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# A STUDY ON THE STAGES OF THE MATERIAL HANDLING PROCESS IN AN INDUSTRIAL ORGANIZATION IN MANAUS, BRAZIL

# UM ESTUDO SOBRE AS ETAPAS DO PROCESSO DE MOVIMENTAÇÃO DE MATERIAIS EM UMA ORGANIZAÇÃO INDUSTRIAL DE MANAUS, BRASIL

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## Abstract

This study analyzed the stages of the materials handling process practiced by an industry that operates in the industrial hub of Manaus. It used the survey method, whose data were collected with the help of a semi-structured interview script and another script to observe the functioning of the process selected for study, constructed based on the theoretical architecture developed based on the literature review. The results showed that a) the materials handling process practiced consists of eight stages, with the first being performed outside the storage area, b) the equipment used for handling is used in specific substages to perform specific activities, and c) the functionalities of the equipment used are associated with the efforts to maintain the integrity of raw materials and products while contributing to streamlining the production process. The conclusion shows that the practice of the materials handling process contradicts the theoretical architecture developed in the first and the last stages.
**Keywords**: Material handling. Material handling equipment. Functionality of material handling equipment. Internal logistics. Logistics at Amazon.

## Resumo

Este estudo analisou as etapas do processo de movimentação de materiais praticados por uma indústria que atua no polo industrial de Manaus. Utilizou o método de levantamento, cujos dados foram coletados com o auxílio de um roteiro de entrevista semiestruturado e outro roteiro para observar o funcionamento do processo selecionado para estudo, ambos construídos com base na arquitetura teórica elaborada com base na revisão da literatura. Os resultados mostraram que a) o processo de movimentação de materiais praticados é composto por oito etapas, com a primeira sendo executado fora da área de armazenagem, b) os equipamentos utilizados para a movimentação são utilizados em subetapas específicas para realizar atividades também específicas e c) as funcionalidades dos equipamentos utilizados estão associadas com os esforços de manter a integridade das matérias-primas e produtos ao mesmo tempo em que contribuiem para racionalizar o processo produtivo. A conclusão mostra que a prática do processo de

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movimentação de materiais contraria a arquitetura teórica elaborada, tanto na primeira quanto na última etapa.
**Palavras-chave:** Movimentação de materiais. Equipamentos de movimentação. Funcionalidade de equipamentos de movimentação. Logística interna. Logística na Amazônia

## 1. Introduction

Logistics is the science, art, and practice of supply (Sarkis, 2024; Boyle, 2024/ van Hoek; Wong, 2025; Moshebah et al., 2024). The purpose of science is to explain and demonstrate the various intricacies of the behavior of this phenomenon, so that the practice can be effective as a decision-making process between viable alternatives for generating the intended results, especially in a way that can be transformed into an action that any individual would take, if the same circumstances were considered, configuring the art of action. Supply chain management theories, despite considering supply in its global form, focus their perspectives and levels of analysis on the upstream (supply) and downstream (distribution) dimensions, leaving in the background that part of the supply chain that makes the interconnections between the two large dimensions, which is internal logistics. Ultimately, the entire supply chain consists of interconnections between the internal logistics of all the organizations that comprise it, so that they are, for example, what make efficiency effective (Costa et al., 2025), generate information for production decisions (Muehlbauer et al., 2024), help reduce processing time (Blanchard et al., 2024) and organizational costs (Ateş, 2024), among other results that have fundamental implications for the entire supply chain.

Three functions of internal logistics are frequently found in scientific studies: storage (Assis et al., 2024), movement (Ateş, 2024; Tubis, 2024), and distribution (Cirillo et al., 2024). It is from these functions that there are interconnections with other organizational sectors, such as human resources, finance, marketing, production, etc., so that they are the ones that support the core activities of any organization, making them competitive, increasing or reducing the level of customer satisfaction with what they deliver. Intrinsically, the movement of materials is the function of internal logistics that enables both the storage and

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distribution of stocks and products in process to the production lines and, in the case of push production, from the production lines to the storage areas. For this and other reasons, it is essential that the movement is efficient, reduces as much as possible the losses and damages caused to materials and is carried out in the fewest possible steps, given that the more steps there are, the greater the possibility of errors and failures and the higher the operating costs of internal logistics. Moving materials, therefore, has been one of the significant logistical challenges of contemporary organizations. In this sense, this study aimed to analyze the stages of the material handling process carried out by an industry that operates in the industrial hub of Manaus. The analysis focused on the stages that constitute the handling process, how each one is executed, the handling equipment used, and the functionalities of this equipment. There were two main justifications for carrying out this research. The first was the small number of scientific studies with a specific focus on the handling process and its stages, and the second was the need to understand whether all material handling begins with the reception stage and ends with the shipping stage as essential organizational substructures.

## 2. Theoretical Architecture of the Study

The literature review presented six distinct but convergent approaches to the material handling process. An approach can be defined as how a phenomenon is viewed and explained. Several approaches can be considered convergent when they focus similarly on the same aspects; if they focus on different elements or the same aspects differently, they can be regarded as divergent. Thus, the first approach found sees handling as art (Wojtczuk, 2024; Ajith et al., 2022), understood as applying human rational capacity to problem-solving, with special emphasis on the beauty of the action, as artists do. The main aspects of handling focused on by this approach are the movement, storage, control and protection of goods and materials (Wojtczuk, 2024) throughout the activities of manufacturing, distribution, consumption and disposal, as well as in the transportation, positioning and packaging of materials (Ajith et al., 2022). The

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second approach sees movement as an activity (Sathees et al., 2022; Chakraborty et al., 2023; Fragapane, 2021; Ariq et al., 2024). An activity can be defined as executing several actions to produce a previously desired result, so the movement's focus will change according to the objective. Thus, the focus can be the added value (Sathees et al., 2022), the deliveries of materials and their specifications (right quantity, appropriate time, correct sequence and intended time), as pointed out in the study by Chakraborty et al. (2023), the planning and control of the internal transport of materials (Fragapane, 2021) and the implementation of a series of activities aimed at maintaining the value of materials in the form of reliability, availability and productivity, through various strategies and technological resources (Ariq et al., 2024). The third approach to material movement comes from science (Durand et al., 2022; Wojtczuk, 2024). Science can be defined as the generation of explanations about the behavior of a given phenomenon using the scientific method. Thus, material movement is the focus of science in its various forms of transportation (Durand et al., 2022) and the resources that are used for this, with essential highlights in the movement, storage, control and protection of goods and materials (Wojtczuk, 2024) in all their positions in the supply chain, such as manufacturing, distribution, consumption and disposal. Science seeks to understand so that simulation and prototyping schemes can be developed to improve the material movement process. Table 1 summarizes the findings of the literature.

Table 1. Approaches and focuses of material movement

| References | Approaches | Material handling focuses |
|---|---|---|
| Wojtczuk (2024); Ajith et al. (2022) | Art | Handling, storage, packaging, positioning, lifting, control, and protection. |
| Sathees et al. (2022); Chakraborty et al. (2023); Fragapane (2021); Ariq et al. (2024) | Activity | Added value, deliveries, planning and control, technical and managerial information, and equipment. |
| Durand et al. (2022); Wojtczuk (2024) | Science | Handling and other processes; storage, control, and protection. |
| Theodara et al. (2022); Abdullah et al. (2024); Tania; Sinambela (2022) | Function | Preparation, placement, and positioning. |
| Srivastav et al. (2022); Mikkelsen; Dahl (2021); Yaacob et al. (2023) | Process | Handling, storage, protection, and control. |

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| | | |
|---|---|---|
| Javat; Tawade (2023) | System | Handling, handling, storage, and control. |

Source: data collected by the authors.

Function was a prevalent approach found in the literature (Theodara et al., 2022; Abdullah et al., 2024; Tania; Sinambela, 2022). The term function can be defined as an obligation that someone or something has to fulfill and a role that must be played. The function of materials handling is to make the supply of an organization's production lines available through three well-defined roles: preparing, placing, and positioning materials so that both the internal movement of raw materials, semi-finished and finished products, and the transportation of products to be distributed to wholesalers, retailers, and end consumers are facilitated.

Process was another approach that was quite commonly found in the literature (Srivastav et al., 2022; Mikkelsen; Dahl, 2021; Yaacob et al., 2023). The idea of a process is equivalent to a series of activities or events, logically ordered, with a beginning, middle, and end, and at the end of the execution of the last activity or event, an inevitable result is generated or the previously desired objective is achieved. Thus, the stages of the material movement process found are transportation, storage, protection, and control, according to the study by Srivastav et al. (2022) and Mikkelsen; Dahl (2021), with the addition of the handling stage, constant in the study by Yaacob et al. (2023). The movement occurs within the organization, linking the production process with the raw materials, in-process and finished products in the warehouses, and the production distribution to the customer chain (wholesalers, retailers, and end consumers).

System was the last approach found (Javat; Tawade, 2023), and the least frequent. A system can be understood as a physical or extraphysical mechanism that transforms inputs, in their various forms, into outputs, according to previously established standards. Material handling can be considered a system because it helps transform raw materials into semi-finished and finished products through various distinct and complementary mechanisms, such as material handling, storage, and control. These mechanisms can have different driving forces, such as gravity, manual effort, and mechanical or automatic machinery. The distinction

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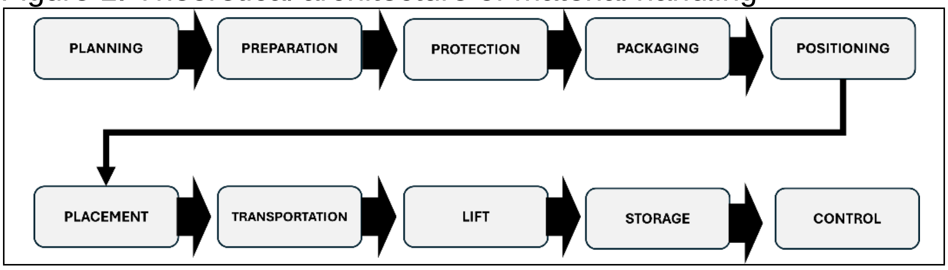
between mechanical and automatic machinery lies in whether electronic and computerized technologies are used to manage the machinery. If they are used, the driving force is automatic to some degree.

Based on these findings, it is possible to create a theoretical architecture encompassing all potential stages of a general material handling process. Considering that a process is a series of logically ordered activities that must be performed to achieve a predetermined objective, the material handling process involves the stages shown in Figure 1. The first stage is process planning, which consists of determining what should be done and how it should be done. Next, the moving material is prepared according to the planned specifications. Then, the material is protected, followed by packaging, corresponding to the appropriate packaging for handling and storage. The next stage is placing the material on the transport vehicle, with its subsequent positioning, to prevent damage or any abnormalities in the movement. Then, the material is transported from the shipping station to its place in the warehouse, in the case of raw materials, or from the production line to storage, in the case of semi-finished or finished products. The process continues by lifting the material to the appropriate location provided for storage, culminating in its constant monitoring, until the finished product is dispatched to the distribution channel.

Figure 1. Theoretical architecture of material handling




Source: prepared by the authors.

This theoretical architecture is a general proposition that aims to encompass most material handling practices. Naturally, as a global architecture, there will be differences due to impacts resulting from various factors, such as the type of material to be handled, the technology used in the handling, the complexity of the production system, the technical capacity of the operators, and many

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others. In everyday practices, however, there will be occasions when the process steps will be significantly reduced, such as with planning, transportation, and storage. In contrast, new and distinct steps must be added on other occasions. Thus, the most generic possible form of a professionalized and rationalized material handling process would involve the following steps: planning, transportation, and storage.

## 3. Research Methodology

This section will specify the procedures used to generate the findings of this study, using the guiding questions defined to achieve the general objective of the investigation. The method used was a survey, carried out using two data collection instruments (interviews and observation), to map the process of movement of materials in each period (synchronous or cross-sectional analysis perspective), with the stages of the process as its units of analysis and the process itself constituting its level of analysis. These procedures follow the guidelines in the studies by Nascimento-e-Silva (2020; 2021a; 2021b; 2021c; 2023).

### 3.1 Guiding questions

The general objective of this research was divided into three specific goals that were operationally transformed into the following guiding questions: 1) What are the steps of the materials handling process? 2) What equipment is used in the material handling steps? 3) What are the different functions of the equipment used in the steps of the materials handling process? The comparison of the empirical answers obtained for the guiding questions with the theoretical architecture of the study generated the main research answer, presented in the results discussion section.

### 3.2 Study design

This study was developed in eleven stages, as shown in Figure 2. The first was the planning of the study, with the determination of the research questions

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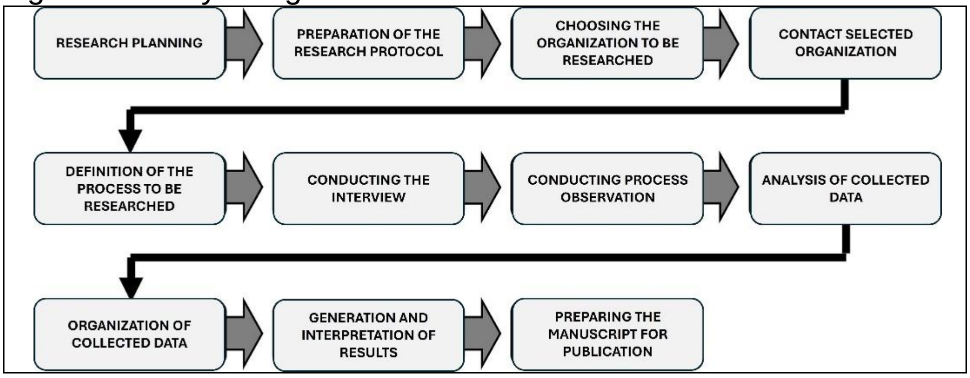
and their theoretical and empirical delimitations. The second focused on elaborating the research protocol, defining the script of the data collection instruments, the inclusion and exclusion factors of the respondents, and the forms of validation of the responses. The third consisted of selecting and obtaining organizational acceptance to carry out the research, which is considered the longest stage of the project execution.

Figure 2. Study design




Source: prepared by the authors.

The fourth stage was carried out by contacting the person responsible for the internal logistics sector of the organization, who agreed to carry out the research, so that a preliminary meeting could be scheduled for further clarification on the work to be carried out. The fifth stage focused on selecting the most appropriate process for the research protocol that could test the theoretical architecture developed, scheduling the face-to-face interview, and observing the movement process under study. The sixth stage was the interview, supported by a previously defined script presented to the interviewee. The seventh stage was observation and recording notes for each stage of the movement process, from the initial to the final phase. The data were digitized and divided into parts per the guiding research questions in the eighth stage. In the eighth stage, the parts were organized based on the research protocol: the stages were placed in chronological order, the equipment was coupled to the movement stages, and the functionalities of the equipment were linked to each stage of the movement process. In the ninth stage, the results were generated, and their due

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interpretations were made, comparing the empirical process with that developed based on the literature review. The last stage was the preparation of this manuscript for publication and submission of the findings for consideration by the scientific community.

### 3.3 Research object

The object of this study was the material handling process used by a packaging company that operates in Porto Chibatão, in Manaus, capital of the state of Amazonas. This process consists of eight handling stages, counting from the movement from the external warehouse in the port to the factory reception, and from the reception to the final movement. In this last stage, the product is packaged and prepared to be delivered to the customer. The process was analyzed to understand how each movement step is carried out, from the raw material and its arrival at the company to the movement of the finished product (PA) to the end customer.

### 3.4 Data collection instruments

Data were collected using two instruments: semi-structured interviews and observation. The interviews were conducted using a set of questions, established based on the theoretical architecture of the study and presented in advance to the respondent indicated by the company as the most suitable to provide the answers with the accuracy required by the study protocol (Nascimento-e-Silva, 2023). For each question in the set, there was a defined space for recording the answers, in the format of a structured electronic table, as the logistics supervisor provided. Another table was used to prepare the set of questions, structured based on the material movement stages identified in the interview stage, and by the constant movement process of the theoretical architecture. The purpose of using the two instruments was to obtain knowledge about how the movement process occurs in the company so that reliable and valid answers could be generated for the research's guiding questions.

### 3.5 Data collection strategy

For the interview to be conducted, it was necessary to contact the Logistics Supervisor to check their availability and time. After contact, the study supervisor was spoken to so they could draft and send a letter to the company formally requesting the researchers to visit the company that would be researched. In addition, information was given about how the data would be collected regarding each stage of the movement process. The semi-structured interview script, with the defined questions, and the observation of the movement process were attached to the letter, in addition to the summarized research project (Nascimento-e-Silva, 2023; 2020; 2021a; 2021b).

The interview was conducted on the day and time scheduled to appear at the company. The first part was done with the Logistics Supervisor, who presented some points regarding what we were going to observe in the company, detailing the processes of how the material was stored, where its branches are located, the raw material used in the production process, its competitors, how the logistics of sending the material to the Manaus plant are, and how the production process is carried out, from the arrival at the company to the delivery of the product to the end customer. The supervisor also showed how each stage is developed and what equipment is needed to safely carry out each raw material (RM) movement stage. The presentation about the company lasted about 30 minutes, as questions arose throughout the explanation. After the explanations and necessary clarifications, we went into practice with the movement process to learn how it happens and verify the accuracy of the information provided in the presentation. The observation began with the movement of the raw material to the company's reception. Before starting each stage, explanations were given about what, how, and why the procedures were carried out; During the execution, each essential aspect was pointed out, so that there would be no doubt; and after the stage was completed, there were the final explanations of the stage and the introductory explanations of the next stage. This procedure was carried out until the end of the observation. With each doubt, new information and explanations were provided.

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### 3.6 Data organization and analysis techniques

According to the research protocol, the data were transcribed into a word processor, maintaining the form and order in which the supervisor asked and answered the questions (Nascimento-e-Silva, 2023). This procedure aimed to ensure that the data analysis process did not undergo any alteration. Then, the groups of questions and answers gave rise to a macro table. On the left side, the first column was called “process stages”, in which each of them was recorded with the sequential order of its position in the movement process, from the first to the eighth stages. The second and third columns were named with the “stage name” and the respective “clients”, using the answers provided by the Supervisor as the source, to clarify who was the supplier stage (who performed it) and who was the client stage (who received the byproduct of the previous stage, considered the supplier). The fourth column listed the equipment used in each stage, and in the fifth column, the functionalities of the equipment. Data analysis was conducted in line with the guiding questions. The macro table was divided into three parts aligned with the research's guiding questions. For the question that sought to know the stages of the movement process, a table was created that showed the origin of the movement of materials (name of the stage) and the destination of these materials (the customers who received them). The question relates to the stages of the movement and which stage is linked to another so that this flow works correctly. Another table was created for the question related to the equipment used in each stage of the movement, and a third for the functionality of the equipment. This procedure allowed us to see precisely the logic underlying each answer sought for each guiding question.

### 3.7 Techniques for generating and interpreting results

The results were generated as answers to the guiding questions (Nascimento-e-Silva, 2020). For the question regarding the steps of the movement process performed in the company, the result was generated from the logically ordered list of the steps of the supplier-customer scheme that the factory performs, as shown in Table 2. The result regarding the question about the equipment used in each step of the movement was generated in the form of a list,

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step by step, so that it was possible to visualize, for example, specific aspects of the movement, such as the most frequently used equipment, the technologies on which this equipment is based, the traction force, etc. The result for the functionalities of the equipment was generated so that it was possible to understand the different ways in which the movement is done, since it is the equipment that performs each of the steps, naturally under human coordination and supervision.

The interpretation of the results consisted of searching for answers to two questions: how and why it happens. The question “how” refers to how the movement process in the company studied is carried out and appears in the empirical data collected from an interview with the logistics supervisor and the observation carried out during the technical visit. The answers to the “why” questions were obtained by comparing the empirical findings with the theoretical architecture of the study and with the stock of scientific knowledge available in the scientific databases. For this reason, the interpretation of the results followed two parallel paths that connected each other: the data from reality and the theoretical framework of reference. In short, the interpretation compared what reality showed with what the theoretical framework predicted.

## 4. Results and Discussion

The study findings will be presented in this section, following the order of the research questions. Thus, the stages of the movement process will be given first, followed by the materials used in each stage and their functionalities. This section ends with a discussion of the results.

### 4.1 Stages of the material handling process

Table 1 describes the stages in the movement process by the company under study, from receiving the material from the external warehouse to its distribution to the end customer. The movement process is carried out in eight stages. The first consists of the movement from the external warehouse to the reception, where the reception is the

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customer of the first stage (external warehouse). The second stage begins at the reception (supplier). It ends with the delivery of the material to the internal warehouse, so that the reception receives the material from the external warehouse, carries out its procedures, and moves it to the company's warehouse (customer). The third stage consists of the movement of the material from the warehouse (supplier) to the supply area (customer), which is the sector responsible for meeting the needs of the company's production lines (customers). The fourth stage consists of the movement from the supply area (supplier), an area designated for storing the raw material so that they can move the material and supply the silos (customers). In the fifth stage, the raw material is transferred from the silos (suppliers), where the raw material is already being transformed into raw materials, to the injection molding machine (client) to complete the production process. In the sixth stage, the raw material leaves the injection molding machine (supplier) for temporary storage (client), where it is finished and stored for a specific period. In the seventh stage, the raw material leaves the temporary storage area (supplier) for the warehouse (client), where it is prepared and awaits distribution. In the eighth and final stage, the final movement is carried out, in which the raw material, already packaged, registered, and documented, is packaged for delivery to the client whenever there is an order for such.

Table 2. Stages and clients of the material handling process

| **Stages** | **Handling** | **Stage Client** |
|---|---|---|
| First | From the external warehouse to the reception | Reception |
| Second | From reception to the internal warehouse | Warehouse |
| Third | From the internal warehouse to the supply area | Supply |
| Fourth | From supply area to silos | Silos |
| Fifth | From silos to injection molding machines | Injection Machines |
| Sixth | From injection molding machines to temporary stock | Stock |
| Seventh | From temporary stock to the warehouse | Warehouse |
| Eighth | From the warehouse to the customers | Clients |

Source: data collected by the authors.

The first stage of the handling process begins in the external warehouse, an external area located in the private port of Manaus (Chibatão). This is the origin of the raw material (resin). After the material arrives at the company from external suppliers, it passes through the reception area to be checked and

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ensured that it complies with the requirements provided by the buyer and is met by the supplier. After being checked and verified, in the second stage, the material leaves the reception area and is moved to the internal warehouse, where it remains until the forklift operator is asked to pick it up. The third stage is structured by moving the material from the internal warehouse to the supply area using equipment that assists in the movement. The supply area consists of a container and a platform on which the material is stored to be sent to the next stage of the process. In the previous stage, the supply area consists of a container area and a platform; After the material is stored in these two locations, it is moved to the silos, which are types of “warehouses” where the material is placed through hoses. Then the resin production process begins to transform it into PA. The fifth stage is the movement of the resin from the silos to the injection molding machines. This subprocess occurs when the material is produced and sent to the injection molding machines. The injection molding machines are responsible for molding the preform, the PA. Each injection molding machine has a specific size, which the operator must know properly, in compliance with the service order, and place the correct quantity. The last three stages (composed of the injection molding machines, temporary stock, and warehouse) occur when the PA is packaged and closed to return to the internal warehouse, awaiting orders for delivery to the end customer.

**4.2 Equipment used in material handling**

For the move to effectively take place and for the material to be transported from one location to another, equipment is needed to assist in this movement, considering the type of material to be transported and the organization's production process. All stages use containers, as shown in Table 3. This is because this equipment stores the resin and maintains its quality. The first stage uses a truck and a container, whose function is to transport and store the raw material from the external environment to the reception area. The second and third stages use five pieces of equipment for movement in an internal environment: containers, forklift, wooden pallet, tractor, and trolley. This equipment moves the material from the reception area to the supply area. The fourth stage involves equipment such as a wooden pallet (which serves to separate the material from the

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ground), a supply platform (which will then be transferred to the silos), containers and a suction hose (the suction hose is used to send the material to the silos).

Table 3. Equipment used in the material handling process

| Stages | Handling | Equipment used |
|---|---|---|
| First | From the external warehouse to the reception | Truck<br>Containers |
| Second | From reception to the internal warehouse | Containers<br>Forklift<br>Wooden pallet<br>Tractor truck<br>Troller |
| Third | From the internal warehouse to the supply area | Forklift<br>Pallet<br>Truck<br>Troller<br>Containers |
| Fourth | From supply area to silos | Wooden pallet<br>Supply platform<br>Containers<br>Suction hoses |
| Fifth | From silos to injection molding machines | Automatic conveyor belts |
| Sixth | From injection molding machines to temporary stock | Cardboard boxes<br>Nylon clamps<br>Wooden pallet<br>Forklift |
| Seventh | From temporary stock to the warehouse | Cardboard boxes<br>Nylon clamps<br>Wooden pallet<br>Forklift |
| Eighth | From the warehouse to the customers | Cardboard boxes<br>Nylon clamps<br>Wooden pallet<br>Forklift |

Source: data collected by the authors.

From the fifth to the eighth stages, the equipment used by the company is the same because it serves almost all subsequent purposes. The fifth stage involves moving the area from the silos to the injection molding machines, whose equipment is automatic conveyors, which are used to transport the PA to the cardboard box for packaging. In the sixth stage, the equipment used to move the material and maintain its quality and integrity are cardboard boxes (to package the PA), nylon clamps (which are used to close the box and wrap it), wooden pallets (to support the boxes) and forklifts (to transport the PA). The seventh and eighth stages involve moving the temporary stock to the warehouse and from the warehouse to the end customer. The equipment used in these two process stages

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includes cardboard boxes, nylon clamps, wooden pallets, and forklifts. The function of this equipment is to package, wrap, separate, and move the material until it is delivered to its destination.

**4.3 Equipment functionalities in material handling**

Table 4 shows the results obtained for the guiding question that sought to understand the functionality of the equipment used to move materials in the company, step by step. The first step (movement from the external warehouse to the reception area) is done by truck and container, whose functionality consists of transporting the material from the external docks in an external warehouse to the production unit located inside the factory. In the second step, the movement is done from the reception area to the internal warehouse using containers, forklifts, wooden pallets, tractor units and trollers, whose functions are to maintain the integrity and quality of the resin coming from the supplier, remove the big bags from the container and place them in the stock, and facilitate the removal of the big bags from the container. The tractor unit and the troller are used together to move the liner containers within the company, after the truck leaves the supplier, leaving the container to be delivered later to the port. Moving the material from the internal warehouse to the supply area uses the same equipment as the previous stage. Its function is to move the big bags from the warehouse to the supply area and package them for movement. The tractor and trolleys move the liner containers from the waiting area to the supply area. In contrast, the trollers keep the container off the ground and move it with their wheels, connected to a tractor, maintaining the integrity and quality of the resin from the supplier. In the fourth stage of movement, the equipment's function is to preserve the integrity of the resin, support the big bags awaiting processing on the platform, raise the big bags to a certain height and position for connection to the suction hose, and transport the resins to the 100T (big bags) and 300T (liners) silos.

Table 4. Functionality of material handling equipment

| Handling | Equipments | Equipment functionalities |
|---|---|---|
| From the external | Truck | It transports material from external docks to the production unit. |

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| | | |
|---|---|---|
| warehouse to the reception | Containers | They maintain the integrity and quality of the resin coming from the supplier. |
| From reception to the internal warehouse | Containers | They maintain the integrity and quality of the resins during transportation. |
| | Forklift | It removes big bags from the container and places them in stock, while awaiting the order request for replenishment. |
| | Wooden pallets | They facilitate the removal of big bags from the container (the PM is moved to the company's pallet so that the supplier can return to the container). |
| | Tractor truck | A tractor and troller are used together to move liner containers within the company; they are used after the supplier's truck leaves the company with the truck and leaves the container for later delivery at the port. |
| | Troller | |
| From the internal warehouse to the supply area | Forklift | It moves big bags from the warehouse to the supply area. |
| | Pallets | They pack big bags for movement. |
| | Tractor | They move liner containers from the waiting area to the supply area; trollers keep the containers off the ground and move them with their wheels connected to a tractor. |
| | Troller | |
| | Containers | They maintain the integrity and quality of the resin coming from the supplier. |
| From the supply area to the silos | Wooden pallets | They support big bags awaiting processing on the supply platform so that the resins do not come into contact with the ground. |
| | Filling platform | It raises big bags to a certain height and position for connection to the suction hose. |
| | Containers | They maintain the integrity and quality of the resins until the refilling process. |
| | Suction hoses | They transport resins to the 100T (big bags) and 300T (liners) silos. |
| From silos to injection molding machines | Automatic conveyors | They transport the resins from the silos to the injection molding machines. |
| From injection molding machines to temporary stock | Cardboard boxes | They package the PA, maintaining the quality and integrity of the batch. |
| | Nylon clamps | They wrap the box and prevent preforms from being lost during movement, closing and sealing the box. |
| | Wooden pallets | They move the boxes with the forklift. |
| | Forklift | It transports the box on the pallet wrapped with the clamps. |
| From temporary stock to the warehouse | Cardboard boxes | They pack the PA, maintaining the quality and integrity of the batch. |
| | Nylon ties | They wrap the box and prevent preforms from being lost during movement, closing and sealing the box. |
| | Wooden pallets | They move the boxes with the forklift. |
| | Forklift | It transports the box on the pallet wrapped with the clamps. |

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| | | |
|---|---|---|
| From the warehouse to customers | Cardboard boxes | They go to customers with clamps to maintain the integrity of the preforms during the transportation of the loads. |
| | Nylon ties | They wrap the box and prevent the preforms from being lost during the movement, closing and sealing the box. |
| | Wooden pallets | They stack PA boxes inside the container. |
| | Forklift | They remove the material with the pallet from the apartment that is located in the stock and place it in the container. |

Source: data collected by the authors.

The fifth stage of movement is carried out by automatic conveyors located inside the injection molding machines, whose function is to transport the resins from the silos to the injection molding machines. The sixth, seventh and eighth stages (which move the injection molding machines to the temporary stock, from the temporary stock to the warehouse and from the warehouse to the end customer) use the following equipment: cardboard boxes, nylon clamps, wooden pallet and forklift, each of which performs different functions in each stage. In the sixth and seventh stages, the cardboard box is used to package the PA, maintaining the quality and integrity of the batch; the nylon clamps are used to wrap the box and prevent the preforms from being lost during movement, closing and sealing the box; the wooden pallet is used to move the boxes with the forklift; and the forklift is used to transport the box on the pallet, wrapped with clamps. Although the equipment used in the eighth stage is the same as that used in the sixth and seventh stages, its functions change due to the need to be ready for delivery to end customers. The function of the cardboard box is to deliver the material to the customer with the clamps wrapped around it to maintain the integrity of the PA during transportation; the nylon clamps wrap around the box and prevent the preforms from being lost during movement, closing and sealing the box; the wooden pallet stacks the PA boxes inside the container; and the forklift removes the material, with the pallet, from the apartment where it is located in the warehouse and places it in the container.

### 4.4 Discussion of results

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The steps of material handling performed by the organization studied are partially based on the theoretical architecture developed based on the literature review, as shown in Figure 3. This means that the general rule that the process begins with reception and ends with shipping has undergone a slight change at the end, in which the organization's relationship with the distribution chain is not with shipping, but with the warehouse, which is the organizational subunit that fulfills the duties of a specialized body in this type of interorganizational relationship. This does not mean that the shipping function is not performed, but that a specialized sector does not perform it, but as an activity coupled with a distinct subunit, in this case, the warehouse. Similar occurrences were reported in the studies by Freiberg and Sholz (2015) and Karandikar et al. (2014).

Some specific aspects of the organization analyzed justify and explain this differentiation. Two of them stand out. The first is related to the product lines produced by the company, which focus on a limited variety and use the same raw material. There is usually a specialized department for shipping when the variety and quantity of products are relatively high. It requires a minimum division of labor in the shipping area, which forces its structural separation from other units, both production and support activities. The second is related to the rationalization of the stages of the movement process, so that the fewer stages that are part of the process, the lower the cost tends to be, because all activities consume resources, as can be seen from the studies by Rajabi et al. (2025), Neumann et al. (2023) and Kulkarni et al. (2023). In this regard, it is essential to consider that storage and its different movement focuses are cost centers that do not add value to the product, which confirms the suitability of shipping being carried out at the end of the storage stage of the PA.

Figure 3. Material handling process

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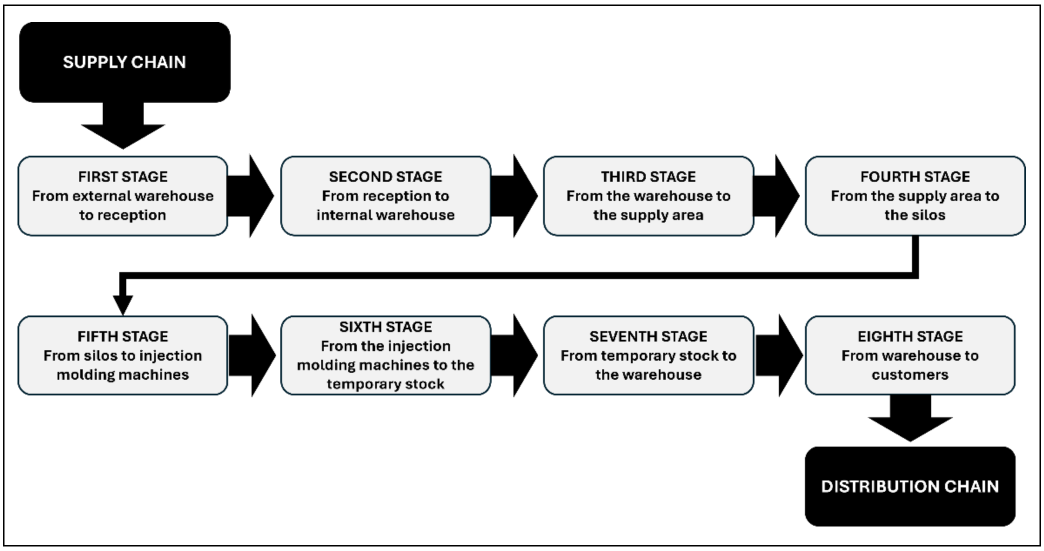

Source: prepared by the authors.

Contemporary organizations rarely move large volumes of materials without the help of mechanical equipment to transport them between sectors (Yazid et al., 2023; Zubair et al., 2019; Xu et al., 2012). As organizations improve their production systems, the form and resources used to move materials follow this evolution. From an initial manual practice, in which the driving force for movement was the human body, which was replaced by animal traction, evolution then followed its course with natural forces, then with the use of mechanical instruments, succeeded by automation and even integrated intelligent instruments (Onwude et al., 2016; Kashiripoor, 2024). The organization uses equipment at the highest levels of evolution, completely replacing the driving force of the human body with automatic and intelligent mechanical instruments. This reality allows for several competitive advantages, such as cost reduction through faster production and handling processes, reduction and even elimination of waste and product failures, and use of physical space, among others. Finally, the functionalities provided by handling equipment allow for the rationalization of movements that reduce the operating time of the external supply chain. This chain is formed by the supplier chain, responsible for supplying raw materials and all types of needs of an organization, and by the distribution chain, formed by all kinds of customers of the organization, who receive its production (Sun et al., 2024; Nahr; Zahedi, 2021; Duan, 2022). The organization, through its logistics and production systems,

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constitutes the intermediate part, which connects these two dimensions of the external chain (Nahr; Zahedi, 2021; Veloso; Nascimento-e-Silva, 2025; Montenegro et al., 2025). Therefore, the more streamlined internal procedures are, the more competitive advantages will be transferred to the global supply chain.

## 5. Conclusion

This study analyzed the stages of the materials handling process carried out by an industrial organization operating in the industrial hub of Manaus, the state of Amazonas. The results indicated that the handling process was composed of eight stages, one of which was performed outside the industrial operations environment, but within its internal environment, and with the shipping functions being performed in the warehouse area, unlike what was predicted by the theoretical architecture developed based on the state of the art, which predicted a sector specialized only in shipping. The reasons for this differentiation were the nature of the product, production process, and rationalization of the production and handling process, in addition to the intensive use of mechanical equipment, automation, and intelligent systems. This shows that the nature of the materials to be processed and the type of production process used can modify the general structure of the materials handling processes. Internal handling is of utmost importance for the supply chain because it helps achieve the production process's efficiency. To achieve this goal, the equipment used and how it is used make a lot of difference, as was shown in this study. For example, when raw materials arrive at the company, they come in containers. This equipment is used to maintain the integrity and quality of the raw materials. Internally, these raw materials are moved to another location using other more appropriate equipment for this specific movement. Each movement is specifically carried out with the proper equipment until the end of the process. The concern with practicing this level of rationality makes it possible to reduce processing time, avoid product loss, and ensure reliability in the finished product. The fruits of this rationality extend to the global supply chain.

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Theoretically, if each organization manages to maximize the efficiency and effectiveness of its material movement processes, its logistics tend to benefit and increase its competitiveness. Since each organization is a link in a larger supply chain, the benefit that the internal logistics of one organization generates also tends to be incorporated into the global chain. Conversely, when the results are negative, this negativity should be felt by at least part of it. In practical terms, every managerial effort to streamline and make internal logistics more agile constitutes a challenge that the organization's management must face and overcome, even though science has not provided explanatory and demonstrative support for those aspects of movement and internal logistics that it has to deal with. In this practical aspect, this study presents several clarifications that help in this aim.

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