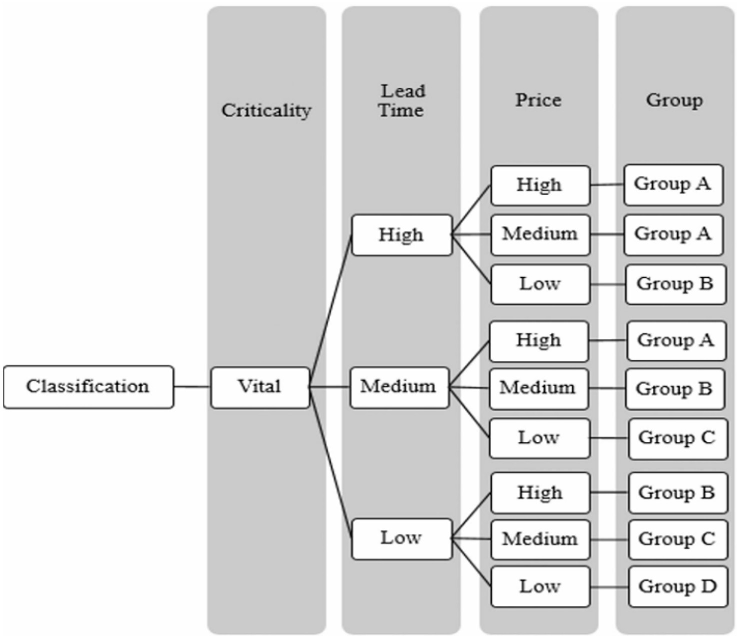

Fig 3. Classification Model

Ravinder & Misra [12]Management attention and control efforts are prioritized for Class A inventory, while Class C receives the least attention, and Class B falls somewhere in between. The ABC analysis is conducted by dividing products into three classifications based on their value [12]. Steps for ABC Analysis: Željko Stević, Ph.D, Bećirović Merima [9]

1. Annual Usage Value (AUV) = Unit Cost × Demand
2. Sort items in descending order based on AUV.
3. The final step is to classify and allocate items into categories A, B, and C based on cumulative percentage of total inventory value and item count, according to the specified thresholds.

4. RESULTS AND DISCUSSION

This section presents the results of data analysis, instrument testing and hypothesis testing (if applicable), answers to the research questions, findings, and interpretation of those findings. If the manuscript requires tables or figures, examples should be provided. Microsoft Excel was used as the analytical tool for data processing. The focus of the analysis is on electrical ex-project spare parts stored in the Project Engineering warehouse.

4.1 Ex-Project Spare Part Process Flow

Every project inevitably leaves behind some spare parts after installation and commissioning are completed. Therefore, to ensure clarity and facilitate execution in the field, a process flow diagram was created as shown in Figure 4. By establishing a clear workflow, it is expected that the classification of ex-project spare parts can be carried out more efficiently.

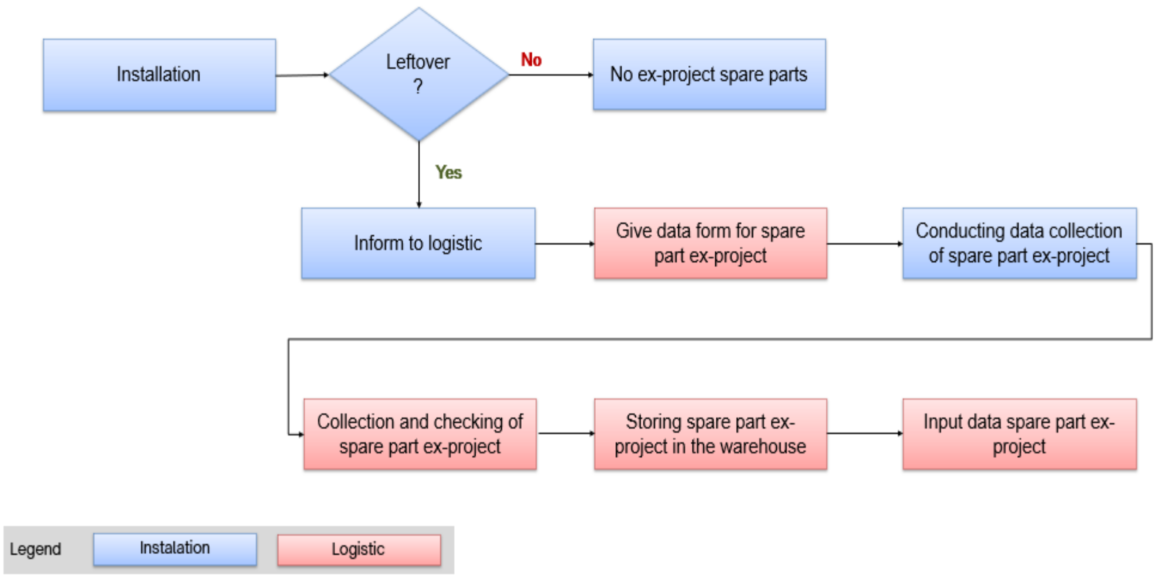

Fig 4. Ex-Project Spare Parts Receiving Process Flow

4.2 Material Class

One of the ways to deal with spare parts management is to group them into specific categories, making it possible to establish specific policies for each group (Roda et al., 2014; Huet al., 2017) [13]. Out of the total 827 types of parts studied, they were grouped into classification categories based on their function and utilization. The classification is based on the categories established in the SAP material master. The classification breakdown is as follows:

1. Actuator – actuator is a device or component in mechanical, electrical, or electronic systems that functions to convert control signals (usually electrical signals) into physical motion, such as rotation, pushing, or pulling.

2. Auxiliary Contact – Auxiliary contact is an additional component in an electrical device, such as a contactor or relay, used to provide status information (ON/OFF) or to indirectly control another circuit.
3. Cable – A cable is an electrical conductor covered by insulation, used to transmit electric current or signals from one point to another.
4. Cable Accessories – Cable accessories are complementary components used to connect, protect, join, or terminate cables in electrical installations or networks. These accessories are crucial for ensuring safety, reliability, and performance.
5. Contactor – contactor is an electromagnetic component that automatically connects or disconnects electrical power to a load (e.g., motors, lights, or heaters) based on control signals.
6. HMI (Human Machine Interface) – HMI is the interface that connects operators with machines or automation systems.
7. Inverter – inverter is an electronic device that converts direct current (DC) into alternating current (AC).
8. Lamp – lamp is a device used to produce light, typically for illumination purposes.
9. Module – module is a device or component designed to perform specific functions within an electronic system. Modules are usually pre-assembled and ready to use, making development easier without having to build from scratch.
10. Panel – panel is a device used to manage, distribute, and protect the flow of electricity in a system, whether in a home, building, or industrial facility. It typically consists of a metal enclosure containing various electrical components.
11. Panel Accessories – These are additional components installed within or around electrical panels to support their main function, enhancing safety, ease of use, and efficiency.
12. PLC (Programmable Logic Controller) – PLC is a digital electronic device used to control automation processes in industrial environments.
13. Power Supply – power supply is a component that provides and regulates electrical power to electronic devices or systems.
14. Protector – protector is a device used to safeguard electrical and electronic equipment from voltage disturbances such as surges, lightning strikes, or short circuits. A common example is a surge protector.
15. Relay – relay is an electromechanical switch that allows a small electrical current to control a much larger current.
16. Sensor – sensor is a device that detects physical or environmental changes and converts them into signals readable or processable by electronic systems, such as microcontrollers or computers.
17. Switch – switch is a device used to connect or disconnect the flow of electricity in a circuit. It is essential in electrical systems to allow users to control when a device is turned on or off.
18. Timer – timer is an automatic time controller used to switch electrical currents on or off at predetermined times. It is useful in automation systems, energy saving, and scheduled device control.
19. Transformer – transformer is an electrical device used to change the voltage level of alternating current (AC), either stepping it up or down.

From the processing of the ex-project spare part data and previous spare part purchase data, Table 2 below was obtained.

Tabel 2. Data Classification, Kuantitas dan Harga Spare Part ex-Project

NO	TYPE OF CLASSIFICATION	UNIT	QUANTITIES (Dt)	TOTAL PRICE
(1)	(2)	(3)	(4)	(5)
1	Actuator	Pcs	117	Rp94.264.747,00
2	Auxiliary Contact	Pcs	231	Rp50.037.504,00
3	Cable	Meter	19.824	Rp578.000.580,00
4	Contactor	Pcs	389	Rp247.904.533,00
5	HMI	Unit	4	Rp38.898.000,00
6	Inverter	Unit	22	Rp330.693.210,00
7	Lamp	Pcs	30	Rp4.143.000,00
8	Panel	Unit	1	Rp586.076,00
9	Panel accessories	Pcs	1492	Rp211.643.971,00
10	PLC	Unit	18	Rp428.244.479,00
11	Power supply	Unit	10	Rp54.025.000,00
12	Protector	Pcs	502	Rp370.060.056,00
13	Relay	Pcs	406	Rp59.169.500,00
14	Sensor	Pcs	189	Rp622.855.728,00
15	Switch	Pcs	137	Rp86.107.815,00
16	Timer	Pcs	4	Rp2.031.000,00
17	Transformator	Pcs	8	Rp15.593.120,00
18	Cable Accessories	Pcs	69.230	Rp788.692.642,00
19	Module	Unit	214	Rp729.334.287,00

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4.3 ABC Analysis

After that, we calculated the percentage of budget absorption based on the data above, followed by the cumulative percentage of budget absorption as shown in the table below.

$$Budget\ Absorption = \frac{Total\ Price}{\sum Total\ Price}$$

$$\%\ Cumulative\ Absorption = \frac{Total\ Price_i + Total\ Price_{i-1}}{\sum Total\ Price}$$

Table 3. Cumulative Budget Absorption Percentage and Ex-Project Spare Part Categories

NO	TYPE OF CLASSIFICATION	UNIT	QUANTITIES (Dt)	TOTAL PRICE	COST ABSORPTION PERCENTAGE	CUMULATIVE PERCENTAGE OF COST ABSORPTION	CATEGORY
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Cable Accessories	Pcs	69.230	Rp788.692.642,00	16,74%	16,74%	A
2	Module	Unit	214	Rp729.334.287,00	15,48%	32,21%	A
3	Sensor	Pcs	189	Rp622.855.728,00	13,22%	45,43%	A
4	Cable	Meter	19.824	Rp578.000.580,00	12,27%	57,70%	A
5	PLC	Unit	18	Rp428.244.479,00	9,09%	66,79%	A
6	Protector	Pcs	502	Rp370.060.056,00	7,85%	74,64%	A
7	Inverter	Unit	22	Rp330.693.210,00	7,02%	81,66%	B
8	Contactor	Pcs	389	Rp247.904.533,00	5,26%	86,92%	B
9	Panel accessories	Pcs	1492	Rp211.643.971,00	4,49%	91,41%	B
10	Actuator	Pcs	117	Rp94.264.747,00	2,00%	93,41%	B
11	Switch	Pcs	137	Rp86.107.815,00	1,83%	95,24%	C
12	Relay	Pcs	406	Rp59.169.500,00	1,26%	96,49%	C
13	Power supply	Unit	10	Rp54.025.000,00	1,15%	97,64%	C
14	Auxiliary Contact	Pcs	231	Rp50.037.504,00	1,06%	98,70%	C
15	HMI	Unit	4	Rp38.898.000,00	0,83%	99,53%	C
16	Transformator	Pcs	8	Rp15.593.120,00	0,33%	99,86%	C
17	Lamp	Pcs	30	Rp4.143.000,00	0,09%	99,94%	C
18	Timer	Pcs	4	Rp2.031.000,00	0,04%	99,99%	C
19	Panel	Unit	1	Rp586.076,00	0,01%	100,00%	C

4.3.1 Category A

Category A consists of five types of spare parts (Cable Accessories, Module, Sensor, Cable, and PLC), which represent only about 26% of the total items but account for 66.79% of the total budget. This aligns with the Pareto principle, where a small portion of items contributes to the majority of the cost. In practice, Category A exhibits the following real-world characteristics:

1. High value, as it includes expensive components such as PLCs, Modules, and Sensors.
2. High frequency of use and direct impact on project operations.
3. Generally consists of items with long procurement lead times.
4. High unit cost, making mismanagement potentially very costly.

- It was found that the critical points in managing category A include:
- Accurate stock recording and monitoring, as even minor errors can have significant impacts.
- Precise procurement planning, since these items are not always readily available from vendors.
- Special storage requirements, as these items often require secure and controlled storage conditions.

4.3.2 Category B

Category B includes the next five items (from Protector to Actuator), with a total budget absorption of 29.68%, bringing the cumulative total to 96.47%. These are items with medium value.

Characteristics and weaknesses of Category B:

1. Prone to being overlooked due to their moderate value and infrequent use.
2. If not properly managed, they can become overstocked or even dead stock.
3. Susceptible to overstock if not utilized in upcoming projects.
4. Requires moderate control, but often lacks managerial attention due to lower priority compared to Category A.

4.3.3 Category C

Category C consists of the last nine items, which absorb only 3.53% of the total budget despite representing the largest number of item types, indicating that they have a low financial impact.

Main weaknesses of Category C:

1. Large in quantity, but low in value and have minimal influence on project operational costs.
2. High potential to become accumulated leftover materials due to minimal supervision and infrequent use.
3. In reality, outdated items are often found and require functionality checks due to inefficient storage and lack of attention.
4. Requires proper logistical arrangement to avoid occupying excessive warehouse space.

From a theoretical perspective, ABC analysis clearly explains how Categories A, B, and C are differentiated based on their contribution to annual consumption value. However, from an empirical standpoint, several differences and additional challenges were identified, as shown in Table 3.

Table 4. Comparison Between Theoretical Concepts and Empirical Realities at PT. Dj

Aspect	Theoritical	Empirical Reality at PT. Dj
Value Distribution	Category A absorbs ~80% 0f value	Category A absorbs **66.79%, not** fully aligned with the Pareto principle
Control	A: Strict, B: Moderate, C: Minimal	In practice, **Category B is often poorly controlled, and C becomes a burden** in the warehouse
Storage	Not discussed in theory	**Actual storage faces many issues**, especially with Category C
Ex-Project Utilization	Not discussed in theory	**Ex-project spare parts are not yet optimally reused**; many remain **idle**

The findings of this study provide practical contributions to PT. Dj, particularly in optimizing the management of ex-project spare parts. Through the implementation of ABC classification, the company can focus on Category A items, which are high-value and critical to project continuity, thereby minimizing the risk of stock outs. Meanwhile, Category C items can be managed with more flexible procurement strategies to reduce storage costs.

From a theoretical perspective, this research expands the application of ABC analysis to the context of ex-project spare parts, which is still rarely discussed in inventory management literature. It offers empirical evidence that the ABC method can be adapted not only for fast-moving items but also for high-value items with uncertain demand.

The results of this research, which show the categorization of ex-project spare parts into A, B, and C classes, are consistent with the principle of the Pareto law applied in inventory management. According to Novarika et al. (2021)[14], the ABC method allows companies to focus their control efforts on high-value items (Class A) that represent a small proportion of total inventory items but contribute the most to inventory value. This aligns with the finding that PT. Dj Class A spare parts require tighter monitoring to avoid stockouts and cost inefficiency.

Furthermore, the justification for applying different control levels across categories is supported by Heizer and Render (2015)[14], who argue that Class A inventories require strict and continuous monitoring, while Class B needs moderate control, and Class C only requires simple and periodic checks. The research results indicate that applying such differentiated strategies will optimize warehouse space and reduce holding costs, which directly responds to the company's challenge of limited production area.

This ensures that critical items (category A) are managed with strict monitoring to avoid stockouts, while less critical items (category C) can be managed with more flexible procurement strategies, thus reducing storage costs. Similar conclusions were reached by Guslan & Saputra (2020) [15], who found that applying ABC classification combined with EOQ analysis significantly reduced total inventory costs.

5. CONCLUSION

This study demonstrates that the systematic management of ex-project parts using the ABC classification method can positively impact the effectiveness and efficiency of warehouse operations in the Project Engineering division of PT. Dj. From the 827 types of electrical spare parts analyzed, it was found that a small portion of items (Category A) accounted for the largest share of the budget and held high strategic value, thus requiring stricter monitoring and control. Meanwhile, Category C consisted of low-value items in large quantities that could be managed with a more flexible approach. Through this method, the company can identify and prioritize truly essential components, reduce waste, and repurpose ex-project parts for future projects. Overall, the implementation of ABC classification has proven effective in improving inventory control accuracy and supporting cost efficiency.

Suggestion and recommendations for Project Engineering Division PT. Dj:

1. Digitization of Inventory Management**:** It is recommended that PT. Dj develop a digital inventory management system for recording, monitoring, and automatically classifying ex-project parts.
2. Integration with Project Planning**:** The classification results should be integrated into project planning processes so that ex-project parts can be fully utilized before initiating new procurement.
3. Training and Standardization**:** Training should be provided for warehouse and project engineering teams on the importance of inventory classification and consistent application of the ABC method.
4. Periodic Evaluation**:** ABC classification should be regularly updated to remain relevant to current conditions and evolving production or project needs.
5. Application of Combined Methods**:** For more comprehensive management, PT. Dj may consider combining ABC with other classification methods such as XYZ or FSN in subsequent phases.
6. Inventory Management Focus on Category A: Since Category A absorbs the majority of the budget, items such as Cable Accessories, Modules, and Sensors must be given top priority in inventory management and control. Strict supervision, purchasing evaluation, and usage planning are essential to avoid waste and overstock in this category.

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