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IMPROVEMENT PROPOSAL FOR WAREHOUSING PROCESSES AND FLOWS: A STUDY IN A MINING COMPLEX IN MARABÁ, PA, BRAZIL

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ABSTRACT

Currently, there is a great challenge for organizations to be able to use their resources efficiently without increasing costs or decreasing the level of service provided to the customer, and, to achieve these objectives, all the activities of an organization must be known. in detail. Two tools that enable better visualization and detailing of processes are the Process Management Methodology combined with process mapping. Together, they make it possible to identify failures and improvements that can be made throughout the activities. Therefore, this is a study of the application of the Process Management Methodology in a mining company facility's warehouse located in the city of Marabá, PA, Brazil. In it, the diagnosis and mapping of the processes was carried out using the flowchart and Spaghetti diagram techniques, which enabled the identification of the main flaws in the process. Using Microsoft Publisher software, movement flows were designed, thus allowing a graphical visualization of all activities. In addition, an action plan was developed using the 5W1H method, through which proposals for improvements to the warehouse under study were made. With the results obtained through the research, it was possible to identify existing bottlenecks in the process and propose viable solutions, thus confirming process management and mapping as tools to support decision making and operational planning in the company. The adopted methodology can be used as an improvement tool in other sectors of the company or other companies, in other situations like the process described in this study.

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INTRODUCTION

The year 2020 was marked by a global crisis, due to the Covid-19 pandemic. The preventive sanitary measures adopted led to a decline in several economic activities and paralysis in many sectors, for example the mineral industry, and as a consequence there was a restriction in transportation, suspension of projects in the industry and variation in the price of ore commodities. (Oliveira and Maldonado, 2020). In the midst of this scenario, the World Bank's metals and minerals price index dropped 4.7% in 2020 compared to the same period in the previous year, which meant a high retraction in world manufacturing activity. In view of this and with many scenarios of uncertainty, investors became more selective and cautious, preferring to invest in safer negotiations, which negatively impacted investments in the mineral sector.

In view of the presented scenario, one of the challenges of companies in the mineral sector is the resumption of their usual income and, for that, it is necessary to reduce costs altogether in their processes. Despite the various areas in mining, logistics is still considered a primary activity for the operation of mining companies. According to Ballou (2006) 25% of an organization's expenses come from storage and material handling activities, exempting inventory maintenance costs. Process management applied in this context becomes an advantageous element for companies looking for improvements and cost reduction. For Bonin (2018) process management aims to help understand the company's processes and relate them to its resources and production capacity, in order to aggregate knowledge for decision making. Process management seeks to reduce costs and improve operations based on the quality and satisfaction of its stakeholders (COSTA, 2009).

Based on the context presented, the present work aims to answer the following research question: What improvements could be proposed in the stocking process and material flows through the management tools and process mapping in a mining company's warehouse? In order to answer this question, this article aims to propose improvements to the stocking process in a warehouse of a mining company located in the city of Marabá, Brazil. The work is divided into five sections, the first consisting of the introduction in which the study's justification, problematic and objective, are presented. The second contains the theoretical framework, used in the development of the work, in which topics such as process management and its importance, process mapping and the tools used are addressed. The third section consists of the research methodology and the main steps used to carry out the study. The fourth consists of the results found followed by the analysis and the proposals for improvements. Finally, there is the fifth section with the final considerations and proposals for future studies.

THEORETICAL FRAMEWORK

Process Management: According to Romano (2015) it is extremely important to think initially about the actions that must be taken so that the processes can be executed within an organization, actions that can become tasks and later activities. During the process mapping, various types of activities, sub-processes and processes are inserted. In order to have a better analysis of this mapping, it is important to know the concept of four types of processes, the critical processes, the key ones, the support ones and the business ones. The objective of process management is to provide the alignment of business processes with the strategy (the processes are the execution of the strategy). According to Mendes and Costa (2018) , process management results in a favorable environment for the formation of management based on knowledge, in which information must be prioritized together with the creation of standards, allowing the environment to be prepared for change and that can quickly respond to consumer desires. Improving processes is a basic action for organizations to respond to changes that constantly occur in their operating environment and to keep the productive system competitive (PAIM et al., 2009). For Cunha (2012) states that within Process Management, mapping emerges as an important tool for controlling and monitoring organizational processes. Mapping is an activity with the objective of designing, executing, documenting, monitoring, and controlling the improvement of processes in order to achieve the intended results in an institution. Generally, this activity is part of a discipline in the management area, which combines the process-centered approach with the improvement of the institution's functioning to achieve goals.

Process Mapping: Process mapping is a managerial and communicative tool that aims to improve existing processes within the company or to create a new structure based on processes. It is excellent for improving the understanding of processes and enabling the simplification or elimination of those that need change. In addition, a good interpretation of it can generate savings in the process of developing products or services, improving the company's performance and reducing the integration failures between systems (Gomes, 2009). For Gomes (2009) also explains that process mapping is a technique used to detail the business process by focusing on the important elements that influence its behaviour. The orientation of the process flow is important because it transforms a simple layout of machines inside a factory into a series of processes, trying to reduce distances between operations, improve the use of space and decrease production time. There are many representation techniques, used to build process models, that assist in the elaboration of different types of maps. But whatever the technique adopted, the process mapping normally follows the following steps Gomes (2009).

- Definition of the processes' boundaries and customers, the main inputs and outputs and the actors involved in the workflow;
- Interviews with those responsible for the various activities within the process and study of the available documents;
- Creation of the model based on the information acquired and its step-by-step review.

Flowchart: The flowchart is a schematic used to graphically visualize the sequencing of the entire process, thus making the visualization of procedures easier and more understandable. Regularly when drawing a flowchart, bottlenecks and failures are found in the process. Failures that are not usually detected in daily tasks, and with their identification it is possible to make improvements in the process to achieve quality (Peinado; Graeml, 2007). Therefore, the mentioned tool is one of the best options considered when talking about processes. Flowcharts have decision and action steps, which show unique symbology for better understanding of the activities, demonstrating in a practical, simple and effective way the many steps contained in a process, from the details of equipment to the system as a whole (ROCHA; ALVES, 2019).

Spaghetti Diagram: The Spaghetti diagram is considered a Lean tool and can be defined as "a method used to present the movement and the distance that a certain element travels throughout the entire organizational process and can be drawn on a site plan" (BAHENSY et al., 2005). It is important that all facilities on site are identified as well as the identification of doors, windows, corridors, and workstations, as they directly impact the performance of processes performed, whereas if there is a divergence in the design of the plant, problems will be caused and may show longer movement flows or wrong patterns. The name of the method is given by the similarity of the possible route drawn or layout to a spaghetti type pasta. Thus, with the traced route, we seek to visualize unnecessary movements in the construction of a product or in the execution of an activity (Lexico Lean, 2013). According to Tanco et al. (2013) to apply the Spaghetti diagram, some steps must be performed as follows:

- Delineate the area to be studied in as much detail as possible;
- Workplaces must be well delimited;
- Observation of the process and initialization of the project;
- Check the movement of materials, people, equipment and information according to the activity carried out and the sector;
- Sketch lines that will represent the movement flow;
- Deliberate flows of each process;
- Analyze the diagram and consider factors such as waste, physical arrangement of objects, time and quality;
- Detect opportunities for improvement.

In this way, tracing the paths taken and plotting them, it becomes easier to visualize the process and identify unnecessary movements or flows (TANCO et al., 2013).

S Five Ws and How (5W1H): The 5W1H according to Mendes and Costa (2018) is a practical tool that allows at any time to identify important data and routines of a project or a production unit, making it possible to identify who is who within the organization, what they do and why they perform such activities. The method consists of six questions used to implement solutions. In order for all of this to be used in an adequate and coherent way for storage logistics, an environment conducive to changes has to be established. Knowing how to absorb information and how to express the problem that will be found and solved, and the quality after all the data collected correctly will be of great success for the company using this tool (FIDELIS, 2017).

METHODOLOGY

Research methodology can be defined as the sum of strategies, intellectual or technical, with the objective of reaching a pre-established target, namely, knowledge (SILVA, 2005). For this purpose, this research will bring about the application of methods and tools to make possible the proposition of solutions to the problems identified in the activities carried out in the warehouse of a mining facility. According to Prodanov and Tanco et al. (2013), as for the level of research, it can be classified as basic, where in addition to developing theoretical knowledge, it also develops practical knowledge, but without application.

Regarding the research approach, it is classified as qualitative where the environment under study becomes a source of data collection for the researcher. In the qualitative approach, data are collected through unstructured interviews, through observation and analysis of the organization 's historical data (GAITHER; FRAZIER, 2012). This study is a research characterized as descriptive explanatory. From the definition of Santos (2000), descriptive research is determined by investigating the elements of fact and explanatory by originating an acceptable concept about the fact. In relation to the procedures, it is a bibliographic research because theses, academic articles, books and course conclusion papers were used as references, and it is also a field research, in which visits and observations were made to the warehouse area for data collection. The collection of data and information was carried out through observation and on-site visits, for about eight months, in addition to unstructured interviews with employees and managers. Visits were made to the warehouse area accompanied by an employee to obtain information on the storage processes carried out and equipment used in the process. The present research was carried out in a facility of a mining company located in the city of Marabá, Brazil. The main steps for development are listed below:

- Delimitation of the problem and scope of the study: through direct contact with the company, it was possible to identify the area that needed more attention, understanding the process to then delimit the research;
- Theoretical Basis: the survey of information related to the researched topic was carried out, through articles, periodicals, books and other research sources in order to explore and substantiate relevant information for the work;
- Preparation of the flowchart with description of the activities;
- Spaghetti Diagram creation, as an initial phase for the process mapping selected for the research;
- Design of the studied process flows using the Microsoft Publisher tool, in which the design of the floor plan was plotted and the movement lines were edited;
- Analysis of the results obtained with aid of process mapping;
- Action plan development, based on the mapping carried out, it was possible to identify flaws in the process and then apply the 5W1H to propose improvements.

RESULTS AND DISCUSSION

Company description: The company under study is a multinational mining company, specifically its facility located in the city of Marabá, in the southeastern region of the state of Pará, Brazil. Founded in 1985 together with Carajás Railway, the facility has always served as a base for the maintenance and supply of trains, as well as the boarding and unboarding of passengers at the station, which is also located inside it. Currently, the facility has an operational sector for control and inspection of ore trains, a project sector, a workshop, and a warehouse for receiving and stocking parts and products supplied to the workshop and other regions. The warehouse under study has a total area equivalent to 708.47 m² and is responsible for the storage and distribution of various materials for all sectors such as: PPE's, uniforms, office supplies and railway maintenance items in general. In stock it has 600 types of different items ranging from R$ 2.00 such as screws, threads, masks, filters, and other types of materials with a value of up to R$ 6,000.00 a single item, including specific train parts and maintenance. The warehouse operates with two employees, an employee working as a tax receipt assistant who receives and verifies the notes received at the warehouse and another worker who performs the rest of the processes. It is divided into three areas: administrative area, pallet area and racking area. This study focuses on the warehouse, its areas, and processes.

Current process analysis: To carry out the research, the steps taken in the process of receiving, storing goods and fulfilling orders from the warehouse were observed. The entire process was then divided into three stages of activities, which are the receipt, storage and separation of orders considered the main and most important activities. According to information provided by the employee, the following equipment is used to carry out these processes: a forklift, used to move larger objects received and to store them after going through the previous steps, and a wheelbarrow that is used for smaller objects. The entire process is carried out by only one employee without the assistance of others, with the exception of the tax receipt that is carried out by another employee. The facility's warehouse exists to support all employees of the mining company, and especially the workshop, where most of the assets that are stored have the purpose of replacing the maintenance of the trains. After verifying the process execution steps, a flowchart was elaborated in order to map the process and provide better visibility to the activities carried out in the warehouse. The company in question has formal documentation of how the processes must be carried out within the warehouse, but because there is no simplified and clear language, the employees end up ignoring it. Thus, there is no way to contextualize these activities and bring simplification, guidance, and greater efficiency to the process.

The process begins with the arrival of drivers to deliver materials, the driver then goes to a verification room where the invoices are validated in the internal system, this process is commonly called “invoice registration” and it is performed by a single collaborator. After the notes have been validated, the driver is then accompanied by another employee named storekeeper, who aids positioning the vehicle at the unloading bay. Once the vehicle is positioned, the storekeeper searches for the necessary equipment to remove the material. The equipment chosen will depend on the type of cargo to be removed. Then the material is received in the unloading bay, the process of checking notes and counting the materials is carried out: each product received is inspected and checked against the invoices, if there is a discrepancy after verification, the employee instructs the driver to collect the cargo and return the next day with the correct material. In the absence of discrepancies, the invoice receipts are signed, and the goods are then transported to the designated receiving area. Often, the receiving area already has other goods that have been unloaded, so, for the process to continue, the employee goes on to identify the goods that arrived first and to store them and because there is no space or proper organization the process takes about thirty minutes or more to complete.

Subsequently, the separated and organized material goes to the storage area where, in the process of registering invoice, the system indicates the place to be stored, however the employee does not follow what is indicated by the system and chooses the storage location using only perception available space, which can be a rack or a pallet. After determining the storage location, the packaging is identified and then the material is stored on the pallet trucks (if they are large and heavy materials) and then a forklift is used, or in the racking area (if they are small), using the wheelbarrow for operations like this. After the warehousing process is completed, the order picking process begins. The employee retrieves from an internal system the delivery orders that the warehouse must carry out throughout the week. Orders are divided into three categories: PPE's delivered to employees, spare parts for the maintenance of the workshop and a specific category called Kit Delivery that consists of a set of various items, such as spare parts and materials, for specific maintenance plans. Generally, the kit materials have different labels to signal that they will be included in one in the future. The assembly of the kit takes longer and, depending on the quantity of items ordered, it can take up to two hours before the material is completely separated and delivered. During the months of study, through observation and interviews with employees, each activity in the storage process was analyzed and then each step was listed. The observations of the site together with the analysis of other researches served to support the construction of the flowchart shown in Figure 1 below. During the process mapping, the storekeeper's total movement and displacements within the warehouse during operations was recorded through a Spaghetti Diagram, which is illustrated in Figure 4 below, in which the blue flow represents the receiving process, orange flow for storage process and pink for order picking.

According to the diagram, it was possible to identify that the employee moves over long distances during the processes and to finish activities, mainly due to the way in which the physical arrangement was made.

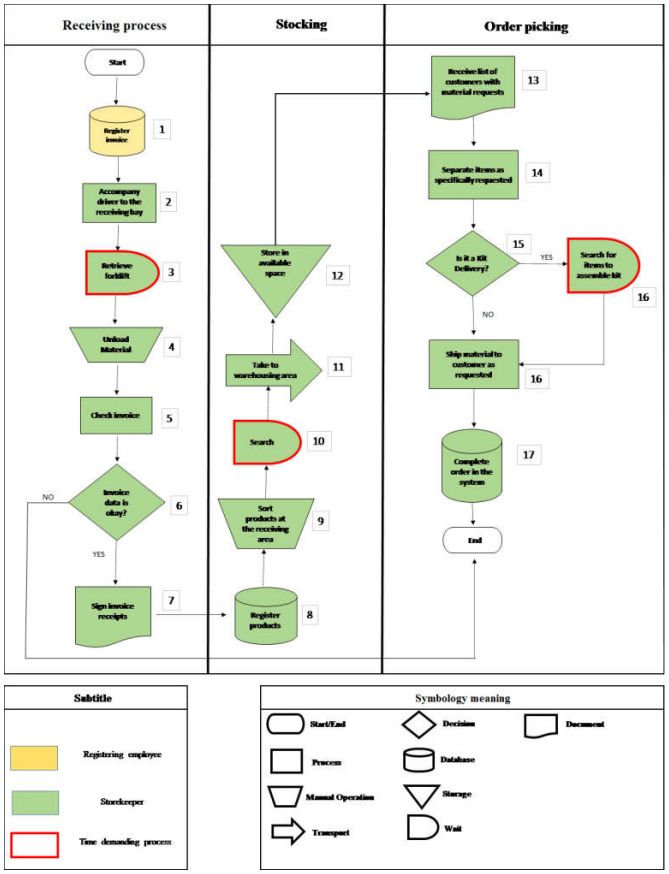

Figure 1. Current process flowchart

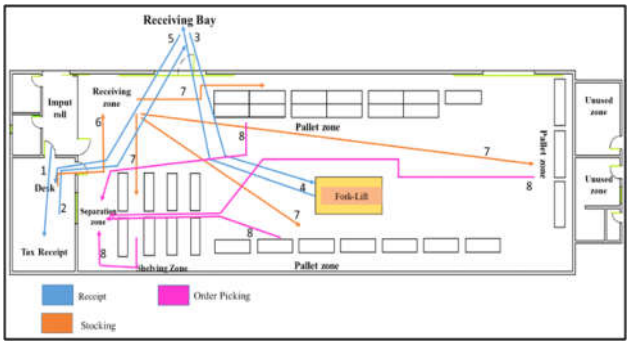

Figure 2. Spaghetti diagram: receiving Materials

Improvement proposals: After monitoring the process and mapping the steps and activities, it was possible to identify some existing problems, not only in the processes performed but also in the organizational structure in general. Among the problems identified are: layout organization, such as the arrangement of some pallet trucks and racks; allocation of some machines, such as the forklift, which for most of the time is positioned far from the unloading bay, resulting in an excess of movement; in the storage stage it was verified that the materials are stored anywhere according to their size, but without previous separation by category (PPE, spare parts or Kit Delivery), which makes it difficult to collect the material, since the employee you have to look on the different racks and on the pallet trucks where these materials may possibly be. The items are labeled with their names and purposes, but due to the lack of organization, a lot of time is spent searching for and gathering these items. Another problem identified is that the processes and activities are centralized in a single employee, demanding much more time to carry out the steps because he is simply overloaded, given the size of the warehouse. Keeping only one employee to carry out all the processes is not feasible. Another critical point identified was a flaw in the performance measurement system of employees, given that it is guided by the completion of orders in the internal system, that is done by the storekeeper, being easily circumventable and consequently making possible gaps unidentifiable. This is because, at the end of each month, to achieve the established goal, all orders are completed in the system, to show efficiency in results and goals, even if not all have not been delivered yet, demonstrating the vulnerability of the system. After analyzing the problems, with the objective of proposing viable solutions in the short term, the 5W1H tool was applied to propose an action plan for the processes carried out in the warehouse with the intention of reducing waste and increasing efficiency. Table 1 below contains the action plan to address the most evident problems that the sector presents. According to the recommended action plan, a new process flow chart (illustrated in Figure 3) was prepared, with the proposal to allocate one more employee to carry out the activities. After applying the action plan, layout must be reorganized and some processes brought together, since some resources used in activities are far away, causing excessive movement. It was also noticed an unnecessary movement of the employee while receiving materials with the forklift. Thus, there was a need to redesign the activity to show a way to save time in the process, shown in Figure 4 with the new diagram model. The area manager must assist in the application of this action plan.

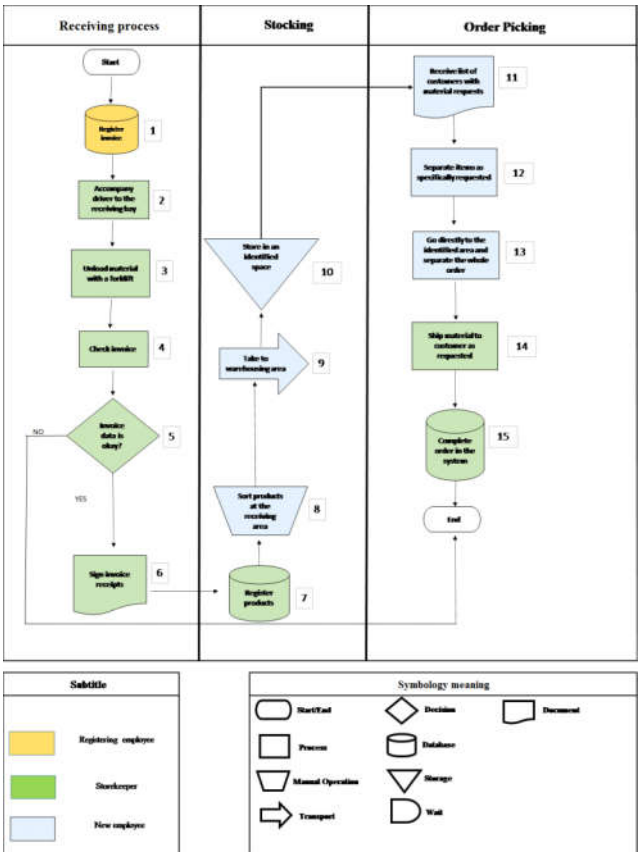

Figure 3. Current process flowchart

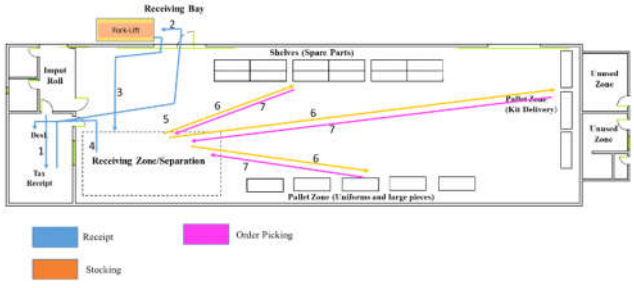

Figure 4. Proposed Spaghetti diagram

Table 1. Action plan: improvements

5W1 H					
What?	Why?	Where?	Who?	When?	How?
Reorganize Layout	To reduce the distance traveled by the employee	Warehouse	Area manager	Start: 01/Apr/2021	Relocating machines, such as the forklift, and identifying each area
Sort materials into areas according to specification	To facilitate identification of materials during order picking	Warehouse	Area manager/ Storekeeper	Start: 05/Jun/2021	Visually identifying the area specifications and, from the date set, placing old materials in their areas as well
Set up another performance measurement system	To achieve better accuracy about task accomplishment	Database information system office	Area manager	05/Mar/2021	Choosing suitable measurement platforms, such as Dashboard
Hire a new employee	Reduce time between activities and assign tasks more equally	Warehouse	Area manager	Start: 10/Jun/2021	Starting the recruitment and selection process
Put together and expand receiving and sorting areas	Reduce the amount of movement and assist in the identification of objects	Warehouse	Area manager/ Storekeeper	01/Apr/2021	Relocating racks and expanding the area
Implement FIFO method	To reduce material losses, and organize and remove spare pallet trucks	Warehouse	Current storekeeper	15/Jun/2021	Performing inventory and discarding materials that have been out of operation for more than a year, and from then on start using the FIFO method

The changes proposed to the warehouse layout are illustrated in Figure 4, having been divided by areas, as proposed in the improvement plan. The activity of receiving materials was redesigned with a change of location for the forklift. The reorganization of the space also included a change in the position of pallets and racks, designed in order to provide better movement of employees within the storage area. The receiving area was unified with the picking area, given that, with the presence of one more employee in the process, as shown in the flowchart of Figure 3, as an employee inserts the goods in the receiving area, the second employee as separates and performs the storage, streamlining the process, promoting a better efficiency in all the executed processes. This study aimed to analyze the stages of the activities of a mining company warehouse located in Marabá, Brazil. Through the process mapping, it was possible to diagnose the activities and thus propose improvements using the 5W1H tool.

Through Flowcharts and Spaghetti Diagram it was possible to map all processes and identify failures and activities that could be more efficient throughout the process. From the warehouse floor plan and the employee's movement tracking during the activities, the need for a reorganization of the layout was verified to minimize movement of employees and simplify the flow of activities. The division of labor was also observed during the visits to the warehouse, and it was clear the overload of activities of the storekeeper. Intending to solve or minimize the problems identified in the warehouse, proposals for improvements were suggested to be used as support tools to help organize changes in the area and future action plans, which, as shown in the redesigned flowchart in Figure 3, allocating one more employee would give the possibility of a more balanced division of tasks and, consequently, the elimination of waiting steps that happen in the current process because there is only one employee performing various tasks in a very large area. The proposed action plans will help to increase performance in the activities and reduce logistical costs, ensuring more satisfaction to end customers and management. Diverse difficulties were encountered during this research, among them: the beginning of the Covid-19 pandemic, which limited access to information and made face-to-face access to the facility area much more restricted. There was also an initial resistance to speak and show how the processes were carried out inside the warehouse, given that employees were afraid of reprisals from management. Despite the difficulties presented, the research question was answered, also providing a decision-making model for the company's management and a vision about its processes, that otherwise seemed not to be clear. This research contributed positively to the literature on Process Mapping involving the perspective of storage.

This research aimed to contribute to future studies, in which the same methodology can be applied in other sectors of the company, as well as the application of the improvement proposals mentioned in this work, to ascertain whether there was an effective improvement in the process. As a suggestion for future studies, since there is no standardization and that several activities were found out to be performable in less time or even able to be eliminated altogether from the process, it is proposed a motion and time study in the warehouse operations to investigate activities more thoroughly, standardize the process and find better ways to improve time. Another proposal is to carry out an ABC Classification to determine the most appropriate reposition method for each item, since it was verified during the research that there is no type of prioritization for items in the warehouse and, in many cases, some products such as filters or specific parts end up quickly in stock, with employees having to request material transfers from the company's other facilities. Therefore, an ABC classification study could inform the management of items that have great representativeness of value for the warehouse due to their demand levels and flows and associate them with a proper stock reposition model.

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