Process improvement of the manufacturing and filling processes in a production unit for mortar and bitumen

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Abstract

Lean Manufacturing, along with continuous improvement, plays a crucial role in today's business landscape. In an environment characterised by the speed of change and the search for efficiency, Lean Manufacturing offers a strategic approach to eliminate waste and optimise processes, ensuring value is delivered to the customer. By applying Lean tools, organisations can identify and eliminate activities that do not generate value, reduce costs, improve quality and increase productivity. Continuous improvement, in turn, promotes a mentality of constant learning and process improvement, allowing companies to quickly adapt to market changes and overcome challenges. In a world where competitiveness is demanding and customer expectations are constantly evolving, the Lean methodology and continuous improvement are essential to drive efficiency, quality, and innovation in organisations, resulting in sustainable competitive advantages.

This project takes place within the context of applying Lean tools as a way of consolidating continuous improvement in the mortar and bitumen production unit of CIN - Corporação Industrial do Norte, S.A. The work consisted of identifying sources of waste and opportunities for improvement in the sector and the implementation and evaluation of solutions that minimised this waste, contributed to the growth of the sector's indicators and resulted in a more efficient operation. In this way, the project was based on Lean Manufacturing and the consequent use of Lean methodologies, such as 5S, SMED, Work Standardisation, Visual Management and evaluation of the OEE indicator.

The application results of the suggested improvements have shown to have a beneficial impact on the sector, confirming the success of the solutions presented. In the case of manufacturing, the reduction of process variability and the increase of its transparency through its standardisation in official documents prove the effectiveness of these applications. The 42% reduction in the duration of Setups of the ME-07 filling machine and the increase of its availability and performance allowed an increase of about 16% of the OEE indicator of the machine, reaching the established goal of 45% and proving again the effectiveness of the proposed solutions. In terms of productivity, due to the lack of load in the sector during the dissertation's development period, which did not allow a continuous analysis, scenarios were drawn up for the filling operating mode in the sector based on demand over a one-year period. This analysis showed that the proposed solution scenario would be the most advantageous and would allow the goal of 150 l/hour.man established for the sector's productivity to be reached, representing an increase of 19.6% compared to the current scenario and a cost reduction of 52.1%.

The involvement of employees in the project also proved to be fundamental, as taking advantage of their knowledge and experience in the field, it was possible to obtain better solutions to the problems detected. This involvement also allowed an increase in the team spirit and in the interest in continuous improvement, which is fundamental to maintain in order to enhance the results acquired so far.

Melhoria dos processos de fabrico e enchimento de uma unidade produtiva de massas e betumes

Resumo

O Lean Manufacturing, juntamente com a melhoria contínua, desempenha um papel crucial no cenário empresarial atual. Em um ambiente caracterizado pela velocidade das mudanças e pela procura por eficiência, o Lean Manufacturing oferece uma abordagem estratégica para eliminar desperdícios e otimizar processos, garantindo a entrega de valor ao cliente. Através da aplicação das ferramentas Lean, as organizações podem identificar e eliminar atividades que não geram valor, reduzir custos, melhorar a qualidade e aumentar a produtividade. A melhoria contínua, por sua vez, promove uma mentalidade de aprendizagem constante e melhoria dos processos, permitindo que as empresas se adaptem rapidamente às mudanças do mercado e superem os desafios. Num mundo onde a competitividade é exigente e as expectativas dos clientes estão em constante evolução, a metodologia Lean e a melhoria contínua são essenciais para impulsionar a eficiência, a qualidade e a inovação nas organizações, resultando em vantagens competitivas sustentáveis.

O presente projeto desenrola-se neste contexto de aplicação de ferramentas Lean, como meio de consolidação da melhoria continua, na unidade produtiva de massas e betumes da CIN – Corporação Industrial do Norte, S.A. O trabalho consistiu na identificação de fontes de desperdício e oportunidades de melhoria no setor e na implementação e avaliação de soluções que minimizassem esses desperdícios, contribuíssem para o crescimento dos indicadores do setor e resultassem num funcionamento mais eficiente. Desta forma, o projeto fundamentou-se no Lean Manufacturing e no consequente recurso às metodologias Lean, como metodologias 5S, SMED, Normalização do Trabalho, Gestão Visual e avaliação do indicador OEE.

Os resultados da aplicação das melhorias sugeridas demonstraram ter um impacto benéfico no setor, confirmando o sucesso das soluções apresentadas. No caso do fabrico, a redução da variabilidade dos processos e o aumento da sua transparência pela sua normalização em documentos oficiais comprovam a eficácia destas aplicações. A redução de 42% na duração dos Setups da máquina de enchimento ME-07 e o aumento da disponibilidade e da performance da mesma permitiram uma subida de cerca de 16% do indicador OEE da máquina atingindo o objetivo estabelecido de 45% e comprovando novamente a eficácia das soluções propostas. Em termos de produtividade, devido à falta de carga no setor no período de desenvolvimento da dissertação que não permitiu uma análise contínua, foram elaborados cenários para o modo de funcionamento do enchimento no setor com base na procura do período de um ano. Nesta análise constatou-se que o cenário da solução proposta seria o mais vantajoso e permitiria alcançar o objetivo de 150 l/hora.homem estabelecido para a produtividade do setor, representando um incremento de 19,6% comparativamente ao cenário atual e uma redução de custos de 52,1%.

O envolvimento dos colaboradores no projeto também se revelou fundamental, uma vez que aproveitando o seu conhecimento e experiência no terreno, foi possível obter melhores soluções para os problemas detetados. Este envolvimento permitiu ainda um incremento do espírito de equipa e do interesse na melhoria contínua, que é fundamental manter para potencializar os resultados adquiridos até ao momento.

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Acronyms

FO: Filling Order

JIT: Just-in-Time

KPI: Key Performance Indicator

L/h.m: Litres per hour man

L: Litres

OEE: Overall Equipment Effectiveness

R&D: Research and Development

SMED: Single Minute Exchange of Die

SO: Shop Order

TPS: Toyota Production System

WIP: Work In Progress

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1 Introduction

The present dissertation was carried out in a business environment at CIN - Corporação Industrial do Norte, S.A, within the scope of the Integrated Master in Mechanical Engineering in the area of Production Management at the Faculty of Engineering of the University of Porto.

This project lasted 5 months and consisted of using Lean Manufacturing tools in sector C6 in order to increase productivity. The biggest focus was on the ME07 filling machine, an automatic filling machine.

Thus, at the beginning of this chapter a contextualization of the project is performed and the company is presented. Then the project objectives and the adopted methodology are presented and finally the structure of the dissertation.

1.1 Project background

With an increasingly demanding industry, companies need to be more competitive and flexible in their responses to the market. Concepts such as continuous improvement allow the maximum use of a company's resources and prevent it from being overtaken by the competition.

To be a more competitive company, CIN resorted to the use of a continuous improvement project using Lean tools in the main sector (C1), which due to the good results obtained, was expanded to Nováqua, the production facility responsible for the company's water-based products. Nováqua is where the mortar and bitumen unit is located and where this project has its main focus.

Thus, this project arises in the continuity of CIN's commitment to continuous improvement, with the focus on sector C6 of Nováqua, the mortar and bitumen sector, due to the great existing opportunities for improvement. To increase the productivity of the sector, Lean tools such as SMED and 5S were used to reduce waste, setup times and obtain a more organized workspace. During this improvement process, it was fundamental to resort to the standardization of processes and the involvement of operators in the concepts of continuous improvement.

In the analysis of the filling equipment, the OEE was calculated, which measures the availability and performance of the equipment under analysis and the quality of the products obtained.

The project focused on the processes of the C6 sector, the identification and analysis of opportunities for improvement and the formulation of possible solutions for the problems founded.

1.2 Company presentation

Due to its size and high international recognition, CIN is among the largest in Europe and in the world in the paint and varnish sector. The CIN group was founded in 1917 under the name of Companhia Industrial do Norte, SARL, but in 1926 it obtained the designation of Corporação Industrial do Norte, Lda.

CIN is headquartered in Maia (Figure 1) and is present in several countries, with production units in Portugal, Spain, France, Angola, and Mozambique and has eight Research and Development centers and Laboratories.

Figure 1 - CIN Headquarters in Maia

CIN is a company that has more than 100 years of experience, more than 25 years of leadership, with more than 1800 employees and around 190 R&D technicians. Dedicated exclusively to the production and sale of paints, varnishes, and related products.

1.2.1 Business areas

Regarding the business areas, CIN operates in 4 main market segments.

These are:

- Decorative (61%): paints and varnishes used in civil construction that account for the largest share of the company's sales;
- Industry (25%): segment divided into two areas. The first consists of solvent-based and water-based liquid paints for the metal, wood, plastics, glass, and industrial vehicle repainting industries. The second is made up of powder paints aimed at the architecture, industrial applications, domestic utilities, automotive components and metallic furniture markets;
- Anticorrosive Protection (9%): high-performance paints and varnishes for protecting metallic or concrete structures when exposed to aggressive environments;
- Yachting and Marine (5%): high quality paints and varnishes for use in all marine applications, both on pleasure craft and in large shipyards involved in the construction of yacht and superyacht projects.

The products for the different market segments presented above are manufactured in different production halls according to their composition. In this way, the next sub-chapter presents the structure of the Maia industrial unit and the production halls that compose it.

1.2.2 Industrial unit in Maia

The Maia industrial unit is the industrial unit with the highest production volume of the entire group. The factory is divided into production halls for different products.

Figure 2 presents the factory layout where all the production halls are identified.

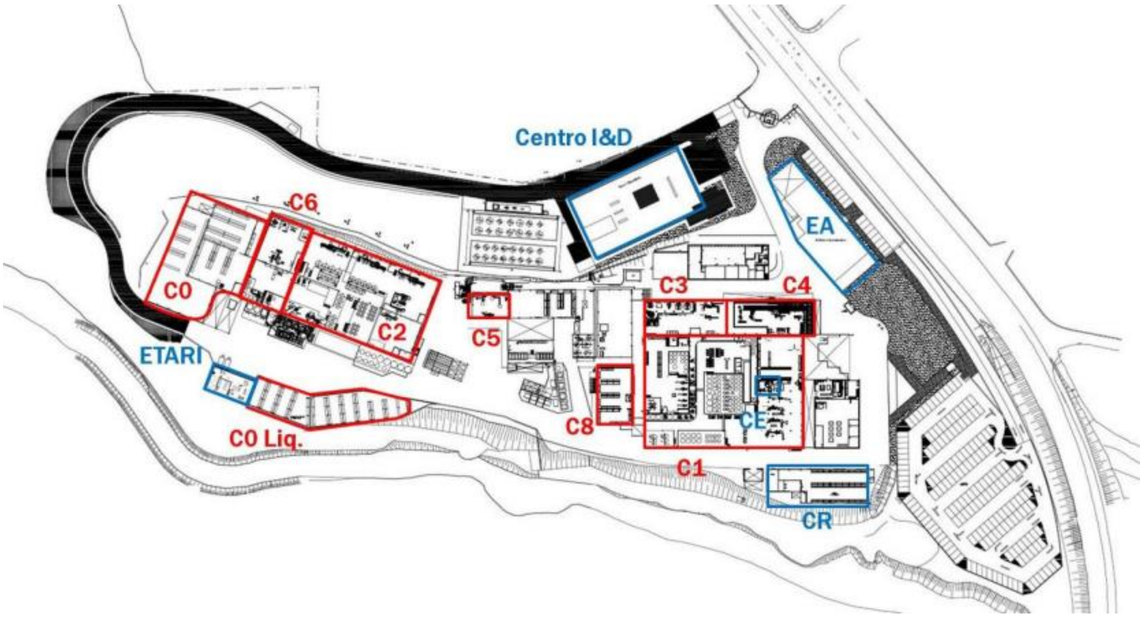

Figure 2 - Maia industrial unit layout (Source: Antas 2020)

Where:

- C0 – Raw materials warehouse;
- C1 – Central Hall: responsible for the general line of products;
- C2 – Nováqua: produces water-based paint;
- C3 – White paint production unit;
- C4 – Varnish production unit;
- C5 – Diluent production unit;
- C6 – Mortar and bitumen production unit;
- C8 – Industrial range production unit

As previously mentioned, the focus of this work is on the C6 hall corresponding to the mortar and bitumen production unit.

1.3 Project main goals

To increase productivity through continuous improvement, objectives were established to be achieved in this dissertation. The three objectives established at the beginning of the project were:

- Increase the productivity of sector C6 to a value of 150 l/hour.man;
- Improve the OEE indicator of the ME07 filling machine, reaching a value of 45%;
- Task standardization.

In addition to these main objectives, the reduction of setup times is also present. It is intended to achieve all these objectives using Lean tools.

1.4 Adopted methodology

To carry out this project, a work schedule was prepared to be carried out in the company to achieve the objectives specified above. This timetable is shown in Figure 3.

Through its analysis it is possible to verify that the methodology adopted in this project initially involves the study of the initial situation, identifying the problems and measuring the times of the tasks both in the manufacturing process and in the filling process of the mortar and bitumen. In a second phase, it consists of the SMED application in the ME07 and ME32 filling machines, where the 5S application, the characterization of the operations, the normalization of tasks, among others, is carried out. Finally, the manufacturing process is optimized, and the results obtained are measured.

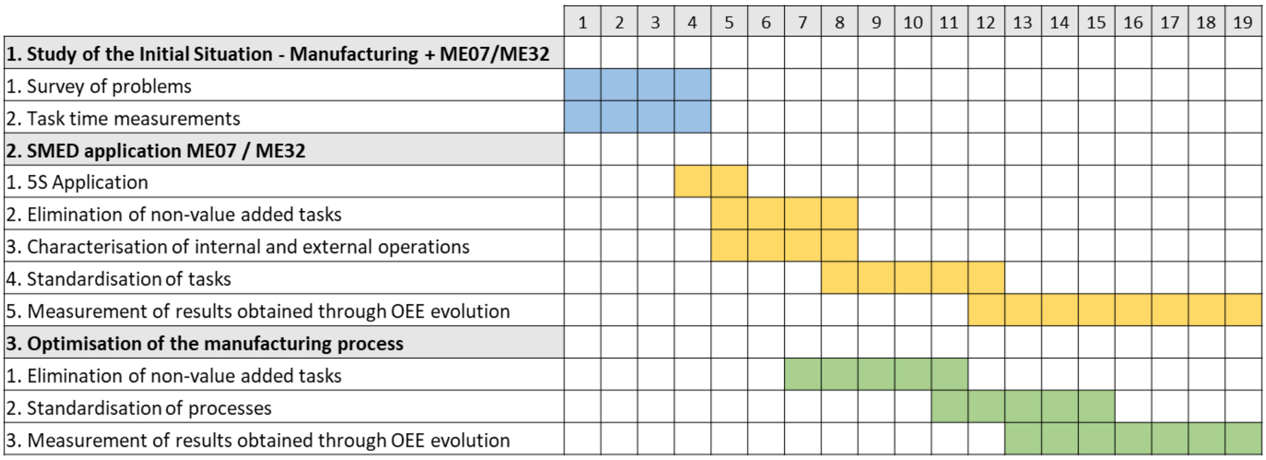

Figure 3 – Schedule of activities in the company

1.5 Structure of the Dissertation

This dissertation is divided into five chapters. The first chapter corresponds to the introduction of the dissertation, a framework of the project is carried out, a presentation of the company is made and the objectives of the project, the method followed in the project and the structure of the dissertation are presented.

The second chapter contains the theoretical context of the concepts and tools used in the constructed solution.

In the third chapter, the current situation of the production processes under analysis is presented and a survey of the detected problems is carried out.

The fourth chapter presents the proposed solutions for the identified problems and, finally, the fifth and last chapter presents the final conclusions about the work carried out and some suggestions for future work.

2 Theoretical background

In this chapter, the theoretical concepts that served as a basis for the development of this dissertation are presented. Initially, an introduction to the concept of Lean Manufacturing is made and a historical framework of this same concept is carried out. Afterwards, the Toyota Production System (TPS) and the principles of the Lean methodology are presented, as well as the Seven Wastes that exist in a production system.

In the second part of this chapter, some Lean tools applied throughout this project are presented and described.

2.1 Lean manufacturing

With the increase in demand and market needs, it becomes important and essential for companies to be flexible and maintain their competitiveness in the industry. Thus, it is visible a greater need for companies to use the concept of Lean Manufacturing for innovation, waste reduction, rationalization of resources and value creation in order to ensure their competitiveness in the market.

Lean concepts emerged in Japan with Toyota's production system. The Lean Manufacturing concept is considered as a technique for eliminating waste, but more specifically as a technique for maximizing the value of a product by minimizing waste (Sundar et al. 2014).

The objectives of Lean manufacturing are the elimination of waste related to human effort and inventory time in the various stages of production (Palange and Dhatrak 2021). It aims to get a faster response to the market and control inventories that are highly variable with customer demand, producing quality products as efficiently as possible (Rahman et al. 2013).

In this way, Lean manufacturing focuses on producing quality services and products as quickly and at the lowest possible cost.

2.1.1 Historical background

With the implementation of his mass production system, Henry Ford revolutionized the automotive industry, where the production process was optimized and divided into individual, quick and invariable stages, ordered chronologically in production lines. This methodology led to a simplification of the assembly lines and the reduction of tasks per operator, which led to a reduction in cycle times and consequent reduction in costs. In this way, this system allowed the production of standardized products in large quantities but with little variability and led the Ford Motor Company to great results.

With the analysis of Henry Ford's mass production model and after some visits to the North American factory, Eiji Toyoda and Taiichi Ohno concluded that this system was not suitable for the market where Toyota was inserted. This eastern market was characterized by a wide variety of products and in small quantities, so the imitation of the mass production system would be dangerous for Toyota as it would generate great waste.

In this way, in Japan, after the Second World War and in a period in which the eastern economy was in decline, the need arose to develop new methods to reduce costs and remain in the market. In this way, Taiichi Ohno develops the Toyota Production System (TPS) that would become the basis for Lean Manufacturing.

The Lean concept emerged later when the Japanese system was brought to the West with the book “The Machine That Changed the World” (Womack et al. 1990). Currently the TPS philosophy is known as Lean Manufacturing.

2.1.2 Toyota Production System

The Toyota Production System evolved due to the company's need to reinvent itself and correspond to the market varieties in the post-war period in Japan.

According to Taiichi Ohno (1988), the most important objective of TPS is to increase production efficiency by eliminating waste. This absolute waste elimination system, providing the best quality to the products, the lowest cost, and the shortest lead time, is supported by 2 pillars:

- Just-in-time (JIT): consists of the arrival of the necessary components to an assembly line, at the right time, in the exact amount and right next to the line to start the assembly. In an ideal situation applied to the entire company, stocks would be reduced to practically zero, completely reducing the stock holding costs (Monden 1998). JIT allows for an increase in efficiency and a quick response to possible changes;
- Jidoka / Autonomation: consists of the autonomous control of defects. Allows the machines to operate autonomously without the need for operator intervention. In the event of any anomaly, the machine stops and there is a consequent response from the operator, allowing an increase in the quality of the output by preventing the production of non-defective parts (Chiarini et al. 2018).

In Figure 4 it is possible to observe the so-called TPS house. Like any house, Toyota has designed its system from the base to the top, where the pillars are keys to maintaining the structure.

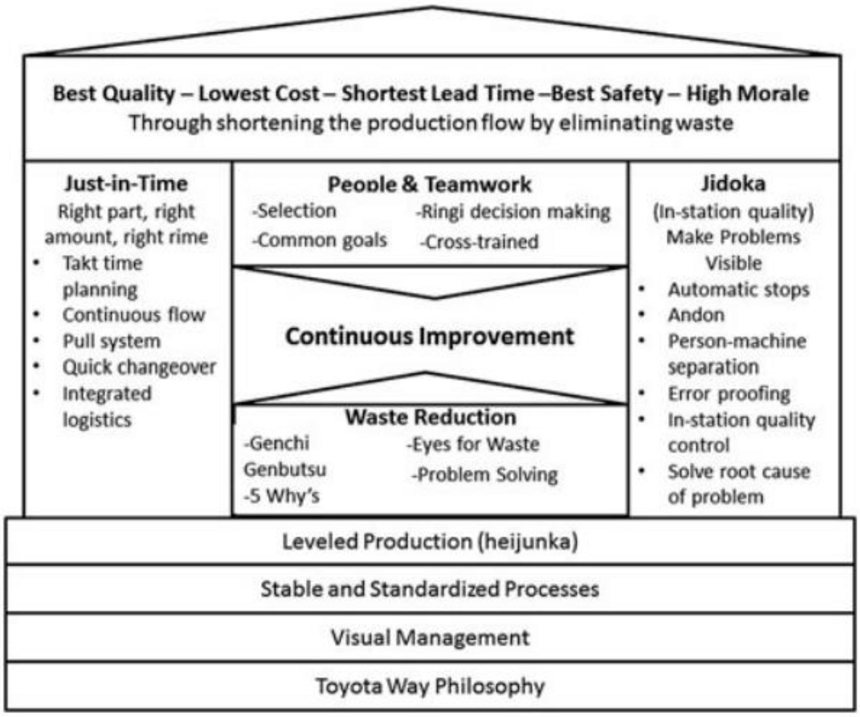

Figure 4 – TPS house (Source: Kehr and Proctor 2017)

In this way, through the analysis of the TPS house, it is verified that at the base there are concepts such as levelled production, stable and standardized processes, visual management, and the Toyota philosophy, and at the top are the objectives that any company intends to achieve with the application of Lean production, such as lowest cost and shortest lead time. Supporting the structure are the pillars of the house, which are JIT and Autonomation.

2.1.3 Lean principles

The Lean methodology is based on 5 principles (Womack and Jones 2010):

- Value – value is something related to market needs, so it is up to companies to determine what these needs are and try to satisfy them at a specific price. Value is defined by the end customer who considers the inherent characteristics of the product or service to be purchased, as well as the price and the effort made to obtain it. Any product with no value to the customer is considered as waste;
- Identify the value chain – the second principle is related to the identification of the value chain. The value chain represents all stages of the processing of a product, from the production of raw materials to the delivery of the final product to the customer. The objective is to identify the activities that generate value for the customer, the activities that do not generate value, but which are inevitable and the activities that do not generate any type of value for the customer. In this way, it is possible to eliminate waste;
- Flow – the third principle is to introduce flow into value-adding activities after eliminating waste in the value chain. This flow is intended to be continuous, that is, a flow without bottlenecks that imply stops at points in the value chain. In this way, the objective is to avoid unnecessary movements, interruptions, and production queues, so that the product is delivered as quickly as possible to the customer.
- Pull system – this system arises as a result of the creation of flow. Production starts to be carried out according to the customer's needs and when he requests it, instead of companies pushing products to consumers. In this way, excess production is reduced, and large amounts of stock are avoided;
- Perfection – the pursuit of perfection is the last principle. It arises from the combination of the four principles presented above and must be constant throughout the value chain. To reach the ideal state with the total elimination of waste, the company must look for continuous improvement and transparent processes where all members of the value chain are aware of the process (Miguel and Azevedo 2011).

2.1.4 The Seven Wastes (*Muda*)

The Lean methodology, which aims at the complete elimination of waste, classifies this same waste into seven types. These wastes are called *Muda* by the Japanese and represent everything that has no value or does not add value to a process (Rene and Domingo 2011). One of the most effective ways to increase profitability is by eliminating waste. In this way, to eliminate this waste it is necessary to understand what waste is and where it exists. Thus, Ohno (1998) identifies 7 types of waste:

1. Overproduction – producing more than necessary or producing faster than necessary. Poor production planning and high equipment capacity are some of the causes for this waste.
2. Inventory – excessive amounts of WIP (work in progress) and inventory of raw materials or materials from suppliers, causing increased storage costs.

3. Defects – production of defective products that arise as a form of waste because these products have no value for the customer and require time and workspace to be produced. Still, the process of repairing defective products is indicated as wasteful as it involves extra handling for their correction.
4. Motion – unnecessary operator movements caused for example by poor layout planning or disorganized workspace.
5. Overprocessing – tasks that do not add value to the item to be produced. An example is the addition of extra steps that do not add quality to the product or that add more quality than what is required by the customer.
6. Waiting – downtime for operators and machines. These downtimes correspond to waiting times for materials, equipment, or people to start the production process.
7. Transportation – unnecessary movement of material, tools, or equipment between processes, caused by poor workspace organization and a poor layout (Rene and Domingo 2011).

2.2 Lean tools

This part of the project presents some of the tools associated with Lean Manufacturing that aim to minimize waste associated with production processes (Karam et al. 2018).

2.2.1 5S Methodology

The 5S methodology is a continuous process improvement tool, used to create a more organized and more ergonomic work environment for a consequent increase in efficiency (Falkowski and Kitowski 2013).

The 5S tool was originated in 1960 in Japan by Sakichi Toyoda (Ohno 1988) and seeks to maximize profit and increase efficiency and safety by minimizing losses. This system consists of a set of direct steps that seek continuous improvement (Zaman, 2019).

The name of this methodology derives from five Japanese words that identify the 5 stages of implementation (Figure 5): *Seiri* (sort), *Seiton* (set in order), *Seiso* (shine), *Seiketsu* (standardize), *Shitsuke* (sustain).

Figure 5 – 5S (Source: “5S TODAY”)

So, the 5s can be explained as (Michalska and Szewieczek 2007):

- Sort – the first stage of this methodology consists of identifying what is needed and eliminating what is considered unnecessary. At this stage, waste material, non-compliant products and damaged tools are eliminated, to obtain a more organized and clean space, making it easier to find something you need.
- Set in order – after completing the first stage, it is necessary to define the specific location for each item, correctly identified so that it is possible for each person to quickly find what they need.
- Shine – indicates the need to keep the space clean. At the end of each shift, the workspace is cleaned and each thing is replaced in its correct place.
- Standardize – way to ensure the previous three steps. It consists of the implementation of rules with procedures and instructions that must be followed to maintain order in the workplace. The rules must be clear and communicative.
- Sustain – consists of a continuous process to maintain discipline and ensure all the steps previously developed. Allows to raise awareness among employees, reduce the number of non-compliant processes, improve internal communication and, as a result, improve human relation.

2.2.2 Overall Equipment Efficiency (OEE)

The OEE tool was developed from the TPM concept and first introduced by Seiichi Nakajima. It is a Key Performance Indicator (KPI) developed to measure the effectiveness of equipment in relation to its expected behaviour. The continuous evaluation of this indicator is used to identify the causes of the decrease in the effectiveness of the equipment and helps in the implementation of actions that combat this same decrease (Muchiri and Pintelon 2008).

In this way, the OEE indicator arises from the multiplication of three factors related to productivity, as shown in Equation (1). These factors are Availability, Performance and Quality rate (Taisir and Almeanazel 2010).

$$OEE = Availability\ x\ Performance\ x\ Quality\ rate \qquad (1)$$

The Availability consists of comparing the time the machine is actually working and the total available time it has to work. It is calculated by equation (2) as follows:

$$Availability = \frac{Loading\ time - Downtime}{Loading\ time}\ x\ 100 \qquad (2)$$

In this equation, the loading time corresponds to the operating time of the equipment minus the time of scheduled stops, such as breaks, meetings or lunch. Downtime is defined by the time the machine is stopped due to unscheduled breaks or setups.

Performance is calculated by dividing the output by the operating time and comparing it to the ideal run rate. Equation (3) demonstrates this calculation.

$$Performance = \frac{\frac{Output}{Operating\ Time}}{Ideal\ Run\ Rate} * 100 \quad (3)$$

In this equation, the output is the total output in a period of time and the operating time is the loading time minus the downtime. The ideal run rate is the number of units produced per unit of time by the machine working under optimal conditions.

The Quality rate is defined by the production input minus the number of defective items divided by the production input. Equation (4) presents the calculation of quality.

$$Quality\ rate = \frac{Production\ input - Quality\ defects}{Production\ input} * 100 \quad (4)$$

The production unit is the quantity of items fed to the process and the quality defects is the number of items that are below the required quality.

Figure 6 presents the times used in the calculation of the OEE indicator, as well as the main losses, downtime losses, speed losses and quality losses.

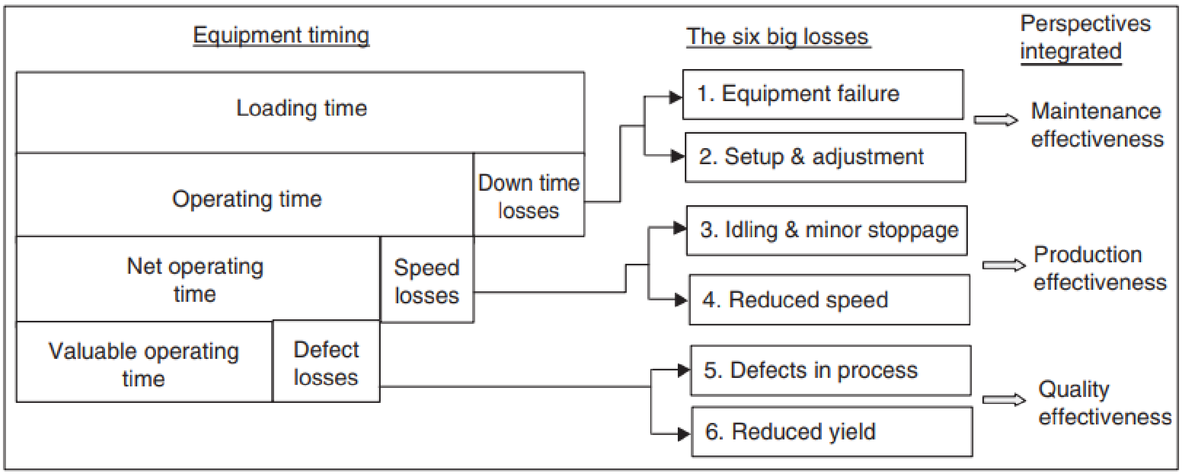

Figure 6 – Times for OEE (Source: Muchiri and Pintelon 2008)

2.2.3 Single-Minute Exchange of Die (SMED)

SMED is one of the Lean tools used to reduce waste in a production process, namely reducing the setup time of any equipment to less than 10 minutes. A setup consists of the preparation carried out before and after the processing of each batch (Shingo 1985). This method provides a quick and efficient way to convert a production process from one current product to the next product (Ulutas 2011).

In 1950, Shigeo Shingo, on a visit to the Mazda Toyo Kogyo plant in the city of Hiroshima, identified and classified setups into 2 types:

- Internal setup: operations that can only be carried out when the machine is stopped;
- External setup: operations that can be carried out while the machine is running.

In this way, Shigeo Shingo divided the SMED methodology into 5 steps, having as a starting point a changeover method not rationalized (Jebaraj Benjamin et al. 2013):

- Study of the actual situation: analyse the times and movements of the operators who carry out the change, through footage and spaghetti diagrams;
- Separate the internal elements from the external elements: perform the division between internal operations and external operations;
- Convert as many internal elements as possible to external elements: identify if some activities that are classified as internal, can be performed while the machine is in operation, in order to reduce the time that it is down during the setup;
- Streamline the remaining internal elements: reduce the time of the remaining internal activities so that the setup consumes less time;
- Streamline the external elements: make external activities faster to free operators for other activities.

2.2.4 Spaghetti Diagram

To apply Lean tools for the purpose of eliminating waste, it is first necessary to identify the waste. The Spaghetti Diagram is used for this purpose.

The Spaghetti diagram is a graphical representation to follow the movement of a person or an object in a system with the help of a line. This system can be a production area, part of a building or workshop (Senderská et al. 2017).

Thus, the elaboration of this diagram allows the identification of opportunities for improvement and the consequent reduction of waste.

2.2.5 ABC analysis

ABC analysis is a tool used for inventory management by classifying items into 3 categories according to their degree of importance:

- Category A: articles of greater importance;
- Category B: articles of moderate importance;
- Category C: practically unimportant articles.

It is a technique that allows the adoption of different ways of managing each type of article according to its category.

The traditional ABC analysis uses the annual use of the dollar criterion to classify the articles, however, many other criteria proved to be significant and should be used in the classification process, such as order size and lead time for example.

This tool is based on Pareto's law, which says that 20% of the articles correspond to 80% of the total value and the remaining 80% of the articles correspond to only 20% of the total value of the articles.

Thus, according to (Douissa and Jabeur 2016), the categories are composed as follows:

- Category A: 5% to 10% of articles;
- Category B: 20% to 30% of articles;
- Category C: 50 to 70% of articles.

2.2.6 Standard Work

Standard Work is defined as a set of clearly described procedures with the aim of establishing the best methods and sequences for each process and for each worker (Pereira et al. 2016). By selecting the best methods for performing the tasks, it is possible to reduce variability and inconsistencies in processes (Ballard 2008).

Standard work involves 3 key elements (Pereira et al. 2016):

- Takt Time: production rate in line with consumer demand. Takt Time is not measured but calculated by dividing the time available for production by the market demand;
- Standard work sequence: order in which tasks must be carried out in a given process. This sequence represents the safest and best way to do it;
- Standard work-in-process inventory: minimum amount of inventory to maintain a continuous process flow without downtimes.

The benefits of Standard Work include creating a reference point from which to continuously improve, controlling the process, reduction in the variability, increase in the quality and flexibility, process stability, visibility into abnormalities, clear expectations, and a platform for individual and organizational learning (Emiliani 2008).

2.2.7 Kanban

Kanban is a subsystem of the Toyota Production System and is defined as a flow of materials that consists of controlling the production of the exact quantities and at the exact time of the necessary products (Kumar and Panneerselvam 2007). It is aligned with the Just-in-Time ideology and allows overproduction to be fought.

Kanban is a plastic card that contains the necessary information for processing a product with details of all steps (Kumar and Panneerselvam 2007). The goal is Just-in-Time delivery of materials to the production stations and the transfer of information to the previous stage on the quantity of the product we want to produce (Huang and Kusiak 1996).

A *Kanban* has the following functions (Huang and Kusiak 1996):

- Visibility function: Kanban attached to materials matching information flow with material flow;
- Production function: processes produce according to the information present in the Kanban that contains the time, quantity and type of parts to be produced;
- Inventory function: the number of Kanban measures the amount of inventory. The more Kanban there are the more inventory there is. It is much easier to control the number of Kanban than the amount of inventory.

2.2.8 Continuous Improvement – PDCA Cycle

In an ideal situation, the processes would have no waste and would only consist of a sequence of value creation steps to satisfy consumers. In a real work situation, perfection cannot be achieved due to the numerous factors that destabilize the process, such as supplier changes and customer requirement changes. Thus, the presence of continuous improvement becomes important for problem solving continuously maintaining a Lean system and avoiding deterioration of process performance (Clark et al. 2013).

In this way, the PDCA cycle is a methodology that allows continuous improvement of the production process through the analysis of the causes of the problems found and through the implementation of actions. This cycle is shown in Figure 7 and its steps are as follows (Chakraborty 2016):

- Plan: define the problem, identify possible causes and possible solutions for its resolution;
- Do: proposed solution implementation;
- Check: evaluate the results and the impact of the implemented solution;
- Act: if the results are satisfactory, use normalization; if they are not satisfactory, go back to the Plan step.

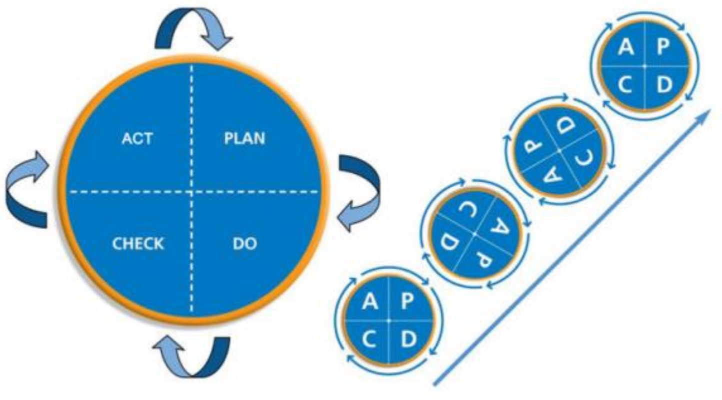

Figure 7 – PDCA Cycle (Source: Clark et al. 2013)

After presenting the Lean tools used in the development of this project, an analysis of the current situation of the processes under study is carried out in the next chapter.

3 Analysis of the initial situation

After the presentation of the project and the theoretical concepts used in its development, this chapter analyses the initial situation of the production sector where this work is focused.

In this way, this chapter initially describes the production process in the company and, in a second part, identifies the problems and sources of waste associated with the process.

3.1 Description of the production process

In Nováqua the production is mainly make-to-stock, which means that the need for production is controlled by the sales forecast. Figure 8 presents a Swimlane model describing the steps for product processing in sector C6, with manufacturing and filling being the two main steps.

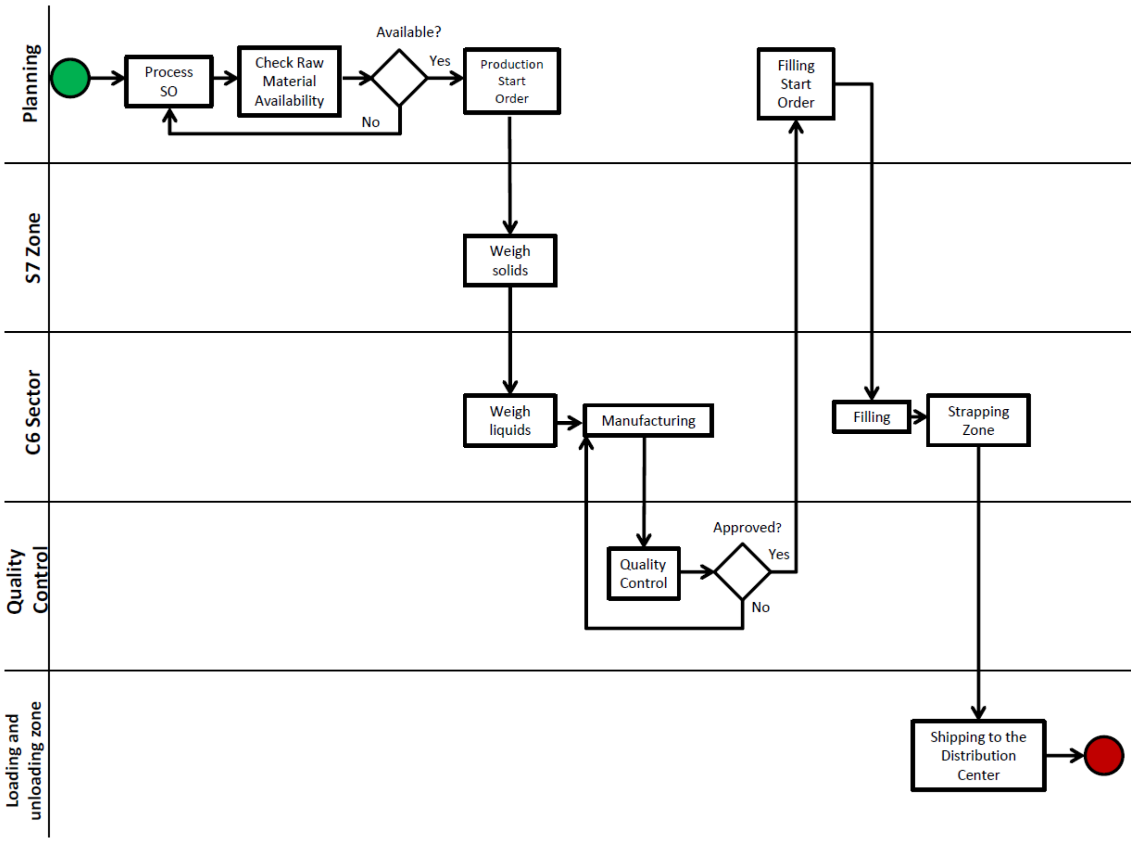

Figure 8 – Swimlane model of product processing in the sector C6

The production process begins with the analysis of needs and orders and the processing of the Shop Order (SO) by the production planning. In this phase, the availability of the raw materials needed for manufacturing is evaluated and if this availability is verified, the order to start the production process is given and the necessary raw materials to supply the sector are separated.

Solid raw materials are weighed in sector S7, a sector specifically developed for weighing solid raw materials in order to reduce space consumption in other sectors. After weighing, the solid raw material is transported on pallets to a specific storage area in sector C6. The solid raw material used to manufacture the products in the C6 sector is powder that is stored in bags and is added to the disperser manually by the operator.

As for the liquid raw materials, these are stored in barrels or cubes located in a specific area of sector C6, where the quantities required for manufacturing are weighed by the manufacturing operator. The raw materials that are used most and in large quantities are stored in silos and are supplied to the disperser through pipes automatically and in the exact quantity required for production.

Then the manufacturing process begins, in which the operator responsible for the operation follows the steps defined in the SO, adding the exact quantities of each raw material to the disperser in the correct order defined in the theoretical formulation. The SO contains all the information required to manufacture the product, in other words, all the raw materials required, their respective quantities and the order in which they should be added. Once the manufacturing process is finished, a sample of the product is taken and sent to quality control, which in accordance with the defined requirements, approves or rejects the product.

After the product has been approved and the Filling Order (FO) has been issued, the filling of the product into the packaging begins. The FO presents the product to be filled and the material necessary for filling, such as packaging, lids, boxes, and anti-slip cards. During the filling process the product is placed in the cans, the lid is then duly placed in order to seal the can, the inkjet is activated and finally the packages are palletised.

After the filling process, the pallets of finished product are transported to the strapping area and then loaded on the truck that takes them to the distribution centre.

3.1.1 Manufacturing process

There are two product manufacturing zones for filling in sector C6, in which in one of the zones the manufacturing is carried out automatically in a large disperser and in the other the manufacturing is carried out manually in smaller mobile tanks with a maximum capacity of 1000 L.

The disperser is located on a platform raised from the ground where the mixing of solid and liquid raw materials required to manufacture the products takes place. The solids are supplied to the platform by a forklift that raises these raw materials to the platform level. Regarding the liquids necessary for the process, those required in larger quantities are dosed automatically and supplied to the disperser through pipes and those that are used in smaller quantities are stored on racks in the liquid weighing area in front of the disperser. Figure 9 shows the disperser of sector C6 and the weighing and storage area for liquid raw materials.

Figure 9 – Disperser of sector C6 and weighing and storage area for liquid raw materials respectively

At the bottom of the platform there is a fixed tank where the product is stored after the manufacturing in the disperser is completed. The manufactured product can either be filled directly into the ME-32 filling machine, which is located next to the tank, or it can be deposited in mobile tanks for filling into the ME-07. These two machines will be presented later in the next subchapter.

Regarding the manual production, this is performed in the smaller disperser shown in Figure 10.

Figure 10 – Disperser for manual production

In this case, the production is carried out in mobile tanks and in smaller quantities than in the previously presented disperser. The operator deposits the raw material manually and regulates the speed of the disperser throughout the production process. In this disperser, only a certain product is produced, which is supplied in mobile tanks only for filling in the ME-07.

3.1.2 Filling process

In sector C6 there are two machines that carry out the filling of all the product manufactured in this sector, designated ME-32 and ME-07 and are presented in Figure 11. As already mentioned, the main focus of this project is on the ME-07 filling machine.

Figure 11 – ME-32 and ME-07 filling machines respectively

ME-07

The ME-07 is a semi-automatic filling machine, meaning that only the product dosing and sealing of the lids is automatic, the rest of the operations are performed by the filling operator. Figure 12 shows the layout of this machine and its components.

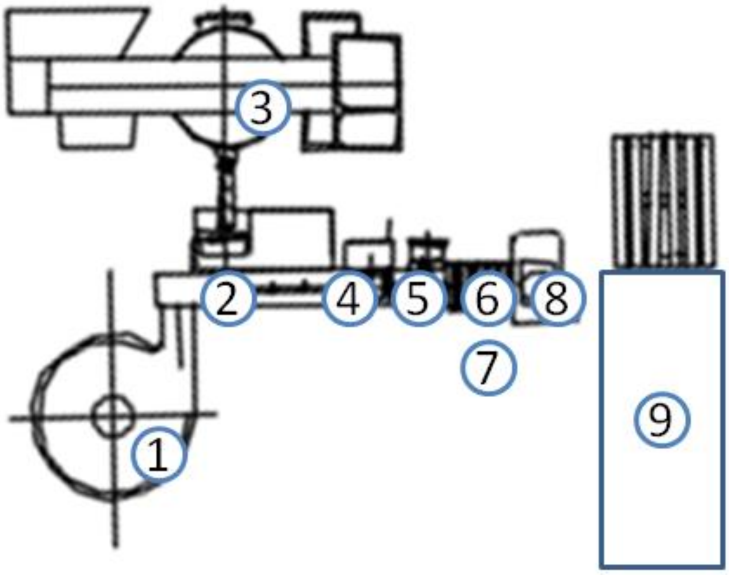

Figure 12 – ME-07 machine layout

Where:

- 1 - Turntable where the cans are filled;
- 2 - Filling nozzle;
- 3 - Press;
- 4 - Place for placing the lids;
- 5 - Tamponer;
- 6 - Inkjet;
- 7 - Scale;
- 8 - Line edge;
- 9 - Area for placing the cans in the boxes.

Before the filling starts, the operator needs the cans and lids to supply the machine. This material is supplied by the logistic operator who transports the pallets with the necessary material to the filling area. The filling material for the ME-07 is stored in the racks located near the machine and in the “Work In Progress” (WIP) zone of raw materials for the production processes. These racks are shown in Figure 13, as well as the WIP area.

Figure 13 – WIP zone and racks for the ME-07 filling materials

After having all the necessary material, the filling operator needs to load the turntable with the cans to be filled and supply the machine with the lids suitable for the respective cans. Once on the turntable, the cans enter the conveyor belt that transports them first to the filling nozzle where the product is dosed, then to the lidding area and then to the tamponer where it is sealed. Once sealed, the inkjet is automatically placed in the can. Once this process is complete, the cans arrive at the line edge where they are accumulated. At this stage, the operator places the cans into boxes and with the help of a machine, seals these boxes with tape. Finally, the operator places the boxes on the pallet.

In this machine only 0.900 Kg and 0.450 Kg cans of product are filled, and every time a new filling starts, the operator has to start the machine setup. So, in the ME-07 there are 2 types of setups:

- Setup PI (Intermediate Product Change without Washing): changing the intermediate product without the need to wash the machine, since the product to be filled is similar to the previous product;
- Setup PIL (Intermediate Product Change with Washing): change of intermediate product with the need to wash the machine since the adjacent product is more or less transparent than the previous product or because they are too different from each other.

The operator fills only two products with different characteristics in this machine, and the change between different products is assigned Setup PIL and Setup PI for the change between products considered to be similar. The product to be filled is supplied to the machine in mobile tanks which with the help of a press pushes the material from inside the tank to the machine.

ME-32

The ME-32 machine has a simpler system. The product required for filling is contained in a fixed tank which is located underneath the disperser in which the same product is manufactured. The disperser and the fixed tank are connected internally by a passage, the opening of which is controlled by the operator. The product used for filling is supplied directly to the machine through a hose with the help of a pump.

The filling in this machine is performed in a less automatic way compared to the filling in the ME-07. In this case, the machine operator is responsible for supplying his workstation with the material needed for filling. This material is located in the same area as the filling material in the ME-07 mentioned above.

Figure 14 shows the layout of this machine and its components.

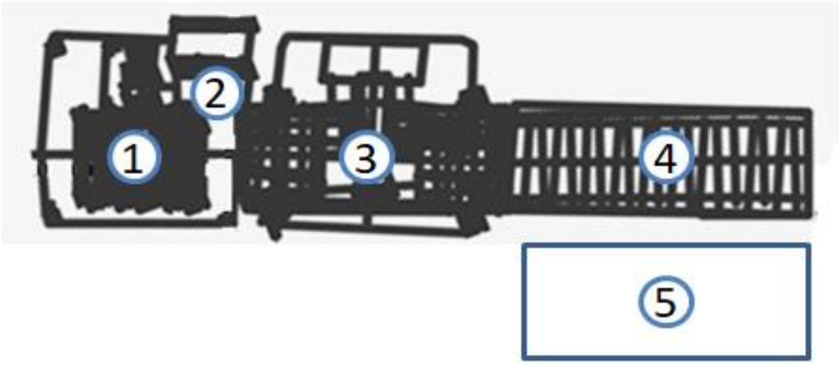

Figure 14 – ME-32 machine layout

Where:

- 1 – Filling nozzle;
- 2 – Scale;
- 3 – Tamponer;
- 4 – Line edge;
- 5 – Pallet area.

During the filling process, the operator identifies the can to be filled by placing the label manually and then places it under the filling nozzle and activates the button to start dosing the product. The machine has a scale that allows weighing the amount of product deposited in the can at the time of filling, so the operator can program the scale so that the machine deposits the desired amount of product. After dosing, the operator places the lid on the can manually and it follows on a conveyor belt to the tamponer where the can is sealed. Finally, the package reaches the line edge and is placed on the pallet.

This machine fills 4 kg and 25 kg cans with product, while 25 kg cans are placed on the pallet with the help of a manipulator.

Regarding the types of setups, this machine besides having the PI and PIL types, like the ME-07, has another type of Setup called Setup E (package change). In this Setup, the intermediate product is the same and there is only a change of litres that implies change of filling material.

3.2 Identification of problems and waste sources

This sub-chapter identifies the main problems detected in the processes presented above. These problems represent the presence of waste in sector C6 and are grouped according to the sector area they affect. The problems mentioned are related to unnecessary movements, lack of organisation, low process standardisation, with the sector productivity and also with the availability and performance indexes of the ME-07 machine.

3.2.1 Problems in the manufacturing area

The mortar and bitumen production process was monitored and analysed, and it was possible to identify some problems.

A lack of documentation of the process was identified and only a few operators were able to perform the process. In case of the manual production process, this problem was even more significant due to its greater complexity and the need for the operator to know how to work with the disperser and how to regulate it throughout the process. In the automatic manufacturing process, there is also a lack of documentation mainly on the operation of the disperser, since it is the large disperser that is most distinct from the others.

Another problem associated with the manual production was the fact that there was only one operator capable of performing the process, so in his absence, the section would be significantly affected. This problem was also evident in automatic production, but less markedly as there were two operators with knowledge of the process.

3.2.2 Problems related to the ME-07 machine

The ME-07 machine is the main focus of this project and was therefore submitted to a more detailed analysis and significant problems were identified. This semi-automatic filling machine recorded an average OEE value in the first two months of this year of around 35%, below the target of 45% set by the company. This objective is defined by the company's production department, which, on a three-monthly basis, reviews the objectives and indicators of all the machines that are recorded daily. In these trimester reviews the improvement actions being taken on each machine, the performance and availability are analysed and consequently the targets for each machine are defined. The target for each machine is redefined after the weekly target is reached several consecutive times.

The records for calculating the OEE indicator are made by the machine operator on a specific sheet present in Appendix A. The graph in Figure 15 shows 24 records of the OEE indicator during the months of January and February 2023.

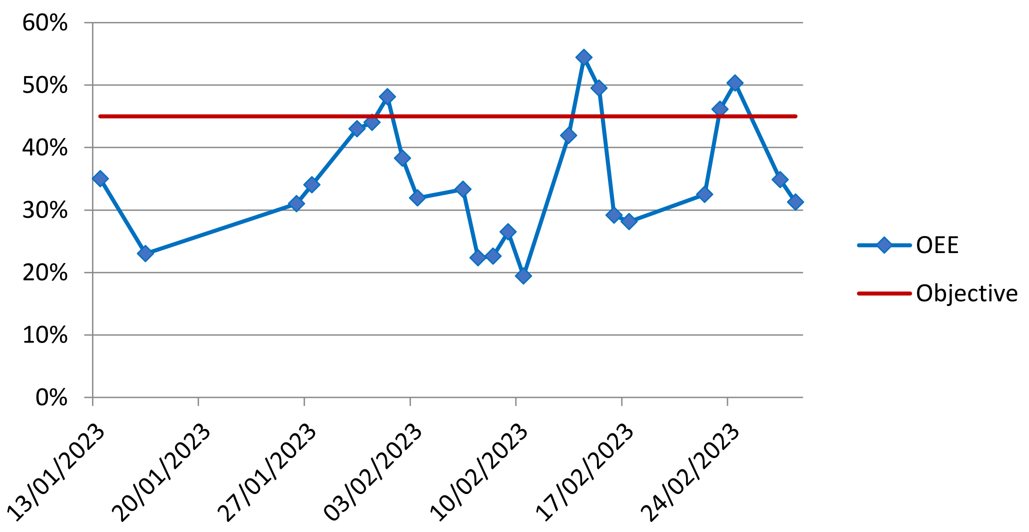

Figure 15 - OEE records from the ME-07 machine during the months of January and February

A normality test was performed on the set of data collected (Appendix B), and it was found that they follow a normal distribution, which allow us to infer that it is possible to use the average of the records obtained as a representative measure of the values.

This OEE value well below target is due to factors affecting machine availability and performance.

Regarding the factors linked to availability, the following are registered in the machine:

- High number of unscheduled stoppages, which account for around 31% of the non-productive time of the machine in the first 2 months of 2023;
- High setup times, which account for 26% of the non-productive time of the machine in the first 2 months of 2023.

The graphic in Figure 16 shows the distribution of the non-productive time of the ME-07. By analysing the graph we can see that the scheduled stoppages represent most of the non-productive time, however these cannot be reduced because they represent the scheduled breaks of the operators and the daily meetings that they have to attend.

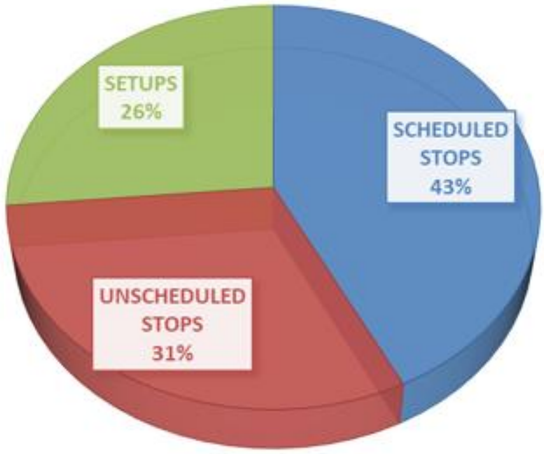

Figure 16 – Distribution of the non-productive time of the ME-07 machine

On the other hand, machine performance is affected by:

- Machine cadence lower than the theoretical cadence due to the difficulty for the operator to match his activities during filling with the filling speed of the machine. At the theoretical machine cadence the operator cannot optimise his operations to avoid machine stoppage and therefore reduces the cadence affecting the performance.

Unscheduled stoppages

As mentioned above, unscheduled stops account for about 31% of the machine's non-productive time and are therefore a great problem from an availability point of view. There are various types of unscheduled stoppages and these are recorded in the OEE record sheet according to the acronym that represents them. Figure 17 shows the different types of unscheduled stoppages recorded in the first 2 months of 2023.

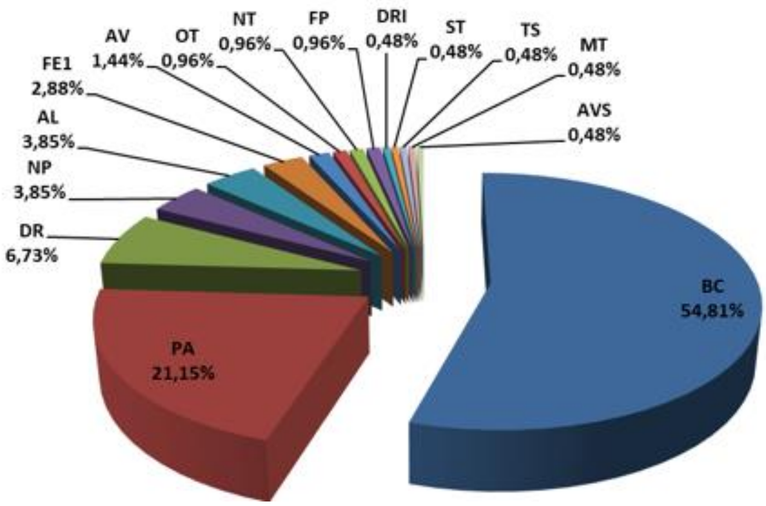

Figure 17 – Distribution of unsheduled stops

Where:

- BC – Full line edge
- PA – Collection of finished pallets
- DR – Spill
- NP – Personal needs
- AL – Supply of packaging material
- FE1 – Lack of Packaging Material (internal delay)
- AV – Breakdown with maintenance intervention
- OT – Others
- NT – New tank
- FP – Lack of pallets
- DRI – Spill ate the installation
- ST – Adjust the Strapex
- TS – Change Strapex tape
- MT – Improperly closed lids
- AVS - Breakdown without maintenance intervention

<u>Full line edge (BC)</u>

It represents the main reason for unscheduled machine stoppages, with around 55% of the total number of occurrences. On average, this type of unscheduled stop consumes about 25 minutes per day, which is equivalent to 12 hours and 30 minutes per month.

Figure 18 shows the full line edge situation that leads to machine stoppage.

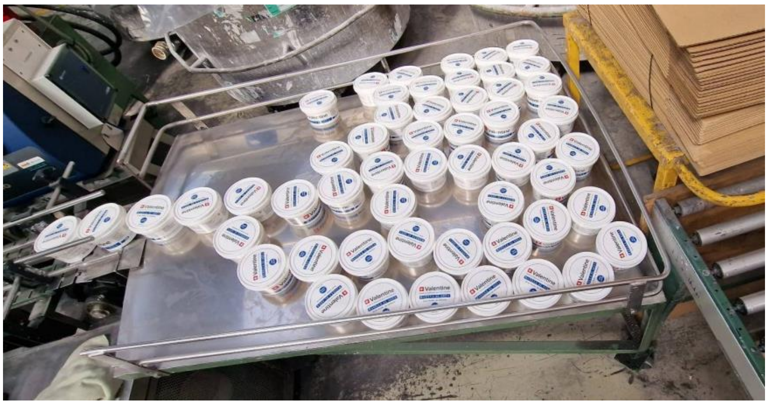

Figure 18 – Line edge full

The operator performs a number of tasks on the machine that are not always carried out sequentially and optimally. The machine stops when the line border is full and the operator has to empty it, so the turntable runs out of cans to continue filling.

These tasks that the operator has to perform during the filling are represented in Figure 19 and can be described as follows:

- Fill the turntable with cans;
- Fill the lid dispenser;
- Check the weight of the cans if necessary;
- Place the cans from the line edge into the boxes;
- Place the cans on the pallet.

Figure 19 – Sequence of tasks during the filling

The boxes where the cans are stored differ according to the product to be filled, so it is important to note that the occurrence of this type of unscheduled stop varies according to the capacity of the boxes. Thus, these stops are more frequent when filling a product whose boxes are smaller and have less can storage capacity, since the operator has to fill more boxes to clear the line, which means more time. The Table 1 shows the products that are filled in the ME-07, the respective quantity in Kg per can and the capacity of the boxes used. For confidentiality reasons the products presented in the table are identified by a code. It is important to note that the product references are composed by the combination of five digits that represent the type of product, followed by another four digits that relate to the colour and two last digits that represent the volume of the container.

Table 1 - products used in the filling of the ME-07 and the number of cans per box

Product reference	Kg per can	Number of cans per box
AAAAA XXXX Y4	0.900	6
AAAAA XXXX Y3	0.450	12
BBBBB XXXX Z6	0.900	12

Collection of finished pallets (PA)

This kind of stop is the second largest contribution to unscheduled stoppages, representing about 21% of the machine's unscheduled stoppages and occurs whenever the operator finishes a filling and has to transport the pallets of finished product to the strapping zone where they are later loaded into the truck. In this activity the operator goes to the strapping zone to collect the pallet truck, once he has the pallet truck in his possession he returns to the work area to collect the pallet of finished product and transport it to the strapping zone. He repeats this activity according to the number of pallets of finished product he has to transport. When the last pallet has been delivered, the operator returns the pallet truck to the strapping zone and returns to his workstation.

This activity not only influences the operator's availability due to the time it takes but also represents a waste due to the large number of unnecessary movements performed by the operator.

To better demonstrate these movements a Spaghetti diagram was drawn based on tracking 25 transports of finished product during the month of February. This diagram is represented in Figure 20. The diagram shows the movements made by the operator when transporting 2 pallets. In this case, the operator moves to the strapping zone to get the pallet truck, then returns to the machine and transports one pallet at a time to the strapping zone.

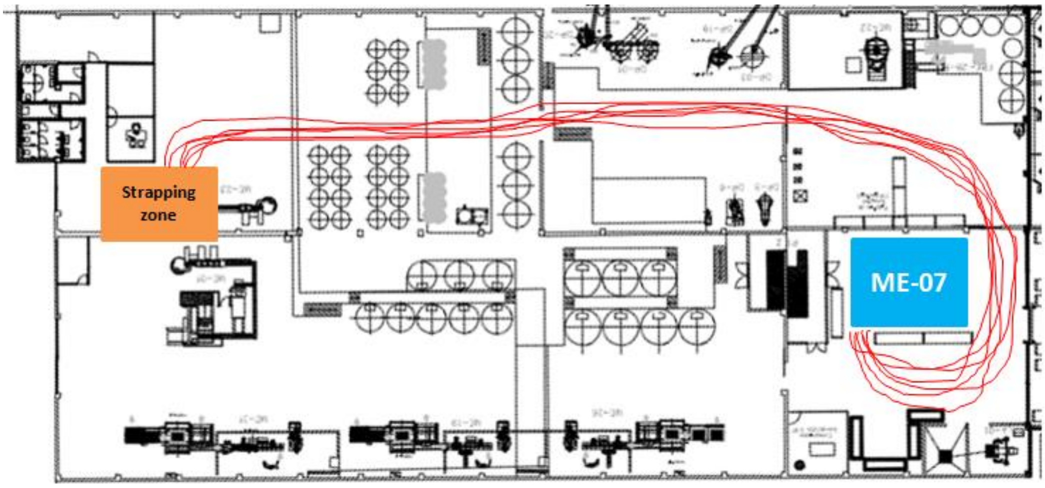

Figure 20 – Spaghetti diagram of the movement made in the transportation of the pallets of finished product

The time consumed by this stop depends on the availability of the pallet truck. On average, this activity takes the operator around 10 minutes and is carried out once or twice a day, which is equivalent to 5 hours per month if it is carried out once a day and 10 hours if it is carried out twice a day.

Setups

As presented earlier, setups represent about 26% of the non-productive time of the machine, so reducing their duration leads to increases in machine availability and consequent increases in OEE value and the productivity index.

The two types of setups existing on this machine, presented earlier in this chapter, have high durations and differ significantly from each other in the time they take to complete. The Table 2 shows the average duration of each type of setup.

Table 2 – Average duration of each type of setup

Setup	Average duration (min)
PI	50
PIL	103

The PI setup is the most frequent, representing about 84% of the number of setups performed on the machine. The PIL setup occurs less frequently as it is only performed when changing between products of different types. The PIL setup takes much longer due to the fact that the machine components have to be disassembled and washed in order to avoid contamination of the next product.

In the PI setup, the mobile tank is changed in order to perform the next filling. The ME-07 filling operator is responsible for transporting the finished product to the strapping area, for performing all activities related to filling material replenishment and for changing the mobile tank. The mobile tank exchange consists of the process of removing the tank that was used for the previous filling and replenishing another tank with product for the next filling. Figure 21 demonstrates the removal of the mobile tank from the press.

Figure 21 - Removal of the mobile tank during setup

The washing of the used tank is a time-consuming process and is performed by another filling operator of sector C6, who is called by the operator of ME-07 at the time of performing the task. It was verified that without the presence of another operator for the washing of the tank, the setup PI presents an average duration of 95 minutes. An opportunity for improvement was detected in the washing of the mobile tanks, more specifically in the washing of the tanks' valve. This activity was time consuming and complicated, the operators had to perform the washing of the tank valve without a specific tool for washing, which often did not lead to the correct washing of the valves.

Performance

The machine performance is negatively influenced by the existence of micro-stops and by the fact that the machine is working at a cadence lower than the theoretical cadence, which means it is working below its capacities. In this analysis, the presence of micro-stops with significant influence was not verified, being the main factor the machine cadence below the theoretical value. The Table 3 shows the theoretical cadence values for each product used in the filling of the ME-07.

Table 3 – Theoretical cadence values for each product

Product reference	Kg per can	Theoretical cadence
AAAAA XXXX Y4	0.900	19
AAAAA XXXX Y3	0.450	16
BBBBB XXXX Z4	0.900	19

The operator reduces the machine's cadence to avoid the machine stopping. With the theoretical cadence values, more machine stops occur because the operator cannot perform his activities before the turntable empties.

It was also found that the operator reduced the cadence of the machine to have more control over the process and avoid possible spills, and that there was manipulation of parameters when solving machine problems.

The filling performance of the three types of products was analysed. To do so, the performance values of a set of fillings of each product were registered. This record is shown in the Table 4.

Table 4 – Performance values of a set of fillings of each product

<table>
<tr><th>Date</th><th>Product reference</th><th>Performance</th><th>Theoretical Cadence</th></tr>
<tr><td>07-02-2023</td><td rowspan="3">AAAAA XXXX Y4</td><td>42%</td><td rowspan="3">19</td></tr>
<tr><td>08-02-2023</td><td>42%</td></tr>
<tr><td>09-02-2023</td><td>47%</td></tr>
<tr><td>17-02-2023</td><td rowspan="3">BBBBB XXXX Z6</td><td>48%</td><td rowspan="3">19</td></tr>
<tr><td>22-02-2023</td><td>48%</td></tr>
<tr><td>23-02-2023</td><td>48%</td></tr>
<tr><td>23-02-2023</td><td rowspan="3">AAAAA XXXX Y3</td><td>86%</td><td rowspan="3">16</td></tr>
<tr><td>24-02-2023</td><td>72%</td></tr>
<tr><td>27-02-2023</td><td>68%</td></tr>
</table>

By analysing the table, it is possible to verify that the performance reaches higher values when filling the product with lower theoretical cadence, since the operator can set a value for the cadence closer to the theoretical value in which he can perform his tasks without filling the edge of the line. The products with higher theoretical cadence present performance values below 50%, especially the reference product AAAAA XXXX Y4 that is packaged in smaller boxes which causes greater difficulty in draining the line edge and a consequent decrease in the cadence by the operator to avoid this event.

Thus, it is important to find opportunities for improvement in order to bring the machine cadence closer to its theoretical value in a way to increase the performance that has direct impact on the OEE value that is intended to improve.

3.2.3 Problems related to the ME-32 machine

As mentioned earlier, the filling process in the ME-32 is considerably simpler than in the ME-07, so the process is subject to fewer problems. Thus, the problems detected are the following:

- Lack of standardization of the machine's operating process;
- Lack of standardization of the machine setup tasks;
- Very time-consuming and unergonomic purge task during the PIL setup, which required physical effort from the operator.

The purging task is performed during the intermediate product change setup with the washing of the machine in which the operator needs to circulate through the machine a quantity of the new product to be filled, so that it does not come out contaminated by the previous one. In this way, the operator filled a quantity of cans sufficient for the product to start to come out with the desired consistency and then emptied the cans one by one into the fixed tank. This process is time consuming and requires physical effort, so it was targeted for improvement.

The time for this task was measured in three PIL setups and an average value of 30 minutes was recorded for the duration of the purge. The operator has to transport the filled 15 kg cans from the filling nozzle to the tank where they will be emptied, covering a distance of about 10 metres. The Figure 22 shows the tank where the cans are emptied one at a time.

Figure 22 - Fixed tank for filling on the ME-32

3.2.4 Productivity

The productivity of each sector is the most important indicator and is discussed every day in the daily Kaizen meeting. This indicator is calculated by dividing the quantity of product filled in the sector by the number of hours of the workers involved in this same filling. Equation (5) presents the calculation of this indicator.

$$Productivity = \frac{Filled\ Quantity}{Working\ Hours * Nr.of\ Operators} \quad (5)$$

The numerator shows the number of litres filled and which are given as closed. The litres that do not reach the customer do not count for this calculation, as do the litres from interrupted fills, which will only count the next day.

The denominator is obtained by multiplying the hours worked by the number of operators who contributed to the filled quantity.

The daily productivity values were recorded during the first 13 weeks of 2023 for sector C6, and it was found that productivity in most weeks was below the target of 150 L/hour.man set by the company. The graph in Figure 23 shows 36 productivity records during the first 13 weeks of 2023 for C6 sector.

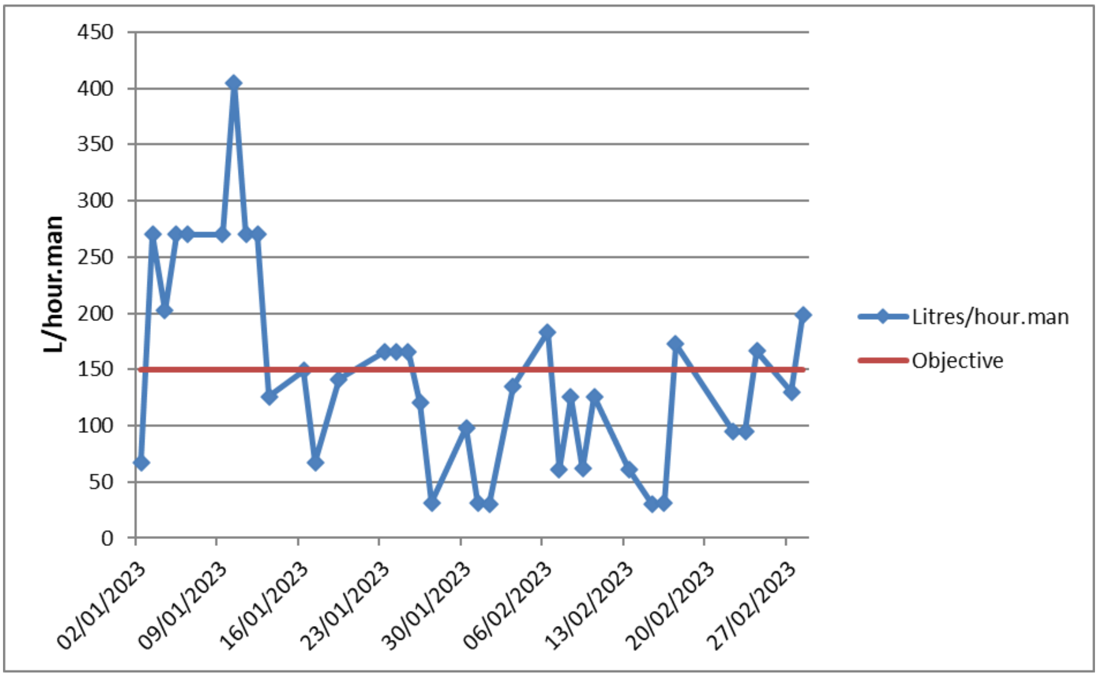

Figure 23 – Daily productivity record during the first 13 weeks of 2023 for sector C6

A normality test was performed on the collected data set (Appendix C), and it was found that they do not follow a normal distribution, which leads to the conclusion that the use of mean productivity values for sector C6, is not a representative measure of the collected values and therefore will not be used.

The target to be reached for the productivity of each sector is analysed by the company's planning department and is defined annually according to the product demand. This indicator is greatly affected by the workload on the machines and in the case of sector C6 it was found that the target was not met in most of the 13 weeks of 2023, only being achieved when there is only workload on the machine that fills the largest cans (ME-32). The lack of workload on the machines is one of the reasons for the set target not being met, which may lead to the need to redefine this target. However, it is verified that even with load in the two machines of the sector, the value of 150 L/hour.man is not reached, so there is a need to create solutions to improve it.

In this case, as a way of improving this indicator, it was considered the possibility of placing the two filling operators from sector C6 working together. Placing two operators at the same workstation brings benefits for the availability and performance of the machines, however it has effects in the productivity. Therefore, the study of the sector's productivity becomes important and will be carried out in the next chapter.

3.2.5 Problems related to the WIP zone of the raw materials and packaging material racks

The raw materials WIP area is located near the ME-07 and consists of racks that are used for storing pallets with solid raw materials used in the manufacture of sectors C2 and C6 and for storing the materials needed for filling the ME-07 and ME-32 machines.

The problem detected in this area lies in its disorganisation. Raw materials and filling material were randomly located on the racks without any kind of defined position. This disorganisation made it difficult for the ME-07 operator to collect the filling material, on the one hand because this material was often found at higher levels of the racks, which implied the use of a forklift, and on the other hand because it was found in racks whose passage was obstructed by manufacturing pallets, as shown in Figure 24.

Figure 24 - Example of obstruction to rack access

Thus, the disorder of the racks and the lack of specific locations for each filling material is a problem not only for the filling operator, who is forced to spend time finding the material required for filling and in several situations has to clear the passage to access the required material, but also makes operations more difficult for the operators responsible for production, who have more difficulty in storing the production due to poor use of space.

4 Improvement implementation

This chapter presents the improvements proposed to solve the problems identified in the previous chapter. These improvements were implemented using methodologies such as 5S, SMED and ABC analysis, among others. This chapter also demonstrates the results obtained through this implementation.

4.1 Manufacturing area

Regarding the problems detected in the manufacturing area, as previously mentioned, they lie in the lack of documentation explaining the processes of manual and automatic production of mortar and bitumen.

In this way, these processes were monitored, all the operations were identified and the correct form and order of carrying them out were established together with the team. They were documented, using work standards that have a strong visual and descriptive component for better understanding by the employees. These standards have not only the correct order to perform the operations, but also the correct running of the machines used.

Thus, two working standards have been developed and are presented in Appendix D:

- NT 35/22 - Operação Fabrico Automático de Massas;
- NT 37/22 - Operação Fabrico Manual de Massas.

Once these standards had been developed, the employees were trained on them.

In addition to the standards created, the standard for weighing liquids (NT 16/21 - Pesagem de Líquidos) was also reviewed and the necessary changes were made to it. This standard is present in Appendix E, and it is important for the manufacturing area and to ensure its correct operation since it presents the correct way to carry out the weighing of liquid raw materials for all manufacturing processes.

4.2 ME-07

As previously mentioned, it is of great importance to focus on solving the problems associated with ME-07, since it is one of the main focuses of this project. Thus, in this sub-chapter the solutions for the previously exposed problems associated with ME-07 are presented.

4.2.1 Unscheduled stoppages

Regarding the ME-07 machine, the first improvements presented refer to the unscheduled stoppages, which constitute about 31% of the non-productive time of the machine as mentioned before.

Full line edge (BC)

As for the improvements associated with this type of stoppage, after a deeper analysis of the filling process, a test was carried out in order to avoid the high occurrence of these stoppages. To perform this test, the operator was asked to perform the tasks in a different way from the current one and in a sequential manner. In this sequence a limit number of boxes was defined for the operator to fill before refilling the turntable, instead of the operator totally emptying the line border leading to the stoppage of the machine. With this sequence it was found that the machine stopped less frequently, as the operator filled the turntable without emptying the line border so that eventually the machine stopped due to the line border being full.

This situation was tested but not applied continuously since it did not suit the operator's way of working and the operator had less control over the machine as he had to pay more attention to the turntable to see if it was emptying.

Therefore, it was hypothesized to have the 2 operators in the sector working together on the same machine. Later in this chapter it is analysed the influence of having 2 operators working together on the productivity of the sector. It was verified that with 2 operators in the ME-07 more than twice as many litres were filled than with 1 operator, which led to an increase in productivity.

Thus, with 2 operators on the machine, this type of stoppage is totally eliminated, and there is greater control of the process and less risk of spillage, because it is possible to divide the tasks between the two operators.

Thus, the tasks to be performed by the 2 operators were defined. Figure 25 shows the activities performed by one of the operators. This operator is responsible for filling the turntable with cans, filling the lid dispenser and controlling the weight of the cans.

Figure 25 - Tasks performed by one of the two operators

Figure 26 shows the tasks performed by the second operator during the filling process. These tasks include emptying the edge of the line, filling the boxes, and placing the boxes on the pallet.

Figure 26 - Tasks performed by the second operator

Thus, by placing 2 operators on the ME-07, machine stoppages caused by full line edge were eliminated. Therefore, the main cause responsible for the machine's unscheduled stops was eliminated and a greater control of the process was achieved, reducing the risk of spillage.

Collection of finished pallets (PA)

Regarding the second biggest reason for non-scheduled stoppages of the ME-07 machine, some improvements were implemented that allowed a drastic reduction in this activity's time and in the waste it represents.

To eliminate the need to transport the pallets of finished product to the other side of the plant, a specific area was defined for the collection of this finished product by the logistics operator. Figure 27 shows the designated area for placing the pallets of finished product.

Figure 27 – Finished product area

To place the pallets in this area, it was necessary to provide a manual pallet truck on a full-time basis so that the operator could have total autonomy in this activity.

The availability of a pallet truck also proved fundamental for the collection and supply of filling material, as the operator did not need to depend on the forklift. All the filling materials were accessible only with the pallet truck thanks to the improvements implemented in the racks presented in topic 4.4 of this chapter.

The provision of the hand pallet truck does not represent an investment, since the hand pallet truck was brought in from another sector of the factory that was not using it.

With these improvements, the operator did not need to make time-consuming and unnecessary movements to the strapping area to pick up the pallet truck or to transport the pallets of finished product. The subsequent transport of these pallets to the strapping zone is carried out by the logistics operator who is signalled by the machine operator through a very simple Kanban system explained in topic 4.4.2.

Figure 28 shows the Spaghetti diagram with the movements made by the operator when transporting the pallets of finished product after the implementation of the improvements.

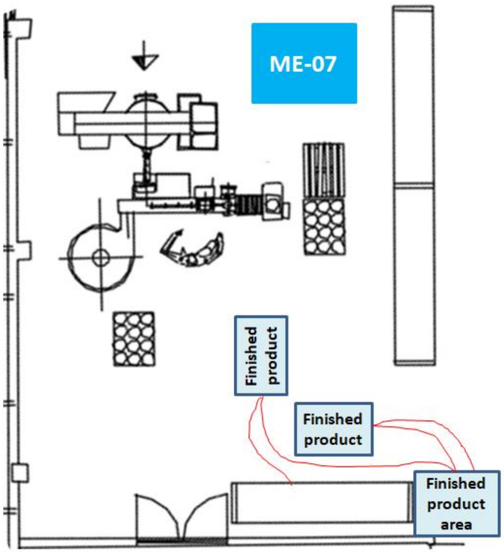

Figure 28 – Spaghetti diagram of the movement made in the transporting the pallets of finished product after the improvements

This diagram represents the transport of 2 pallets to the finished product zone. As it is possible to verify by its analysis, there was a great reduction in the operator movements and in the average time of the activity, which went from 10 minutes to 1 minute, being carried out without stopping the machine in the presence of 2 operators in it.

Later, with the analysis of the setup tasks, this activity was considered as an integral part of the machine setup, so it was no longer performed during the filling and started to be accounted in the setup time. The analysis of the setup process and its improvements are presented in the next subchapter.

After implementing the improvements to the 2 major causes of unscheduled machine stoppages, results can be seen in the distribution of non-productive machine time.

The Figure 29 shows the distribution of non-productive time during the months of April and May 2023, in which the improvements had already been fully implemented.

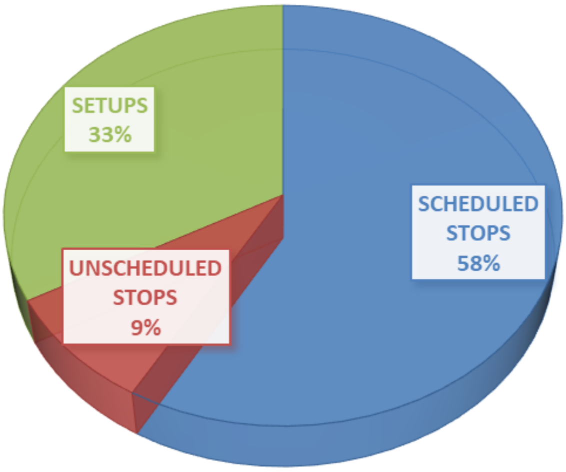

Figure 29 - Distribution of non-productive time of the ME-07 machine after unscheduled downtime improvements

There was a reduction in non-productive time related to unscheduled stoppages from 31% to 9%. After reducing the non-productive time due to unscheduled downtime, it is necessary to reduce the setup time.

4.2.2 Setups – SMED analysis

The analysis and improvement of the setup becomes very important because this activity has a high duration and the tasks that compose it are performed randomly and without any kind of optimized sequencing.

Thus, initially the tasks that made up the setup were analysed, and their respective durations were recorded in a sequence chart presented in Appendix F.

After this analysis, measures were implemented to reduce the setup times:

- Study of the ideal sequence of operations;
- Redefinition and division of tasks between the two operators involved in the setup;
- Identification of the tasks during the change that do not require a stopped machine transformed into external tasks;
- Elaboration of a standard with the new sequence of tasks and respective responsible parties;
- Test of the standard elaborated and necessary adjustments.

The definition of the ideal sequence was carried out in the presence of the 2 operators responsible for the setup and started by clearly defining the tasks that marked the beginning and the end of the setup.

To better carry out the sequencing and division of tasks, their mapping was performed as shown in Figure 30.

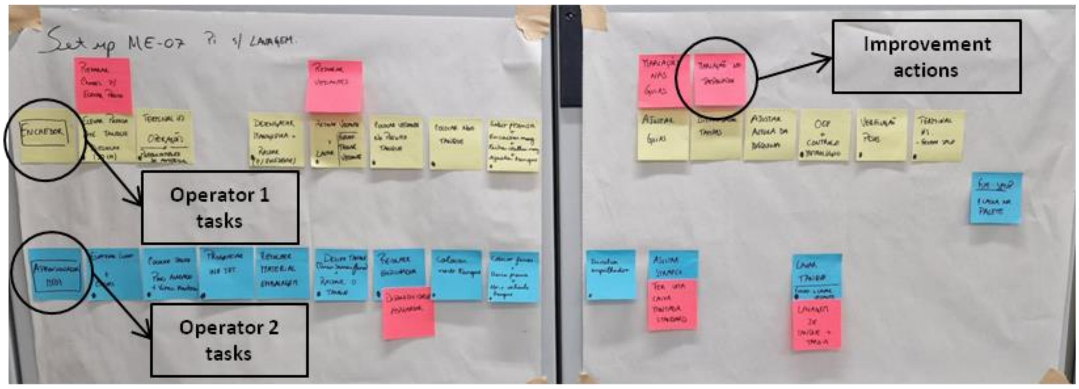

Figure 30 – Sequencing of the PI setup activities on the ME-07 machine

With the help of this mapping and by recording the duration of each task, it was possible to identify the most time-consuming tasks and the ideal time to perform them. In this way, the most time-consuming task was the tank washing and therefore it was considered as an external task, being performed at the end of the setup by one of the operators. During this analysis, improvement actions also emerged to facilitate and reduce the duration of some of the tasks considered as internal. These actions are:

- Repair of the structures that separate the tank from the press during the setup - these structures were inoperative and the operators simply waited for the tank to detach from the press;
- Purchase of an O-ring to seal the product at the moment of pressing - there is only one working O-ring, which means that it has to be washed between setups and the machine has to stop if it becomes inoperative;

- Identification of the machine's rails to facilitate adjustment when changing the size of the package - permanent identification so that the operator can see where he has to place the rails when changing the package;
- Preparation of a standard box of each model to facilitate the adjustment of the Strapex (box sealing equipment) - by placing a previously prepared model, the operator only has to use this model to adjust the height and width of the equipment.

The tasks were established in order to put the machine into operation as quickly as possible and therefore both operators should prioritize the tasks of replacing the tank and preparing the machine for the next filling, leaving the tasks of washing the previous tank to the end.

With this situation, after the setup has been carried out, one of the operators washes the previous tank and the other starts the filling process alone. As soon as the second operator has finished washing the tank, he goes to the machine to assist in the filling process.

Once the operational flow had been defined and the tasks had been separated, the next step was to elaborate the standard that define the tasks to be carried out, by whom and in what order, in order to eliminate the variability in the duration of the setups. A standard for the operation of the mobile tank washing machine was also created and training was given not only to the operators of ME-07, but to the whole team, as there are other tanks that can be washed by any operator in this machine. The main reason for the creation of this standard is related to safety issues in the use of the machine. These 2 standards created are the following:

- NT 18/23 – <u>Setup de PI ME-07</u> (Appendix G);
- NT 31/22 – <u>Lavagem de Tanques Móveis</u> (Appendix H).

To analyse in more specific manner the changes made in the PI type setup, some details of this activity are presented below. It is important to refer that this activity was performed by 2 operators, however the second operator was called only for the washing of the tank. With the definition of the optimal sequence of activities, the two operators are present in the setup since its beginning.

Firstly, the setup begins at the moment when the filling line is drained and then the operator designated as the "provisioner" transports the pallets of finished product to the respective area, while the operator designated as the " filling operator " starts the operation in the operating system and fills in the necessary documents. After these tasks, the provisioner carries out the programming of the inkjet for the next filling while the filling operator starts the removal of the tank from the press.

After the removal, the provisioner scrapes the used tank and places the remaining product in the new tank, while the filling operator removes the O'ring from the tank and washes it for use in the next filling. Subsequently, the provisioner picks up the forklift to place the tank in the press and the filling operator places the O'ring in the new tank.

The new tank is placed on the press by the forklift while the filling operator moves up the press and makes the necessary adjustments. Once the tank is properly positioned, the filling operator makes the adjustments on the machine if there is a change of packaging and the provisioner returns the forklift and makes the adjustments to Strapex. After these adjustments, the provisioner finally starts the process of washing the used tank and the filling operator starts the machine. From this moment on, the filling operator continues the filling process alone while the provisioner finishes the tank washing operation. Regarding the difficulty in washing the valve of the tanks due to the lack of a proper tool, a crimped steel cylinder wire brush was acquired which facilitated the task and allowed a better cleaning.

Thus, with the implementation of the described improvements, a reduction in the PI setup time of the machine was achieved. The graph in the Figure 31 presents the average duration of the PI setup in the first 5 months of 2023.

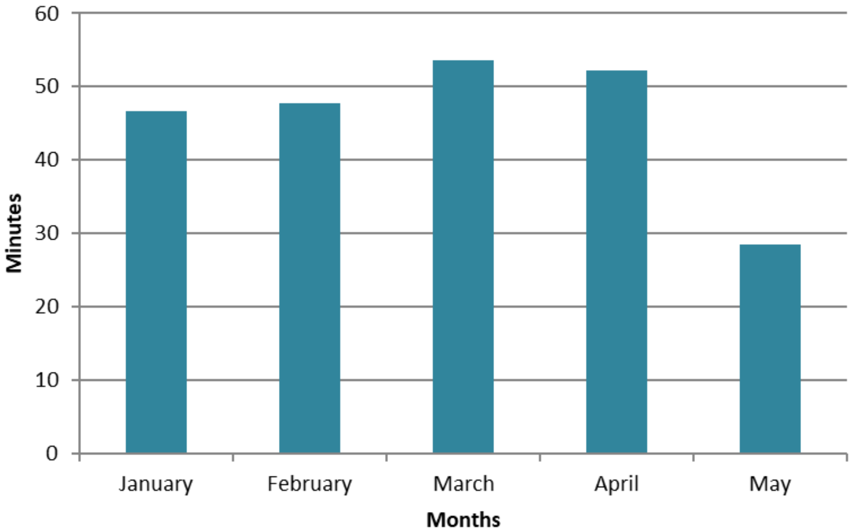

Figure 31 – Graph of the average duration of PI setups in the first 5 months of 2023

By analysing the graph, the average duration of PI setups in January, February, March, and April 2023 is about 50 minutes while the average duration of such setups in May of this year (the month from which the setup improvements were implemented) is about 29 minutes. There was then a 42% reduction in the PI setup duration at ME-07.

4.2.3 Performance

As mentioned before, the machine performance is impaired by the operator reducing the cadence. The operator reduces the machine's cadence in order to avoid stopping the machine and to have more control over the process. These situations are eliminated by having 2 operators in the filling process, since the tasks are equally divided between the operators, which gives more control over the process and allows the machine to run at higher cadences without stopping. The manipulation of machine parameters in problem solving was also mentioned as prejudicial to performance, however, with the presence of two people the occurrence of problems, such as spills, was reduced.

To evaluate the influence of the placement of two operators on the performance of the ME-07, the machine's cadences were measured before and after the placement of the 2 operators working together. The cadences were measured by counting the number of packages that were filled in 1 minute. In this way, with the register of the cadences, it was possible to obtain the performance. The performance values before and after the placement of the 2 operators in the ME-07 machine are shown in Table 5.

Table 5 - Records of the performance before and after the placement of two operators in the ME-07 filling machine

Product reference	Performance (Before)	Performance (After)	Theoretical Cadence
AAAAA XXXX Y4	42%	75%	19
	42%	65%	
	47%	82%	
AAAAA XXXX Y3	86%	96%	16
	72%	89%	
	68%	94%	

By analysing the table, there was a considerable increase in the value of the performance in the filling of products AAAAA XXXX Y4 and AAAAA XXXX Y3. It is important to note that no comparison was made with the filling of product BBBBB XXXX Z6, since no filling of this product was scheduled after the implementation of all improvements, which represented a constraint to the work developed.

The difference in the performance obtained when filling the product AAAAA XXXX Y4 was superior to when filling the product AAAAA XXXX Y3, since with this product the operator, when alone on the machine, performed a more drastic reduction in cadence as he had greater difficulty in keeping up with the speed of the machine due to the fact that the boxes he filled had less capacity and there was greater difficulty in emptying the edge of the line. With the 2 operators and the division of tasks this difficulty is overcome, and the machine's cadence can be increased.

4.3 ME-32

As mentioned in topic 3.2.3, the processes developed in the ME-32 filling machine present a lack of standardisation. It is important to create a standard for the operation of the machine, since there are processes, such as programming the scale weight, which have a set of more extensive steps and which only one of the machine operators has knowledge. The creation of standards for machine setups becomes important to reduce process variability and also to increase safety in task performance. The standards created are in Appendix I and are as follows:

- NT 33/22 – Funcionamento ME-32;
- NT 34/22 – Setup Embalagem ME-32;
- NT 07/23 – Setup de PIL ME-32;
- NT 24/23 – Lavagem do dispersor DP22.

Regarding the machine purging task, as previously mentioned, this was quite time consuming and very unergonomic, so it was subject to improvement actions. The process of filling the cans, transporting and emptying them into the tank to perform the purging, takes the operator an average of 30 minutes.

Then, it was suggested to directly connect the hose coming out of the tank to another input in the tank, in order to circulate the product until it comes out with the desired consistency. In this way, with the help of maintenance, an extension was made to one of the fixed tank pipes and a camlock was placed to fit the hose. Figure 32 shows the tube extension and the hose fitting location.

Figure 32 - Fixed tank pipe extension for purging in the ME-32 machine

With this implementation, to perform the purging, the operator only has to fit the hose on the tube that was extended, open the passage and activate the pumping of the product, which circulates from inside the tank to the hose and back to the tank. This activity has become much more ergonomic, much easier for the operator to perform and its duration is down to an average of 3 minutes, which means that there has been a 90% reduction in the average duration of this activity and a 27-minute reduction in the duration of the machine's PIL Setup. This change was later included in the NT 07/23 – Setup de PIL ME-32 standard.

In addition to the creation of the mentioned standards, a validation and cleaning checklist for the machine was developed to assist the operator in the tasks he has to perform at the beginning and ate the end of each shift and to help keep the workspace cleaner. This checklist can be found in Appendix J.

4.4 Productivity

As mentioned throughout this document, productivity is the most important indicator and is analysed every day. It was verified that placing 2 filling operators from sector C6 working together on the ME-07 machine brought great advantages in eliminating stoppages and increasing machine performance. However, it is necessary to evaluate the impacts of this situation on productivity.

Firstly, it is important to note that a productivity analysis was performed individually for each machine of the sector (ME-07 and ME-32), the litres filled by only 1 operator in ME-07 and ME-32 were recorded and according to the working hours the respective productivity was calculated. The same process was carried out for the case where 2 operators worked together: the litres filled by 2 people at ME-07 and ME-32 were recorded and, taking into account the hours available for filling these litres, the productivity of each machine was calculated.

Table 6 shows the average productivity values obtained in ME-07 with the presence of 1 and 2 operators in the filling. The values for filling with only 1 operator were obtained through the average of litres and filling hours from January to March 2023, while the values for filling with 2 operators were obtained in the months of April and May.

Table 6 – Average litres filled and productivity values in ME-07

ME-07				
Product	Litres filled		Productivity (litres/hour.man)	
	1 operator	2 operators	1 operator	2 operators
AAAAA XXXX Y4	749	1512	94	95
AAAAA XXXX Y3	494	1473	62	92

When filling the product AAAAA XXXX Y4, the difference in productivity between the two situations is minimal, given that with 2 operators the quantity of litres filled is about twice as high in twice the time compared with filling with just 1 operator. On the other hand, when filling the product AAAAA XXXX Y3 with 2 operators on the ME-07 machine there is a great increase in productivity compared to filling with 1 operator, with 3 times more litres filled in twice the time. The filling of the product BBBBB XXXX Z6 was not analysed because its production was not requested during the months of April and May.

The same study was carried out for the ME-32 filling machine, for the same periods of time as for the ME-07. The values are recorded in Table 7.

Table 7 - Average litres filled and productivity values in ME-07

ME-32				
Product	Litres filled		Productivity (litres/hour.man)	
	1 operator	2 operators	1 operator	2 operators
CCCCC VVVV QQ	2314	8400	289	600
DDDDD VVVV WW	1088	2500	136	156

In this situation there is a big difference in productivity between 1 operator and 2 operators. This situation is due to the fact that the operator responsible for the filling in this machine is also responsible for the product manufacturing, so he alternates his tasks between manufacturing and filling. When 2 operators are present, one is filling while the other prepares the manufacture of the next filling product never stopping the filling task. The difference between the 2 products is due to their volume. The CCCCCCC VVVV QQ product is filled in 25 litre cans and DDDDD VVVV WW in 2.5 litre cans, which makes the CCCCCCC VVVV QQ filling much quicker.

This analysis showed that the ME-32 machine has a greater contribution to the productivity values of the sector, since the filled cans have a higher capacity compared to those filled in the ME-07 machine.

It can also be concluded that, in addition to the benefits in the elimination of stoppages and in machine performance, placing 2 operators from the sector together in the filling machines also brings benefits in terms of productivity.

The weekly productivity values for sector C6 are not presented because it was not possible to perform a time-continuous analysis of the results from placing the 2 operators together on the machines. This situation was due to the lack of workload on the machines during the analysis period and was a limitation of the project.

4.5 Organization of the WIP area and the racks for the filling material

To proceed with the organisation of the space, the first task to be carried out was the definition of the zones for raw material and filling material. Thus, it was defined that the 2 racks represented on the left side and in the centre of Figure 33 would be for the filling material and the U-shaped racks and their centre space (represented on the right side of Figure 33) would be for storing the raw material.

Figure 33 - Racks for storing filling material and raw material

4.5.1 ABC analysis

To better organise the racks, it was necessary to define fixed positions for the filling materials in the ME-07. A floor level location for each product has been defined as mandatory, so that the operator does not have to use the forklift at any time and relies only on the hand pallet truck. Thus, an ABC analysis of all the materials used in the filling was performed in order to organise the respective racks.

Data was then collected from the beginning of 2022 until March 2023 and 2 criteria were applied for the classification of the materials, the frequency with which the material was required, and the quantity of material required.

In the frequency criterion, the materials that represented about 80% of the number of times required were classified as A, those representing about 15% as B and finally C those representing about 5%. The table with this classification can be found in Appendix K.

As for the criterion of required quantity, the materials that represented about 75% of the total required quantity were classified as A, B those that represented about 15% and C those that represented only 10%. The table with this classification is shown in Appendix L.

Thus, the materials classified as AA represented the materials most used and with the largest required quantity.

After the analysis, the organization of the 2 racks would be defined by the criterion of frequency with which each material was required, which means that the materials classified as A would be positioned closer to the machine and the materials classified as B further apart, but all at floor level. Those classified as C are placed at higher levels, because they are requested infrequently. For A-rated products, a second location on higher levels was also defined, in order to store more. The replacement of materials from the top level to the floor level implies the use of a forklift and therefore the need to create a system to facilitate this replacement arose, which will be presented in the next subchapter.

The required quantity criterion emerged as an auxiliary criterion, in which the materials classified as AA, which is, materials that are used the most and in large quantities, are preferably stored at floor level in the rack behind the machine, since it is the rack closest to it. Figure 34 shows this rack after its organization.

Figure 34 - Rack located behind the ME-07 machine after its organization

In the area close to this rack, it is more difficult to handle the forklift, so it was decided that the upper levels would be set for materials classified as C and for other exceeding material, since these levels would be less requested.

Labels were prepared with all the references of the materials and placed with magnets in order to facilitate the change of their locations if necessary. An example of a label is shown in Figure 35.

Figure 35 - Example of a rack identification label

Figure 36 shows the situation of the other rack designated for the filling material, after the organisation process.

Figure 36 - Rack for the filling material after the organizing process

The most frequently used material is located closest to the machine in order to reduce the displacement of the operator, for example, the boxes are located near the edge of the line so that the operator can access them without having to move. A location for the pallets used in the filling has also been created.

The floor markings on the ME-07 machine were also redefined in order to make better use of the space and free up more locations in the racks. Figure 37 demonstrates the changes made, showing the situation before and after the redefinition of the floor markings.

Figure 37 - Situation before and after the floor markings refinement, respectively

One of the new markings has been defined for the storage of an A-rated product and the others for the material in current use during the filling.

4.5.2 Kanban System

As mentioned in the previous subchapter, there is a need to create a system that facilitates the process of replenishing materials from the top level to the floor level. In this way, whenever the filling operator uses all of a material that is at the floor level, it needs to be replenished so that it can be accessed with the hand pallet truck whenever necessary.

To facilitate this process, a Kanban system was created, consisting in a set of cards with the reference of the materials in the racks. These cards had a green side with the material code and a red side which indicated the order for the replacement of that same material. Figure 38 presents an example of a Kanban developed.

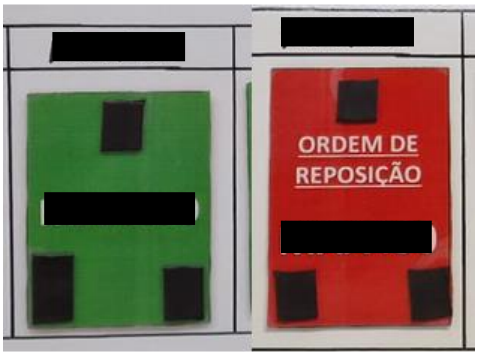

Figure 38 - Example of Kanban cards developed

With the existence of these Kanban, whenever the ME-07 operator uses the material on the floor level, he turns the card with the respective reference to the red side. Thus, the factory logistic operator is signalled and knows that he has to replenish the material on the floor level. In this way, the replenishment is done during filling and the ME-07 operator always has material available that he can access with the hand pallet truck.

These Kanbans were placed in a board affixed to the rack in order to be visible to the logistic operator and practical for the ME-07 operator. The Figure 39 presents the Kanban board realized.

Figure 39 – Kanban board

This board also allows the logistics operator to be informed of the need to supply pallets for filling, and to indicate the need to transport the finished product.

A standard was prepared with the location of all the materials on the racks and with an explanation of how the Kanban board works (Appendix M). Once the standard was developed, training was given to the respective operators.

4.6 Overall results

Throughout this project, the evolution of the OEE indicator of the ME-07 filling machine and the productivity of the C6 sector were recorded, being these the 2 most important indicators to be analysed.

4.6.1 OEE indicator

Regarding the OEE indicator, it is important to report the evolution of the machine's availability, of its unscheduled stoppages and the duration of the PI setups, as well as the evolution of its performance.

The unscheduled stoppages of the ME-07 suffered a great reduction as shown in Figure 40, where is present the graph of time distribution of this machine before and after the implemented improvements. The analysis period in both cases was 2 months, January, and February for the situation before the improvements and April and May for the situation after the improvements.

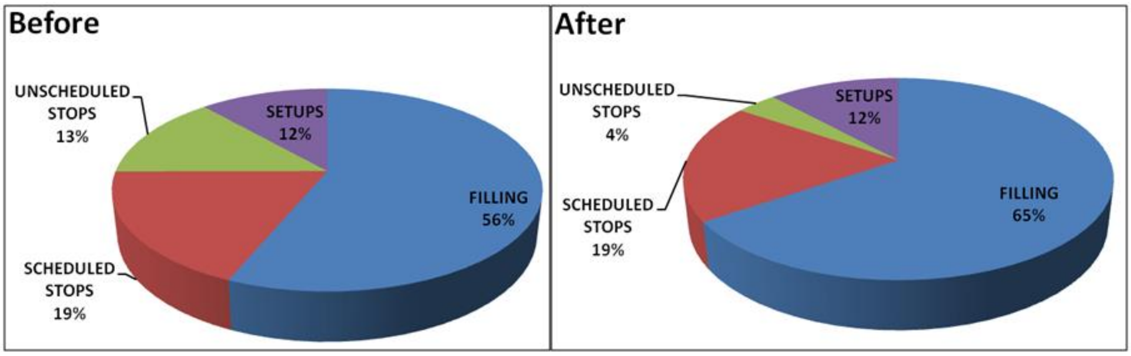

Figure 40 – Graphs of time distribution on ME-07 machine before and after the improvements

By analysing the two graphs it is possible to conclude that there was a 9% reduction in the time related to the machine's unscheduled stoppages, which resulted in an increase in the time available for filling. In the graph of the "after" situation, the percentage relative to the setups remained unchanged since the implementation period of the improvements in the setup corresponded only to the month of May, being this percentage influenced by the longer setups in April.

The evolution of the average duration of the PI setups in the ME-07 machine is presented in the graphic of the Figure 31 in subchapter 4.2.2. However, due to the high variability of registers, the different nature of the products and the possibility of anomalies, the average is not an accurate indicator for the analysis of this evolution. Therefore, a boxplot graph was developed, represented in Figure 41, which supports the analysis of this evolution.

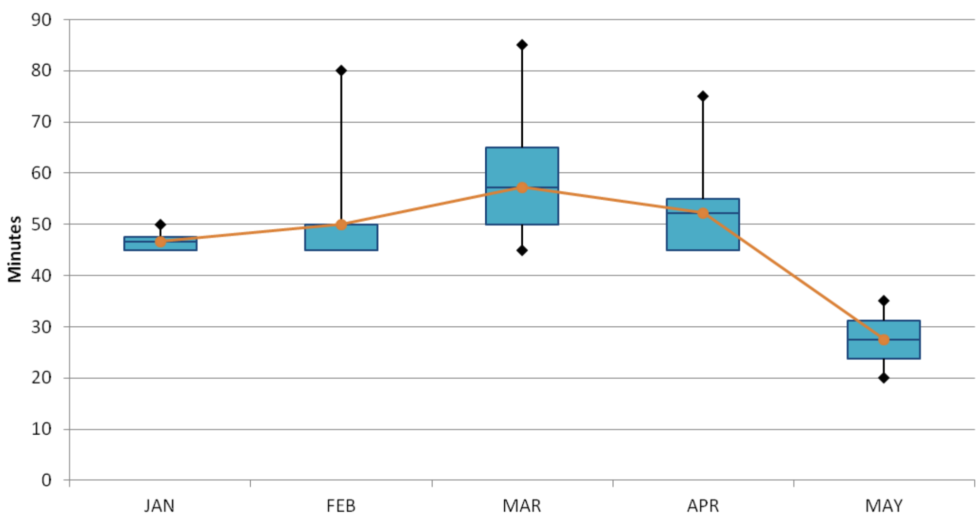

Figure 41 – Boxplot chart with the evolution in PI setup duration

By the analysis of the graph, it is possible to infer that besides the remarkable reduction of the average duration of the PI setups, it was obtained a great reduction of the variability in the month of May due to the implementation of the setup standard.

The availability of the machine suffered alterations and its evolution is present in the graphic of the Figure 42.

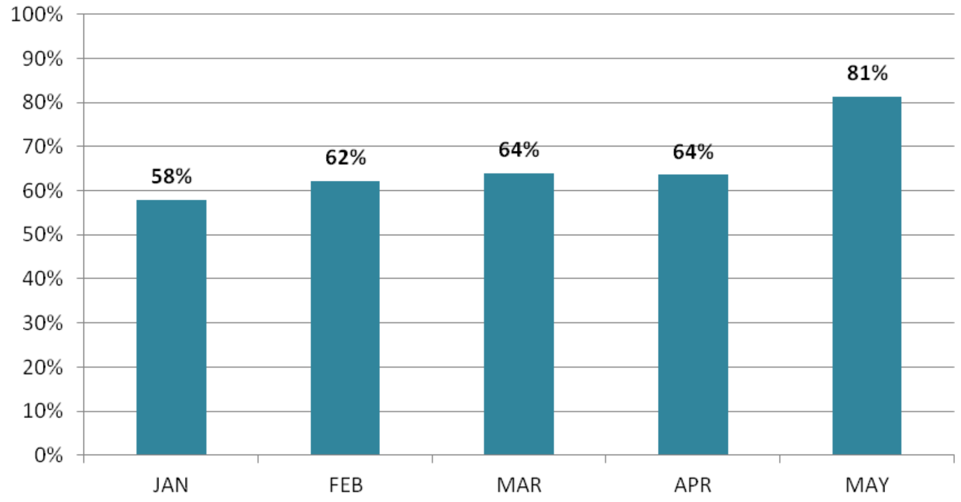

Figure 42 – Evolution of the availability from January through May 2023

The graph shows an increase in the average availability value in May, reaching a total of 81%. In this month it is possible to verify the impact of the improvements referred in chapter 4 regarding the stoppages and setups that caused the increase of the machine availability. In the month of April only the improvements referring to the stoppages were in course, however there was no increase in the availability in this month because there were atypical problems that influenced this indicator, like inkjet problems and delays in packaging material from the supplier.

In relation to machine performance, the graph in Figure 43 shows its evolution.

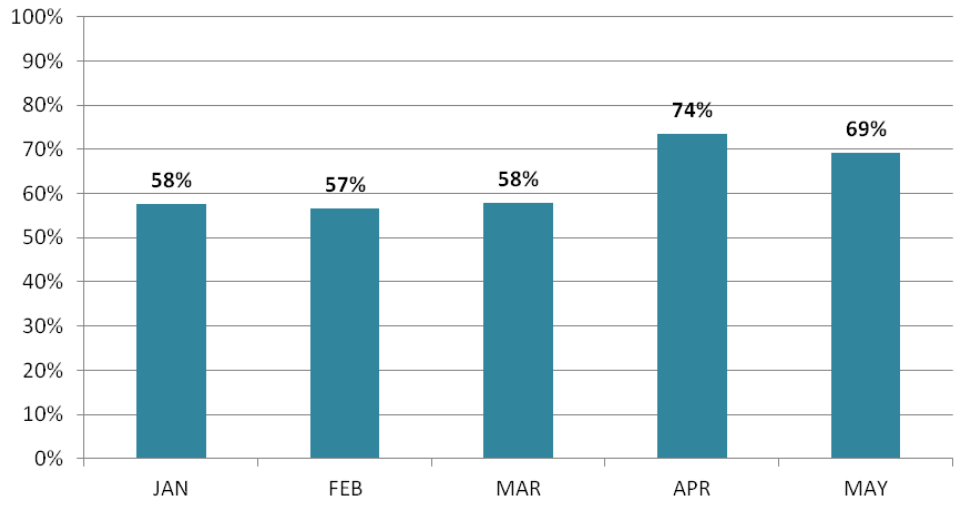

Figure 43 – Evolution of the performance from January and May

By analysing the graph, it can be seen that in the months corresponding to the implementation of improvements, the performance values are higher than those recorded in other months, proving the impact of these improvements. The average value of performance in April (74%)

is higher than in May (69%), this is due to the fact that in May has been applied the sequencing of activities of the setup that made the washing of the mobile tank later and implied the operation of the machine with only 1 operator during this same washing. Although the operating time of the machine with only 1 operator was reduced, it was enough to cause an impact on its performance.

Thus, the evolution of the average of the overall OEE indicator can be presented in the graph of Figure 44.

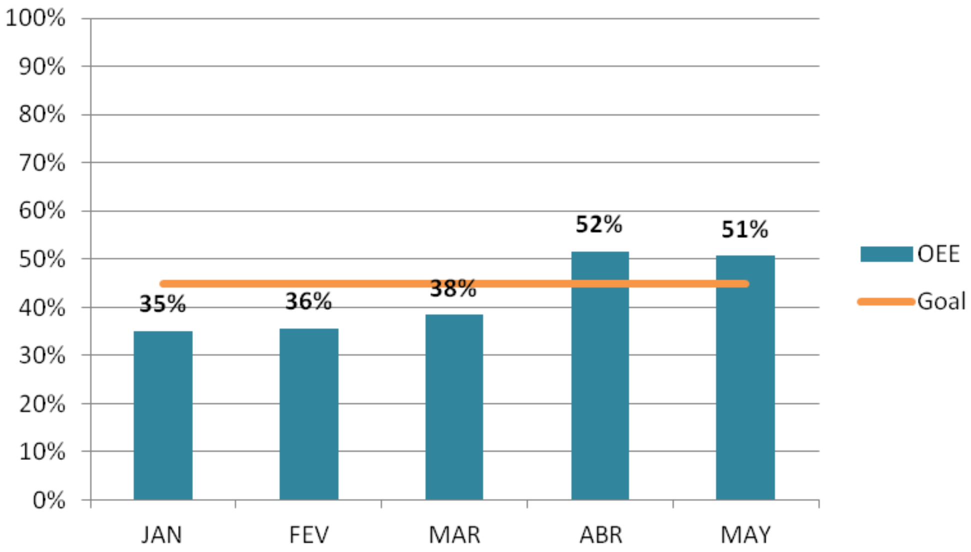

Figure 44 – Average values of the OEE indicator from January through May 2023

The graph shows that in April and May the objective of 45% for the OEE indicator was reached and even exceeded, making it possible to infer that the improvements implemented had a positive effect on the average for this indicator.

4.6.2 Productivity

It was not possible to analyse the weekly productivity of the sector continuously due to the lack of workload on the machines during the dissertation period. With this limitation, an analysis of the different possible scenarios that could be addressed in sector C6 was carried out, in which productivity was determined and the respective cost calculated for each one of them. These scenarios were drawn up based on the annual demand for the products that are filled in sector C6.

It is important in a first stage to present the data that served as a basis for this analysis. Then, using the data from the previous year (2022), it was possible to determine the annual demand for each product filled in the sector. With this information it was also possible to calculate the litres that need to be filled in each of the machines annually and weekly. Table 8 shows all this information.

Table 8 – Annual and weekly demand of litres in each machine

	Annual demand (litres)	Weekly demand (litres)
ME-07	130224	2713
ME-32	228650	4764

The table shows that more litres are required in the ME-32 than in the ME-07, since the products filled in the ME-32 have more litre volume compared to the ones filled in the ME-07.

The average values of litres filled per day in each of the machines with the presence of 1 and 2 operators were calculated, in the same way explained in subchapter 4.4. Table 9 presents these values.

Table 9 – Average litres filled per day by 1 and 2 operators on each machine

	Average amount of litres filled per day	
	1 operator	**2 operators**
ME-07	688	1512
ME-32	1854	5450

Using this data, the following scenarios were then analysed:

- Scenario 1: Filling with 1 operator in each machine;
- Scenario 2: Filling with 2 operators in each machine;
- Scenario 3: Filling with 2 operators in the ME-07 and 1 operator in the ME-32;
- Scenario 4: Filling with 1 operator in the ME-07 and 2 operators in the ME-32.

For each of the scenarios it was determined how many days per week each of the machines would have to work in order to meet the respective weekly demand. Once the number of days each machine will work per week is defined, it is possible to determine the litres filled in each scenario and the hours spent filling them each week. With the total number of litres filled and the total number of hours spent filling these litres, it is possible to calculate the weekly productivity in each scenario. Table 10 shows all the values for each of the scenarios under analysis.

Table 10 – Weekly analysis of the different scenarios

		ME-07	**ME-32**	**Total**	**Productivity (l/h.m)**
Scenario 1	**Filling days in a week**	4	3	7	**148**
	Litres filled in a week	2752	5562	8314	
	Working hours in a week	32	24	56	
Scenario 2	**Filling days in a week**	2	1	3	**177**
	Litres filled in a week	3024	5450	8474	
	Working hours in a week	32	16	48	
Scenario 3	**Filling days in a week**	2	3	5	153
	Litres filled in a week	3024	5562	8586	
	Working hours in a week	32	24	56	
Scenario 4	**Filling days in a week**	4	1	5	171
	Litres filled in a week	2752	5450	8202	
	Working hours in a week	32	16	48	

Analysing the data in the table, scenario 2 presents the highest weekly productivity index. This scenario corresponds to the placement of 2 operators in the same machine and indicates that to satisfy the weekly demand, ME-07 needs to fill 2 days per week and ME-32 only 1 day. This scenario reaches a productivity of 177 litres/hour.man, representing an improvement of about 19.6% when compared to the worst-case scenario, scenario 1, which represents the current situation where the operators work individually.

Considering the days that the machines work in each scenario, the number of days that the machines need to work during the year to satisfy the respective annual demand was also determined. The litres filled in that period and the hours available for filling those litres in each scenario were calculated. Table 11 shows this data as well as the productivity obtained in each scenario.

Table 11 – Annual analysis of the different scenarios

		ME-07	ME-32	Total	Productivity (l/h.m)
Scenario 1	**Filling days in a year**	190	124	314	**144**
	Litres filled in a year	130720	229896	360616	
	Working hours in a year	1520	992	2512	
Scenario 2	**Filling days in a year**	87	42	129	**175**
	Litres filled in a year	131544	228900	360444	
	Working hours in a year	1392	672	2064	
Scenario 3	**Filling days in a year**	87	124	211	152
	Litres filled in a year	131544	229896	361440	
	Working hours in a year	1392	992	2384	
Scenario 4	**Filling days in a year**	190	42	232	164
	Litres filled in a year	130720	228900	359620	
	Working hours in a year	1520	672	2192	

Again, scenario 2 presents a higher productivity value than the others, where ME-07 would work 87 days of the year, twice a week (43 weeks and 1 day) and ME-32 would work 42 days of the year, once a week.

In this way, the necessary litres are filled to satisfy the weekly demand without creating stock storage problems and the annual demand is also fulfilled with a productivity value above the established goal of 150 l/h.m.

In addition to the productivity analysis, a cost analysis was carried out for each scenario. In Table 12 the work centre cost, which corresponds to the hourly cost of running the machine, and the cost of each operator per hour were recorded.

Table 12 – Cost of each machine's work centre and cost per operator

	Work center cost (€/h)	Cost per operator (€/h)
ME-07	51.75	7.50
ME-32	34.50	

With this data, as well as the number of days that each machine is working during the year and the information regarding the number of hours spent by each worker on filling, it was possible to determine the costs associated with each one of the scenarios. These costs are shown in Table 13.

Table 13 – Cost analysis of the different scenarios

		ME-07	ME-32	Total
Scenario 1	**Filling days in a year**	190	124	314
	Annual cost (€)	90060	41664	**131724**
Scenario 2	**Filling days in a year**	87	42	129
	Annual cost (€)	46458	16632	**63090**
Scenario 3	**Filling days in a year**	87	124	211
	Annual cost (€)	46458	41664	88122
Scenario 4	**Filling days in a year**	190	42	232
	Annual cost (€)	90060	16632	106692

Analysing the table, it can be seen that scenario 2 presents the lowest annual cost of all the scenarios, in contrast to scenario 1 which presents the highest cost. The difference between the 2 scenarios is around 68634 euros per year, where scenario 2 presents a reduction of around 52.1% compared to scenario 1, the scenario of the current situation.

The analysis of these results leads to the conclusion that the placement of 2 operators on both machines allows the established productivity objective to be achieved for sector C6, meeting the weekly demand for the products, without the creation of storage problems and at the lowest possible cost. Thus, with all these advantages and the benefits for the OEE indicator of the ME-07, it can be concluded that the placement of 2 operators on the same machine is very advantageous.

5 Conclusions and future work

As mentioned in the initial phase of this project, the application of Lean tools along with continuous improvement play a fundamental role in increasing productivity and in various aspects of the business environment, promoting the elimination of waste, the optimisation of processes, the involvement of employees and the increase in operational efficiency. This project, based on the application of these concepts in a business environment, confirms their effectiveness and the importance of maintaining the practices applied so far in order to remain competitive in the market and meet customer demands.

This project arose from the expansion of the continuous improvement project to CIN's mortar and bitumen production unit, and its main objectives were to increase the sector's productivity, to increase the OEE indicator of the ME-07 filling machine and to standardise tasks.

Thus, the project began with an analysis of all the processes, in order to understand how the sector worked and identify the inherent problems and wastes. The most relevant problems identified in the sector were associated with the lack of process standardisation, which led to a high variability of the processes and to tasks being carried out with less safety. They were also associated with the lack of knowledge of the constraints of the sector's filling machines, the high setup times of the ME-07, its reduced availability due to the high number of stops and low performance levels. The disorganisation present in the racks and in the storage space for raw materials and filling products also revealed to be an important problem to be solved in order to improve the availability of the filling machines and to facilitate access and storage of the necessary items. Finally, the analysis regarding the distribution of the two filling operators by the machines of the sector also revealed to be very important, as it allowed to identify the best scenario to increase the productivity of the sector and at the same time fight problems affecting the availability and performance of ME-07.

Regarding the increase of the OEE indicator, this objective proved to be quite challenging to achieve, because it was necessary to fully monitor the operation of the machine to analyse the status of the current situation, the dedication of the operators for the correct filling of the OEE record sheets and it was also necessary to explain in more detail to the operators how the indicator could be affected by their own actions performed during the filling process. The evolution of this indicator was monitored in daily meetings where the stops present during the filling, the quantity filled, the duration of the setups and the occurrence of eventual problems were discussed. These meetings made it possible to discuss the points to be improved and the sharing of ideas, contributing to the creation of a mentality to reach a common objective.

With the implemented measures it was verified that the objective of 45% established for the OEE indicator of the ME-07 machine was reached and even exceeded, registering an average of 52% in April and 51% in May. However, it is important in the future to ensure continuous monitoring of this indicator to ensure its continued growth.

Very positive results were obtained in terms of machine availability, reaching an average of 81% in May, resulting from the presence of two operators on the machine, the elimination of the need for the operator to travel, the organisation of racks for storing filling material and the reduction in the duration of setups.

The reduction of the setups duration through the SMED application was a challenging task but with very positive results. In this application the optimal sequence of tasks to be performed during the Setup was defined, as well as their distribution by the operators, which in an initial phase revealed some resistance by those involved in the process, who had their working method changed. After the explanation of the benefits of the new sequence and the creation of the standard with all the steps to be followed, there were very significant results in the reduction of the setups duration, with a decrease of 42%. In this sense, the monitoring of the process is a fundamental point to be developed in the future, since the need to change the established standard may arise as changes are implemented in the sector.

Regarding the performance of the machine, an average value of 74% was recorded in April and 69% in May, which once again confirms the positive impact of placing two operators on the machine and dividing the tasks during filling. The two operators working together during the filling process did not prove to be problematic and the adaptation proved to be quite easy. The performance of the machine proved to be an indicator that can be greatly influenced by the behaviour of the machine and the consistency of the product, since in some of the situations analysed the dosing of the product was carried out without any problem at the theoretical speed of the machine and in other situations the product spilled out of the can at the same speed. This situation was not analysed in depth during the project period due to lack of time; therefore, it becomes an interesting aspect to be analysed in a future work in order to enable the potential growth of the machine performance.

The ABC analysis of the filling materials proved to be relevant in the organisation of the racks and of the storage space for raw material and filling material, as it facilitated not only the tasks of the filling operator but also the tasks of the manufacturing operators. Before the shelves were put away, the obsolete material that was occupying important space that could be used to store material with more use was sorted. After tidying up, the standard with the defined locations was then created.

Finally, regarding the productivity of the sector, through the analysis of the different scenarios prepared, it was verified that in the scenario where the sector's operators worked together on the two filling machines, productivity reached the established weekly objective of 150 l/h.m. This scenario verified a 19.6% increase in productivity in relation to the sector's current scenario (1 operator on each machine) and a 52.1% reduction in the costs associated with filling. In this way, the placement of two operators working together in the machines is justified, since it allows reaching the productivity goal established for the sector and brings several benefits to the availability and performance of ME-07. It is important to mention that this data was obtained from an analysis based on the annual demand of the products, given the lack of load on the machines in the analysis period. Therefore, an interesting work for the future would be to put this scenario into practice continuously and prove the results obtained so far.

To conclude, it is possible to state that the implementation of these improvements, often simple and implemented using resources already existing in the company, revealed a very positive impact and allowed the objectives set at the beginning of the project to be reached. It is also important to highlight the professional and personal experience obtained by carrying out this project.

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APPENDIX

Appendix A – OEE Registry Sheet

CIN

REGISTO DE DESEMPENHO DE EQUIPAMENTO

Data: ______ / ______ / ______

Hora de Abertura: ____ : ____

Máquina: __________ **Hora de Fecho:** ____ : ____

Microparagens	**Nr Ocorrências**

	Qtd	Produto	Vol.	OE	Hora Inicio Enchimento	Hora Fim Enchimento	Tipo Setup	Setup Int.	Nº Operadores	Observações
1					:	:		☐		
2					:	:		☐		
3					:	:		☐		
4					:	:		☐		
5					:	:		☐		

Não Conformidades

Enchimento	Lata Danificada	Tampa/Bocal mal aplicado	Correção de Peso	Rótulo mal aplicado	Paletização
1					
2					
3					
4					
5					

08:00 5 10 15 20 25 **08:30** 35 40 45 50 55 **09:00** 5 10 15 20 25 **09:30** 35 40 45 50 55 **10:00** 5 10 15 20 25 **10:30** 35 40 45 50 55 **11:00** 5 10 15 20 25 **11:30** 35 40 45 50 55 **12:00** 5 10 15 20 25 **12:30**

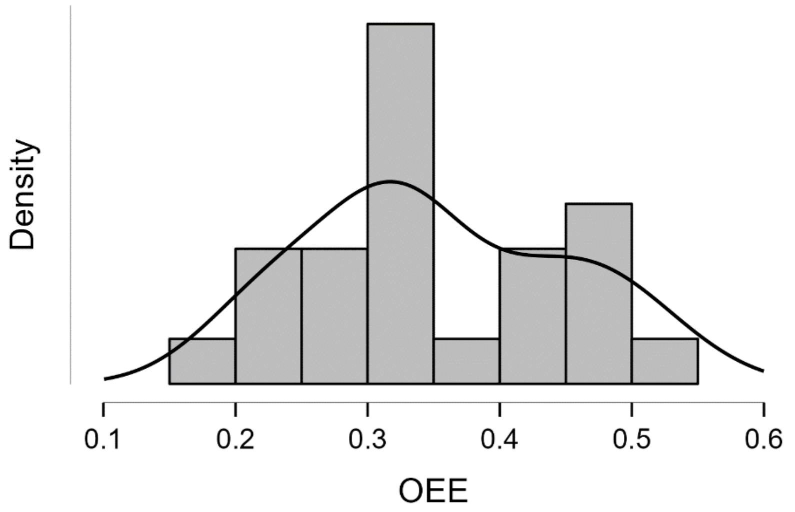
12:30 35 40 45 50 55 **13:00** 5 10 15 20 25 **13:30** 35 40 45 50 55 **14:00** 5 10 15 20 25 **14:30** 35 40 45 50 55 **15:00** 5 10 15 20 25 **15:30** 35 40 45 50 55 **16:00** 5 10 15 20 25 **16:30** 35 40 45 50 55 **17:00**

Appendix B – Normality test of daily OEE records during January and February 2023

Descriptive Statistics

	OEE
Valid	24
Missing	0
Mean	0.353
Std. Deviation	0.098
Skewness	0.250
Std. Error of Skewness	0.472
Kurtosis	-0.888
Std. Error of Kurtosis	0.918
Shapiro-Wilk	0.963
P-value of Shapiro-Wilk	0.491
Minimum	0.190
Maximum	0.540

Histogram



Appendix C - Normality test of daily productivity records for sector C6 during the first 13 weeks of 2023

Descriptive Statistics

	Litres/hour.man
Valid	36
Missing	0
Mean	146.135
Std. Deviation	89.250
Skewness	0.779
Std. Error of Skewness	0.393
Kurtosis	0.496
Std. Error of Kurtosis	0.768
Shapiro-Wilk	0.925
P-value of Shapiro-Wilk	0.018
Minimum	30.188
Maximum	405.000

Histogram

Appendix D – Mortar and bitumen manufacturing standards

CIN — **OPERAÇÃO FABRICO AUTOMÁTICO DE MASSAS**

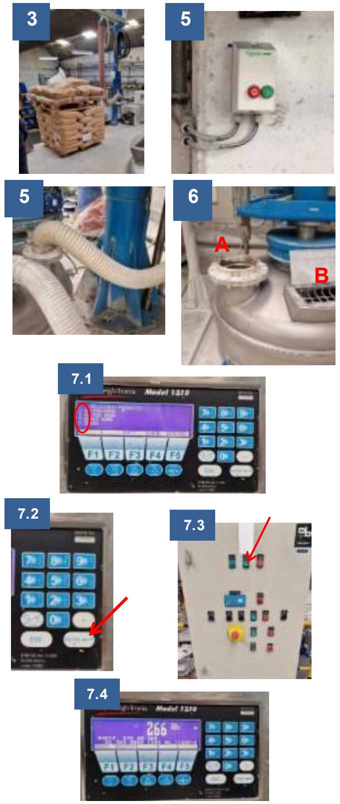
Responsável:	Operador fabrico automático	Setor:	C6	NT 35/22

RISCOS	EPIs
 - Sobre-esforços - Queda de objetos em altura - Queda de pessoas ao mesmo nível - Queda de pessoas em altura - Queda de carga em transporte - Choque contra objetos e/ou pessoas - Surdez - Projeção de líquidos - Projeção do manipulador - Inalação, absorção ou ingestão de substâncias perigosas - Entalamento - Corte - Esmagamento / Cisalhamento Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa	 NOTA: As luvas descartáveis são para utilizar na manipulação JFX20, JF105, JF109, JF110 e JMD98 assim como a máscara 3M-4279 e o avental e mangas Tyvek. A máscara 3M-4279 é para utilizar na manipulação do ZIX07 assim como o avental e mangas Tyvek. Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

Página 1/4	DATA: 25/05/2022	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

CIN — **OPERAÇÃO FABRICO AUTOMÁTICO DE MASSAS**

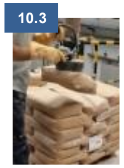
Responsável:	Operador fabrico automático	Setor:	C6	NT 35/22

Nº	Atividade	Fotografia
1	Recolher a ordem de fabrico da sala de comandos.	
2	A pesagem de matérias primas líquidas é realizada na zona das pesagens de C2. Ver norma **NT 16/21.** Os líquidos pesados são transportados pelo operador para a plataforma.	
3	Recolher a palete com as matérias primas sólidas e colocá-la na plataforma, junto ao dispersor onde o fabrico irá ocorrer.	
4	Iniciar operação fabrico no IFS.	
5	Ativar o sistema de extração e/ou ventilação da zona de trabalho e colocar o tubo de exaustão no dispersor.	
6	As operações no dispersor ocorrem de acordo com a folha da fórmula teórica. As matérias-primas líquidas são inseridas pela entrada "A" e as matérias-primas sólidas pela entrada "B".	
7	No doseamento automático: **7.1** Consultar o ecrã do painel e selecionar o produto que se pretende adicionar pressionando o número correspondente a esse produto; **7.2** Inserir a quantidade em Kg de produto a adicionar e pressionar o botão "Enter"; **7.3** Pressionar botão "Marcha Dosificador"; **7.4** Durante o doseamento é possível consultar o produto e a quantidade que está a ser dosificada do mesmo.	

Página 2/4	DATA: 25/05/2022	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

CIN — **OPERAÇÃO FABRICO AUTOMÁTICO DE MASSAS**

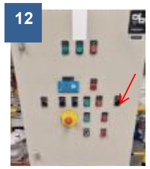
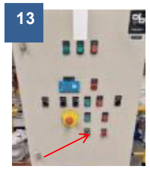
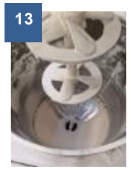
Responsável:	Operador fabrico automático	Setor:	C6	NT 35/22

Nº	Atividade	Fotografia
8	Ligar o agitador pressionando o botão "Marcha Agitador" e ligar o raspador pressionando o botão "Marcha Raspador".	 
9	Controlar a velocidade do agitador durante o fabrico (é possível consultar as RPM do agitador no quadro): **9.1** Aumentar a velocidade pressionando o botão "Subir Velocidade"; **9.2** Reduzir a velocidade pressionando o botão "Baixar Velocidade".	 
10	Na adição de sólidos em saco: **10.1** Colocar exaustão; **10.2** Colocar a tremonha de sólidos na boca do dispersor de forma a assistir a transferência de sacos; **10.3** Usar o manipulador de sacos para auxiliar o transporte dos sacos da palete para o dispersor; **10.4** Fazer um corte no saco com a faca; **10.5** Inserir a matéria -prima sólida no interior do dispersor.	   
11	Após o fabrico estar completo, parar o agitador e o raspador, pressionando os botões "Parar agitador" e "Parar raspador" respetivamente.	

DATA:	ELABORADO/REVISTO:	APROVADO:
25/05/2022	C. Carneiro, D. Santos	A. Mendonça, J. Teixeira

CIN — **OPERAÇÃO FABRICO AUTOMÁTICO DE MASSAS**

Responsável:	Operador fabrico automático	Setor:	C6	NT 35/22

Nº	Atividade	Fotografia
12	Subir dispersor pressionando o botão da figura e raspar o produto presente no agitador com o auxílio de uma pá.	 
13	Abrir válvula de ligação entre o dispersor e o tanque que se encontra por debaixo, de forma a passar todo o produto para o tanque inferior. Com a pá empurrar o produto das paredes do dispersor para baixo.	

DATA:	ELABORADO/REVISTO:	APROVADO:
25/05/2022	C. Carneiro, D. Santos	A. Mendonça, J. Teixeira

CIN — OPERAÇÃO FABRICO MANUAL DE MASSAS

Responsável:	Operador fabrico manual	Setor:	C6	NT 37/22

RISCOS	EPIs
	
- **Sobre-esforços** - **Queda de objetos e/ou pessoas em altura** - **Queda de pessoas ao mesmo nível** - **Queda de carga em transporte** - **Choque contra objetos e/ou pessoas** - **Surdez** - **Projeção de líquidos** - **Projeção de sólidos** - **Inalação, absorção ou ingestão de substâncias perigosas** - **Golpe / Decepamento** - **Corte** - **Enrolamento** - **Choque contra estruturas fixas** Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa	<u>**NOTA:**</u> As luvas descartáveis são para utilizar na manipulação JFX20, JF105, JF109, JF110 e JMD98 assim como a máscara 3M-4279 e o avental e mangas Tyvek. A máscara 3M-4279 é para utilizar também na manipulação do ZIX07 assim como o avental e mangas Tyvek. Cinto de segurança obrigatório na condução de empilhador. Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

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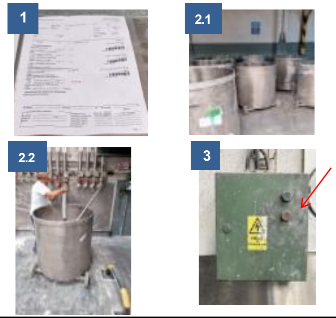
CIN — OPERAÇÃO FABRICO MANUAL DE MASSAS

Responsável:	Operador fabrico manual	Setor:	C6	NT 37/22

Nº	Atividade	Fotografia
1	Recolher a ordem de fabrico da sala de comandos.	
2	A pesagem de matéria primas líquidas é realizada na zona das pesagens de C2. Ver norma **NT 16/21.** No caso de pesagem de resina em Bulk (cód. BWXXX BK): **2.1** Recolher tanque da zona de armazenamento de tanques. **2.2** Realizar a pesagem na balança de enchimento de cubos com o auxílio do tanque.	
3	Ligar extração.	
	1ª PARTE FABRICO	
4	Abrir operação fabrico manual no IFS.	
5	Retirar tanque de lavagem (ZIX28 + 01000) e colocá-lo encostado à parede coberto com plástico. Para subir o dispersor é necessário pressionar o botão representado na figura.	
6	Colocar tanque móvel no dispersor, verificar se está bem fixo e garantir que os sensores estão bem colocados.	
7	Baixar o dispersor, rodando o indicador assinalado na figura, e verificar se o mesmo está centrado.	
8	Iniciar dispersor e raspador, pressionando os botões da figura: **8.1** Ligar dispersor. **8.2** Ligar raspador. **Nota:** Sempre que se ligar o dispersor e o raspador, verificar se estes se encontram na velocidade mínima. Estes devem arrancar na velocidade mais baixa.	

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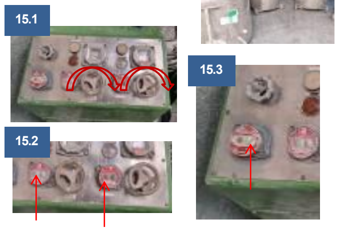
CIN — **OPERAÇÃO FABRICO MANUAL DE MASSAS**

Responsável:	Operador fabrico manual	Setor:	C6	NT 37/22

Nº	Atividade	Fotografia
9	Ajustar velocidade do dispersor e do raspador (rodar o indicador para a esquerda para aumentar a velocidade e para a direita para diminuir) : **9.1** Controlar velocidade do dispersor **9.2** Controlar velocidade do raspador	
10	Inserir as matérias primas no tanque de acordo com a sequência e instruções mencionadas. Preencher a ordem de fabrico de acordo com o estipulado na norma **NT 01/18**. **Nota:** No caso da matéria prima BWXXX BK, colocar cinta no tanque e recorrer ao empilhador para a sua inserção. Com o auxílio de uma pá e de uma escada, empurrar o material que ficar no fundo do tanque.	
11	À medida que as matérias primas são adicionadas deve-se ajustar a velocidade do dispersor e do raspador.	
12	Lavar a mangueira e a tubagem respetiva à matéria prima BWXXX BK.	
13	Lavar o tanque respetivo à matéria prima BWXXX BK com a mangueira na zona de lavagem.	
14	Colocar o tanque respetivo à matéria prima BWXXX BK no local destinado após a sua lavagem.	
15	Reduzir a velocidade do dispersor e do raspador até estes pararem, desligar os mesmos e subir dispersor. **15.1** Reduzir velocidade do dispersor e do raspador. **15.2** Desligar dispersor e raspador. **15.3** Subir dispersor.	

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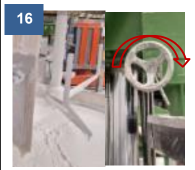
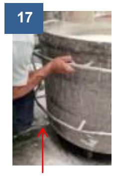
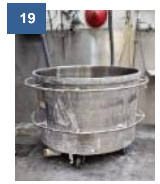
CIN — **OPERAÇÃO FABRICO MANUAL DE MASSAS**

Responsável:	Operador fabrico manual	Setor:	C6	NT 37/22

Nº	Atividade	Fotografia
16	Raspar o material das paredes laterais do tanque, do raspador das paredes do tanque e da hélice do dispersor com uma espátula de forma a uniformizar toda a mistura. Para facilitar a limpeza do raspador das paredes do tanque, é possível afastá-lo da parede rodando o indicador da figura. **NOTA:** Procedimento sempre com dispersor parado.	
17	Retirar o tanque móvel debaixo do dispersor, pressionando com o pé a alavanca demonstrada na figura.	
18	Colocar tanque de lavagem (ZIX28 + 01000) e baixar dispersor.	
19	Pesar o tanque móvel com o fabrico na zona de pesagem de líquidos.	
20	Transportar 2 tanques móveis vazios da zona de armazenamento de tanques na ME-07 para a zona de pesagem de líquidos. **Nota:** Fechar as válvulas dos tanques.	
21	Vazar 1/3 do produto existente no tanque móvel com fabrico para os outros 2 tanques vazios. Utilizar sempre a cinta na elevação dos tanques.	
22	Após dividir o fabrico pelos três tanques de forma igual, é necessário plastificar os tanques exceto aquele cuja 2ª parte do fabrico será iniciada em primeiro lugar.	

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CIN

OPERAÇÃO FABRICO MANUAL DE MASSAS

Responsável:	Operador fabrico manual	Setor:	C6	NT 37/22

Nº	Atividade	Fotografia
	2ª PARTE FABRICO	
23	Transportar os 3 tanques móveis com produto para a zona de fabrico.	
24	Subir dispersor, retirar tanque de lavagem (ZIX28 + 01000) e colocá-lo encostado à parede coberto com plástico.	
25	Colocar o tanque móvel (a ser usado em primeiro lugar) e baixar o dispersor. Se necessário aproximar o raspador das paredes laterais rodando o indicador da figura.	
26	Ligar dispersor e raspador e controlar a sua velocidade, tal como explicado nos passos 8 e 9.	
27	Inserir as matérias primas no tanque de acordo com a sequência e instruções mencionadas. Preencher a ordem de fabrico de acordo com o estipulado na norma **NT 01/18**. **Nota:** Para adição de sólidos em saco, recorrer à utilização do suporte para a inserção. Após a sua finalização, guardar o suporte no local adequado.	
28	À medida que as matérias primas são adicionadas deve-se ajustar a velocidade do dispersor e do raspador.	
29	Durante o fabrico, sempre que seja necessário raspar/limpar as hélices do dispersor, o raspador da parede lateral do tanque ou as próprias paredes do tanque com a espátula, é obrigatório ter o **dispersor completamente parado**. Para proceder à tarefa de raspagem/limpeza em primeiro lugar deve-se **parar completamente o dispersor** e de seguida subir o tampo do mesmo.	

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CIN

OPERAÇÃO FABRICO MANUAL DE MASSAS

Responsável:	Operador fabrico manual	Setor:	C6	NT 37/22

Nº	Atividade	Fotografia
30	No fim do fabrico retirar a amostra necessária e entregar a mesma no laboratório.	
31	Antes de retirar o tanque, raspar a hélice e o raspador das paredes do tanque com uma espátula de forma a aproveitar a maior quantidade de produto possível.	
32	Retirar o tanque móvel debaixo do dispersor.	
33	Colocar plástico no tanque encostado ao produto para ser usado na prensa da ME-07 e cobrir o tanque com plástico por cima.	
34	Sangrar o tanque para o interior do tanque a ser usado no fabrico seguinte.	
35	Lavar a válvula do tanque na zona de lavagem com a mangueira.	
36	Colocar o tanque na zona de tanques da ME-07.	
37	Proceder ao fabrico nos restantes tanques, repetindo os passos 25 e seguintes. **Nota:** Após o fabrico no último tanque, colocar no dispersor o tanque de lavagem (ZIX28 + 01000) e baixar dispersor.	
38	Fechar operação fabrico manual no IFS.	

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Appendix E - Liquid weighing standard

CIN — **PESAGEM DE LÍQUIDOS**

Responsável:	Operador Fabrico	Setor:	C2	NT 16/21

RISCOS	EPIs
ATENÇÃO - **Sobre-esforços** - **Queda de objetos em altura** - **Queda de pessoas ao mesmo nível** - **Choque contra objetos e/ou pessoas** - **Surdez** - **Entalamento** - **Projeção de líquidos** - **Inalação, absorção ou ingestão de substâncias perigosas** Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa	Pesagem de líquidos  Pesagem de Biocidas, Dispersantes e Amoníaco (JFX20, JF105, JF109, JF110 e JMD98, ZIX07)  <u>NOTA:</u> As luvas descartáveis são para utilizar na manipulação JFX20, JF105, JF109, JF110 e JMD98 assim como a máscara 3M-4279 e o avental e mangas Tyvek. A máscara 3M-4279 é para utilizar na manipulação do ZIX07 assim como o avental e mangas Tyvek. Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

Página 1/6	DATA: 26/05/2023	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

CIN — **PESAGEM DE LÍQUIDOS**

Responsável:	Operador Fabrico	Setor:	C2	NT 16/21

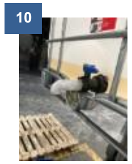
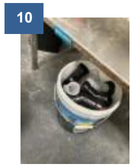
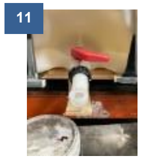
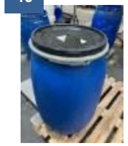
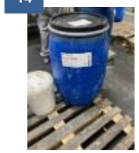
Nº	Atividade
1	Recolher a ordem de fabrico e fórmula teórica.
2	Iniciar operação de pesagem no IFS.
3	Iniciar registo na balança. Em caso de dúvida consultar **NT 30/18**.
4	Após identificar a matéria prima a pesar, recolher os recipientes (barricas e baldes de vários tamanhos) necessários para a pesagem da primeira matéria prima e colocá-los junto à balança. Nota: Um balde ou barrica não deve ser usado para a pesagem de matérias primas diferentes, é possível identificar o correto a usar através da etiqueta da pesagem anterior.
5	Recolher as paletes necessárias para a pesagem e colocá-las junto à balança.
6	Recolher a matéria prima. Sempre que necessário consultar a lista de localizações. **Nota**: Em caso de necessidade de JAE85, JMD15, JMD34, JTE65, JT035, verificar se há maquia disponível na zona das maquias na estante. Se existir, gastar essa quantidade primeiro e de seguida, se necessário, usar o recipiente da estante.
7	Após colocar a cinta, posicionar o empilhador de forma a verter a matéria prima para a barrica. As marcações no chão servem de auxílio. Nota: Em caso de dúvida ou de utilização de outras formas de acondicionamento consultar secção "Transferência de matéria prima".
8	Colocar uma barrica/balde vazio na balança.
9	Inserir dados para a pesagem na balança. Em caso de dúvida consultar **NT 30/18**.

Fotografia

Página 2/6	DATA: 26/05/2023	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

CIN — **PESAGEM DE LÍQUIDOS**

Responsável:	Operador Fabrico	Setor:	C2	NT 16/21

Nº	Atividade	Fotografia
10	Rodar curva para baixo e abrir a torneira. Caso o IBC não contenha curva, retirar uma curva do balde e colocar no IBC.	10  10 
11	Quando o peso for atingido, fechar a torneira e virar a curva para cima. Nota: Durante a transferência da matéria prima para a barrica/balde, sempre que possível, antecipar a recolha de barricas para as pesagens seguintes.	11  13 
12	No caso da ordem de fabrico que está a ser pesada ter mais que uma misturada, retirar o recipiente pesado da balança e repetir os passos 8, 10 e 11. Se possível, realizar o passo 13, 14 e 15 durante a espera da pesagem da matéria prima.	
13	Colocar a tampa na barrica/balde.	14  15 
14	Acondicionar a barrica pesada na palete.	
15	Etiquetar a barrica.	
16	Preencher a ordem de fabrico de acordo com o estipulado na **NT 01/18**.	16  17 
17	Devolver a matéria prima à localização, colocando novamente no sítio devido. Caso a MP pesada tenha sido JAE85, JMD15, JMD34, JTE65, JT035, e a quantidade remanescente for igual ou inferior a 100kg, transferir para uma barrica e colocar na zona de maquias na estante.	

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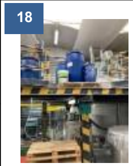
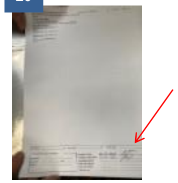
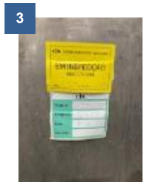
CIN — **PESAGEM DE LÍQUIDOS**

Responsável:	Operador Fabrico	Setor:	C2	NT 16/21

Nº	Atividade	Fotografia
18	Se a pesagem estiver concluída, recolher as matérias primas sólidas necessárias e juntar à palete e colocar as paletes na zona de espera de fabricos. Caso contrário, proceder para a pesagem da próxima matéria prima.	18  19 
19	Recolher aproveitamentos indicados na SO, caso existam. Ver **NT 01/23 – Gestão de Aproveitamentos**.	
20	No fim das pesagens, assinalar a data de início da pesagem e a data de fim da mesma e assinar.	20 
21	Finalizar operação pesagem IFS.	
22	Entregar ordem de fabrico ao responsável da sala de controlo.	
	Pesagem para fabrico manual	
0	Caso a pesagem seja realizada para o fabrico manual antes de realizar o passo 20 proceder à pesagem da primeira matéria prima a ser inserida no fabrico manual.	1  2 
1	Recolher tanque móvel.	
2	Usando a balança apropriada (BA 31 D ou BA 20 D) pesar a quantidade necessária da matéria prima.	
3	Etiquetar tanque móvel.	2  3 
4	Finalizar operação pesagem IFS	
5	Prosseguir com o fabrico manual, ver **NT 17/21**.	

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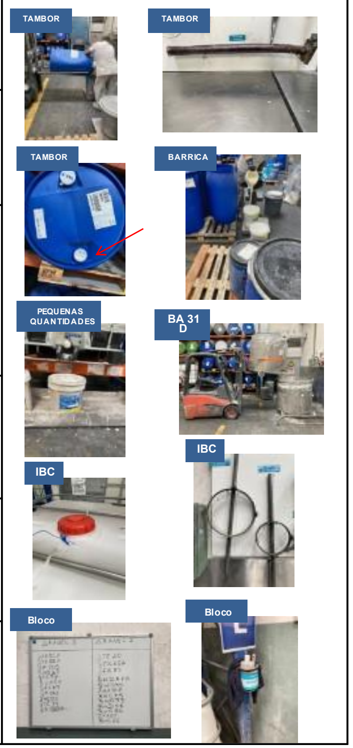
CIN — PESAGEM DE LÍQUIDOS

Responsável:	Operador Fabrico	Setor:	C2	NT 16/21

Acondicionamento	Atividade	Fotografia
Transferência de Matérias primas		
Tambor	Com o empilhador, posicionar o tambor junto ao recipiente na balança. Utilizando a chave de abrir tambores retirar a tampa indicada na imagem.	
Barricas	Colocar um plástico entre a barrica e o recipiente onde será pesado e utilizando um balde apropriado, transferir a quantidade desejada.	
Pequenas quantidades	No caso de a pesagem ser de pequenas quantidades e a matéria prima se encontrar no primeiro nível, utilizando o balde que se encontra junto à matéria prima, recolher a quantidade necessária, sem retirar o IBC da localização. Transferir do balde para o recipiente onde se pretende pesar.	
BA 31 D	BA 31 D - pesagem de tanques móveis, IBCs ou de pesos elevados.	
IBC	Abertura de um IBC novo: utilizando a chave de abrir IBCs, retirar a tampa na parte superior do IBC.	
Bloco	Caso a matéria prima se encontre armazenada num bloco verificar o quadro dos blocos. Sempre que um IBC seja removido ou acrescentado ao bloco o quadro deve ser atualizado.	

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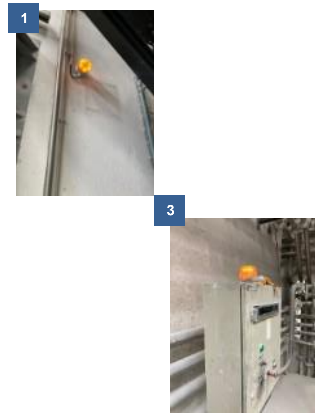
CIN — PESAGEM DE LÍQUIDOS

Responsável:	Operador Fabrico	Setor:	C2	NT 16/21

Nº	Atividade	Fotografia
Fabrico automático		
0	Ao longo das pesagens poderá ser necessário abastecer os dispersores de fabrico automático.	
1	Ao longo do fabrico, sempre que é necessário abastecer manualmente o dispersor o alarme aciona.	
2	Assim que possível, as pesagens devem ser interrompidas de forma a proceder à adição da matéria prima necessária.	
3	Para identificar com facilidade o dispersor que necessita de assistência, a lâmpada junto ao ecrã do dispersor acende.	

Nota:
1. Caso os IBCs fiquem vazios, ou as embalagens em mau estado, acondicionar no respetivo local, de acordo com a **NT 11/21 – Organização do Espaço Exterior.**

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Appendix F - Sequence chart for setup tasks

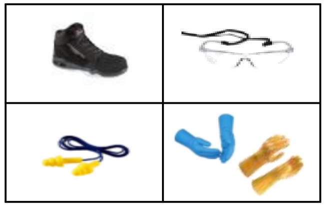
Sequence Chart	Sumário		
Máquina: Tipo setup:	Atividades		Valor
	Operação	◯	
	Movimentação	⇨	
	Armazenar	▽	
	Controlo	□	
	Espera	D	
	Distância (m)		
	Tempo (s)		

Nº	Descrição operações	Distância (m)	Tempo (s)	Simbolos ◯	⇨	▽	□	D	Tipo operação
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									

Appendix G - Standard for the ME-07 machine PI setup

CIN — **SETUP PRODUTO INTERMÉDIO (SEM LAVAGEM) – ME07**

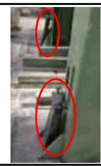
Responsável:	Operador do enchimento, Aprovisionador ME07	Setor:	Enchimento	NT 18/23
		Máquina:	07	

RISCOS	EPIs
 - Queda de objectos em altura - Queda de pessoas em altura - Queda de pessoas ao mesmo nível - Choque contra objectos e/ou pessoas - Sobreesforços - Projecção de líquidos/ mangueira - Entalamento entre objectos - Surdez - Esmagamento - Absorção de substâncias perigosas Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa	Para purgas, troca de filtros ou situações de manipulação de produto  Para preparação de equipamentos  NOTA: Na utilização do empilhador, obrigatória utilização de cinto de segurança. Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

Página 1/5	DATA: 19/04/2023	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

CIN — **SETUP PRODUTO INTERMÉDIO (SEM LAVAGEM) – ME07**

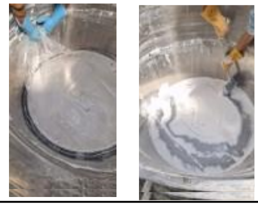
Responsável:	Operador do enchimento, Aprovisionador ME07	Setor:	Enchimento	NT 18/23
		Máquina:	07	

Nº		Atividade	Fotografia
O Setup inicia -se no momento em que a linha de enchimento é escoada			
1	Enchedor	Após o escoamento da linha, subir a prensa um pouco (cerca de 30 cm) para descolar do tanque e abrir kamlock da mangueira. Para movimentar a prensa é necessário pressionar o botão e manipular a alavanca assinalados na figura.	
	Aprovisionador	Após o escoamento da linha, encher as caixas que faltarem e coloca -las na palete.	
2	Enchedor	Operações no terminal IFS, preencher a SO anterior, folha OEE e controlo metrológico. Levar SO para a zona de reunião diária.	
	Aprovisionador	Colocar as paletes na zona de produto acabado e virar cartão "PRODUTO ACABADO", que está no quadro Kanban da ME-07, para a face vermelha.	
3	Aprovisionador	Programar inkjet e imprimir na SO.	
4	Enchedor	Desengatar a mangueira do tanque e raspar a massa. Esta massa é aproveitada para o enchimento seguinte ou para excedente.	
	Aprovisionador	Colocar paletes CIN para o próximo enchimento. Se necessário recolher o material de embalagem e abastecer com o material necessário ao enchimento seguinte.	
5	Aprovisionador	Retirar as barras de ferro, que suportam o tanque, assinaladas na figura e descer a prensa.	

Página 2/5	DATA: 05/06/2023	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

SETUP PRODUTO INTERMÉDIO (SEM LAVAGEM) – ME07

Responsável:	Operador do enchimento, Aprovisionador ME07	Setor:	Enchimento	NT 18/23
		Máquina:	07	

Nº	Atividade		Fotografia
6	**Enchedor**	Retirar o vedante (O 'Ring) do tanque e lavá-lo com a mangueira na zona de lavagem .	
	Aprovisionador	Após o vedante estar retirado, raspar a massa existente no tanque e depositar no próximo. Caso o produto usado no enchimento seguinte seja diferente, guardar a massa retirada para excedente .	
7	**Enchedor**	Colocar vedante (O 'Ring) no próximo tanque.	
	Aprovisionador	Recolher empilhador.	
8	**Aprovisionador**	Colocar novo tanque com auxílio do empilhador.	
9	**Enchedor**	Subir a prensa, encaixar a mangueira no tanque e fechar kamlock da mangueira. Se necessário ajustar a posição do tanque com a alavanca.	
	Aprovisionador	Colocar suportes de ferro do tanque, descer a prensa e abrir válvula do tanque com a ferramenta demonstrada na figura .	

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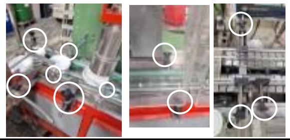
SETUP PRODUTO INTERMÉDIO (SEM LAVAGEM) – ME07

Responsável:	Operador do enchimento, Aprovisionador ME07	Setor:	Enchimento	NT 18/23
		Máquina:	07	

Nº	Atividade			Fotografia
10	**Aprovisionador**		Devolver empilhador	
11	**Enchedor**	Mudança de litragem	Ajustar todas as guias da máquina. As guias apresentam marcações que identificam o local exato onde devem ser ajustadas para cada litragem.	
	Aprovisionador		Se necessário ajustar Strapex à medida da caixa a usar. Este ajuste é feito com uma caixa standard do modelo requerido, já previamente preparada.	
12	**Enchedor**	Mudança de litragem	Ajustar as guias do dispensador das tampas e a altura do tamponador.	
13	**Enchedor**	Mudança de litragem	Ajustar altura da máquina e do bico de enchimento, com o auxílio da alavanca representada na figura.	

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CIN

SETUP PRODUTO INTERMÉDIO (SEM LAVAGEM) – ME07

Responsável:	Operador do enchimento, Aprovisionador ME07	**Setor:**	Enchimento	**NT 18/23**
		Máquina:	07	

Nº	Atividade		Fotografia
14	**Enchedor**	Preencher OEE e controlo metrológico com os dados do novo enchimento.	 
	Aprovisionador	Lavar tanque na máquina de lavagem de tanques móveis e posteriormente lavar a válvula do tanque com a mangueira na zona de lavagem. Ver norma de lavagem de tanques móveis NT 31/22.	
15	**Enchedor**	Verificar os pesos das embalagens cheias.	
16	**Enchedor**	Encher a primeira caixa e colocá-la na palete.	
17	**Enchedor**	Operações no terminal IFS, fechar Setup.	

O Setup termina quando a primeira caixa é colocada na palete.

	DATA:	ELABORADO/REVISTO:	APROVADO:
Página 5/5	05/06/2023	C. Carneiro, D. Santos	A. Mendonça, J. Teixeira

Appendix H - Mobile tanks washing standard

CIN — **LAVAGEM DE TANQUES MÓVEIS**

Responsável:	Operador Fabrico	Setor:	C6	NT 31/22

RISCOS	EPIs
ATENÇÃO	

- Sobre-esforços
- Queda de pessoas ao mesmo nível
- Queda do Colaborador (Empilhador)
- Choque contra objetos e/ou pessoas
- Surdez
- Lesões diversas resultantes do contacto mecânico
- Projeção de líquidos
- Inalação, absorção de substâncias perigosas

Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa

NOTA : Máscara obrigatória na utilização de substâncias com simbologia de perigo.

Cinto de segurança obrigatório na utilização de empilhador.

Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

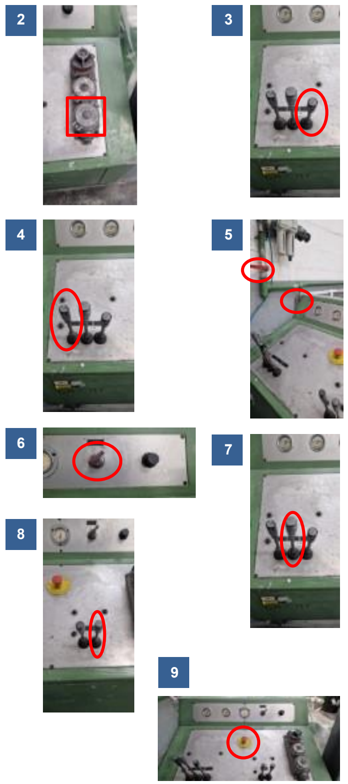
Página 1/3	DATA: 20/03/2023	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

CIN — **LAVAGEM DE TANQUES MÓVEIS**

Responsável:	Operador Fabrico	Setor:	C6	NT 31/22

Nº	Atividade
1	Posicionar o tanque móvel debaixo da escova e encostado às maxilas de aperto.
2	Ligar a máquina clicando no botão indicado na figura.
3	Fixar o tanque com as maxilas de aperto, controlando com a alavanca indicada na figura.
4	Descer a escova até esta tocar no fundo do tanque, usando a alavanca indicada na imagem.
5	Ligar a água abrindo as duas passagens assinaladas na imagem.
6	Realizar o acoplamento da escova às paredes laterais do tanque, rodando o indicador demonstrado na imagem, para a direita.
7	Iniciar o movimento de rotação da escova, usando a alavanca indicada na imagem.
8	Iniciar o movimento de translação da escova, usando a alavanca indicada na imagem.
9	Em caso de ser necessária a intervenção para raspar as paredes laterais do tanque de forma manual, é necessário parar a máquina ativando o botão de emergência. Desativar este botão após raspar as paredes do tanque para dar seguimento à lavagem.

Fotografia



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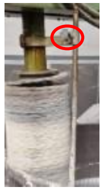
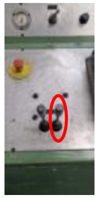
CIN

LAVAGEM DE TANQUES MÓVEIS

Responsável:	Operador Fabrico	**Setor:**	C6	**NT 31/22**

Nº	Atividade	Fotografia
10	Caso seja preciso ajustar a altura do tubo de saída da água à altura do respetivo tanque, é necessário parar a máquina ativando o botão de emergência representado na figura 9, ou ajustar a altura antes de ligar a máquina. Desapertando o indicador representado na figura 10 é possível realizar este ajuste de altura.	10 
11	Concluída a lavagem do tanque, desligar o movimento de translação das escovas, usando a alavanca representada na figura.	11 
12	Parar o movimento de rotação das escovas, usando a alavanca destacada na fotografia.	12 
13	Realizar o desacoplamento da escova às paredes laterais do tanque, rodando o indicador demonstrado na imagem, para a esquerda.	13 
14	Desligar a água fechando as duas passagens indicadas na figura.	14 
15	Subir a escova, usando a alavanca indicada na figura.	15 
16	Desprender o tanque manipulando as maxilas de aperto com a alavanca da figura.	16 
17	Desligar a máquina clicando no botão da imagem .	17 

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Appendix I - ME-32 machine standards

CIN — **FUNCIONAMENTO ME -32**

Responsável:	Operador do enchimento	**Setor:**	Enchimento	**NT 33/22**
		Máquina:	ME-32	

RISCOS	EPIs
ATENÇÃO - **Queda de objectos em altura** - **Sobreesforços** - **Projecção de líquidos/ mangueira/ manipulador** - **Entalamento entre objectos** - **Surdez** - **Esmagamento** Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa	 **NOTA:** **Óculos de protecção** obrigatórios no caso de existir risco de projecção de líquidos (por exe. fim do enchimento). Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

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CIN — **FUNCIONAMENTO ME -32**

Responsável:	Operador do enchimento	**Setor:**	Enchimento	**NT 33/22**
		Máquina:	ME-32	

Nº	Atividade	Fotografia
	Configuração da balança	
1	Para configurar a balança é necessário inicialmente clicar no botão "M". No ecrã deverá aparecer "SP1 0" após pressionar o botão.	
2	De seguida, para configurar o peso em que a máquina deverá fazer o primeiro corte, clicar no botão indicado na imagem. Após clicar no botão, no ecrã deverá aparecer "SP1 1".	
3	Clicar no botão indicado na figura para aceder à alteração do peso do primeiro corte da máquina. Após clicar no botão, no ecrã deverá aparecer o valor atual do peso definido para o primeiro corte.	
4	Pressionar o botão "M" para mover o cursor entre as casas decimais apresentadas no ecrã. Depois de selecionar a casa decimal do número que se pretende alterar, clicar no botão imediatamente à direita do botão "M" para alterar o número selecionado.	
5	Depois de alterar os valores pretendidos, é necessário clicar no botão mais à direita do painel de forma a prosseguir para a alteração do peso do segundo corte. Após clicar neste botão, no ecrã deverá aparecer "SP2 0".	
6	De seguida, para configurar o peso em que a máquina deverá fazer o segundo corte, clicar no botão indicado na imagem. Após clicar no botão, no ecrã deverá aparecer "SP2 1".	
7	Clicar no botão indicado na figura para aceder à alteração do peso do segundo corte da máquina. Após clicar no botão, no ecrã deverá aparecer o valor atual do peso definido para o segundo corte.	
8	Repetir a etapa 4 para alterar o valor do peso.	
9	Depois de alterar os valores pretendidos, clicar no botão mais à direita do painel de forma a finalizar a configuração da balança.	

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CIN

FUNCIONAMENTO ME -32

Responsável:	Operador do enchimento	Setor:	Enchimento	NT 33/22
		Máquina:	ME-32	

Nº	Atividade	Fotografia
	Ligar os restantes componentes da máquina	
10	Ligar o tapete da máquina colocando o interruptor da figura para cima.	 
11	Ativar o tamponador colocando o indicador da figura no automático e desativando o botão de emergência.	
	Operações de enchimento	
12	No enchimento de latas mais pequenas (4 Kg) é necessária a colocação de um suporte, como o representado na figura, para aproximar a lata do bico de enchimento. Nas latas maiores (25 Kg) não é necessária a utilização deste suporte uma vez que a lata tem altura suficiente para se aproximar do bico.	
13	Antes de iniciar o enchimento é sempre necessário colocar a etiqueta na respetiva lata a encher.	
14	Quando a lata estiver devidamente identificada e colocada debaixo do bico, é necessário remover o peso da tara na balança pressionando o botão destacado na figura.	
15	Proceder ao enchimento da lata desativando o botão de emergência e pressionandoo botão assinalado na figura.	
16	Colocar as latas na palete após o bordo de linha estar cheio. No caso da colocação das latas maiores (25 Kg), usar o manipulador para auxiliar o movimento.	

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CIN — SET UP EMBALAGEM NA ME -32

Responsável:	Operador do enchimento	Setor:	Enchimento	NT 34/22
		Máquina:	ME-32	

RISCOS	EPIs

- **Queda de objectos em altura**
- **Choque contra objectos e/ou pessoas**
- **Queda de carga em transporte**
- **Sobreesforços**
- **Projecção de líquidos**
- **Entalamento entre objectos**
- **Surdez**
- **Esmagamento**

Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa

Para preparação de equipamentos/ Enchimento

NOTA: **Luva mecânica** obrigatória na preparação dos equipamentos.
Óculos de protecção obrigatórios no caso de existir risco de projecção de líquidos (por exe. fim do enchimento).

Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

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CIN — SET UP EMBALAGEM NA ME -32

Responsável:	Operador do enchimento	Setor:	Enchimento	NT 34/22
		Máquina:	ME-32	

Nº	Atividade
1	Após finalizar o enchimento colocar o balde com a designação "BICOS DE ENCHIMENTO" no bico de enchimento.
2	Preencher SO com quantidade cheia, número de paletes completas e incompletas, data e assinatura.
3	Fechar operação enchimento IFS.
4	Iniciar setup IFS.
5	Transporte da palete de produto acabado para a zona de cintagem.
6	Colocar SO na respetiva caixa de SO terminadas, que se encontra na zona de reunião diária.
7	Recolher nova SO da caixa "1º TE SEGUINTE".
8	Guardar latas que restarem do enchimento anterior.
9	Colocar embalagens necessárias junto da máquina.
10	Configurar a etiquetadora de acordo com o produto a ser cheio.
11	Configurar peso da balança conforme explicado na norma NT 33/22.
12	Ajustar bico de enchimento à quantidade que se pretende encher. No enchimento de latas de 4 Kg colocar os dois indicadores da figura no número 5 e no caso do enchimento de latas de 25 Kg colocar no número 7.
13	Trocar tamponador. **Nota:** Na troca de tamponador é necessário colocar sempre o indicador no "0" tal como representado na figura e ativar o botão de emergência.

Fotografia

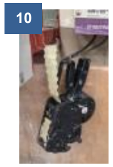
1

2

3

5

7

10

11

12

13

13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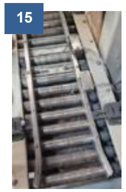
CIN

SET UP EMBALAGEM NA ME -32

Responsável:	Operador do enchimento	Setor:	Enchimento	NT 34/22
		Máquina:	ME-32	

Nº	Atividade	Fotografia
14	Ajustar batentes da máquina	14  15  16 
15	Ajustar guias da máquina.	
16	No caso do enchimento de latas pequenas, colocar um apoio para aproximar a lata do bico.	
17	Ligar o tapete e ativar o tamponador. Ver **NT 33/22**.	
18	Encher o número de latas necessário para acertar o peso da balança.	
19	Fechar setup IFS.	
20	Iniciar operação enchimento.	

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CIN

SETUP PRODUTO INTERMÉDIO COM LAVAGEM - ME32

Responsável:	Operador do enchimento	**Setor:**	Enchimento	**NT 07/23**
		Máquina:	ME-32	

RISCOS	EPIs

- Choque contra objectos e/ou pessoas
- Queda de pessoas em altura
- Sobreesforços
- Projecção de líquidos/ mangueira
- Entalamento / esmagamento
- Choque contra estruturas fixas
- Surdez
- Inalação de substâncias perigosas
- Corte

Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa

NOTA: Máscara obrigatória na utilização de solvente na limpeza.
No enchimento obrigatória calçado de segurança e auriculares.

Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

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CIN

SETUP PRODUTO INTERMÉDIO COM LAVAGEM - ME32

Responsável:	Operador do enchimento	**Setor:**	Enchimento	**NT 07/23**
		Máquina:	ME-32	

Nº	Atividade
1	Após finalizar o enchimento, colocar o balde com a designação "BICOS DE ENCHIMENTO" no bico de enchimento.
2	Preencher SO com quantidade cheia, número de paletes completas e incompletas, data e assinatura.
3	Fechar operação enchimento IFS.
4	Iniciar setup IFS.
5	Transporte da palete de produto acabado para a zona de cintagem.
6	Colocar SO na respetiva caixa de SO terminadas, que se encontra na zona de reunião diária.
7	Recolher nova SO da caixa "1º TE SEGUINTE".
8	Em caso de troca de embalagem, consultar **NT 34/22**.

Fotografia

1

2

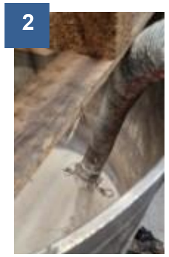
3

5

7


Lavagem da máquina e do tanque fixo

Nº	Atividade
0	Iniciar a sequência de passos seguintes após concluir a lavagem do dispersor DP22. Consultar **NT 24/23.**
1	Encher um balde na máquina para fazer passar a água no interior do bico de enchimento de forma a retirar as maiores quantidades de massa.
2	Desapertar a mangueira da máquina e colocá-la num tanque móvel para escoar a água e os restos de massa que se encontram no tanque fixo em baixo do dispersor.
3	Retirar restos de massa do local de aperto da mangueira à máquina com uma espátula.

2

3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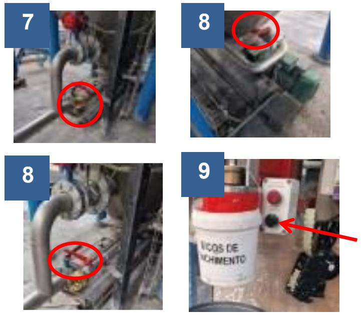
CIN

SETUP PRODUTO INTERMÉDIO COM LAVAGEM - ME32

Responsável:	Operador do enchimento	Setor:	Enchimento	NT 07/23
		Máquina:	ME-32	

Nº	Atividade	Fotografia
4	Colocar um balde debaixo do bico de enchimento para escorrer os restos que se encontrem no interior.	
5	Lavar a parte inferior do tanque com a máquina de pressão.	
6	Lavar o tanque móvel que contém a água e os restos de massa que foram retirados do tanque, na zona de lavagem .	
	Purga	
7	Encaixar a mangueira no Camlock indicado na figura.	
8	Abrir os passadores representados nas figuras.	
9	Realizar a purga fazendo circular o produto do tanque fixo pela mangueira, diretamente para o tanque novamente, pressionando o botão de início de enchimento assinalado na figura.	
10	Desligar a máquina após a realização da purga pressionando o botão de emergência .	
11	Fechar os passadores.	
12	Retirar a mangueira do Camlock e encaixá-la na máquina novamente.	
	Iniciar enchimento – Consultar NT 33/22 para funcionamento da máquina	
13	Encher o número de latas necessário para acertar o peso da balança.	
14	Fechar setup IFS.	
15	Iniciar operação enchimento.	

Página 3/3	DATA:	ELABORADO/REVISTO:	APROVADO:
	19/05/2023	C. Carneiro, D. Santos	A. Mendonça, J. Teixeira

CIN

LAVAGEM DO DISPERSOR DP22

Responsável:	Operador fabrico automático	Setor:	C6	NT 24/23

RISCOS	EPIs

- Choque contra objectos e/ou pessoas
- Queda de pessoas em altura
- Sobreesforços
- Projecção de líquidos/ mangueira
- Entalamento / esmagamento
- Choque contra estruturas fixas
- Surdez
- Inalação de substâncias perigosas
- Corte

Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > CIN – Maia > Produção de Tintas de Base Aquosa

NOTA: Máscara obrigatória na utilização de solvente na limpeza.
No enchimento obrigatória calçado de segurança e auriculares.

Para aceder a mais informação ver Portal > Aplicações > Sistema QAHS > Documentação > Análise e Avaliação de Riscos > Listagem de Equipamentos de Proteção Individual (EPIs) > CIN – Maia > Fábrica.

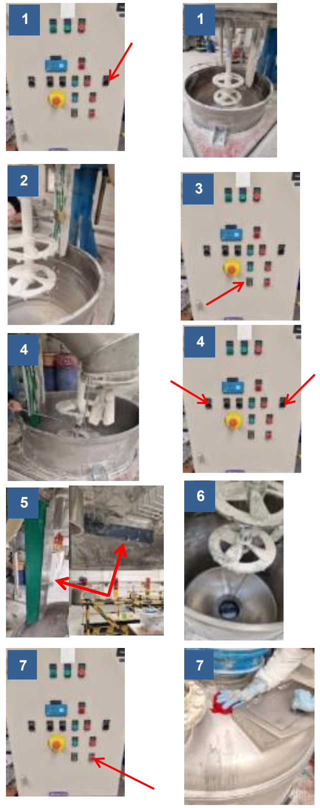
Página 1/2	DATA: 19/05/2023	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

CIN

LAVAGEM DO DISPERSOR DP22

Responsável:	Operador do fabrico automático	Setor:	C6	NT 24/23

Nº	Atividade	Fotografia
1	Subir o tampo do dispersor pressionando o botão assinalado na figura.	
2	Raspar a massa das paredes interiores do dispersor e dos raspadores com o auxilio de uma pá própria.	
3	Abrir a válvula de passagem para o tanque debaixo, pressionado o botão assinalado na figura.	
4	Usar máquina de pressão para lavar o interior do dispersor, as pás e os raspadores. Durante a lavagem, ir baixando o tampo do dispersor para facilitar a lavagem e se necessário usar uma espátula para raspar os restos de produto. Para realizar a descida do tampo do dispersor é necessário pressionar os dois botões assinalados na figura em simultâneo.	
5	Verificar o estado dos raspadores e o seu desgaste e avaliar a necessidade de intervenção da manutenção.	
6	Usar novamente a máquina de pressão para empurrar a massa para o tanque debaixo.	
7	Fechar a válvula de passagem para a parte inferior pressionando o botão indicado na figura. Baixar o dispersor e limpar a parte exterior do tampo.	



Página 2/2	DATA: 19/05/2023	ELABORADO/REVISTO: C. Carneiro, D. Santos	APROVADO: A. Mendonça, J. Teixeira

Appendix J – Validation and cleaning checklist for ME-32

CIN

CHECK -LIST ME32
TURNO DIURNO – INÍCIO DE TURNO

CLK117
06/06/2023

Nº	TAREFA	___/___/___	___/___/___	___/___/___	___/___/___	___/___/___
1	Verificar os materiais de limpeza.	❑				
2	Limpar zona de documentação, zona adjacente (Estante, Separadores, Caderno documentos) e tapete.		❑		❑	
3	Verificar condições da torre do manipulador de latas e limpar se necessário.		❑			
4	Verificar o Quadro de Ferramentas e limpar.			❑		
5	Esvaziar o caixote do lixo no contentor de resíduos banais.	❑	❑	❑	❑	❑
5	Ligar o ar comprimido da máquina.	❑	❑	❑	❑	❑
6	Retirar balde de solução 01-000.000 do bico.	❑	❑	❑	❑	❑
7	Colocar indicador do tamponador no modo automático.	❑	❑	❑	❑	❑
8	Ligar tapete da máquina.	❑	❑	❑	❑	❑

Página 1/2 **Colaborador:**

CIN

CHECK -LIST ME32
TURNO DIURNO – FIM DE TURNO

CLK117
06/06/2023

Nº	TAREFA	__/__/___	__/__/___	__/__/___	__/__/___	__/__/___
1	Desligar o tapete da máquina.	❑	❑	❑	❑	❑
2	Colocar indicador do tamponador no "0".	❑	❑	❑	❑	❑
3	Desligar ar comprimido.	❑	❑	❑	❑	❑
4	Colocar balde de solução 01 -000.000 no bico.	❑	❑	❑	❑	❑
5	Verificar o Quadro de Ferramentas.	❑	❑	❑	❑	❑
6	Verificar anomalias na zona de trabalho (derrames, sujidade, etc.) e limpar se necessário.	❑	❑	❑	❑	❑

Página 2/2	Colaborador:					

Appendix K – ABC analysis according to the frequency of the required material

Product	Counting of the quantity required	% Times required	% Accumulated	
[redacted]	232	25,03%	25,03%	A
[redacted]	101	10,90%	35,92%	A
[redacted]	101	10,90%	46,82%	A
[redacted]	101	10,90%	57,71%	A
[redacted]	98	10,57%	68,28%	A
[redacted]	98	10,57%	78,86%	A
[redacted]	97	10,46%	89,32%	B
[redacted]	25	2,70%	92,02%	B
[redacted]	25	2,70%	94,71%	B
[redacted]	25	2,70%	97,41%	C
[redacted]	8	0,86%	98,27%	C
[redacted]	8	0,86%	99,14%	C
[redacted]	8	0,86%	100,00%	C
Total	927	100,00%		

Appendix L - ABC analysis according to the quantity of material required

Product	Sum of the quantity required	% Required quantity	% Accumulated	
[redacted]	200499	25,76%	25,76%	A
	200499	25,76%	51,52%	A
	96743	12,43%	63,95%	A
	96738	12,43%	76,38%	A
	54875	7,05%	83,43%	B
	54875	7,05%	90,48%	B
	16503	2,12%	92,60%	C
	16503	2,12%	94,72%	C
	16176	2,08%	96,80%	C
	15757	2,02%	98,83%	C
	4586	0,59%	99,41%	C
	3182	0,41%	99,82%	C
	1372	0,18%	100,00%	C
Total	778308	100,00%		

Appendix M - Kanban board operating standard

CIN | **FUNCIONAMENTO DO QUADRO KANBAN – ME07**

Responsável:	Operador Logístico, Operador de Enchimento	**Setor:**	C6	**NT 11/23**
		Máquina:	ME-07	

LOCALIZAÇÃO DO MATERIAL DE ENCHIMENTO PARA ME-07

Descrição			Fotografias
	Nº	**Produto**	
Estante1	1	[redacted]	
	2		
	3		
	4		
	5		
	6		
	7		
	8		
Estante 2	9		
Estante 1/2	10		
Estante 2	11		

Estante 1

Estante 2

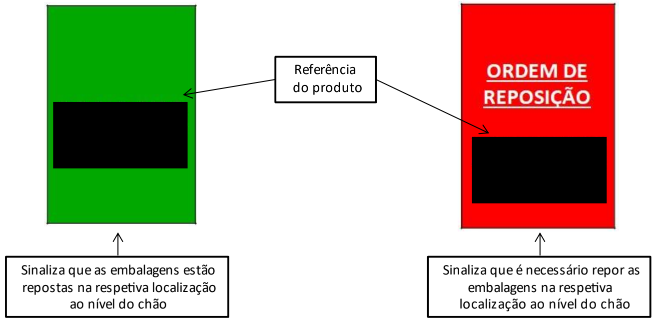
Página 1/5	DATA: 14/04/2023	ELABORADO/REVISTO: Diogo Santos	APROVADO: João Teixeira

CIN | **FUNCIONAMENTO DO QUADRO KANBAN – ME07**

Responsável:	Operador Logístico, Operador de Enchimento	**Setor:**	C6	**NT 11/23**
		Máquina:	ME-07	

MATERIAL DE ENCHIMENTO GERIDO POR KANBAN

CARTÕES DE REPOSIÇÃO



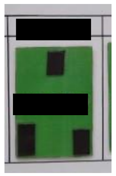
QUADRO KANBAN

Página 2/5	DATA: 14/04/2023	ELABORADO/REVISTO: Diogo Santos	APROVADO: João Teixeira

CIN

FUNCIONAMENTO DO QUADRO KANBAN – ME07

Responsável:	Operador Logístico, Operador de Enchimento	**Setor:**	C6	**NT 11/23**
		Máquina:	ME-07	

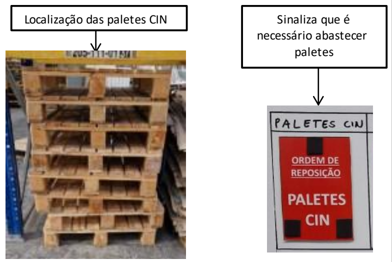
Nº	Atividade	Fotografias
Consumo de material de enchimento		
1	O operador de enchimento deve consumir sempre os materiais necessários ao enchimento que se encontram nas localizações inferiores das estantes até estes terminarem.	
2	Sempre que os materiais forem consumidos na totalidade, a localização do material usado ficará livre e portanto o operador de enchimento deverá virar o Kanban do respetivo produto para a face vermelha.	
Reposição de material de enchimento		
0	As estantes encontram-se devidamente identificadas com etiquetas que possuem o código dos materiais. O operador logístico deverá colocar o material de embalagem nas respetivas localizações definidas.	
1	Sempre que um Kanban do quadro se encontrar voltado com a face vermelha, significa que o operador logístico deve retirar as embalagens com essa mesma referência que se encontrem em níveis superiores e repô-las no nível do chão na respetiva localização.	
2	Após a reposição do respetivo material no nível do chão, o operador logístico deverá virar o Kanban para a face verde.	

Página 3/5	DATA: 14/04/2023	ELABORADO/REVISTO: Diogo Santos	APROVADO: João Teixeira

CIN

FUNCIONAMENTO DO QUADRO KANBAN – ME07

Responsável:	Operador Logístico, Operador de Enchimento	**Setor:**	C6	**NT 11/23**
		Máquina:	ME-07	

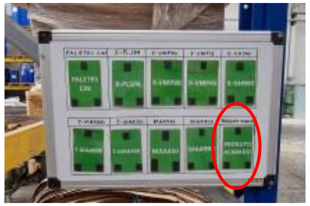
Nº	Atividade	Fotografias
Paletes CIN usadas no enchimento		
0	O quadro possui uma cartão específico para as paletes CIN que são usadas para colocar as caixas durante o enchimento.	
1	Na localização definida para as paletes CIN deve sempre existir um <u>stock mínimo de 3 paletes</u>. Quando o número de paletes na localização é inferior ao stock mínimo, o operador de enchimento deve virar o Kanban para a face vermelha.	
2	Quando o operador logístico fizer a reposição das paletes deve virar o Kanban para a face verde.	

Página 4/5	DATA: 14/04/2023	ELABORADO/REVISTO: Diogo Santos	APROVADO: João Teixeira

CIN

FUNCIONAMENTO DO QUADRO KANBAN – ME07

Responsável:	Operador Logístico, Operador de Enchimento	**Setor:**	C6	**NT 11/23**
		Máquina:	ME-07	

Nº	Atividade	Fotografias
Transporte de produto acabado		
0	Para além dos materiais necessários ao enchimento, o quadro também possui um Kanban para o produto acabado.	
1	Sempre que o operador de enchimento termina o enchimento de uma palete e a coloca na zona de paletes de produto acabado, deve virar o Kanban para a face vermelha.	Zona de produto acabado  Sinaliza que é necessário transportar o produto acabado 
2	Quando o operador logístico fizer a recolha das paletes de produto acabado deve virar o Kanban para a face verde.	

Página 5/5	DATA: 14/04/2023	ELABORADO/REVISTO: Diogo Santos	APROVADO: João Teixeira