Development of methodologies to support maintenance planning, process and analytics in an electric company

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Masters Dissertation

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Master in Mechanical Engineering

2023-07-03

To my family

Abstract

This project was carried out in order to improve the ability to monitor and control the maintenance performed and requests for acquisition/intervention received, as well as to implement the Total Productive Methodology, more specifically autonomous maintenance, and to extend to the entire Efacec Power Solution (EPS) a nomenclature for identifying the equipment owned.

Each of the five business units that make up Efacec had its own way of recording and identifying assets. Thus, a standard and transversal form was defined for all the units, in order to improve the quality of the information. The next step was to physically register all the assets of the Mobility and Service business units that fall into the identification categories created, increasing the amount of equipment with physical records from 300 to 622, and creating an analytical dashboard for this process.

Simultaneously, a template was created for the preparation of autonomous maintenance manuals, as well as the description of this process and the creation of specifications for an autonomous maintenance management platform.

Once the description of the process was finalized, the preparation of Autonmous Maintenance (AM) manuals for equipment began, with a total of seven manuals prepared.

The preventive maintenance was also subject to improvements, with the creation of a new register file for planning and execution and the creation of analytical dashboards for planning compliance.

Finally, an analytical methodology was created for intervention/acquisition requests for Equipamentos Auxiliares de Trabalho (EATs) and Equipamentos de Movimentação de Carga (EMCs), in order to control and monitor these requests. KPIs were also identified to evaluate maintenance performance in response to requests.

Resumo

Desenvolvimento de metodologias de suporte a planeamento, processo e analítica de manutenção numa empresa do setor elétrico.

Este projeto foi realizado com o objetivo de melhorar a capacidade de monitorizar e controlar as manutenções realizadas e os pedidos de aquisição/intervenção recebidos, bem como implementar a metodologia TPM, mais concretamente a manutenção autónoma, e alargar a toda a Efacec Power Solution uma nomenclatura de identificação dos equipamentos que se possui. Cada uma das cinco unidades de negócio que compõem a Efacec tinha a sua própria forma de registo e identificação de ativos. Assim, foi definida uma forma standard e transversal a todas as unidades, de modo a melhorar a qualidade da informação. Procedeu-se, então, ao registo físico de todos os ativos das unidades de negócio de Mobilidade e Service que se enquadram nas categorias de identificação criadas, aumentando o número de equipamentos com registo físico de 300 para 622, bem como à criação de um dashboard analítico para este processo. Em simultâneo, foi criado um template para a elaboração de manuais de manutenção autónoma, bem como a descrição deste processo e a criação de especificações para uma plataforma de gestão de manutenção autónoma.

Uma vez finalizada a descrição do processo, iniciou-se a elaboração dos manuais de Manutenção Autónoma dos equipamentos, tendo sido elaborados um total de sete manuais. A manutenção preventiva foi também alvo de melhorias, com a criação de um novo ficheiro de registo para planeamento e execução e a criação de dashboards analíticos para cumprimento do planeamento.
Por fim, foi criada uma metodologia analítica para os pedidos de intervenção/aquisição de Equipamentos Auxiliares de Trabalho (EATs) e Equipamentos de Movimentação de Carga (EMCs), de forma a controlar e monitorizar estes pedidos. Foram também identificados KPIs para avaliar o desempenho da manutenção na resposta aos pedidos.

Acknowledgments

To my family, more specifically my parents, Armando and Isabel, my brothers, Pedro and Martim, uncles and cousins, Henriqueta, Duarte, Mário, Nela and Frederica, who were my greatest support in this journey that is now ending. Without their love, trust and support I would not have reached this point in my life.

To my housemate, Lécia, considered family, for her friendship, concern and kindness that was undoubtedly fundamental to my success.

To my friends, both those who have been with me since childhood and those who in these 5 years have made this adventure so special. Without them it would be much more difficult to overcome the difficulties and challenges I have faced. They are the family one chooses.

To FEUP, a very special thank you for all the knowledge transmitted throughout the years and for all the support provided so that I could finish my study cycle in such a demanding house as this one.

To my supervisor at FEUP, Eduardo Costa, for the support and availability presented during the internship.

To Efacec, for such a warm welcome and for showing me how is the working method of an engineer in a company as big as this one, a company built by the people.

More specifically, I would like to thank my supervisor at Efacec, João Ribeiro, for the unconditional support, commitment, motivation, help, friendship and teachings that he always showed and transmitted throughout the internship. To Ana Viana, who accompanied me throughout all the work developed, advising and guiding me the right way. Finally, to Leandro Martins, Pedro Lopes and Pedro Dias for always being available to help me overcome the challenges and difficulties encountered.

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Abbreviations

EPS – EFACEC Power Solutions

AM – Autonomous Maintenance

TPM – Total Production Maintenance

MTTA – Mean Time to Attend

MTTR – Mean Time to Repair

MTBF – Mean Time Between Failure

KPI – Key Performance Indicators

MIT – Manutenção Industrial Transversal

BU – Business Unit

ASE – Systems

EEM – Electric Mobility

SRV – Service

TRF – Transformers

AMT – Automation

EAT – Equipamentos Auxiliares de Trabalho

EMC – Equipamentos de Movimentação de Cargas

PBI – Power BI

OI – Operational Intruction

EHS – Environmental Health and Safety

MMA – Manual de Manutenção Autónoma

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1 Introduction

This project, carried out in a business environment, within the scope of the Integrated Master's Degree in Mechanical Engineering of the Faculty of Engineering of the University of Porto, had a duration of 4.5 months, between February and June 2023. The project was developed in Efacec Power Solutions, SA, specifically in the Department of Transversal Industrial Maintenance (MIT). The applied methods were based on the Total Productive Maintenance (TPM) methodology, as well as on Data analytics and Data visualization.

In this first chapter, a description of the company where the project was developed will be made, followed by the intended objectives. Then, the methodology that will be followed to successfully complete the project will be addressed. Finally, the structure of the thesis is presented.

1.1 Company Presentation

The company where the project was developed is Efacec Power Solutions, SA (EPS), located in the business park of Arroteia (West), São Mamede de Infesta. This company is a reference in several areas and operates mainly in activities related to Energy, Engineering, Mobility, and Transport.

EPS is a Portuguese company with an export profile and international presence in over 65 countries, such as Argentina, Spain, Central Europe, India, Brazil, France, USA, and with about 2000 employees, as shown in Figure 1. It is a supplier of fully integrated solutions, from manufacturing products to integrating systems and services (Efacec).

Figure 1 – Collaborators and Active Markets

This company is organized in Business Units (BU) that are active in the development of the following areas:

- Systems (ASE) - Energy, environment, and transportation industry.
- Energy Products - Transformers (TRF), Service (SRV), Switchgear (AMT), and Automation.
- Mobility (EEM) - Electric mobility.

1.2 The project in EFACEC Power Solutions, SA

The project for the preparation of the thesis was carried out in the newly created Department of Transversal Industrial Maintenance, a department that now takes care of the industrial maintenance of all equipment across all business units. Due to the fact that BUs such as mobility or systems did not have any kind of equipment maintenance, the need arose to create this department to respond to all BUs' equipment failures.

Currently, there are several administrative and bureaucratic processes related to maintenance, DL 50/2005, Calibrations, Logistics, KPI control, and digitalization of information manually, all of them with the potential for digitalization.

There is, also, an intensive use of paper (8400 sheets per year only in preventive maintenance), manual data registration (400h per year spent only in printing and digitalizing preventive maintenance reports), difficult analysis and possible loss of information, and excessive communication via email or without registration.

A good project management software also serves as a collaboration tool, allocating the following advantages:

- Information accessible to all employees.
- More interactive activities and on-the-job training.
- Data transparency and greater clarity in information.
- Greater control of time and resource usage (tools, labor, spares);
- Better action planning;

So, the digitalization of autonomous maintenance processes and active registration are very important to the company's development and future.

EPS is recently implementing Autonomous Maintenance (AM) policies, and digitalizing these processes is vital to successfully implementing them. As this way of maintenance is recently used, not all the equipment have AM, so it is necessary to build manuals for those who do not have it.

With the creation of this new department, one of the policies established was the need to know all the existing equipment, so the process of active registration began.

1.3 Project scope and objectives

This project's main objectives are the digitalization of the autonomous maintenance (AM) process implemented through the TPM methodology with its performance indicators and the physical and systems registry of industrial equipment, accompanied by analytics to this process.

Digitization of the maintenance system seeks to optimize workforce efficiency and accessibility to all data. In this way, it is possible, for example, to show faults early, enabling integrated interventions that maximize total asset availability and minimize total cost.

As more practical goals, the following were defined regarding the Autonomous Maintenance process:

- Creation and officialization of the AM template;
- Regulation of the process;
- Specification of the management platform and collaboration in its development and implementation;
- Elaboration of autonomous maintenance manuals;

Regarding the asset register, the objectives defined are;

- Physical and systems register of industrial equipment (Equipamentos Auxiliares de Trabalho (EATs), and equipment);
- Introduction of improvements and analytics in the process;

For the preventive maintenance, the objectives are:

- Developing a new file for registration of preventive maintenance actions;
- Creation of analytic dashboards of these actions, to control and analyze the performance and planning compliance;

Finally, regarding the Analytics/PowerBI (PBI), the objectives defined are:

- Preparation of dashboards in PBI to analyze EAT and EMC (Equipamentos de Movimentação de Cargas) requests, physical active registration, etc;

1.4 Methodology followed in the project

In order to carry out the project of digitalization and registration successfully, it was required to create a strategy with several methods. Figure 2 illustrates the steps and phases chronologically.

In the first phase concerning the AM, an analyzing method of the existing manuals was performed to understand the need to create a new template and new manuals for equipment that do not have AM. Alongside this and as for the active registration, an exploratory approach was considered by performing several *Gemba* visits to the different BUs to understand the number of EATs and equipment that each BU possessed, and a coding approach was used to register the equipment.

In the second phase, a literature review of the autonomous maintenance process and the TPM methodology was predesigned to establish theoretical support for the regulation of this process, to help create the specifications for the management platform, and to elaborate the new autonomous maintenance template manual for the equipment.

For the third phase, with this new template created and in order to elaborate the new manuals, an exploratory approach was used again managing informal interviews with the operators that are more familiar with the equipment to provide the best steps to perform this maintenance process properly. In addition, the already built manuals were analyzed to understand if the steps defined were the best and rebuild them in the new template.

Concerning Preventive Maintenance (PM) and analytics of requisitions, the first step was to idealize a new file for registering the preventive maintenance actions planned and performed, and where to register requests of EMCs and EATs so that this helps in the creation of dashboards.

The second step was to create dashboards to analyze and monitor the impact of the different improvements, steps, and actions that were taken during the project.

Regarding the active registration, after the *Gemba* visits, the second step was to idealize a new nomenclature transversal to all the BUs, standardize it and begin the actual registration.

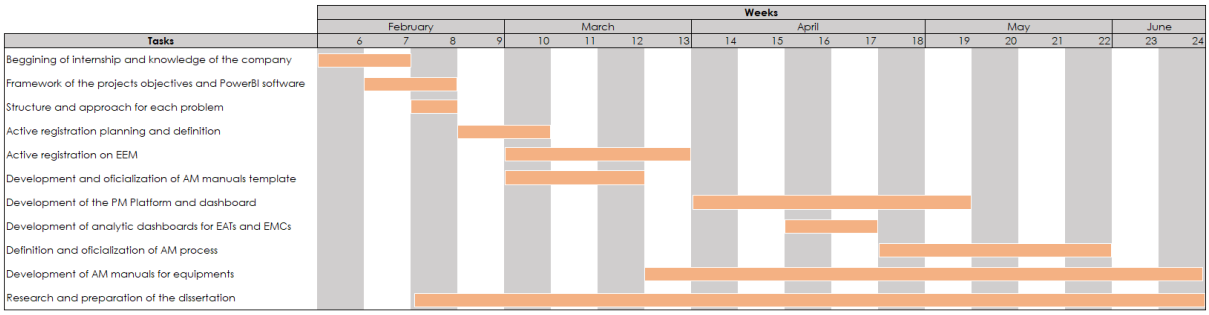


Figure 2 - Gantt diagram

1.5 Thesis structure

To enable a better and more accurate comprehension of the themes presented, this dissertation is structured into five chapters, each one with sub-chapters.

The project's framework, goals, and methods were all briefly introduced in the first chapter, along with a brief description of the company and the department where the project was established, and the rationale for the theme's creation.

The theoretical ideas that served as a foundation for the project's development are introduced in the second chapter. Certain techniques, like total production maintenance and data visualization, are developed and presented in some detail.

The third chapter provides an overview of the initial state of the situation. This chapter also introduces the primary issues found, as well as any underlying issues and the desired outcomes.

The fourth chapter reveals the several improvement phases that were used as well as the methods employed to arrive at those results and the documents created to complete the autonomous maintenance manuals and the registration processes.

To comprehend the project's evolution and key findings, the fifth chapter compares the project's starting and ending states. In addition, potential ideas for new works are offered.

2 Literature review

The theoretical ideas and development processes for this project will be covered in this chapter. To do this, the study was done on books and articles that focused on the areas where the central theoretical concepts are based, such as maintenance, TPM methodology, data analytics, and data visualization.

2.1 Maintenance

Industrial processes are designed to use the least amount of capital in plant, machinery, and labor while yet achieving the target quality and quantity, allowing for the most possible benefits to be realized in a normal, non-speculative societal context.

The most logical, effective, and economical use of the industrial facility and its workforce results in maximum productivity. Thus, maintaining the machinery and installations in top condition is one of the variables involved in achieving this goal (Mouta, 2011).

Depending on the bibliographic reference, maintenance can have different definitions.

According to Cabral (2013), maintenance is defined as a set of actions to ensure the proper functioning of machinery and facilities, being these actions performed within a correct period and opportunity, considering the various technical practices and legal requirements and in a way that does not affect, or minimally affects, productivity and yield.

If we follow EN 13306:2010, defined by European Standard, maintenance is a “combination of all technical, administrative and managerial actions during the life cycle of an item and intended to retain it in, or restore it to, a state in which it can perform the required function”.

Kobbacy and Murthy (2008) further define maintenance can be considered as "a set of activities necessary to maintain assets in the desired operating condition, or to restore them to that condition".

2.1.1 History of Maintenance

Maintenance has seen several significant advancements during history, mostly through four generations.

The first generation began before the second world war, when machines were very large, slow, and rugged, with not many complex systems and instrumentation. Machines’ downtime was not a problem because the demand for production was not as severe as it is now, and maintenance actions were performed after these breakdowns. Maintenance was classified as a “necessary evil”, only performed when needed and without optimization (Pinciroli *et al.*, 2019).

The reconstruction of the industry after the war, the second generation, marked the start of the following phase in the history of equipment maintenance. The market became considerably more competitive, which compelled producers to raise output. Increased downtime and higher repair costs are the results of overworking machinery. An important development in the history of manufacturing industry standards resulted from this increase in production's requirement for better maintenance procedures. In this generation, maintenance was classified as a “technical matter”, with optimization of technical solutions and organization of maintenance work.

During the 1970s, manufacturing facilities grew even more mechanized and sophisticated. Safety, quality, the environment, multi-skilling, reliability, availability, and maintainability were all seen to be of utmost importance. The industry started using maintenance management information systems (MMIS), condition monitoring (CM), and condition-based maintenance (CBM), which were developed primarily for the aerospace and defense sectors (Alsyouf, 2007).

Around the 1980s, still in the third generation, maintenance expenses escalated, as well as the demands of the cutthroat business and the intolerance of downtime. Coupled with the demands for better reliability, a greater understanding of failure mechanisms, enhanced management strategies, and new technology enabled a machine and component's health to be understood on a wider scale. Here, maintenance management is already a complex function.

The fourth generation started around 2000. This phase intends to save costs for businesses by improving equipment dependability. Everyone in the firm is particularly interested in using predictive maintenance approaches, which results in more reliable and available equipment. The problem facing maintenance in this generation is reducing untimely failures.

Figure 3 illustrates the maintenance evolution through the years.

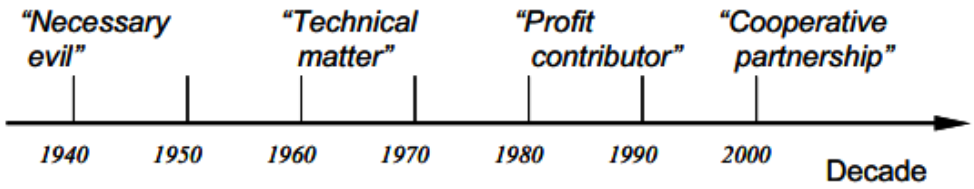


Figure 3 - Maintenance evolution (Kobbacy and Murthy, *2008*)

2.1.2 Maintenance objectives and importance

One common type of waste at manufacturing companies refers to breakdowns due to machine failures. The best way to minimize this type of waste is the adoption of strategic maintenance management policies (Pinto *et al*., 2020).

The introduction of Lean Manufacturing has highlighted the influence on product quality and process productivity, which results in a reduction in production costs and increased customer satisfaction (Oliveira *et al*., 2016).

The principal objectives of maintenance are to improve productivity while utilizing the fewest resources possible and concentrating on each company's assets (Pinto *et al*., 2019).

Maintenance objectives are based on four categories: quality, safety, availability, and cost.

These goals can be influenced by several factors, showed in Figure 4.

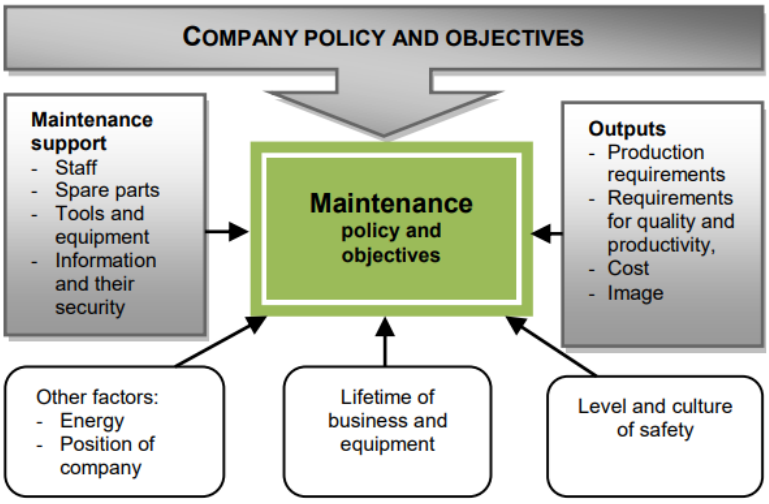


Figure 4 - Factors influencing maintenance goals (Pacaiova and Glatz, 2015)

The kind of facility and its output have a big impact on how essential maintenance is. It is crucial to production management since plant failure leads to a wide range of issues. A major

issue is a demand for a maximum workforce due to temporary work shortages and the need for overtime and subcontracting. Thus, a facility may incur significant costs if planned maintenance management is not implemented. A plant manager and operator must understand the many kinds of maintenance to operate the facility effectively.

2.1.3 Types of Maintenance

According to Ding and Kamaruddin (2015), maintenance policies can be grouped into different classes according to how they deal with breakdowns and maintenance. It is usually grouped into five types of policies divided into three categories.

The manufacturing industry uses corrective maintenance policies, which are the first and most traditional types of maintenance policies. The second policy is the preventive policy which is used to prevent the occurrence of failure and to retain the system in proper operating condition. The third one is the predictive policy that also aims to prevent failure and maintain the system's operational condition but with the utilization of advanced technology (Ding and Kamaruddin, 2015).

The fourth and fifth policies of maintenance are autonomous maintenance and design-out maintenance, which are more related to an improvement category (Ding and Kamaruddin, 2015).

By Ferreira *et al.* (2020), maintenance can be subdivided into proactive maintenance and reactive maintenance. Any maintenance procedures carried out before the failure occurs are referred to as proactive maintenance. Conversely, reactive maintenance takes place immediately following an equipment failure.

Some problems in maintenance routines are already clearly identified, such as lack of proactive maintenance, recurring problems, poorly planned maintenance activities, lack of tracking and vision in the maintenance program, and predictive maintenance practices (Gulati and Smith, 2012).

Following the NP EN 13306 (2021), the maintenance policies are divided into three groups: corrective maintenance (CM), preventive maintenance (PM), and improvement maintenance (IM), a similar structure to the one that Ding and Kamaruddin (2015), idealized.

Figure 5 illustrates the segmentation of the maintenance policies according to Ding and Kamaruddin (2015).

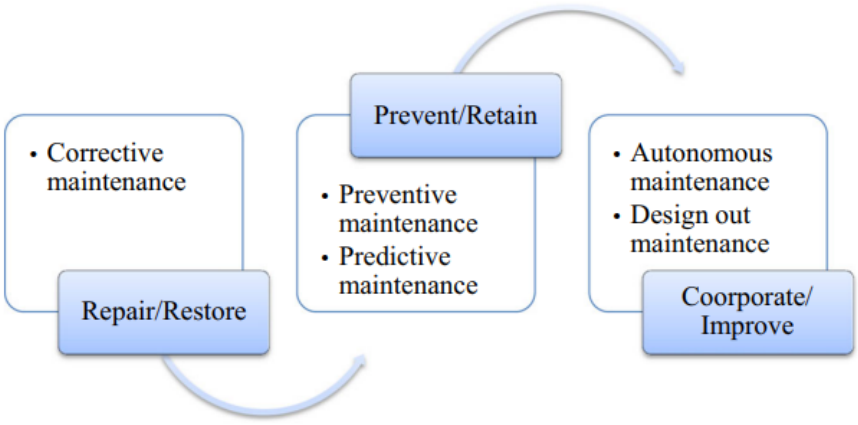


Figure 5 - Segmentation of maintenance policies (Ding and Kamaruddin, 2015)

Corrective maintenance – is a maintenance procedure used to find and fix the root causes of a failing system (Wang *et al.*, 2014). To identify the damaged component, fix it, and decrease

downtime, this maintenance procedure depends on human judgment and knowledge (Yepez *et al*., 2019). Upon the identification of a fault, maintenance is performed with the goal of restoring the item to its pre-required state (EN 13306, 2021).

The different maintenance strategies can be categorized depending on the author (Gakowiec, 2019).

Following Erbiyik (2022) perspective, corrective maintenance strategies can be divided in:

- Corrective repair – after identifying or seeing the breakdown, this form of equipment repair is carried out to restore the issue to a state where it can work normally.
- Basic overhaul – regardless of finding any specific breakdown, this type of repair is done to return the equipment's overall parts to their normal operational state for overloaded equipment.
- Predictive maintenance – carries on the philosophy of "execute at the right time". Service actions take place only when necessary (Wang, 2016). It signals when to undertake maintenance, i.e., just before a component actually fails but as it is about to fail. Machines spend less time offline when maintenance is only performed when essential, and parts are only replaced when absolutely necessary (De Paz *et al*., 2017).

Predictive maintenance – analyzes the condition of an item of equipment by doing both prediction and diagnosis, providing details on the issue's nature, its location, and its cause, as well as the likelihood that the item will fail (De Paz *et al.*, 2017).

Wang (2016) and Theissler *et al*. (2021) state that this type of maintenance can be classified into two kinds, according to the methods of detecting the signs of failure:

- Condition-based predictive maintenance – depends on continuous or periodic monitoring conditions of equipment to detect the signs of failure and make a maintenance decision using data mining technology.
- Statistical-based predictive maintenance – develops models for predicting failures based on statistical data from the meticulous recording of the stoppages of the in-plant items and components.

Preventive maintenance – Preventative maintenance is based on pre-scheduled maintenance periods that mostly depend on predetermined time intervals, with the usage of a system occasionally added. Preventative maintenance does not consider the system's actual health status; instead, it tries to repair a system before a problem occurs (Theissler *et al.,* 2021).

Preventive maintenance is also divided into two types:

- Conditioned Preventive Maintenance – "based on monitoring the functioning of the property and/or the significant parameters of that functioning, integrating the resulting actions", according to EN 13306:2021.

  Some advantages are the increased equipment availability and reduced production losses; reduction of non-maintenance costs; allow reduction of production defects and rework rates (Figueira, 2021);

- Systemic Preventive Maintenance – according to EN 13306:2021, this technique is "a preventive maintenance performed at predetermined time intervals or according to a defined number of operating units, without prior checking of the condition of the asset".

  The advantages are costs already stipulated for each intervention; simplified financial management since it is possible to identify the main interventions and the costs associated with them; scheduling of interventions and stops according to production allowing the global costs to be lower when compared with production (Figueira, 2021).

2.1.4 Levels of Maintenance

The complexity of the maintenance task is a popular way to describe the level of maintenance. As a result, different maintenance levels are more often associated with acts of varying technical complexity than with actions at various indenture levels. Table 1 shows the levels of maintenance according to Márquez (2007).

Table 1 - Maintenance levels (Márquez, 2007)

Level	***Description***	***Performer***
I – Autonomous Management	Simple repairs and replacements, cleaning, inspection, adjustments, and lubrification	Operator
II – Corrective maintenance	Equipment cards removal, fault diagnosis, repairs, and equipment anomaly solving	Operator or qualified technician
III – Preventive maintenance	Training, standardization, overhauls, preventive and predictive maintenance	Qualified technician
IV – Maintenance prevention	Improvements, early equipment management, new equipment, techniques, and systems	Specialized technician
V – Contracted maintenance	Maintenance providers interventions, important supplier activities	Specialized technician or manufacturer

Usually, higher maintenance levels are attributed to more complex tasks, so a more specialized performer is required to complete the task. European standard establishes that a level of maintenance is “a set of maintenance actions to be carried out at a specific indenture level” (Márquez, 2007).

2.1.5 TPM

TPM is a method focused on the participation of all employees, from management to the shop floor, that aims to maximize equipment effectiveness during its full life cycle (Tortella *et al*, 2021). The six major losses – equipment failure, setup and adjustment time, idle time and small stops, reduced speed, process faults, and decreased yield – are the focus of TPM activities (Mwanza and Mbohwa, 2015).

TPM is one of the primary strategies for fostering production flow stability since well-maintained equipment is less likely to break down or produce quality problems. TPM can be analyzed in three words, according to Mwanza and Mbohwa (2015):

- **Total**: Refers to every employee in the business, from senior management to shop floor laborers.
- **Productive**: This entails minimizing waste and ensuring that all products and services produced meet or exceed consumer expectations.
- **Maintenance**: Maintaining machinery and plant in good functioning order, that is, in a condition that is equal to or superior to that of the original, at all times.

Eight pillars make up the structure of TPM: autonomous maintenance; focused improvement; planned maintenance; education and training; quality maintenance; safety, health, and the environment; office TPM; and development management (Figure 6). The number of pillars may change between approaches, although the first four pillars listed are considered the key ones (Tortorella *et al.*, 2021). Yet, it is important to note that throughout the entire TPM installation, 5S also plays a crucial role to achieve stable performance, involving the employees (Ribeiro *et al.*, 2019).

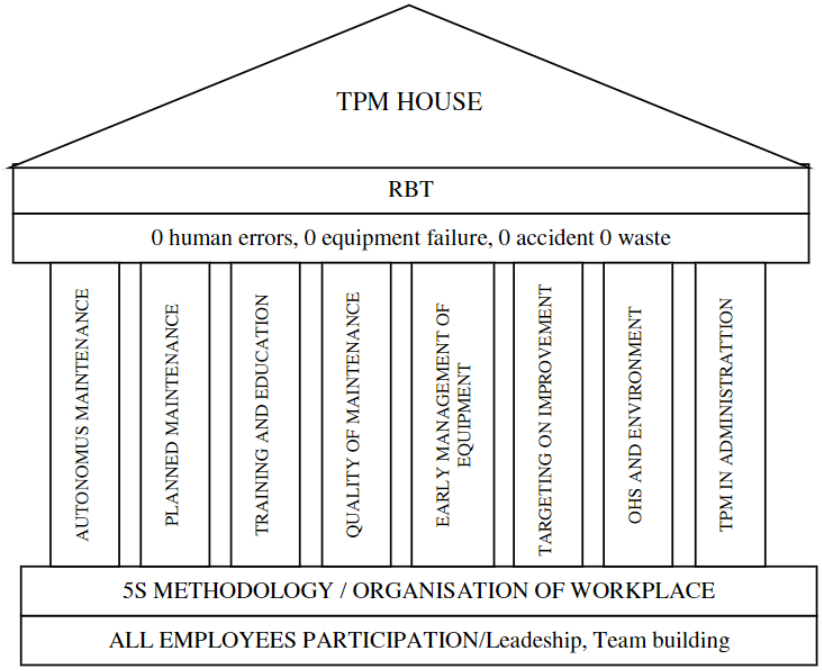


Figure 6 - TPM Pillars (Pačaiová and Ižaríková, 2019)

Table 2 describes each one of the TPM pillars, to understand better how to implement them successfully.

Table 2 - TPM Pillars description (Shinde and Prasad, 2018) (Adesta *et al.*, 2018) (Jain *et al.*, 2014)

Pillars	***Description***
Autonomous Maintenance	This is the mother pillar. Hands operators of equipment are responsible for carrying out basic maintenance of equipment.
Focused Improvement	Aims to identify and minimize waste, quality, and manufacturing losses. Elimination of losses helps improve OEE. Use of cross-functional teams for improvement activities.
Planned Maintenance	Deals with a preventive breakdown (time base maintenance). It establishes preventative and predictive maintenance systems for equipment and tooling. The effectiveness of the maintenance department is increased to the point where 8 big losses are not generated. Maintenance is scheduled using the historical failure rate of the equipment.
Education and Training	Boosts the morale and expertise of the operators and persons involved by providing soft skill training and technical training.
Quality maintenance	It monitors the factors affecting variability in product quality. It focuses on accomplishing zero quality defects. Quality is ingrained in the equipment to reduce defects.

Pillars	*Description*
Safety, Health, and Environment	Providing an ideal working environment devoid of accidents and injuries.
Development Maintenance	Minimal problems and running on time on new equipment. Utilizing learning from existing systems to new systems. Maintenance improvement initiatives.
Office TPM	Achieve zero functional losses, create highly efficient offices, and provide effective service and support to other departments. Administrative and support departments can be seen as process plants whose principal tasks are to collect, process, and distribute information. Process analysis should be applied to streamline information flow.

2.1.6 Autonomous Maintenance

The goal of autonomous maintenance is to eliminate all time-consuming activities connected to interruptions in the productive system brought on by equipment failures, which invariably have a negative influence on the efficiency of processes. It is a key pillar to implement the TPM methodology because it permits higher production throughput and includes assistance from the staff of the company (Guariente *et al.*, 2017).

With the AM, operators get to know their equipment better and are able to intervene or alert maintenance technicians as soon as they detect malfunctions. This alert at an early stage is something that all technicians wish for and that is now possible (Ribeiro, 2009).

When equipment breaks down, quality issues could appear, production might cease, and deliveries might be delayed, which affects customer service and increases costs, to which the costs of fixing the breakdown are added. The prevention of equipment failure is a common problem in every industry because it is essential to cut expenses in order to generate profits given the present economic climate (Ribeiro, 2009).

The first line of defense against equipment failure must therefore be the operators for them to also contribute to cost reduction, in addition to creating value and generating profits.

As for Mohan *et al.* (2021), there are six basic reasons for machines breakdown:

1. Uncleaned machine;
2. Blaming attitude of Break Down;
3. Poor operator knowledge about equipment;
4. Depending on the maintenance person even to tight a bolt;
5. Premature parts failure due to poor cleaning, lubrification, inspection, and tightening;
6. No physical support during breakdown when maintenance person needs help;

To implement Autonomous Maintenance, or Jisu Hozen, Mohan *et al.* (2021) specifies a seven-step methodology, as is shown in Figure 7.

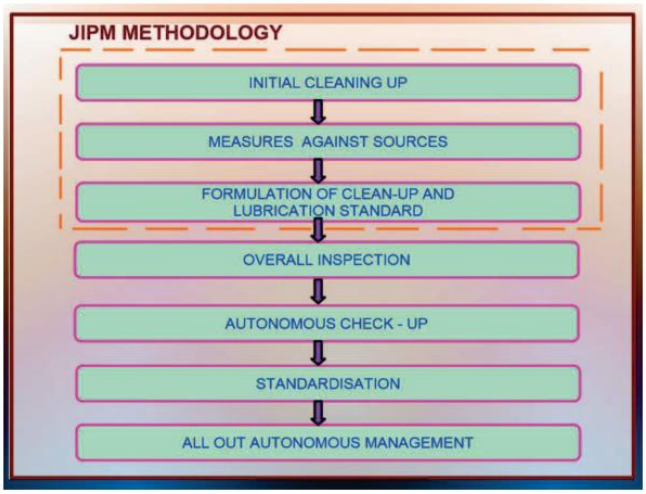


Figure 7 - The seven-step methodology to implement Jisu Hozen (Mohan *et al.*, 2021)

2.1.7 Industry 4.0 on Maintenance Processes

The industry entered a new phase as a result of the necessity to adapt and adopt new technologies. Industry 4.0 was made possible by connectivity, data volume, new devices, inventory reduction, customization, and managed production **(**Zonta *et al.*, 2020).

Industry 4.0 is built on the extraction of massive amounts of data from the systems and the utilization of improvements in robotics, sensors, and new technologies like augmented reality, big data analytics, and the Internet of Things (IoT) (Pinciroli *et al.*, 2023).

With technology evolution and the emergence of Industry 4.0, a new maintenance paradigm, innovative methods, and tools have to be developed. In this context, the maintenance function is also defined as Maintenance 4.0 or Smart maintenance (Jasiulewicz-Kaczmarek *et al.*, 2020).

According to Kinz *et al.* (2018), "Smart Maintenance stands for an intelligent and learning maintenance management focusing on permanent improvement". As for Kumar and Galar (2016), "Maintenance 4.0 does predictive analytics and suggests a feasible solution, with major application in Industry 4.0 and especially on those maintenance aspects that deal with the collection of data, its analysis and visualization and asset decision-making".

In digital maintenance, the autonomous maintenance personnel is informed when the equipment's health condition changes so they may find the issue, troubleshoot it, and make the necessary corrections to prevent a breakdown. The digitalization of Cleaning, Lubrification, Inspection, and Tightening is a way to reduce operators working time by eliminating minor stoppages and breakdowns (Mohan *et al.*, 2021).

2.1.8 KPIs

Using KPIs (key performance indicators) is one of the most useful methods for assessing the effectiveness of any system or process. KPIs can offer data on how several areas, including energy, raw materials, control & operation, maintenance, planning & scheduling, product quality, inventory, safety, etc., are performing (Lindberg *et al.*, 2015).

The BS EN 15341:2019 provides guidelines for defining a set of appropriate indicators that can be used to evaluate and improve the effectiveness, efficiency, and sustainability of maintaining existing physical assets, such as industrial infrastructures, facilities, civil buildings, transportation systems, etc., within the context of external and internal influencing factors.

This European Standard 15341:2019 also states that the KPIs can help organizations to:

- Measure performance;
- Compare performances with internal and external benchmarking;
- Identify strengths and weaknesses;
- Control progresses and changes;
- Define plan/strategies of improvement;
- Monitor the results over time.

When tying business and market goals to production resources, indicators are crucial benchmarks to keep in mind at all stages of the manufacturing strategy – from product creation to manufacturing system design. Generally speaking, these indicators have three basic functions: reporting, managing, and improving, as shown in Figure 8 (Wiktorsson *et al.*, 2018).

Figure 8 - KPI purpose (Wiktorsson *et al*, 2018)

An excessive number of unexpected stops due to insufficient maintenance leads to lost productivity and emergency maintenance. Every time necessary maintenance is performed, excessive maintenance results in high maintenance expenses and lost production (Lindberg *et al.*, 2015).

Regarding maintenance function, the most used KPIs are Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR), Overall Equipment Efficiency (OEE), and Mean Time To Attend (MTTA) (Ferreira *et al.*, 2020). Table 3 represents these KPIs and how to calculate them.

Table 3 - KPI Formula (Gonzalez *et al.*, 2017) (Ding *et al.*, 2014)

Indicator	***Formula***
MTBF	$= \frac{Overall\ time\ of\ operation}{Total\ number\ of\ breakdowns}$
MTTR	$= \frac{Overall\ repair\ time}{Total\ number\ of\ repairs}$
MRT	$= \frac{Efective\ repair\ time}{Total\ number\ of\ repairs}$
MTTA	$= \frac{Average\ waiting\ time}{Total\ number\ of\ breakdowns}$

MTBF is used on repairable components, and it is expressed as the number of operational hours divided by the number of failures for a particular component. The term MTBF is usually used to describe reliability (Gonzalez *et al.*, 2017).

MTTR is known as the mean time to return a component to its functional state. The term "restoration" refers to either a repair or a complete replacement of the defective component. By

dividing the entire restoration time by the total failures, one can calculate this indication. This word should instead be referred to as the "mean time to restoration" given the description in the maintenance standards (Gonzalez *et al.*, 2017).

MTTR includes the time lost from the moment an alert is triggered to the start of repair – MTTA – and it is different from the MRT (Mean Repair Time). MRT is the actual time to repair a component/equipment (Ding *et al.*, 2014). Figure 9 illustrates these definitions.

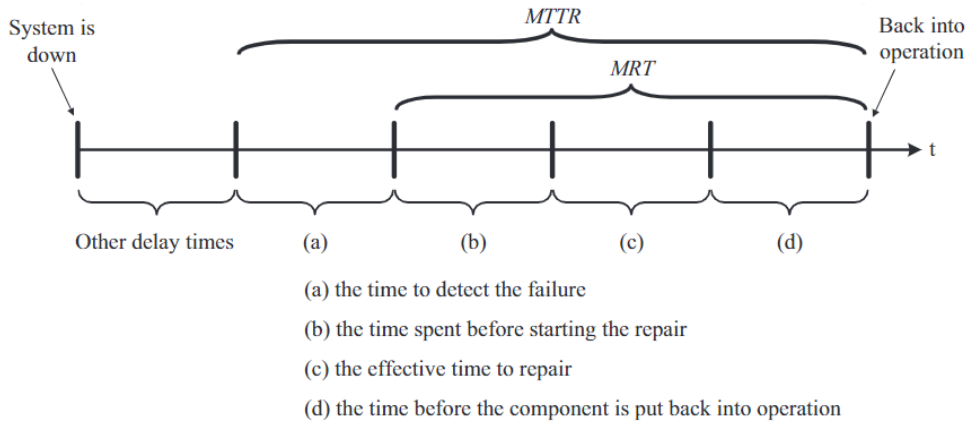


Figure 9 – MTTR and MTR (Ding *et al.*, 2014)

2.2 Data Visualization

When people visualize data, they take the data values and transform them into the visual components that make up the final picture methodically and logically. Although a scatter plot, a pie chart, and a heatmap appear to have little in common at first glance and there are many different types of data visualizations, all of these visualizations can be described using a common language that encapsulates how data values are transformed into blobs of ink on paper or colored pixels on screen. This is called aesthetics (Wilke, 2019).

Aesthetic describes every aspect of a given graphical element, as is shown in Figure 10. Some critical aspects of graphic elements are position, shape, size, and color. All aesthetics in each graphic element can be divided into two groups: continuous data values and discrete data values (Wilke, 2019).

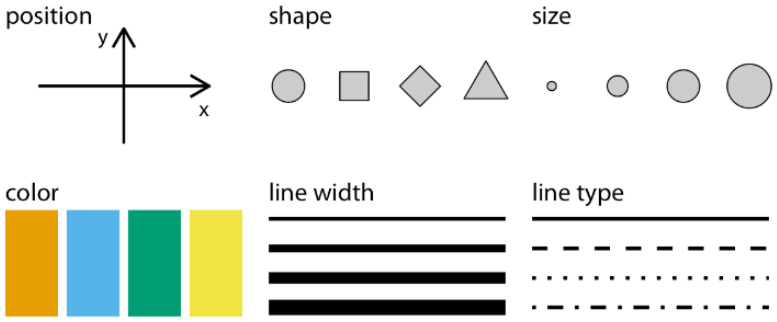


Figure 10 - Aesthetics in Data Visualization (Wilke, 2019)

Monitoring, regulating, and improving organization's operations are all based on the visualization of organizational performance. Because they are an effective tool for combining pertinent information in a single view that provides a graphical summary of the current condition, dashboards are frequently employed for this purpose (Staron, 2015).

In order to increase organizational performance, visual management aligns the company's vision, core values, goals, and organizational culture with other management systems, work processes, and other components, then stakeholders (Vilarinho, 2019).

2.2.1 Dashboards

A dashboard is a set of graphic elements or a communication tool, that displays information (Habidin *et al.*, 2017). By connecting various information systems, Karami and Safdari (2016) highlight the significance of dashboards in aiding informed workflow decisions.

Staron (2015) states that "a dashboard is defined as an easy-to-read real-time user interface, showing graphical presentation of the current status (snapshot) and historical trends of an organization's Key Performance Indicators to enable decisions".

In addition to the traditional ideas of monitoring and decision assistance, the dashboard concept has developed from single-view reporting displays to interactive interfaces with various views and objectives, including communication, learning, and incentive (Sarikaya *et al*, 2019).

There are two main design perspectives when building dashboards (Sarikaya *et al*, 2019):

- Visual genre - a tiling arrangement of basic graphs and/or huge numbers used to display visual data (Figure 11, left);
- Functional genre - a real-time monitoring tool for dynamically updating data through an interactive display (Figure 11, right)

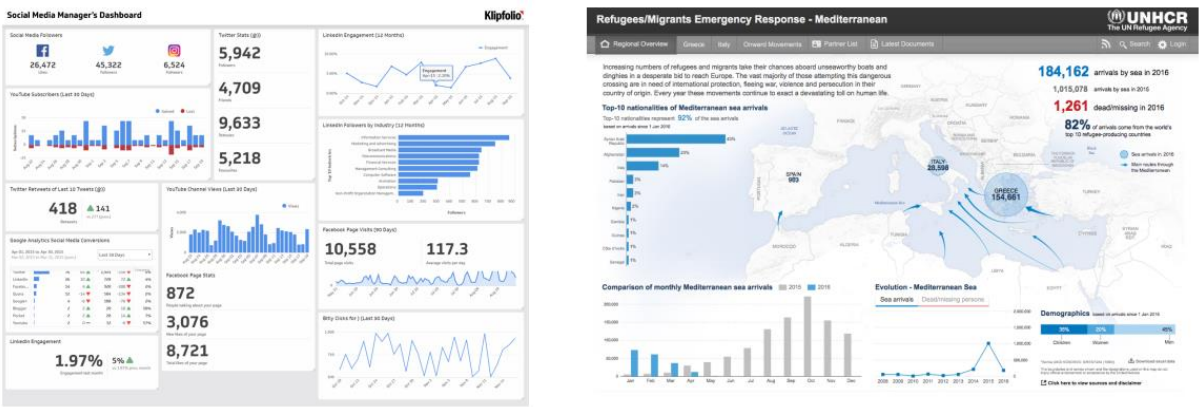


Figure 11 - Types of dashboards (Sarikaya, 2019)

Dashboards have a variety of uses, and depending on the use cases listed below, their design, technology, and scope may change (Staron, 2015):

- Information radiators – Dashboards designed to present the information to a big group of people, or as an information screen in central places.
- Management dashboards – Give information to notify managers of the project's status and the factors that determine it, frequently in the form of desktop reports that allow for deeper exploration of the data.
- Business intelligence dashboards - Built as a desktop application with the ability for web-based report access, it aids product managers in accessing, visualizing, and evaluating data relevant to product development and its surrounding market.
- Hybrid dashboards – The ones combining two or more use cases above.

2.2.2 Dashboard Development Process

Dashboards may be built in different ways, but they usually are divided into five phases, as illustrated in Figure 12.

Figure 12 - Main phases to design a dashboard (Vilarinho, 2017)

Table 4 specifies the goal of each step to design a good and functional maintenance dashboard, according to Vilarinho *et al*. (2017) and Staron (2015).

Table 4 - Dashboard design procedure

Phase	***Goal***
Diagnosis	Recognize and comprehend the current situation and identify the top considerations for process and equipment improvement.
Requirements for the dashboard	Knowing the organization's needs will help ensure that they are satisfied with the finished product.
Development of a dashboard template	Translate the specifications into technical answers. Prepare the information system for the collection of data and the generation of information. Iteratively design and evaluate the dashboard.
Assuring the necessary resources	Create and enhance information records and make the information system adequate. Determine the essential elements for its administration and operation.
Implementation, evaluation, and improvement	To make the dashboard operational, implement it and the supporting resources. Observe and assess dashboard effectiveness and suggest any upgrades.

3 Problem framework and description

The purpose of creating this new Transversal Industrial Maintenance department is to provide the possibility of intern maintenance to all Efacec's BUs. For that, it is necessary to know how much equipment of each type is owned in each BU, since one of the main problems encountered in audits is the amount of money spent on equipment that is already owned, but because it is not registered, its whereabouts are unknown, or it is not known that they have more equipment after all, so there is no need to buy it.

Thus, a start was made to the process of registering assets, more specifically EATs and equipment that needs calibration, in the various BUs.

As far as autonomous maintenance is concerned, the department was already trying to implement the TPM methodology in its work base, more specifically the AM, but it is still in the early stage of implementation.

To implement the AM, it is necessary to build an official template, validated by the company, to create the different autonomous maintenance manuals for the different equipment, thus evolving in what concerns the digitalization of the AM process.

Besides this, it is necessary to create a platform where autonomous maintenance can be managed, in order to achieve adequate control of this pillar and to describe the process itself.

Regarding preventive maintenance, the file used in the planning of this type of maintenance is dated from 2009, which is already considered old for what is possible to do nowadays.

Thus, a new file and planning method for preventive maintenance is necessary to achieve better control and analytical method to the process of carrying out these preventive maintenances.

As for EATs and EMCs requisition requests, better control of them is necessary. Thus, dashboards will be built in order to understand the quantities and costs of the requests made by the different BUs, as well as monitor some KPIs.

For the asset register and preventive maintenance planning, dashboards will also be created with the objective of better control, more accessibility to the information and so that other areas of the company, if they need the information, can quickly find it available online.

The following sections will explain in more detail the status of each of these topics in the company and identify the points for improvement in each of them.

3.1 Active registration

As mentioned in the introduction of this chapter, the need arose to register all the assets that each BU has, for better control of the inventory it has. The lack of this control over the inventory of hand tools and machine tools owned at Efacec was the main reason for this registration action because without it there is no data in the equipment possessed.

The first problem found in the way the assets were registered was the nomenclature used, which was not uniform and transversal to all units. Figure 13 shows the difference in the nomenclature used in the ASE unit and in the TRF unit.

Figure 13 – Label used in ASE (left) and TRF (right)

The first step in the work plan for this topic is to define a standard nomenclature that will be used in all BUs.

Next, it is necessary to know how many equipment records each BU has, in order to know how many new records were made. Concentrating the focus on the EEM unit, because this was where the monitoring was higher, the number of equipments that already had a record was 161. All these equipments will have to be re-registered with the newly defined nomenclature.

A limitation in the type of registry currently used is also the detail to which one can go on equipment to describe the type of malfunction it suffered. For example, with the current type of registration, it is not possible to define in detail in which elements of the equipment the malfunction is located.

The fact that there are no photographic records of the equipment or where the registered equipment is located can be considered another type of limitation since the company is adopting a philosophy of digitalization of data and processes.

3.2 Autonomous Maintenance and Management Platform

One of MIT's main objectives is to implement the TPM methodology, specifically AM, in its BUs. To begin this implementation, the department created autonomous maintenance manuals for some equipment, specifically for about 10, in TRF but without official process and registration of documentation.

No template for the creation of manuals is yet officialized, only the manual creation process was defined.

The methodology used for creating these manuals is based on the seven steps that Mohan *et al*. (2021) specifies, as shown in Table 5.

Table 5 -Autonomous maintenance steps description (Mohan *et al*. 2021)

Stage	Description
1 – Initial Cleaning 2 – Measures against sources 3 – Clean-up and lubrification standards	• Cleaning instructions; • Clean environment using the 5S methodology;
4 – Overall equipment inspection	• Making use of visual management techniques that make it easier for maintenance workers and operators to locating equipment defects;
5 – Autonomous check-up	• Using the instruction manual to locate equipment issues.
6 – Standardization	• The use of record sheets for anomalies or enhancements in the areas of production, maintenance, and safety will assist the employees in becoming more independent and integrated into the procedure.
7 – Autonomous Management	• Developing AM check sheets to track its application; • Providing practical guidance describing the objectives and significance of this implementation to every employee as well as those in charge of the production centers.

The maintenance manuals already created are based on root-cause analysis, through the use of the 3C method. This tool is used to analyze the case, find the causes, and define countermeasures, thus being possible to structure the problems in a concrete and objective way and find possible solutions and improvement proposals, such as retrofitting and revamping.

The results obtained through the use of this analysis method are used to proceed with the implementation of Autonomous Maintenance.

The necessary interventions in the equipment are carried out by the equipment operators, after getting approval from the Quality, Environment and Safety (QES) department, and after training by the MIT members.

Figure 14 shows one of the existing AM manuals, as well as Appendix A. Appendix B, shows the attendance record sheet of the autonomous maintenance training sessions.

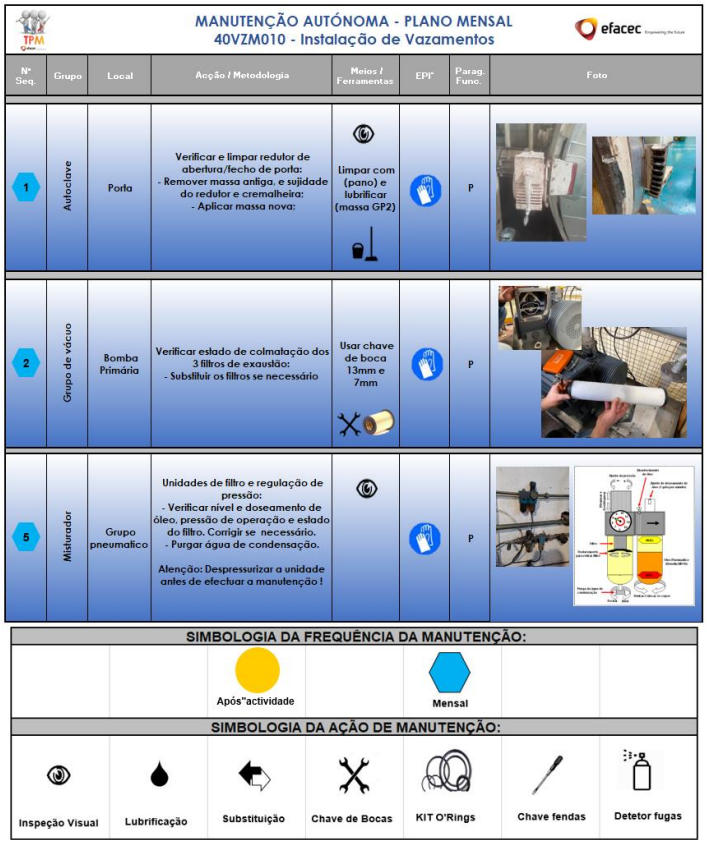


Figure 14 – Old autonomous maintenance manual for 40VZM010

After describing the methodology used to prepare the manuals, it is also necessary to know what should be done for each piece of equipment, as well as what information the manual should display.

For each piece of equipment, an analysis must be made of its operating mode, equipment manual, preventive maintenance manual, and failure history, thus helping to define the most appropriate tasks to be performed by the operator.

For the manual, on the other hand, it presents:

1. Task order (sequence);
2. Description;
3. Means (Tools to be used, spares);
4. Personal Protective Equipment (PPE);
5. Need to stop the equipment;
6. Estimated duration;
7. Photograph of the equipment;
8. Demonstration Video/Image;

Another goal of the MIT department is the creation of a new AM management platform. There is an attempt to create this platform, but it did not meet expectations.

The platform goal is to compile all the information in the same document, such as templates, execution records, and anomalies, in order to achieve better monitoring of interventions and have all information in one place. Through this platform, the information would be accessible online for anyone through a more simplified consultation.

Figure 15 illustrates a part of the existing management platform, created in Excel.

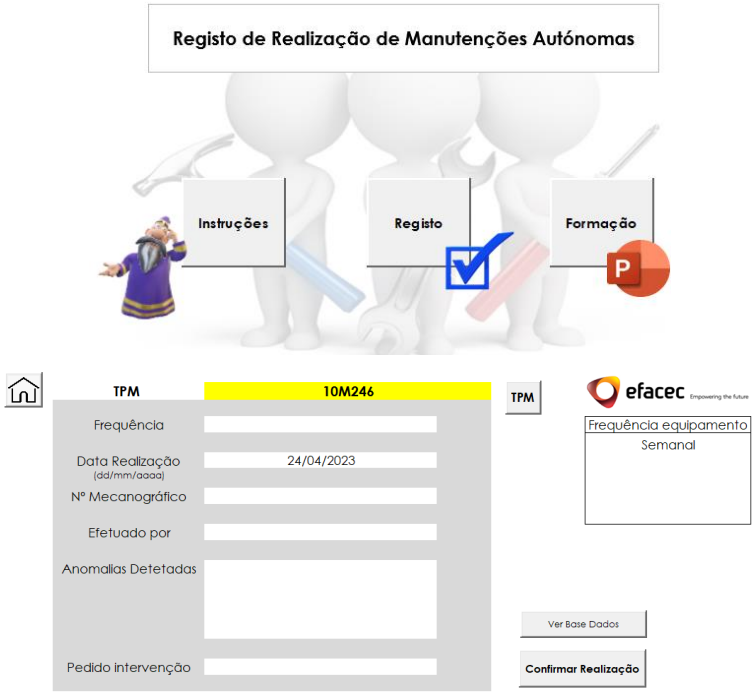


Figure 15 – Autonomous maintenance management platform

3.3 Preventive Maintenance Management

Preventive maintenance is of utmost importance to ensure the life and longevity of equipment. Therefore, good planning for this type of maintenance is necessary, as well as a proper method of controlling this planning and its execution.

The planning of preventive maintenance is recorded in an Excel file that has been in use for over 13 years. Although it still meets the requirements, it is subject to changes and improvements. The planning is done for 760 equipment units across 3 business units of Efacec.

The currently used file exposes the following fields:

1. Area;
2. Cluster;
3. Equipment Description;
4. Yearly Calendar;

The file user enters different preventive maintenance actions in the calendar for each equipment, depending on their frequency. The three established frequencies are quarterly, biannual, and annual.

Figure 16 shows the file used for this planning.

efacec Transformadores 760

Plano de Manutenção Preventiva - PREVISTO

Area	Baan	Equipamento - (..)	Mês / Sem.	JAN 1	2	3	4	5	FEV 6	7	8	9	MAR 10	11	12	13	ABR 14	15	16	17	MAI 18	19	20	21	22	JUN 23	24	25
CT - Bobinagem	10M019	Enrolador de carretas						A																				
CT - Bobinagem	10M027	Berço de virar bobines																										
CT - Bobinagem	10M033.01	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.02	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.03	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.04	Mandril expansivel fuso central c/ cunhas																										
CT - Bobinagem	10M033.07	Mandril expansivel de 3 fusos																										
CT - Bobinagem	10M033.08	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.09	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.10	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.12	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.13	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.14	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.15	Mandril expansivel fuso central																										
CT - Bobinagem	10M033.16	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.18	Mandril expansivel fuso central																										
CT - Bobinagem	10M033.20	Mandril expansivel de 2 fusos																										
CT - Bobinagem	10M033.21	Mandril expansivel fuso central																										
CT - Bobinagem	10M033.23	Mandril expansivel fuso central c/ cunhas																										
CT - Bobinagem	10M033.24	Mandril expansivel fuso central																										
CT - Bobinagem	10M033.25	Mandril expansivel fuso central																										
CT - Bobinagem	10M033.29	Mandril expansivel fuso central																										
CT - Bobinagem	10M033.30	Mandril expansivel fuso central																										
CT - Bobinagem	10M033.37	Mandril Ø450 a 720mm (L=2700mm)																										
CT - Bobinagem	10M033.38	Mandril Ø450 a 720mm (L=2700mm)																										
CT - Bobinagem	10M033.39	Mandril Ø1200 a 1900mm (L=2700mm)																										
CT - Bobinagem	10M033.40	Mandril expansivel fuso central Ø300 a 410mm																										
CT - Bobinagem	10M033.41	Mandril expansivel fuso central c/ cunhas Ø400 a 610mm																										

Figure 16 – Preventive maintenance plan

When operators perform a preventive maintenance (PM) action, they need to fill out another Excel sheet similar to the one shown in Figure 16, but with the executed actions.

A third Excel sheet within the file organizes all the actions that need to be executed in a specific week established by the user, in order to determine the planned actions for that week, as shown in Figure 17.

Imprime MANUT | Semana 15

Manutenção Industrial 2023

Área	Baan	Equip.	Manu	OS	obs.
DT - Construção Soldada	40ELV213	Ponte rolante Tegopi 2,5T Nº436	A		
DT - Montagem EEE	40M310	Plataforma aérea eléctrica	A		
ENAI - AMT	30FZD226	Fresadora	S		
ENAI - AMT	30PSF756	Purificador de SF6	T		
ENAI - AMT	30RHE755	Recuperador de Helio	T		
ENAI - AMT	30SRR234	Serrote de Corte	S		
ENAI - AMT	30TRN232	Torno Mecânico Grande	S		
ST - Bobinagem	10M006	Máquina de bobinar galetes	A		
ST - Bobinagem	10M007	Máquina de bobinar galetes	A		
ST - Bobinagem	10M010	Desenrolador de carretas	A		
ST - Bobinagem	10M011	Desenrolador de carretas	A		
ST - Isolantes	10M022.07	Transportador pneumático	T		
ST - Isolantes	10M187	Serra fita	A		
ST - Isolantes	10M485	Máquina cintar	A		
ST - Isolantes	10M487	Prensa pneumatica de entalhes	A		
ST - Montagem Grupos	10P004	Ponte rolante	T		
ST - Montagem PA	10M077	Plataforma elevatória (6000Kg)	A		
ST - Montagem PA	10M080	Plataforma elevatória (500kg)	A		
ST - Montagem PA	10M082	Plataforma elevatória (6000kg)	A		
ST - Montagem PA	10M486	Esmeriladora	A		

Figure 17 – Preventive actions planned for Week 15

As for the analytics, the file is very limited. Some of its limitations include the lack of information regarding overdue actions, actions not performed, actions planned for the future, and the quantities planned for each week. Another limitation is the need to create a new file every year, resulting in a lack of continuous historical data for the PM actions.

A fourth Excel sheet illustrates the overall execution percentage by comparing what was planned with what is actually being executed. However, there are also limitations in this regard, as it is not possible to search for this information specific to a particular business unit (BU) or equipment type. Figure 18 illustrates this execution percentage calculation.

	JAN					FEV				MAR				ABR			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Previstas	1	11	15	17	37	31	20	21	15	23	22	22	26	25	22	23	24
Previstas acumuladas	1	12	27	44	81	112	132	153	168	191	213	235	261	286	308	331	355
Realizadas	0	9	8	30	32	11	5	19	24	9	23	0	17	0	0	0	0
Realizadas acumuladas	0	9	17	47	79	90	95	114	138	147	170	170	187	187	187	187	187
%Realização	0%	1%	1%	4%	7%	8%	8%	10%	12%	13%	15%	15%	16%	16%	16%	16%	16%

	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ	Total
Realizadas	79	59	49	0	0	0	0	0	0	0	0	0	182
Previstas	81	87	93	94	140	82	103	114	103	92	113	35	1137
% Realização Mensal	98%	68%	53%	0%	0%	0%	0%	0%	0%	0%	0%	0%	16%
% Realização Acumulado		83%	68%	60%	53%	26%	0%	0%	0%	0%	0%	0%	
Realizadas-Previstas	-2	-28	-44	-94	-140	-82	-103	-114	-103	-92	-113	-35	-955
Real.-Prev. acum	-2	-30	-74	-168	-308	-390	-493	-607	-710	-802	-915	-950	
NE	5												

Figure 18 - % Overall execution

3.4 EAT and EMC requisitions

Whenever repairs or acquisitions of EMC or EAT are required, requests are made to the logistics department. However, no analytical approach is undertaken to understand the quantities of requests made and their associated costs.

The requisitions for this equipment are typically made without proper records, usually through emails or phone calls, resulting in limited control over them, failures in fulfilling the requests, and duplicate tool acquisitions due to the lack of information on whether the request was already resolved or still in progress.

The only record of these requests is the so-called "pool," as shown in Figure 19, where the number of pending requests and unresolved issues could be determined, but with limited monitoring capabilities.

Processo	Data Pedido	Mês	Unidade	Divisão	Equipa	Centro de Custo (C.C)	Nº Mec. Pedido Efetuad	Cód. Equipament	Descrição	Marca	Modelo
REP_006.22	18/01/2022	1	TRF	CT	Isolantes	ENCT01	1206		Fresa para corte de réguas trapezoidais	FREZITE	S001.24134
REP_019.22	07/03/2022	3	TRF	CT	Isolantes	ENCT01	1206		Lâminas	FLAI	
REP_035.22	29/04/2022	4	TRF	CT	Isolantes	ENCT01	4252		Serra de Fita	FREZITE	
REP_064.22	19/07/2022	7	TRF	CT	Isolantes	ENCT01	1206		Disco de corte 450x4.0/2.8x55 HW Z66/W		9863.4504006655
REP_064.22	19/07/2022	7	TRF	CT	Isolantes	ENCT01	1206		Serra de Fita	FREZITE	
REP_092.22	14/11/2022	11	TRF	CT	Isolantes	ENCT01	4252		Serra de Fita	FREZITE	

Figure 19 – Pool

The member responsible for the requisition requests in the logistics department records the requests considering the fields represented in Figure 19, as well as the cost, quantity, request launch date, and repair/acquisition date.

However, due to a lack of time or failure to review the emails containing the requests, the responsible person often did not populate the file with all the requested orders, resulting in misleading outcomes.

The utilized file is extensive, with numerous fields that provide limited utility, multiple sheets corresponding to different years of records, unnecessary sheets for the proper functioning of the file, and confusion regarding which fields should be filled in.

Therefore, there are significant limitations in this area and several opportunities for improvement.

3.5 Summary of the work plan

In summary, there are several improvement proposals that can be implemented in each of these areas to achieve better control and simplified access to information. The main work plans/objectives for each topic are as follows:

1. Active Registration:
    - Standardize and implement a consistent nomenclature for equipment across all business units.
    - Create control dashboards for the registration process in each business unit.
    - Provide support for registration in the EEM and SRV business units.
2. Autonomous Maintenance and Management Platform:
    - Develop and establish a template for the Autonomous Maintenance manual.
    - Create manuals for certain equipment and officially document them.
    - Prepare specifications for the management platform.
    - Description and officialization of the AM process.
3. Preventive Maintenance Planning:
    - Develop a new file for preventive maintenance planning.
    - Create analytics dashboards for monitoring and analyzing the planning process.
4. EAT and EMC Requisitions:
    - Develop analytics dashboards for EAT and EMC requisitions.
    - Establish a new area for recording and tracking the requests.
    - By implementing these improvement proposals, it is expected to achieve better control, standardization, and enhanced access to information in each respective area.

4 Project development

In this chapter, the improvements and developments in each of the previously mentioned topics will be presented. Before delving into the work carried out, it is necessary to explain the new concepts adopted by this new department.

After several team discussions, it was decided that assets are divided into two main categories:

1. EATs (Equipment for Auxiliary Tasks):

- These are equipment used to perform specific tasks or as aids in carrying out activities;
- They are typically standard/cataloged, portable, and technologically less complex;
- They do not require specialized preventive maintenance, such as portable machine tools, ladders, material handling trolleys, among others.

2. Equipment:

- These can be generic equipment (GEN), lifting platforms (PE), load lifting equipment (EC), gas equipment, etc;
- They may or may not require specialized preventive maintenance.

Regarding EATs, subcategories known as Clusters were created. The key concept here is that "each type of equipment is a cluster.", ie, clusters for EATs are groups of equipment.

As for equipment, the adopted concept is that "each equipment is a cluster." The reason behind this difference in concepts is that by assigning a cluster to the equipment, we can assign serial numbers to the equipment components. This allows to specify which component of the equipment has failed, for example, when making a repair request.

With these concepts in mind, 50 clusters of EATs and 21 equipment types were created. A table with the different clusters created for EATs and equipment can be found in Appendix C.

4.1 Active registration

Once the essential concepts were established and explained, the asset registration process began. The first step in this process was to define the nomenclature to be used. After long team discussions, serial numbers were created, which are engraved or labeled on the equipment/EATs. These serial numbers consist of the following components: the number associated with the business unit (BU), the number associated with the cluster/equipment type, and a sequential number.

By implementing this standardized nomenclature, it becomes easier to identify and track each asset, providing a clear and consistent system for asset management and maintenance.

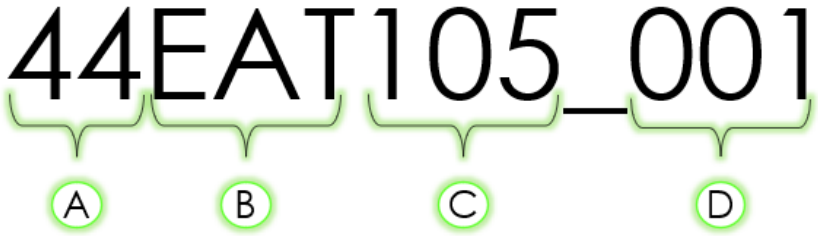


Figure 20 – Example of a serial number defined for EATs in EEM

A) The number is associated with the business unit (BU) to which the equipment/EAT belongs.

B) Abbreviation of the equipment/EAT type.

C) In the case of EATs, the number is associated with the cluster.

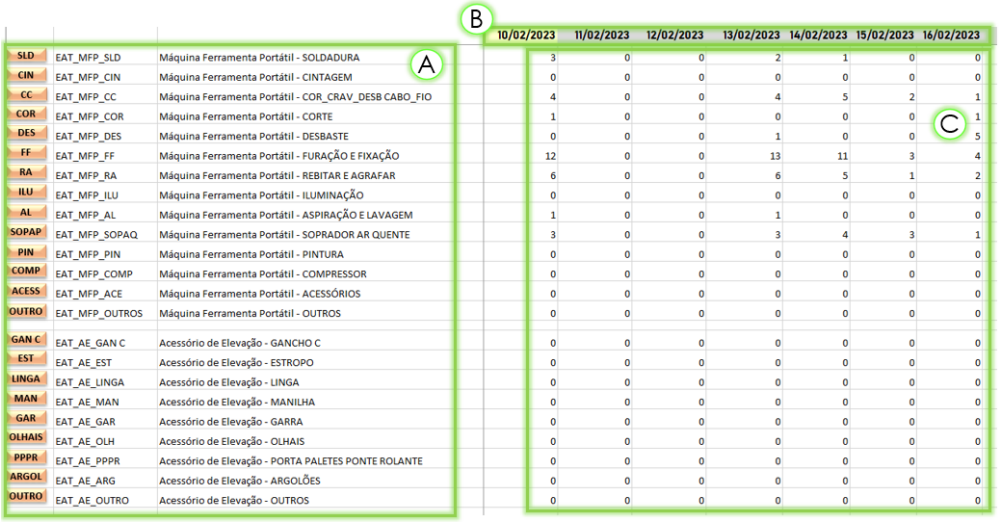
D) Sequential number.

Table 6 establishes the relationship between the BU and the number assigned.

Table 6 - Number assigned to each BU

BU	Number
TRF	10
AMT	17
SRV	22
EEM	44
ASE	50

Once the standardized nomenclature for asset registration was defined, an Excel file was developed to record the registered assets as the process progresses.



			10/02/2023	11/02/2023	12/02/2023	13/02/2023	14/02/2023	15/02/2023	16/02/2023
SLD	EAT_MFP_SLD	Máquina Ferramenta Portátil - SOLDADURA	3	0	0	2	1	0	0
CIN	EAT_MFP_CIN	Máquina Ferramenta Portátil - CINTAGEM	0	0	0	0	0	0	0
CC	EAT_MFP_CC	Máquina Ferramenta Portátil - COR_CRAV_DESB CABO_FIO	4	0	0	4	5	2	1
COR	EAT_MFP_COR	Máquina Ferramenta Portátil - CORTE	1	0	0	0	0	0	1
DES	EAT_MFP_DES	Máquina Ferramenta Portátil - DESBASTE	0	0	0	1	0	0	5
FF	EAT_MFP_FF	Máquina Ferramenta Portátil - FURAÇÃO E FIXAÇÃO	12	0	0	13	11	3	4
RA	EAT_MFP_RA	Máquina Ferramenta Portátil - REBITAR E AGRAFAR	6	0	0	6	5	1	2
ILU	EAT_MFP_ILU	Máquina Ferramenta Portátil - ILUMINAÇÃO	0	0	0	0	0	0	0
AL	EAT_MFP_AL	Máquina Ferramenta Portátil - ASPIRAÇÃO E LAVAGEM	1	0	0	1	0	0	0
SOPAP	EAT_MFP_SOPAQ	Máquina Ferramenta Portátil - SOPRADOR AR QUENTE	3	0	0	3	4	3	1
PIN	EAT_MFP_PIN	Máquina Ferramenta Portátil - PINTURA	0	0	0	0	0	0	0
COMP	EAT_MFP_COMP	Máquina Ferramenta Portátil - COMPRESSOR	0	0	0	0	0	0	0
ACESS	EAT_MFP_ACE	Máquina Ferramenta Portátil - ACESSÓRIOS	0	0	0	0	0	0	0
OUTRO	EAT_MFP_OUTROS	Máquina Ferramenta Portátil - OUTROS	0	0	0	0	0	0	0
GAN C	EAT_AE_GAN C	Acessório de Elevação - GANCHO C	0	0	0	0	0	0	0
EST	EAT_AE_EST	Acessório de Elevação - ESTROPO	0	0	0	0	0	0	0
LINGA	EAT_AE_LINGA	Acessório de Elevação - LINGA	0	0	0	0	0	0	0
MAN	EAT_AE_MAN	Acessório de Elevação - MANILHA	0	0	0	0	0	0	0
GAR	EAT_AE_GAR	Acessório de Elevação - GARRA	0	0	0	0	0	0	0
OLHAIS	EAT_AE_OLH	Acessório de Elevação - OLHAIS	0	0	0	0	0	0	0
PPPR	EAT_AE_PPPR	Acessório de Elevação - PORTA PALETES PONTE ROLANTE	0	0	0	0	0	0	0
ARGOL	EAT_AE_ARG	Acessório de Elevação - ARGOLÕES	0	0	0	0	0	0	0
OUTRO	EAT_AE_OUTRO	Acessório de Elevação - OUTROS	0	0	0	0	0	0	0

Figure 21 - Main sheet of the developed file

A) Clusters of EATs and equipment types.

B) Dates of asset registration.

C) Quantity of EAT/equipment registered for a certain cluster/equipment type each day.

Each type of EAT has its own sheet where the beige fields (equipment/EAT specifications and characteristics) and light gray fields (fields with selectable options) are filled in, as shown in Figure 22.

HOME			A			B						C				
Cluster	Descrição	Descrição (30 caracteres)	Cadastro a Registar em Baan	Cadastro Existente (caso exista)	Search argument	Centro de trabalho	Marca SPEC A	Modelo SPEC B	Nº Série	Ano	Data Cadastro	Características Particulares	Características Particulares	Características Particulares	Características Particulares
CLUSTER	CLUSTER	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	ITEM	NÃO BAAN	NÃO BAAN	NÃO BAAN	NÃO BAAN	NÃO BAAN
Cluster	Ownership Descrição	General Descrição	General Serial Number	Item control Characteristics Size		Service Control Work site info	Origem SPEC A	Origem SPEC B	General Alternate Serial Number	Origem Manufacturing Date		Tipo de Linga /Liga/Cabo de aço	Capacidade (T)	Comprimento Útil (m)	Número de pernadas
44EAT202	Acessório de Elevação - LINGA	Linga_2,8T_0,9m_2Per	44EAT202_001		EAT_AE_LING	Armazém				2001	23/03/2023	Linga	2,8	0,9	2
44EAT202	Acessório de Elevação - LINGA	Linga_2,8T_0,9m_2Per	44EAT202_002		EAT_AE_LING	Armazém				2001	23/03/2023	Linga	2,8	0,9	2
44EAT202	Acessório de Elevação - LINGA	Linga_1,5T_0,3m_1Per	44EAT202_003		EAT_AE_LING	Produção			1029	2006	27/03/2023	Linga	1,5	0,3	1
44EAT202	Acessório de Elevação - LINGA	Linga_1,5T_0,3m_1Per	44EAT202_004		EAT_AE_LING	Produção			1028	2006	27/03/2023	Linga	1,5	0,3	1
44EAT202	Acessório de Elevação - LINGA	Linga_1,5T_0,3m_1Per	44EAT202_005		EAT_AE_LING	Armazém			1026	2006	27/03/2023	Linga	1,5	0,3	1
44EAT202	Acessório de Elevação - LINGA	Linga_1,5T_0,3m_1Per	44EAT202_006		EAT_AE_LING	Armazém			1025	2006	27/03/2023	Linga	1,5	0,3	1
44EAT202	Acessório de Elevação - LINGA	Linga_1,5T_0,5m_1Per	44EAT202_007		EAT_AE_LING	Armazém			3033		27/03/2023	Linga	1,5	0,5	1
44EAT202	Acessório de Elevação - LINGA	Linga_1,5T_0,5m_1Per	44EAT202_008		EAT_AE_LING	Armazém			3032		27/03/2023	Linga	1,5	0,5	1
44EAT202	Acessório de Elevação - LINGA	Linga_2,1T_0,8m_2Per	44EAT202_009		EAT_AE_LING	Linha 1			5434		27/03/2023	Linga	2,1	0,8	2
44EAT202	Acessório de Elevação - LINGA	Linga_1,6T_0,7m_2Per	44EAT202_010		EAT_AE_LING	Armazém					27/03/2023	Linga	1,6	0,7	2

Figure 22 – Example of a registration information sheet

Fields A, B, and C are the most important fields to consider when registering in the file, as they provide information about the registered equipment/EAT number, the area within the BU where it is located, and the date of registration. This information will be used in the dashboard created to monitor the registration process. This sheet was replicated for the 71 clusters/equipment types.

Since the registration process started in the EEM, a dashboard was developed to monitor and control the process as it progresses. The dashboard was designed based on the following requirements defined by the team:

- Quantity of equipment registered per day;
- Accumulated quantity of equipment registered each day;
- Total registered by cluster/equipment type;
- Clusters/equipment types registered on a selected day;
- Total registered and daily average;

With the essential points defined, the development of the dashboard began using the PowerBI software. The created dashboard can be seen in figure 23.

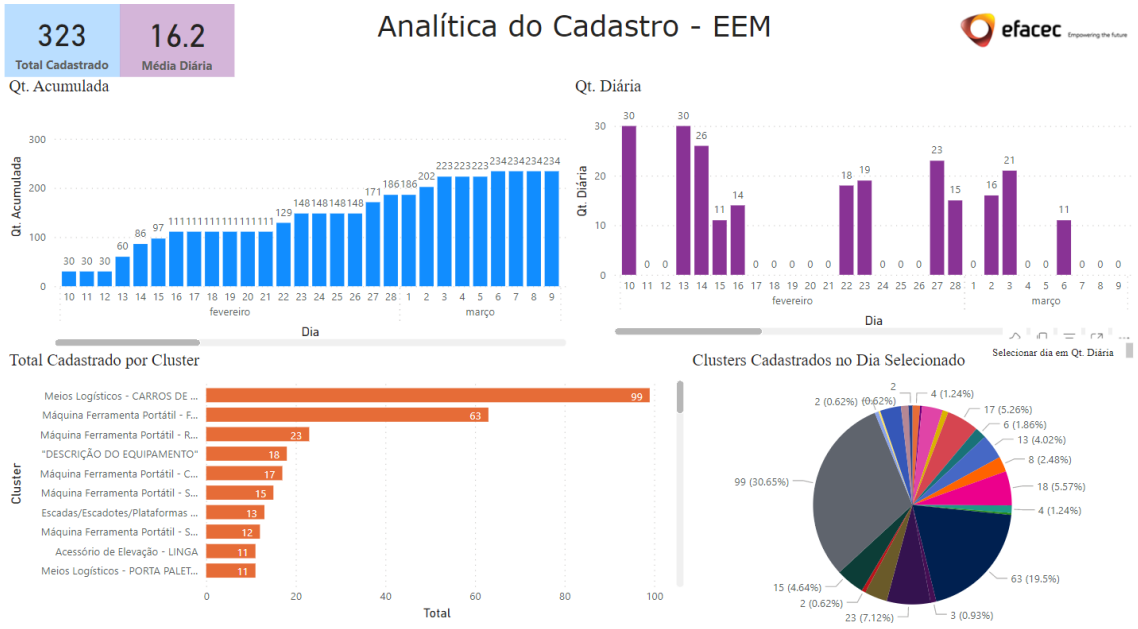


Figure 23 – EEM asset management analytics dashboard

From this platform, various analyses can be performed. For example, by selecting a cluster, it is possible to determine the quantity of that cluster registered on each day. Similarly, by selecting a specific day, one can obtain information such as the registered quantity, accumulated quantity, and the clusters that were registered on that day, as shown in Figure 24.

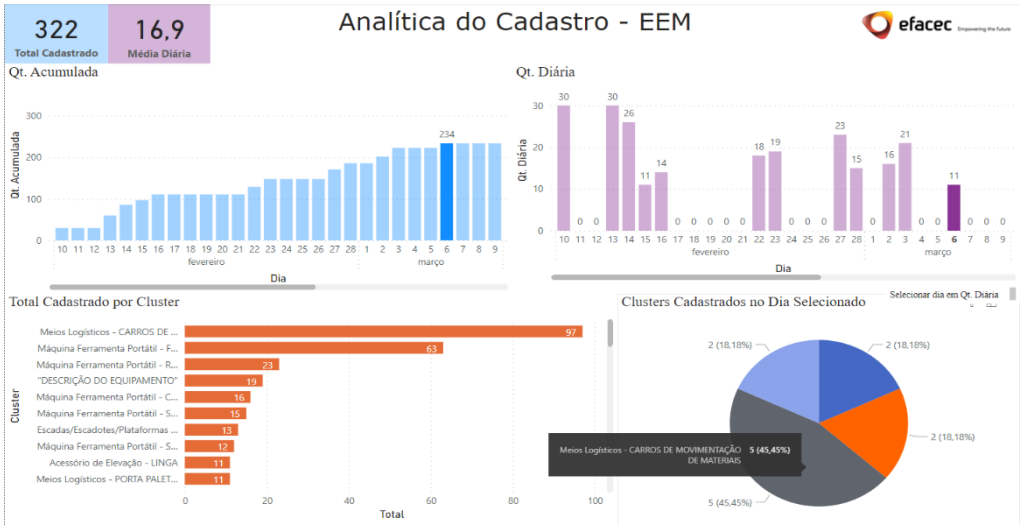


Figure 24 - Example of a possible analysis made in the dashboard

With the development of this analytics platform, good control and monitoring of the process was achieved in this BU, optimizing it.

Whenever equipment/EATs were registered, it was necessary to take a photographic record of the equipment and its registration label. Figure 25 provides an example of the photographic record that was taken.

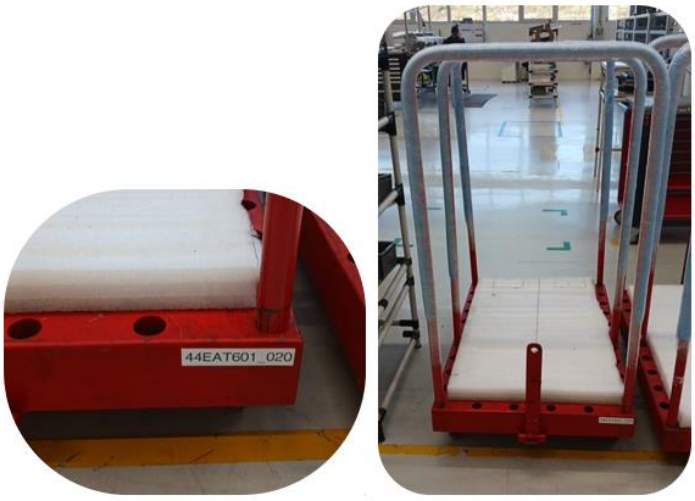


Figure 25 – Photographic record made of each registered element

In the EEM, there were initially 161 equipment/EATs registered. After completing the registration process in this BU, a total of 322 equipment were registered, resulting in a 200% increase in the number of registered equipment. This achievement aligns with one of the main objectives of creating the department, which is to have greater and better control over the assets.

Subsequently, the registration process was initiated in the other BUs, although it was not closely monitored as in the EEM.

In the SRV unit, there were 233 equipment and EATs registered before the start of the registration process. With the process still in execution, a total of 330 equipment and EATs are already registered, increasing by 142%.

4.2 Description of the Autonomous Maintenance Process

The Autonomous Maintenance process was not well implemented or documented in the factory. Another of the main objectives of creating the department is to implement this process throughout the entire factory. In order to achieve this, it is necessary to present and officially establish the Autonomous Maintenance process. The regulation of the Autonomous Maintenance process, along with the creation of an Operational Instruction (OI), which formalizes the Autonomous Maintenance process, clarifies the following points:

- Objective and scope of application;
- Description of the process;
- Process control;
- Responsibilities.

Each of these points is further developed in this chapter.

4.2.1 Objectives and Scope of Application

The Instructional Order for the Autonomous Maintenance process aims to describe the following fields:

1. Autonomous Maintenance process: This section outlines the step-by-step process of Autonomous Maintenance, providing guidelines and instructions for carrying out maintenance tasks independently;
2. Maintenance support template (Autonomous Maintenance Manual): This template serves as a reference guide for carrying out Autonomous Maintenance tasks. It includes detailed instructions, checklists, and procedures specific to each equipment type or cluster;
3. Information platform for Autonomous Maintenance needs: This section covers the development and implementation of an information platform to track and manage Autonomous Maintenance requirements. It may include digital tools or software systems for recording maintenance activities, analyzing data, and generating reports;
4. Responsibilities of the stakeholders: This part clarifies the roles and responsibilities of the individuals involved in the Autonomous Maintenance process. It defines the responsibilities of operators, maintenance personnel, supervisors, and other relevant parties, ensuring clear accountability and effective collaboration.

Regarding the scope of application, this document extends to all Business Units within Efacec in Portugal and applies to all equipment requiring Autonomous Maintenance.

4.2.2 Process description

The autonomous maintenance process can be initiated by identifying the need for a manual or solely by the need to perform autonomous maintenance. The autonomous maintenance activities are described and compiled in manuals, which will be included in the annexes, and their officialization follows in Figure 26.

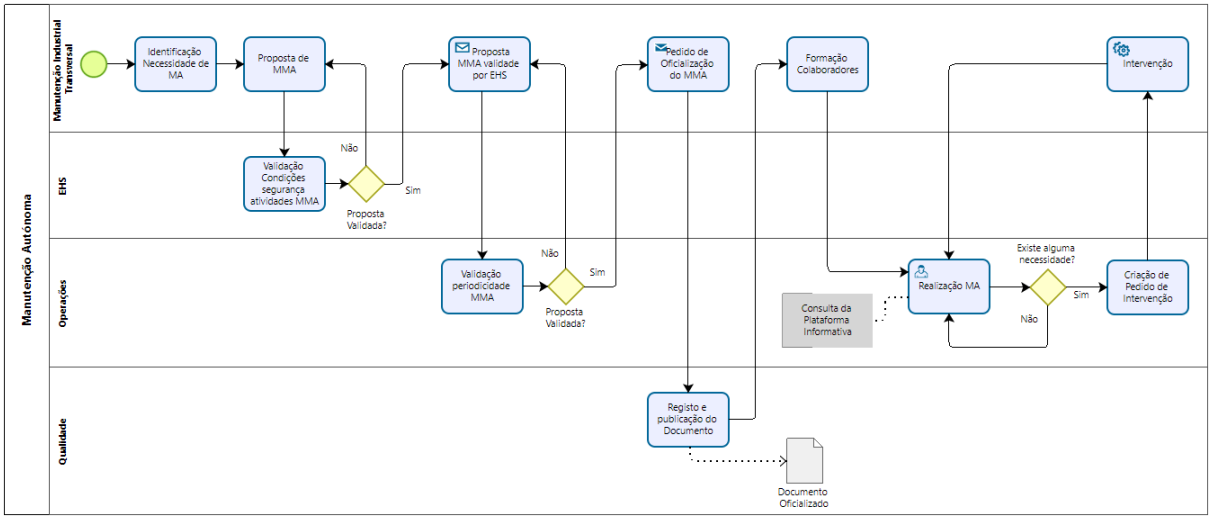


Figure 26 – Flowchart of the autonomous maintenance process

4.2.3 Identification of the need for AM

The need for autonomous maintenance can arise from various factors, such as:

- Analysis of 3C's countermeasures;
- Manufacturer recommendations;
- Contractual obligations;
- Evidence of need resulting from interventions by the MIT team;
- Equipment revamping;
- Suggestions of identified needs by the BU/AC.

Once this need is identified, the creation of the AM manual begins. To create this manual, it is necessary to develop an official template that will be used for the creation of all manuals.

4.2.4 Template for Autonomous Maintenance Manual

The execution of autonomous maintenance manuals is the responsibility of the Transversal Industrial Maintenance team, and all manuals are developed using the official template created and approved by the team, as presented in Appendix D.

In order to develop the checklist presented in these manuals, it is important to address the following points related to the equipment in question:

- History of downtime and failures;
- Current condition and level of wear of the equipment;
- Recommendations from suppliers;
- Suggestions from equipment operators.

Figures 27 and 28 show the fields that should be filled in for the development of an autonomous maintenance manual using the approved template. Each field in the manual is also explained.

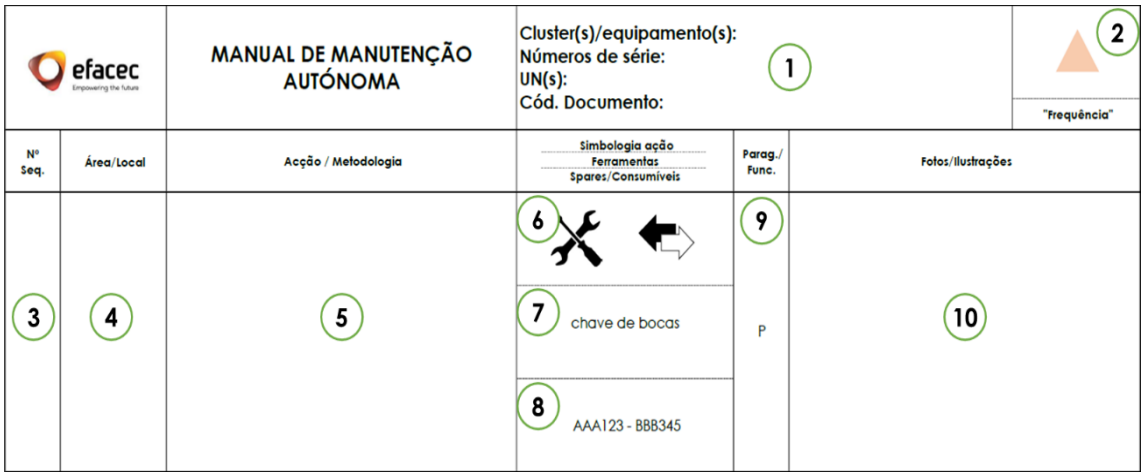


Figure 27 – Fields to be filled in the template for MMA – A

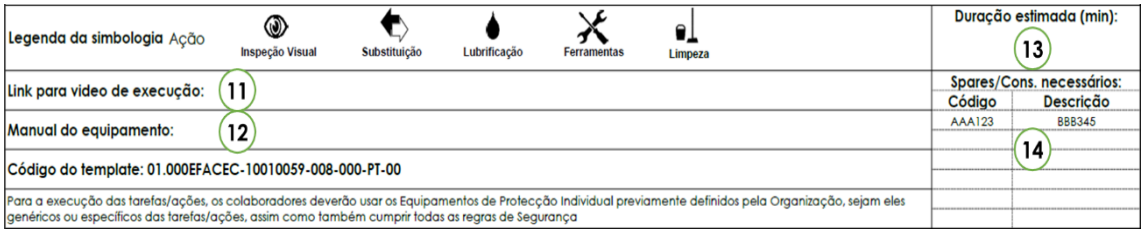


Figure 28 – Fields to be filled in the template for MMA – B

1. **In this header, the following information related to the equipment should be filled in:**

   a. Cluster: This field represents the equipment's identification;

   b. Serial number: For equipment, this code will be similar to the cluster, with the only differentiation of "_00". However, for EATs, this code serves as the equipment identifier, as the cluster refers to a specific group of EATs, as explained earlier;

   c. Business unit: This field indicates the business unit to which the document belongs;

   d. Document code: This code is generated after the official approval of the document.

2. **Maintenance Frequency**

   The filling of this field should follow the symbology for maintenance frequency as presented in Figure 29, which can be found on the "Symbol Legend" page within the template itself.

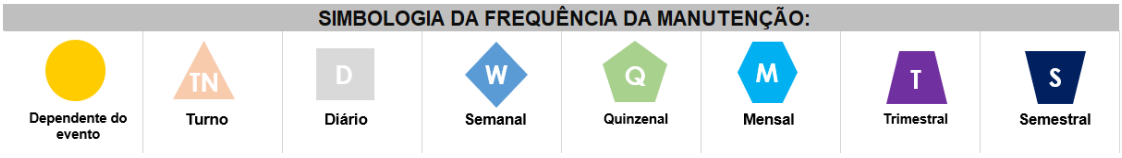


Figure 29 – Maintenance frequency symbology legend

3. **Sequence Number**

   This is a sequential number assigned to the activities described, following the form and color corresponding to their respective maintenance frequencies.

4. **Intervention Area/Location**

   In this field, the target of the action on the equipment should be described, that is, the components where the operator will perform the respective action.

5. **Action/Methodology**

   Description of the activity to be performed at this point of autonomous maintenance by the operator. These activities may include checks, cleaning, lubrication, minor adjustments, or component replacements. Instructions should be clear and objective, addressing the questions "How to perform it; When to perform it; Where to perform it; Under what conditions to perform it," leaving no room for any doubts regarding the action/methodology.

6. **Action Symbolism**

   In this field, a brief summary of the corresponding action point is provided, indicating the activities to be performed using the symbolism presented in Figure 30, where each symbol represents a different type of action to be executed.

Figure 30 – Symbolism of the types of AM actions to be performed

7. **Required Tools**

   This field is used to specify the tools that need to be used in the execution of the task at hand.

8. **Spares/Consumables**

   This field is used to specify the required spares or consumables for the task. Here, a code corresponding to the spare or consumable, as well as its description, is provided.

9. **Stoppage/Operation**

   Indication whether the equipment should be stopped or if it can be in operation during the execution of the activity.

10. **Photos/Illustrations**

    The field for explanatory images that provide a better understanding of the task to be performed, as they depict the components described and highlight the targets of action.

11. **Link to Execution Video**

    If available, the link directs the user to a folder containing instructional videos demonstrating the execution of all steps in the manual.

12. **Equipment Manual**

    Since the equipment manuals are associated with the respective equipment in the Baan system, which serves as the company's central database, this field contains the link to the SharePlace where the document is located.

13. **Estimated Duration**

    The estimated time required to complete all tasks presented in the manual is in minutes. This time is estimated by summing up the time taken to perform each task. During the recording of the instructional videos, the duration of each task is timed to obtain the total estimated duration.

14. Code for Required Spares or Consumables

A summary of all the spares or consumables needed for performing all the tasks presented in the manual, along with their Baan codes. The codes and descriptions of these spares or consumables are provided.

4.2.5 Validation/Oficialization of the AM Manual

After the development of the AM manual, it must go through two validation stages:

- Environmental Health and Safety department, which validates the safety conditions, considering the risks associated with the activities described in the manual and the respective preventive measures;
- Operations Department, which validates the recommended action frequency by MIT.

Once the document is validated by both departments, MIT submits a request for its official approval to the Quality Department.

4.2.6 Employee training

Once the AM manual is completed and approved, a training session should be conducted for the operators and team leaders of the respective equipment. During this training, all activities described in the manual should be thoroughly explained. If possible, the trainer should be accompanied by a technician who can simulate and demonstrate all the operations.

For each training session conducted, there should be a record of attendance, following the current procedure and using the official template provided in Appendix B, as said earlier.

4.2.7 Execution of actions

After the AM manual is published and the operators have received training, the guidelines outlined in the template should be followed. The execution of AM activities does not require formal records, as it is intended to instill a sense of ownership and care for the equipment among the operators. However, the execution and compliance of AM activities should be monitored and controlled according to the instructions provided in Section 4.3.

The decision not to keep records of AM activities was made by the team with the objective of fostering a sense of responsibility, ownership, and care among the operators. Although formal records of AM actions are not maintained, there will be some verification of evidence to ensure that these actions have been carried out, and further details regarding this verification will be provided later.

4.2.8 Needs or findings arising from the execution of AM

During the execution of AM activities, various needs may arise, including:

- Spares or consumables: There might be a need to procure additional parts or consumables for maintenance activities;
- Corrective intervention by MIT: In some cases, the intervention of the Maintenance Industrial Transversal team may be required to address any corrective issues or unexpected problems encountered during AM;
- Clarification of doubts: Operators may have questions or uncertainties about certain aspects of the maintenance activities, and clarification may be needed to ensure proper execution;

- Identification of improvement opportunities: While performing AM, operators may identify areas where improvements can be made to enhance the maintenance process or optimize equipment performance;
- Other needs: Depending on the specific circumstances and equipment, there may be other needs that arise during AM, such as additional training, specialized support, or technical guidance.

In the case of the need for spares or consumables, as well as the need for intervention by MIT, requests should be made by the team leaders via Baan for general equipment, or through the EMCs platform if there is a specific need for that type of equipment.

For requests made via Baan, they should be generated in the repair request section, specifying that it is related to Autonomous Maintenance intervention, Figure 31. In the "Symptom" field, it should be indicated whether spares/consumables are required and specify which ones, or if MIT intervention is needed.

The remaining fields should be filled out in the same way as a regular repair request, providing relevant details and information about the equipment and the specific need.

By following this procedure, the necessary resources and support can be efficiently requested and coordinated to address the needs arising during the Autonomous Maintenance process.

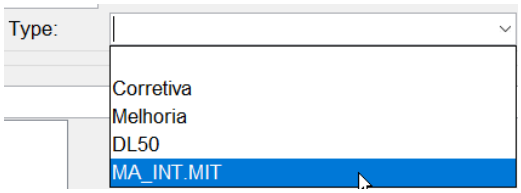


Figure 31 – Type of intervention to select, MA_INT.MIT – MIT Intervention Autonomous Maintenance

As suggestions for improvement opportunities should be made through the information platform, as explained below.

4.2.9 Specifications for the Informative Platform

The informative platform for control and management of Autonomous Maintenance aims to achieve the following points:

- Access to manuals and equipment with Autonomous Maintenance;
- Consultation of the planning of Autonomous Maintenance activities (by work center or business unit, according to the user);
- Identification of improvement opportunities from various perspectives;
- Analytics consultation by equipment/EAT, work center, or business unit;
- Knowledge of the status of suggestions and improvement opportunities.

Regarding the MIT team, they are able to:

- Add/modify/remove Autonomous Maintenance plans and manuals;
- Interact with identified improvement opportunities, including assessing feasibility, status, progress, and planning.

To facilitate and enable access management for the mentioned functionalities, each equipment has the following user utilization and ownership characterization:

- **Equipment User** - can access manuals and equipment information;

- **Equipment Owner (Team Leader/Supervisor: N - 5)** – can interact with and obtain information about their own equipment;
- **Area #1 Owner (Coordinator N - 4)** – can interact with and obtain information about equipment within a specific area or team;
- **Area #2 Owner (Coordinator N - 3)** – can interact with and obtain information about equipment within a group of areas;
- **BU Owner** – can interact with and obtain information about equipment within a specific business unit or department.

Considering the above characterization, the platform is designed to send notifications for the need to perform AM to the respective Equipment Owner, according to Table 7.

Table 7 – Frequency of sending notifications for the need to perform AM

Frequência	Hour	Day	Week	Month
Shift	6h/15h/23h	Business days	All weeks	All months
Daily	6h	Business days	All weeks	All months
Weekly	6h	2af	All weeks	All months
Fortnightly	6h	2af	Every 2 weeks	All months
Monthly	6h	2af	1st week of the month	All months
Quarterly	6h	2af	1st week of the month	Mar/Jun/Sept/Dec
Semi-annually	6h	2af	1st week of the month	Apr/Oct

Regarding suggestions/opportunities for improvement, the operating mode is as follows:

- The owner selects the equipment/EAT/manual and then selects:
  - "Need for clarification in action";
  - "Suggestion for addition/modification of action";
  - "Suggestion for improvement";
  - "Other".
- The AM manager should receive an email indicating a new suggestion/ticket;
- The AM manager should analyze and provide feedback (in the respective ticket) and, once completed, close the ticket.

The analytics that are intended to be available on the platform involve the following topics, where information can be filtered by equipment/EAT and UN:

1. Current quantity and temporal evolution of equipment with maintenance manuals;
2. Deviation from the process: Quantity of non-conformities issued;
3. Quantity of Improvement suggestion tickets, "Created," "In progress," and "Closed";
4. Average time to close tickets (from creation to closure);
5. Map showing quantity, frequency, and estimated time of planned maintenance activities.

4.3 AM Process Control

a) Team Leader/Production Supervisor

• Periodically, according to Table 8, the Team Leader/Production supervisor should monitor and validate the execution of an Autonomous Maintenance (AM) task.

Table 8 – Relationship between the frequency of AM execution and the frequency of its monitoring and validation

Frequency of AM execution	Frequency of monitoring and validation
Per Shift/Daily/Depending on the event	1x/week
Weekly	1x/month
Monthly	1x/quarter
Quarterly	1x/semester

b) EHS

- By EHS, during operational visits, the indications/evidence of operators' execution of AM should be evaluated;

c) MIT

During preventive or corrective maintenance, MIT should assess the indications/evidence of operators' execution of AM.

- Quarterly, compliance with the process should be verified by selecting an equipment with an AM plan and evaluating:

  a) Employees' knowledge of the process;

  b) Familiarity with the AM activity plan;

  c) Confirmation from the team/operators of its execution;

  d) Evidence of AM completion;

  e) Autonomy/proficiency in performing the tasks.

This monitoring should be recorded in the AM Monitoring platform (Forms-Lists), where any non-conformities resulting from process non-compliance are also recorded, if applicable.

In the case of:

1. Evidence of non-performance or non-compliance with AM manual activities, a non-Conformity should be recorded in the appropriate platform;
2. Need for clarification of doubts or reinforcement of training, they should be requested through the platform described in Section 4.2.9.

It should be noted that BUs or ACs may develop additional methods of control and monitoring in addition to the ones indicated.

4.3.1 Performance Indicators

In order to assess the performance and effectiveness of autonomous maintenance, performance indicators have been defined based on the non-conformities identified and the number of AM manuals developed during a specific period, as indicated in Table 9.

Table 9 - Performance Indicators

Monitoring	Indicator	Frequency	Definition	Data Source/Dashboard
Process deviation	Number of non-Conformities	Quarterly	Quantity of NCs issued regarding process compliance	AM management platform – "under construction"
Evolution of the quantity of equipment with AM Manual	Number of manuals developed	Quarterly	Quantity of AM manuals developed per period	AM management platform – "under construction"

4.3.2 Responsibilities

Finally, regarding this process, it is necessary to assign responsibilities to the department, business unit, and security. The responsibilities are assigned according to the RACI matrix in Table 10:

Table 10 - RACI matrix of responsibilities

ID	Activity description	MIT	BU	EHS
1	*Development of AM manuals*	**R/A**	-	-
2	Validation of activity safety conditions	**C/I**	**C/I**	**R/A**
3	Validation of periodicity	**C/I**	**R/A**	-
4	Training of employees in performing the actions	**R/A**	**I/C**	-
5	Execution of the actions	-	**R/A**	-
6	Process monitoring	**A**	**R1**	**R2**

R1: Periodically, according to point 5;

R2: During operational visits;

R: **Responsible** for performing the task, which can be performed by oneself or a team; A: **Accountable** for the task - approves the task performed by R; C: **Consulted** before the task; I: **Informed** after the task is executed.

4.4 Development of AM Manuals

With the autonomous maintenance manual template defined and officialized, the creation of new manuals for the already referenced equipment can be started through the described methods. An example of the creation and development of a manual will be given since the process of elaboration of the different manuals is similar.

To create an AM manual, it is necessary to define the frequencies of performing the actions, the targets/areas for inspection, the specific actions to be performed, the required spares, consumables, tools, and the types of actions to be taken. It is also important to determine whether the equipment needs to be in operation to carry out the action.

Other concerns include the organization of the manual, the language used, and the clarity of the instructions provided.

As an example, the process of developing an AM manual for Stackers, which requires a manual due to the high number of breakdowns it experiences and supplier recommendations, will be shown.

1. **Definition of the target/area of action and its type:**

To define the targets of the action, various approaches can be followed:

- Supplier recommendations, which specify some maintenance actions that can be performed by operators;
- Suggestions from the operators themselves, as they are most familiar with the breakdowns they have encountered and equipment behavior;
- History of breakdowns that the equipment has experienced and that are related to tightening issues, visual inspections, cleaning, or lubrication;
- And others.

Thus, the elements that will be subject to autonomous maintenance actions for the Stackers have been defined, namely the battery, the load forks, the load lifting system, the wheels, and the braking and emergency system. Regarding the types of actions to be carried out, it was concluded that the most recurrent and necessary actions are visual inspections.

2. **Action description and photos/illustrations**

As previously explained, the description of the actions is a crucial aspect of their correct execution. A well-described action is objective and addresses the questions of how, when, and where to perform it. The field of photos/illustrations complements the description of the actions, helping to understand the areas where the checks should be conducted.

Figure 32 provides an example of an action to be performed to check the distilled water levels.

efacec	MANUAL DE MANUTENÇÃO AUTÓNOMA	**Cluster(s)/equipamento(s):** EMC - Stacker **Números de série:** 17968; 17961; 17966; 17957; 17963; 18003; 17969; 17953; 17965; 17959; 17954; 17958; 17951; 18005; 17952; 17964; 17960; 18004; 17967; 17955; 17949; 18006; 17956; 18007; 17962; 17950; 0098 **UN(s):** Geral **Cód. Documento:**	W Semanal

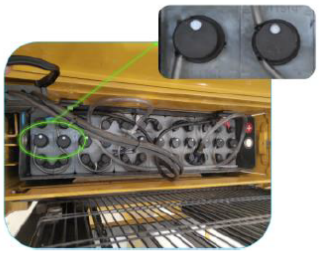
Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
1	Bateria	Após carregar a bateria, verificar se os flutuadores brancos indicadores de nível de água estão visíveis. Caso não estejam, ligar ao dispensador de água destilada automático para repor o nível. **Aconselha-se verificação sempre que se efetue o carregamento da bateria**	- -	P	

Figure 32 – Example of an action to perform on Stackers

Some actions, such as battery checks or emergency actions, although included in maintenance manuals with a weekly frequency, have recommendation notes within the actions to alert that those specific actions are recommended to be performed on a daily or even shift basis. This is because they involve safety checks that require special attention.

3. Definition of manual's periodicity

The frequency of the manual is determined as a team, analyzing the difficulty and criticality of the actions. For the Stacker manual that has been developed, a weekly frequency has been defined. The BU can also give their opinion about the periodicity of the manual.

4. Creation of videos to support the execution of the actions

In case there is still any doubt about executing the actions described in the manuals, videos have been created to demonstrate their execution. The videos highlight the use of Personal Protective Equipment (PPE).

5. Manual organization

In order to organize the actions in the manuals, the following rules were established:

- Maximum of 5 actions per page;
- Divide sections per area of intervention;
- Execute first the cleaning actions, then the visual inspection and lubrification, respectively.

During the execution of the tasks, the following manuals were created, which can be found in Annex E to I:

- Weekly AM manual for EMCs (Stacker, Forklift, Tow Tractor, and Electric Pallet Truck);
- Per shift, weekly, and monthly AM manual for the BERMAQ machine.

AM Manuals consultation

In order to be able to access the manuals online, and since the AM management platform is not yet available, a dashboard in PowerBI was created for this purpose. This dashboard allows users to access the manuals through the link provided in the table, with the ability to filter by equipment number (Cluster), equipment type (Search Argument), or Business Unit, as shown in Figure 33.

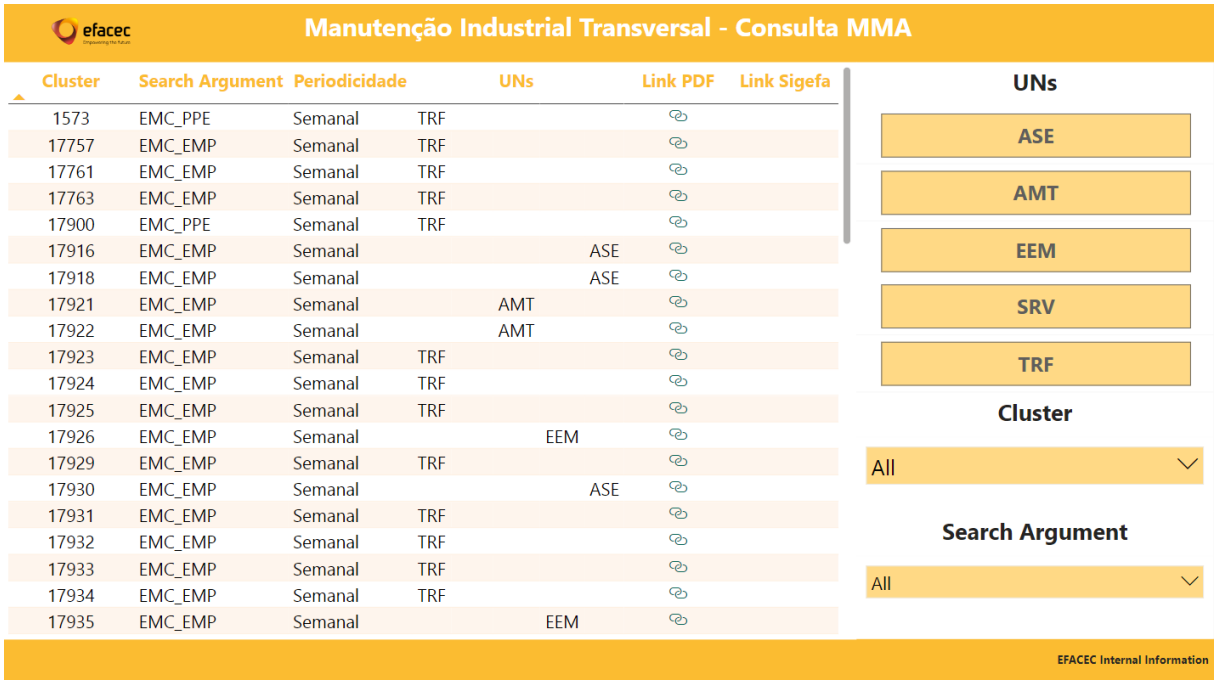


Figure 33 – AM manuals consultation platform

4.5 Preventive maintenance

As mentioned in Chapter 3, the analytics and monitoring of preventive maintenance could be improved. In order to achieve proper analysis, the root of preventive maintenance, the planning file, was modified.

In the old file, each line represented an equipment, which made data analysis and processing more challenging.

In the new file, it was assumed that each line represents a planned action. This principle offers the following advantages:

- Greater ease in data analysis and processing;
- Ability to maintain a historical record of different years of planning;
- Simplification of recording action completion, as both planning and execution can be filled out on the same page;
- Possibility of analyzing the planning itself.

Therefore, applying this principle, the newly created planning file consists of five pages, with one being informational, two being auxiliary pages, one containing the planning itself, and one containing the planning calendar.

The equipment page includes all the equipment that has planned preventive actions, with each equipment identified by a code, as shown in Figure 34.

Service Dept	Cluster	UN	Descr. Cluster	Search Argument Cluster
SAI00	10P00132	AMT	Ponte Rolante_6,3T	ELEV CARG_PR
SAI00	20ELV002	AMT	Ponte Rolante_1T	ELEV CARG_PR
SAI00	20ELV003	AMT	Ponte Rolante_5T	ELEV CARG_PR
SAI00	20ELV004	AMT	Ponte Rolante_2T	ELEV CARG_PR
SAI00	20ELV005	AMT	Ponte Rolante_2,5T	ELEV CARG_PR
SAI00	20ELV006	AMT	Ponte Rolante_2,5T	ELEV CARG_PR
SAI00	20ELV007	AMT	Ponte Rolante_2,5T	ELEV CARG_PR
SAI00	20ELV008	AMT	Ponte Rolante_2,5T	ELEV CARG_PR
SAI00	20ELV009	AMT	Ponte Rolante_1T	ELEV CARG_PR
SAI00	20GRS261	AMT	Grupo de Recuperador de SF6	GEN

Figure 34 – Some of the equipment with preventive maintenance

Next, the planning page for the preventive actions to be taken was prepared, illustrated in Figure 35.

A Periodicidad	Equipament	B Descrição Equip.	Unidad	Ano Planea	C Semana Planeada	Ano Realiza	D Semana Realizada	E Estado	F Motivo NE
Anual	3TRP1077	Plataforma Elevatória_Docagem_9T	AMT	2023	10	2023	19	REALIZADA	
Semestral 2	30TRN232	Torno Mecânico Grande	AMT	2023	41	2023		PLANEADA FUTURO	
Semestral 1	30TRN232	Torno Mecânico Grande	AMT	2023	15	2023	19	REALIZADA	
Anual	30TAC429	e de Armazenamento de Componentes N	AMT	2023	38	2023		PLANEADA FUTURO	
Anual	30TAC428	e de Armazenamento de Componentes N	AMT	2023	38	2023		PLANEADA FUTURO	
Anual	30TAC427	e de Armazenamento de Componentes N	AMT	2023	38	2023		PLANEADA FUTURO	
Anual	30TAC422	e de Armazenamento de Componentes N	AMT	2023	38	2023		PLANEADA FUTURO	
Semestral 2	30SRR234	Serrote de Corte	AMT	2023	41	2023		PLANEADA FUTURO	
Semestral 1	30SRR234	Serrote de Corte	AMT	2023	15	2023	18	REALIZADA	
Trimestral 1	30RHE755	Recuperador de Helio	AMT	2023	2	2023	2	REALIZADA	
Trimestral 3	30RHE755	Recuperador de Helio	AMT	2023	28	2023		PLANEADA FUTURO	
Trimestral 2	30RHE755	Recuperador de Helio	AMT	2023	15	2023	17	REALIZADA	
Anual	30RHE755	Recuperador de Helio	AMT	2023	50	2023		PLANEADA FUTURO	
Trimestral 1	30PSF756	Purificador de SF6	AMT	2023	2	2023	2	REALIZADA	
Trimestral 3	30PSF756	Purificador de SF6	AMT	2023	28	2023		PLANEADA FUTURO	
Trimestral 2	30PSF756	Purificador de SF6	AMT	2023	15	2023	17	REALIZADA	
Trimestral 4	30PSF756	Purificador de SF6	AMT	2023	41	2023		PLANEADA FUTURO	
Anual	30PEE972	Plataforma Elevatória_Monta Cargas_0,5T	AMT	2023	17	2023	18	REALIZADA	
Anual	30PEE282	Plataforma Elevatória_Tesoura_2T	AMT	2023	17	2023	18	REALIZADA	

Figure 35 – Preventive Maintenance Planning

A) **Periodicity**

Depending on the equipment, the performed preventive maintenance actions can have three types of frequencies: Quarterly (1, 2, 3, and 4), Biannual (1 and 2), or Annual.

B) **Equipment description**

Set in which the equipment code is displayed for possible identification, description of the equipment and BU to which it belongs.

C) Planned date

Year and week of the PM action planning.

D) Date of completion

Year and week of execution of the PM action.

E) Action state

The team has decided that preventive maintenance actions can be in five different states, which are:

- Completed: The action has already been performed;
- Future Planned: The action is scheduled but has not yet reached the due date;
- Overdue: The action was not performed within the expected timeframe;
- On Hold: The action was not performed due to a specific reason but can still be executed;
- Expired Deadline: The action was not performed and will not be executed because another action is already planned for the equipment shortly or is already overdue.

F) **On Hold reason**

Reasons for an action to be On Hold can originate from various factors, such as:

- Partner Unavailability;
- Equipment Unavailability;
- Equipment Out of Service;
- Equipment Under Repair.

On this page, a filtering facilitator was created to view and print the actions planned for a selected week. The yellow cell is filled with the desired week number, as shown in Figure 36.

Figure 36 – Selecting the intended week

With the planning dates filled in, the annual planning calendar was prepared, Figure 37.

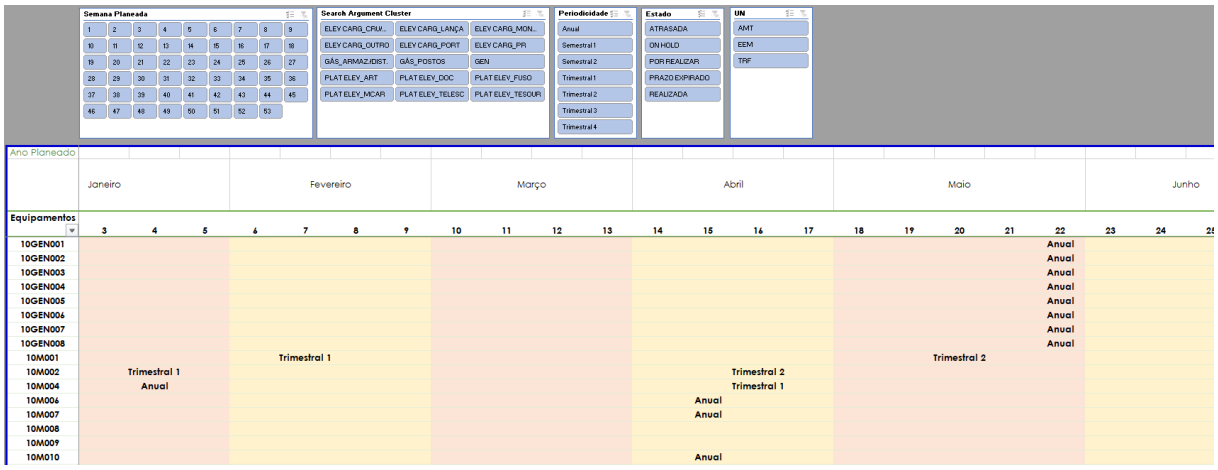


Figure 37 – Preventive maintenance calendar

In the calendar, it is possible to filter the equipment by their Business Unit, action periodicity, action status, equipment type, and the week in which actions are planned.

After the development of the new file that will be used for recording the planning and execution of preventive maintenance, an analytics dashboard was created for this process using Power BI.

It was established that the analytics should highlight the following:

A) PM Map (Figure 38)

Summary of all planning and execution of preventive maintenance, with the ability to filter by Business Unit (BU) and equipment type, displaying:

- Weekly Completion - Quantities and %;
- Year-to-Date (YTD) Completion - Quantities and %;
- Quantities by status, both weekly and YTD;
- Accelerometers of weekly, YTD, and annual completion.

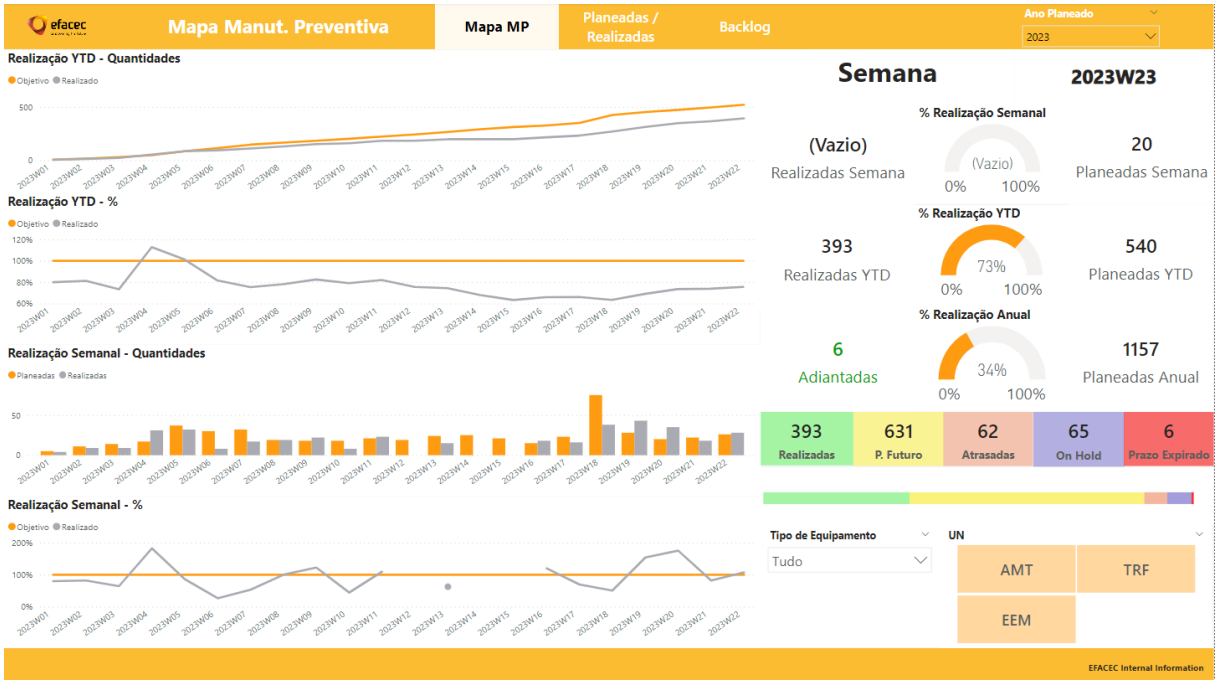


Figure 38 – Preventive maintenance map

B) Planned and Executed (Figure 39)

List of all planned and executed actions, with the ability to filter by:

- Week of planned action and week of executed action;
- Periodicity;
- Action status;
- Equipment type;
- Business Unit.

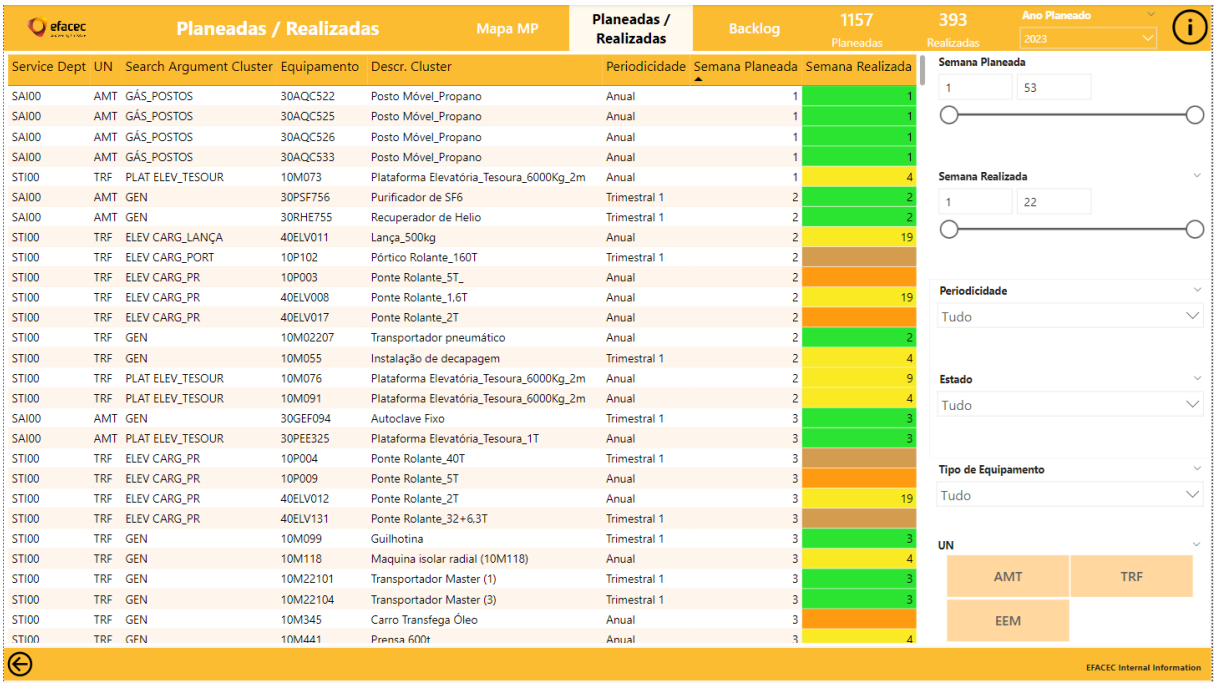


Figure 39 – Planned and executed

In the indicator located in the upper right corner, you can observe the legend for the colors applied to the "Week Executed" column can be observed in Figure 40.

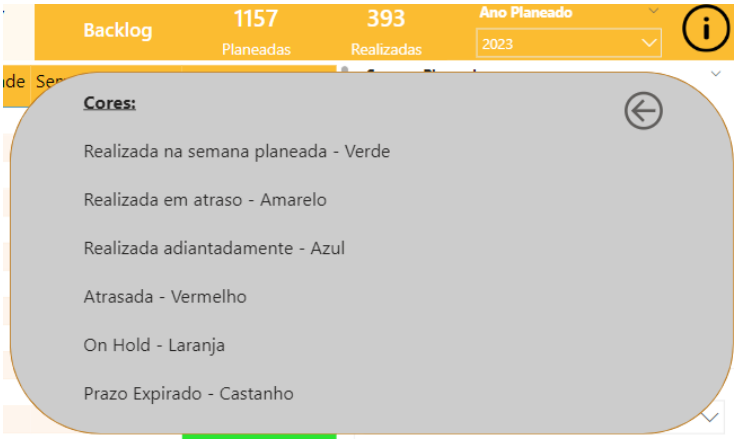


Figure 40 – Color legend

C) **Backlog** (Figure 41)

Listing of all outstanding actions, whether they are "Planned Future", "Delayed" or "On Hold". The filtering capability is:

- BU;

- Equipment type;
- Action status and reason for On Hold;
- Periodicity;
- Planned week.

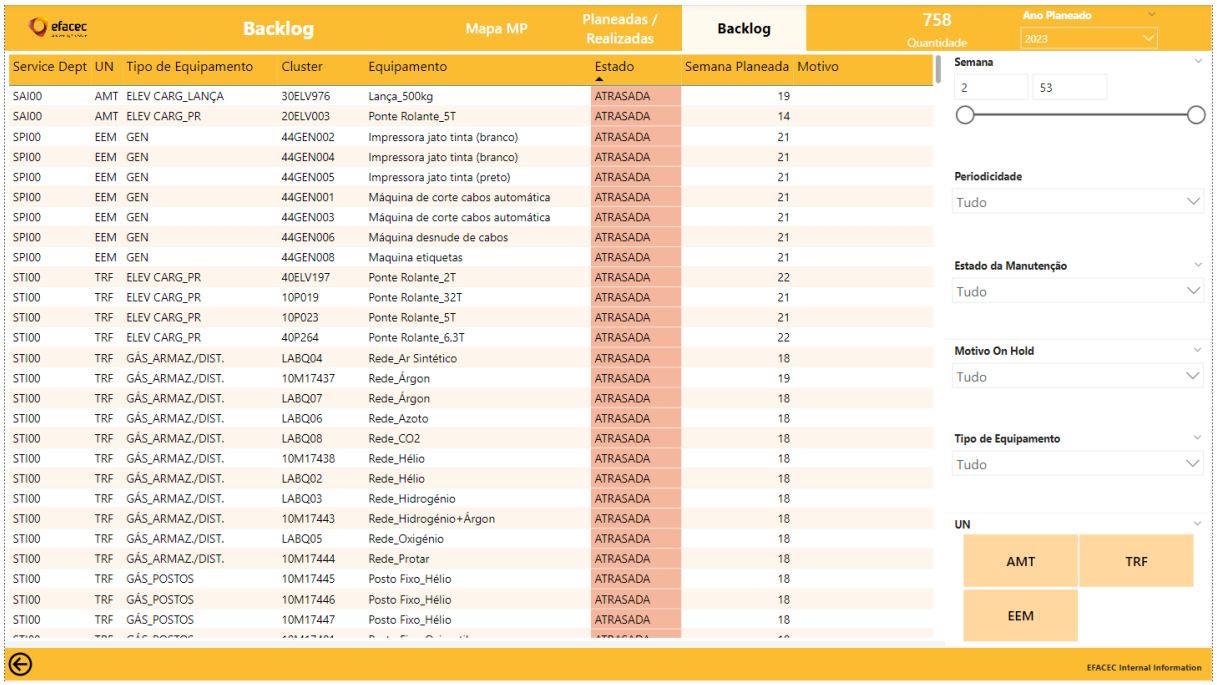


Figure 41 – Backlog

Through this analysis it is possible to analyze the performance of industrial maintenance in compliance with the plan defined at the beginning of the year regarding PM actions, as well as highlight and control information that, with the resources previously available, it was not possible to consult.

4.6 EAT and EMC requisitions analytics

In order to better control and monitor EAT acquisition and EMC maintenance requests, it was decided to develop an analytic. This analytic is very useful for controlling expenses, knowing in which BUs and cost centers there are more needs, and controlling MTTA and MTTR.

4.6.1 EAT Requests

Whenever there is a need to purchase or repair EATs, it is necessary to fill an order addressed to the industrial maintenance department. Thus, a SharePoint List was created for this purpose, as shown in Figure 42.

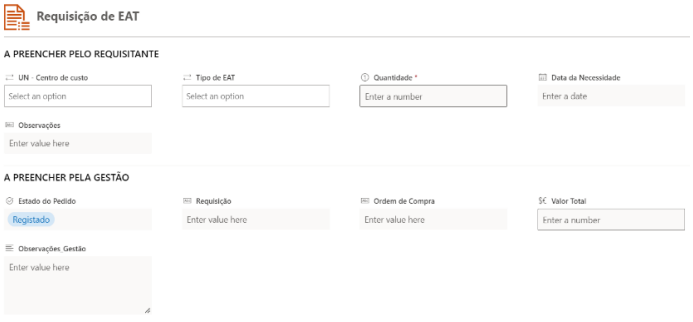


Figure 42 - EAT requisition lists

From this record, the analytics was then elaborated. This evidences:

- Main page with a summary of the quantity and cost of orders by order status and month/year;
- Quantity of requests made by Business Unit, Cost Centre, EAT Type, Month of the request, State of the request;
- Cost (cost associated with the month in which the order was made) by Business Unit, Cost Centre, EAT Type, Month of the Order and Order ID.

Figures 43, 44 and 45 show the elaborated PowerBI dashboard which shows this analytic.

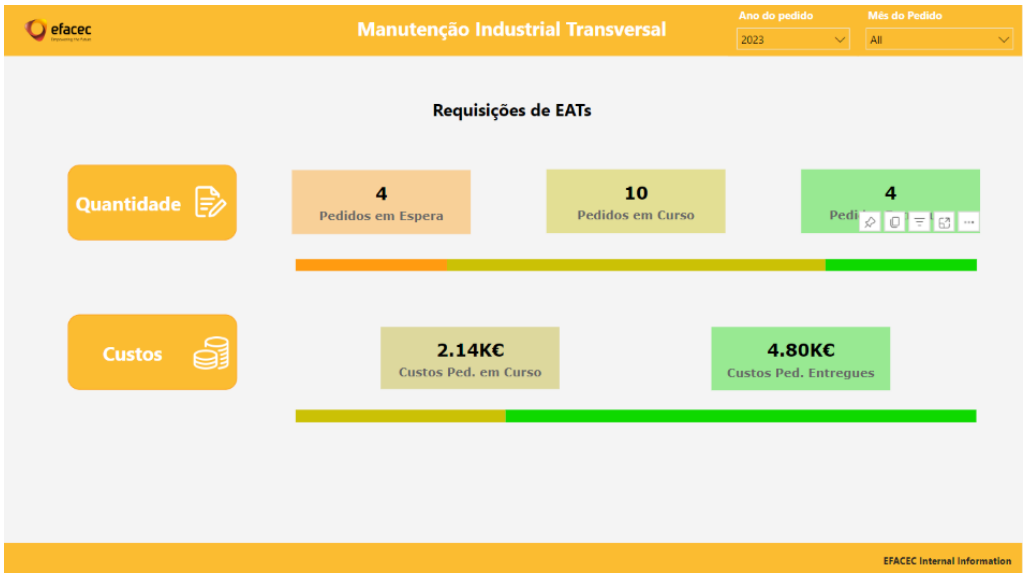


Figure 43 - Main page EATs

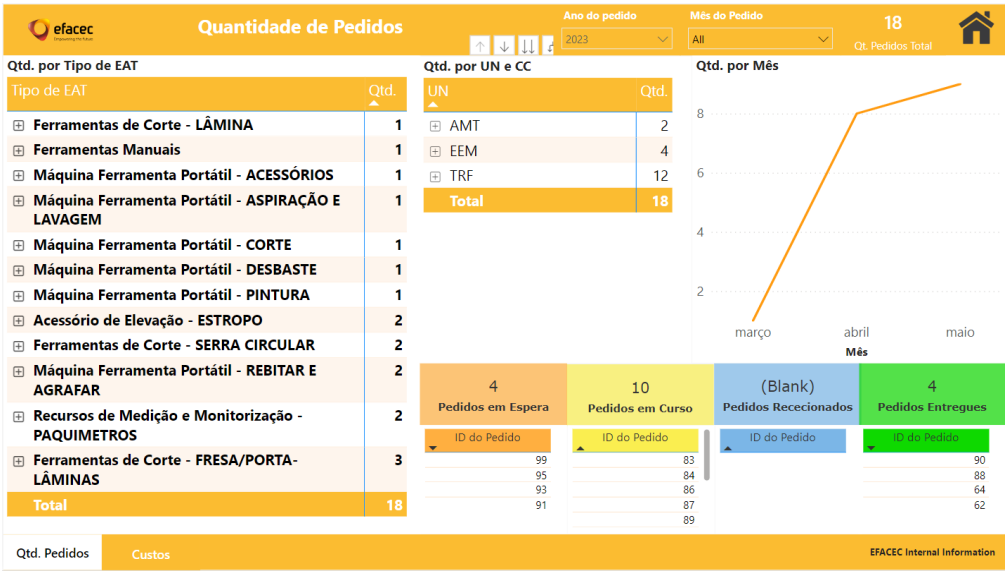


Figure 44 - Quantity of requests EATs

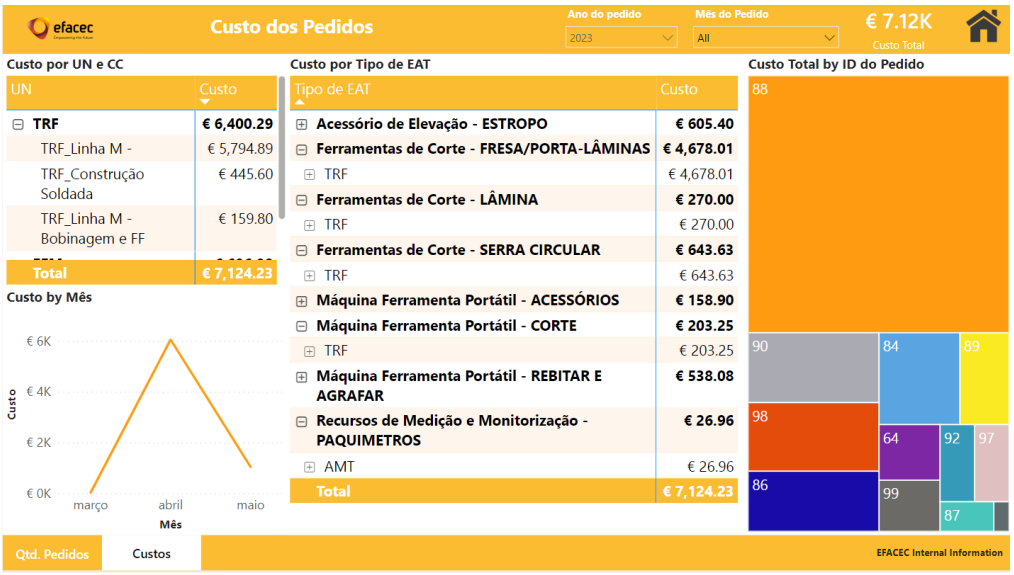


Figure 45 - Costs of requests EATs

4.6.2 Requests of EMCs

The same procedure was used in the case of EMCs. A List is also used to record the maintenance/acquisition requests. The difference between these and EATs is in the analytics developed, being that of the EMCs more in-depth.

The EMC analytics shows the following:

- Quantity of requests by type of EMC, Month, Intervention Type, Bu, Cost Center and equipment;
- Costs by type of EMC, Month, Intervention Type, BU, Cost Center and equipment;
- MTTA (h) and MTTR (h) by type of EMC, BU, Cost Center, Intervention Type, equipment and request;
- Unavailability (h) by type of EMC, BU, Cost Centre, Intervention Type, equipment and order.

Performance indicators are calculated according with Equations (1) and (2), for corrective interventions only:

$$MTTA\ (h) = Date\ and\ time\ of\ start\ of\ intervention - Date\ and\ time\ of\ request\ for\ action \quad (1)$$

$$MTTR\ (h) = Date\ and\ time\ of\ end\ of\ intervention - Date\ and\ time\ of\ start\ of\ intervention \quad (2)$$

In order to calculate the unavailability of the equipment, it is necessary to consider if the equipment is stopped, or not, from the moment the request was made until the moment when the intervention started. Then, the unavailability is calculated by Equation (3):

$$Unavailability\ (h) = \begin{cases} Date\ of\ end\ of\ intervention - Date\ of\ occurrence, & idle\ equip. \\ MTTR, & operating\ equip. \end{cases} \quad (3)$$

Once the formula for calculating the performance indicators had been established, the analytical dashboards were prepared, as shown in Figures 46 to 50.

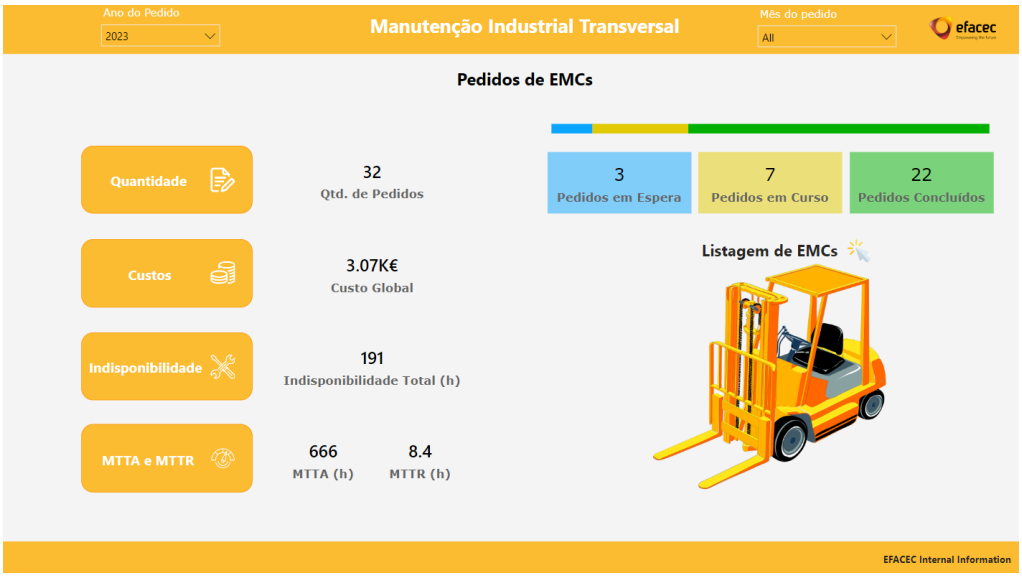


Figure 46 - Main page of EMC dashboard

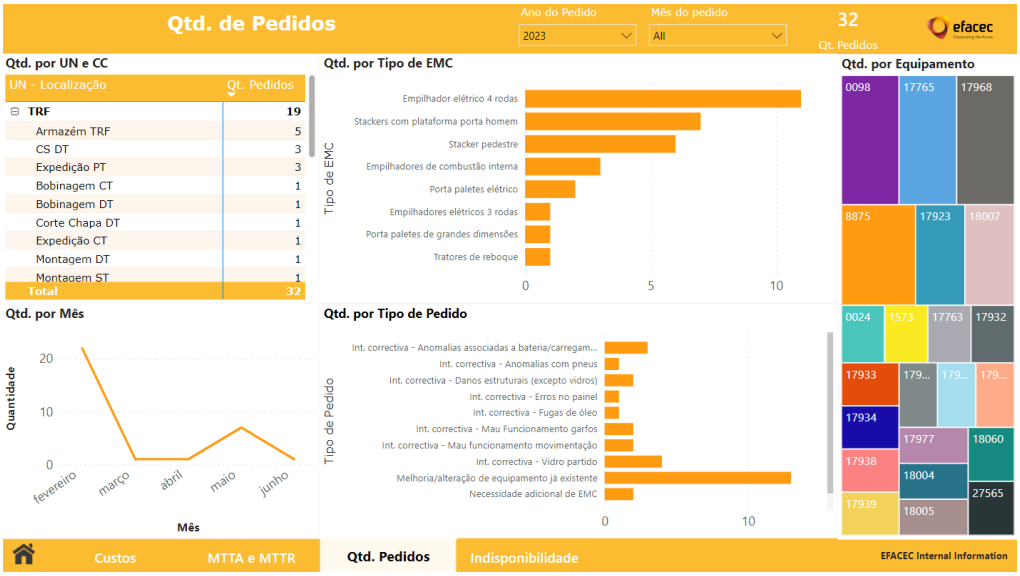


Figure 47 - Quantity of EMC requests

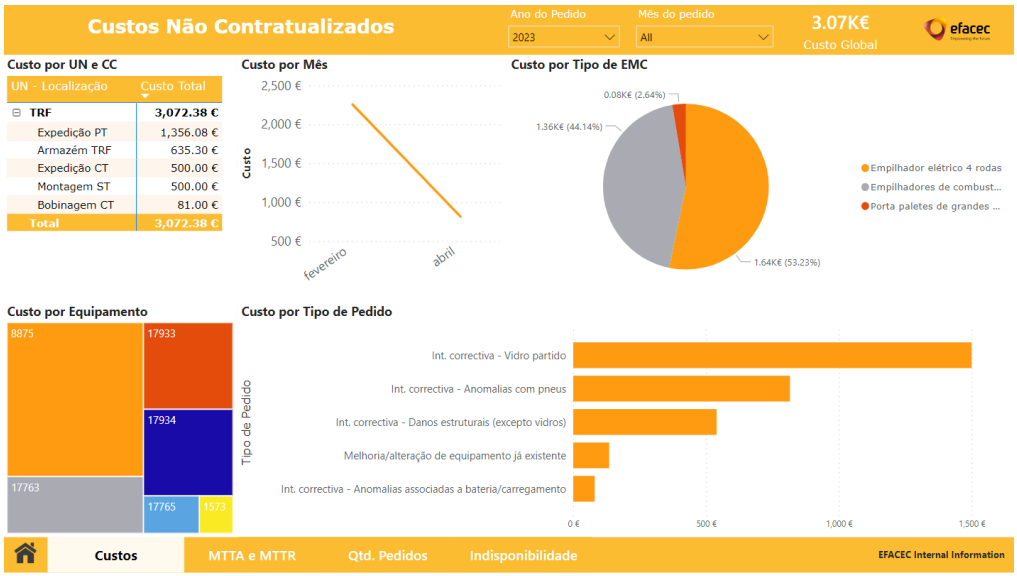


Figure 48 - Costs of EMC requests

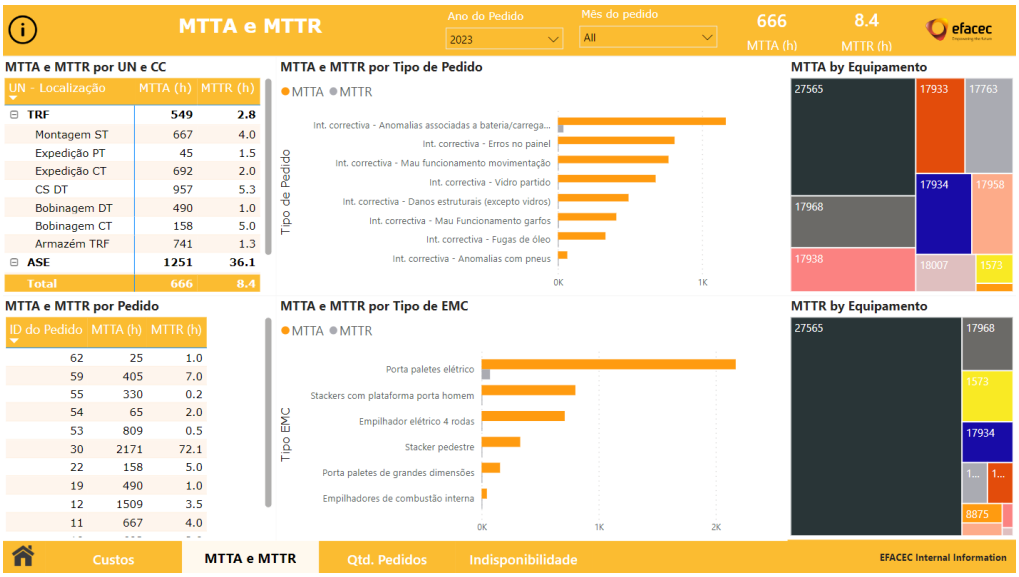


Figure 49 - MTTA and MTTR of EMC requests

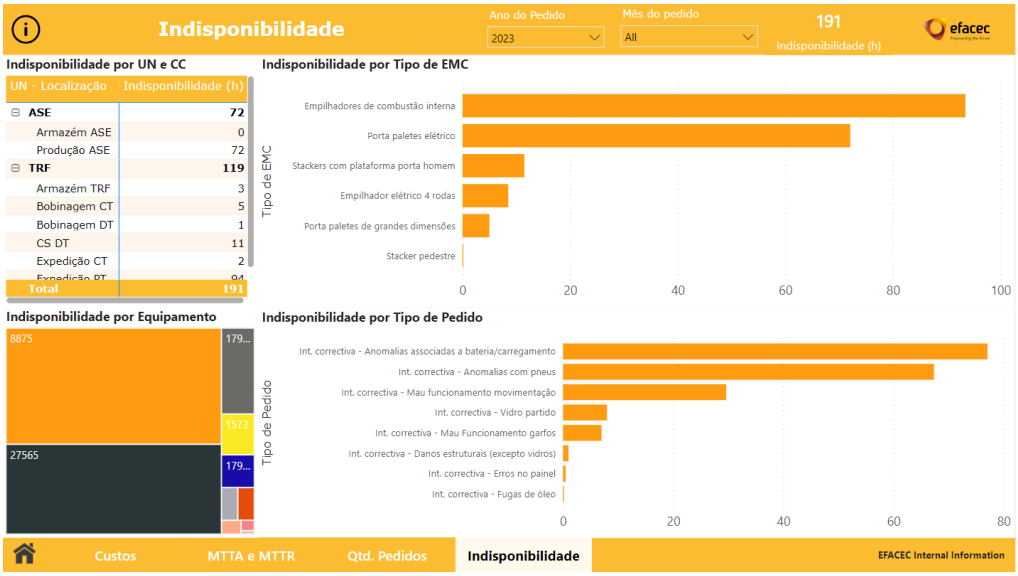


Figure 50 - Unavailability of EMC requests

With these dashboards, it is possible to analyze the origin of requests and the corresponding costs, evaluate maintenance response capacity, analyze which equipment and types of equipment suffer the most corrective interventions and obtain information that, previously, was not evident and available.

In order to present the work developed, a MIT communication website was created in which the dashboards, manuals and processes developed about the topics discussed are displayed to the whole company. This way, any department can consult the information quickly and with total transparency.

5 Conclusions and Future Works

The conclusions of the work done on this project are outlined in this chapter, along with a final revision of the status of each project area. Proposals are also made for improving other maintenance topics that can be subject to similar analyses and methodologies to those applied in the areas under study.

5.1 Conclusions

Positive outcomes were seen when the internship and dissertation were finished, not just for the organization but also for the student's personal development in terms of learning.

The goal of this work's development was to execute changes in MIT through the provision of improvement tools and methodologies in order to help in the planning, process and analytics of different areas.

As Efacec is a large company in Portugal and the world, the quality, availability, access, and monitoring of information are of great importance for its success.

At the beginning of the internship there was very little equipment registered in the business units, not knowing what was owned or how much was spent on equipment. The fact that each BU had its own nomenclature for identifying equipment also made it difficult to organize and standardize the information.

In relation to preventive maintenance actions, the lack of analytics, and the fact that the file used for its registration was too old and could be improved did not make it easy to monitor and control the process.

The lack of description of the autonomous maintenance process, the inexistence of a manual template for AM and a platform to manage it resulted in a low implementation of this type of maintenance.

Table 11 describes the status of each of the areas addressed in the project at the end of the internship.

Table 11 - Status of each project area

Area	Status
Active registration	In progress
Autonomous Maintenance	In progress
Preventive Maintenance	Concluded
EMC and EAT requisitions analytics	Concluded

Regarding the asset register at this point, the EEM business unit is completed, while the SRV is at 60%. This registration will be continued in the remaining BUs.

In total the two units that were the target of this action, 652 equipment/EATs were registered, increasing the number of registered equipment by 165%.

Autonomous maintenance will also continue to be implemented. Addressing the objectives defined for this theme, it is possible to state that the process is already described and made official, the specifications for the Management Platform are created, the manual template is created and made official, and some manuals are also created and made official. Another 7 autonomous maintenance manuals for equipment have been created.

The development and implementation of the AM management platform, defined as an objective in the project, ended up not being executed. Only the specifications for this management

platform were defined, and its development will be the responsibility of the IT systems or outsourcing.

The preventive maintenance log file, as well as the elaborated analytics, are already in use. These provide better monitoring of the actions, as well as the possibility of an elaborate and concrete analysis of the compliance with the plan, and greater ease in filling it in.

Finally, order analytics for EMCs and EATs also provide further monitoring and analysis of costs, order quantities and identified KPIs. This dashboard is also already in use and available company-wide, making information available that previously did not exist.

The trainee also benefited personally and professionally, in addition to the company, from the following:

- Consolidation of theoretical knowledge and its practical application;
- Contact with an industrial organization;
- Improvement of teamwork and problem-solving skills;
- Acquiring responsibility skills.

The dissertation demonstrated that methodologies and philosophical approaches are not always used in a straight line. Because each organization has unique characteristics, it can be challenging to determine the appropriate course of action for resolving the issues found. Since this project intends to improve maintenance performance while ensuring equipment efficiency, a TPM methodology approach plan was mostly used.

5.2 Future works

Although during the project improvement suggestions were found and elaborated, other improvement opportunities were validated, which is essential for preserving the good working of the tools built after the stated objectives were attained.

Suggestions for improvement are listed below:

- In a short-term perspective, apply the same type of analytics elaborated for the planning of preventive maintenance to the planning of inspections DL50/2005. This planning is extremely important because any equipment that does not comply with the law decree nr. 50, cannot be in operation;

  A new file, similar to the preventive maintenance planning, would have to be created, but the basis of the dashboard and analytics prepared would be the same as the preventive maintenance dashboard and analytics;

- From a long-term perspective, create an online platform, based on Office 365, which records the DL50 inspections carried out and, through this record, is able to draw up a plan for the next inspections to be carried out on the various equipment.

- As mentioned in Chapter 4, when explaining the platforms used to register requests for EATs and EMCs, Lists are used for this purpose. An opportunity for improvement here is the implementation of maintenance software to handle and manage these requests;

- Regarding the autonomous maintenance management platform, create a section so that when corrective action is required on equipment, the request can be generated automatically and on time on the platform, saving time and facilitating the process;

  Another function to implement on this management platform is when a spare/consumable is required, the operator can request it through the platform, instead of Baan, creating a direct link with the ERP;

- Create a preventive maintenance management platform, similar to the one designed for autonomous maintenance, to record the execution of the actions instead of using an Excel file for that purpose. This proposal facilitates the registration of executions, it could inform operators of the actions that have to be executed in the different weeks, the overdue actions and on hold, and consultation of the analytics developed.
- Finally, regarding the management of physical assets, the implementation of software that performs their management would offer a great benefit in controlling the life cycle of all equipment, location through georeferencing, technical data and certificates. It would thus be possible to solve one of the main problems that Efacec has, the lack of data on equipment.

References

Adesta, E. Y. T., Prabowo, H. A., & Agusman, D. (2018). "Evaluating 8 pillars of Total Productive Maintenance (TPM) implementation and their contribution to manufacturing performance." IOP Conference Series: Materials Science and Engineering, 290(1). https://doi.org/10.1088/1757-899X/290/1/012024

Alsyouf, I. (2007). The role of maintenance in improving companies' productivity and profitability. International Journal of Production Economics, 105(1), 70–78. https://doi.org/10.1016/j.ijpe.2004.06.057

Cabral. (2013). "Gestão da Manutenção de Equipamentos, Instalações e Edifícios". (2013, 3.a ed.). Lidel.

de Paz, J. F., Julián, V., Villarrubia, G., Marreiros, G., & Novais, P. (n.d.). Advances in Intelligent Systems and Computing 615 Ambient Intelligence-Software and Applications-8th International Symposium on Ambient Intelligence (ISAmI 2017). http://www.springer.com/series/11156

Ding, L., Wang, H., Kang, K., & Wang, K. (2014). A novel method for SIL verification based on system degradation using reliability block diagram. Reliability Engineering and System Safety, 132, 36–45. https://doi.org/10.1016/j.ress.2014.07.005

Ding, S. H., & Kamaruddin, S. (2015). Maintenance policy optimization—literature review and directions. In International Journal of Advanced Manufacturing Technology (Vol. 76, Issues 5–8, pp. 1263–1283). Springer London. https://doi.org/10.1007/s00170-014-6341-2

Erbiyik H. (2022), "Definition of Maintenance and Maintenance Types with Due Care on Preventive Maintenance", IntechOpen. http://dx.doi.org/10.5772/intechopen.106346

Ferreira, S., Martins, L., Silva, F. J. G., Casais, R. B., Campilho, R. D. S. G., & Sá, J. C. (2020). A novel approach to improve maintenance operations. Procedia Manufacturing, 51, 1531–1537. https://doi.org/10.1016/j.promfg.2020.10.213

Figueira A. R. M. D. C. (2021), "Desenvolvimento de um sistema de controlo da manutenção numa PME", Instituto Superior de Engenharia de Lisboa.

Gackowiec, P. (2019). General overview of maintenance strategies – concepts and approaches. Multidisciplinary Aspects of Production Engineering, 2(1), 126–139. https://doi.org/10.2478/mape-2019-0013

Gonzalez, E., Nanos, E. M., Seyr, H., Valldecabres, L., Yürüşen, N. Y., Smolka, U., Muskulus, M., & Melero, J. J. (2017). Key Performance Indicators for Wind Farm Operation and Maintenance. Energy Procedia, 137, 559–570. https://doi.org/10.1016/j.egypro.2017.10.385

Guariente, P., Antoniolli, I., Ferreira, L. P., Pereira, T., & Silva, F. J. G. (2017). Implementing autonomous maintenance in an automotive components manufacturer. Procedia Manufacturing, 13, 1128–1134. https://doi.org/10.1016/j.promfg.2017.09.174

Gulati R., & Smith R. (2012), "Maintenance and Reliability Best Practices" (2nd Edition), Industrial Press Inc., South Norwalk, CT, U.S.A.

Habidin, N. F., Hudin, N. S., Mustaffa, W. S. binti W., Rosli, S. A. M., Ong, S. Y. Y., Fuzi, N. M., & Zulkifle, N. N. (2017). A Proposed Total Productive Maintenance (TPM) Tool for Lean

Dashboard, Statistics and Performance Efficiency in Malaysian Modern Manufacturer. International Journal of Academic Research in Business and Social Sciences, 7(6). https://doi.org/10.6007/ijarbss/v7-i6/3061

Jain, A., Bhatti, R., & Singh, H. (2014). Total productive maintenance (TPM) implementation practice: a literature review and directions. International Journal of Lean Six Sigma, 5(3), 293–323. https://doi.org/10.1108/IJLSS-06-2013-0032

Jasiulewicz-Kaczmarek, M., & Antosz, K. (2023). Industry 4.0 Technologies for Maintenance Management – An Overview. Lecture Notes in Mechanical Engineering, 68–79. https://doi.org/10.1007/978-3-031-09382-1_7

Karami, M., & Safdari, R. (2016). *"From information management to information visualization: development of radiology dashboards".* Applied clinical informatics, 7(2), 305-308.

Kinz A., Bernerstaetter R., & Biedermann H. (2016), *"Lean Smart Maintenance –Efficient and Effective Asset Management for Smart Factories"*, MOTSP 2016 – 8th International Scientific Conference.

Kobbacy K. A. H., & Murthy D. N. P. (2008). "*Complex System Maintenance Handbook"* (Vols. 978-1-84800-011-7.). Springer-Verlag. DOI 10.1007/978-1-84800-011-7

Kumar U., & Galar D. (2018), *"Maintenance in the Era of Industry 4.0: Issues and Challenges"*, [in:] Quality, and Business Operations: Modeling and Optimization, 231–250.

Lindberg, C. F., Tan, S., Yan, J., & Starfelt, F. (2015). Key Performance Indicators Improve Industrial Performance. *Energy Procedia*, *75*, 1785–1790. https://doi.org/10.1016/j.egypro.2015.07.474

Maintenance history, Advanced Technology Services, "The Evolution if Industrial Maintenance", Accessed: 17/02/2023

Available: https://www.advancedtech.com/blog/evolution-of-industrial-maintenance/

Márquez A. C. (2007). "*The Maintenance Management Framework"* (Vols. 978-1-84628-821-0.). Springer-Verlag.

Méndez J. D. M., & Rodriguez R. S. (2017), *"Total productive maintenance (TPM) as a tool for improving productivity: a case study of application in the bottleneck of an auto-parts machining line"*, Int J Adv Manuf Technol, 92, 1013–1026. https://doi.org/10.1007/s00170-017-0052-4

Mohan, R. T., Preetha Roselyn, J., & Annie Uthra, R. (2021). Autonomous Maintenance in Industrial Revolution 4.0 During Covid-19 - A Real Time Approach. *Proceedings of the 8th International Conference on Signal Processing and Integrated Networks, SPIN 2021*, 53–58. https://doi.org/10.1109/SPIN52536.2021.9566019

Mouta, C. S. P. (2011), *"Gestão da Manutenção"*, Universidade da Beira Interior.

Mwanza, B. G., & Mbohwa, C. (2015). Design of a Total Productive Maintenance Model for Effective Implementation: Case Study of a Chemical Manufacturing Company. *Procedia Manufacturing*, *4*, 461–470. https://doi.org/10.1016/j.promfg.2015.11.063

"Maintenance - Maintenance Key Performance Indicators", BS EN 15341:2019, The British Standards Institution. 2019

"Maintenance — Maintenance terminology". The British Standards Institution. 2013

Oliveira, M., Lopes, I., & Rodrigues, C. (2016). Use of Maintenance Performance Indicators by Companies of the Industrial Hub of Manaus. Procedia CIRP, 52, 157–160. https://doi.org/10.1016/j.procir.2016.07.071

Pacaiova, H., & Glatz, J. (2015). Maintenance management system. MM Science Journal, 2015(OCTOBER), 665–669. https://doi.org/10.17973/MMSJ.2015_10_201532

Pačaiová, H., & Ižaríková, G. (2019). Base principles and practices for implementation of total productive maintenance in automotive industry. Quality Innovation Prosperity, 23(1), 45–59. https://doi.org/10.12776/QIP.V23I1.1203

Pinciroli, L., Baraldi, P., & Zio, E. (2023). Maintenance optimization in industry 4.0. Reliability Engineering and System Safety, 234. https://doi.org/10.1016/j.ress.2023.109204

Pinto, J. (2013). Manutenção Lean (2013.a ed.). Lidel – Edições Técnicas.

Pinto, G., Silva, F. J. G., Baptista, A., Fernandes, N. O., Casais, R., & Carvalho, C. (2020). TPM implementation and maintenance strategic plan - A case study. Procedia Manufacturing, 51, 1423–1430. https://doi.org/10.1016/j.promfg.2020.10.198

Pinto, G. F. L., Silva, F. J. G., Campilho, R. D. S. G., Casais, R. B., Fernandes, A. J., & Baptista, A. (2019). Continuous improvement in maintenance: A case study in the automotive industry involving Lean tools. Procedia Manufacturing, 38, 1582–1591. https://doi.org/10.1016/j.promfg.2020.01.127

Ribeiro I. M., Godina R., Pimentel C., Silva F. J. G., & Matias J. C. O. (2019), "Implementing TPM supported by 5S to improve the availability of an automotive production line", Procedia Manufacturing, 38, 1574–1581.

Ribeiro J. P. S. (2009), "Plano estratégico de manutenção – implementação de melhorias", Faculdade de Engenharia da Universidade do Porto.

Sarikaya, A., Correll, M., Bartram, L., Tory, M., & Fisher, D. (2019). What do we talk about when we talk about dashboards? IEEE Transactions on Visualization and Computer Graphics, 25(1), 682–692. https://doi.org/10.1109/TVCG.2018.2864903

Shinde, D. D., & Prasad, R. (2018). Application of AHP for Ranking of Total Productive Maintenance Pillars. Wireless Personal Communications, 100(2), 449–462. https://doi.org/10.1007/s11277-017-5084-4

Staron M. (2015), "How to build sustainable and useful dashboards to support software development and maintenance", Department of Computer Science and Engineering, Chalmers University of Technology and University of Gothenburg, Report no 2015:02, ISSN: 1651-4870.

Theissler, A., Pérez-Velázquez, J., Kettelgerdes, M., & Elger, G. (2021). Predictive maintenance enabled by machine learning: Use cases and challenges in the automotive industry. Reliability Engineering and System Safety, 215. https://doi.org/10.1016/j.ress.2021.107864

Tortorella, G. L., Fogliatto, F. S., Cauchick-Miguel, P. A., Kurnia, S., & Jurburg, D. (2021). Integration of Industry 4.0 technologies into Total Productive Maintenance practices. International Journal of Production Economics, 240. https://doi.org/10.1016/j.ijpe.2021.108224

Vilarinho S., Lopes I, & Sousa S. (2017), “Design procedure to develop dashboards aimed at improving the performance of productive equipment and processes”, Procedia Manufacturing, 11, 1634 – 1641. https://doi.org/10.1016/j.promfg.2017.07.314

Vilarinho, S., Lopes, I., & Sousa, S. (2018). Developing dashboards for SMEs to improve performance of productive equipment and processes. Journal of Industrial Information Integration, 12, 13–22. https://doi.org/10.1016/j.jii.2018.02.003

Wang, K., Dai, G., & Guo, L. (2016). Intelligent Predictive Maintenance (IPdM) for Elevator Service Through CPS, IOT&S and Data Mining.

Wang, Y., Deng, C., Wu, J., Wang, Y., & Xiong, Y. (2014). A corrective maintenance scheme for engineering equipment. Engineering Failure Analysis, 36, 269–283. https://doi.org/10.1016/j.engfailanal.2013.10.006

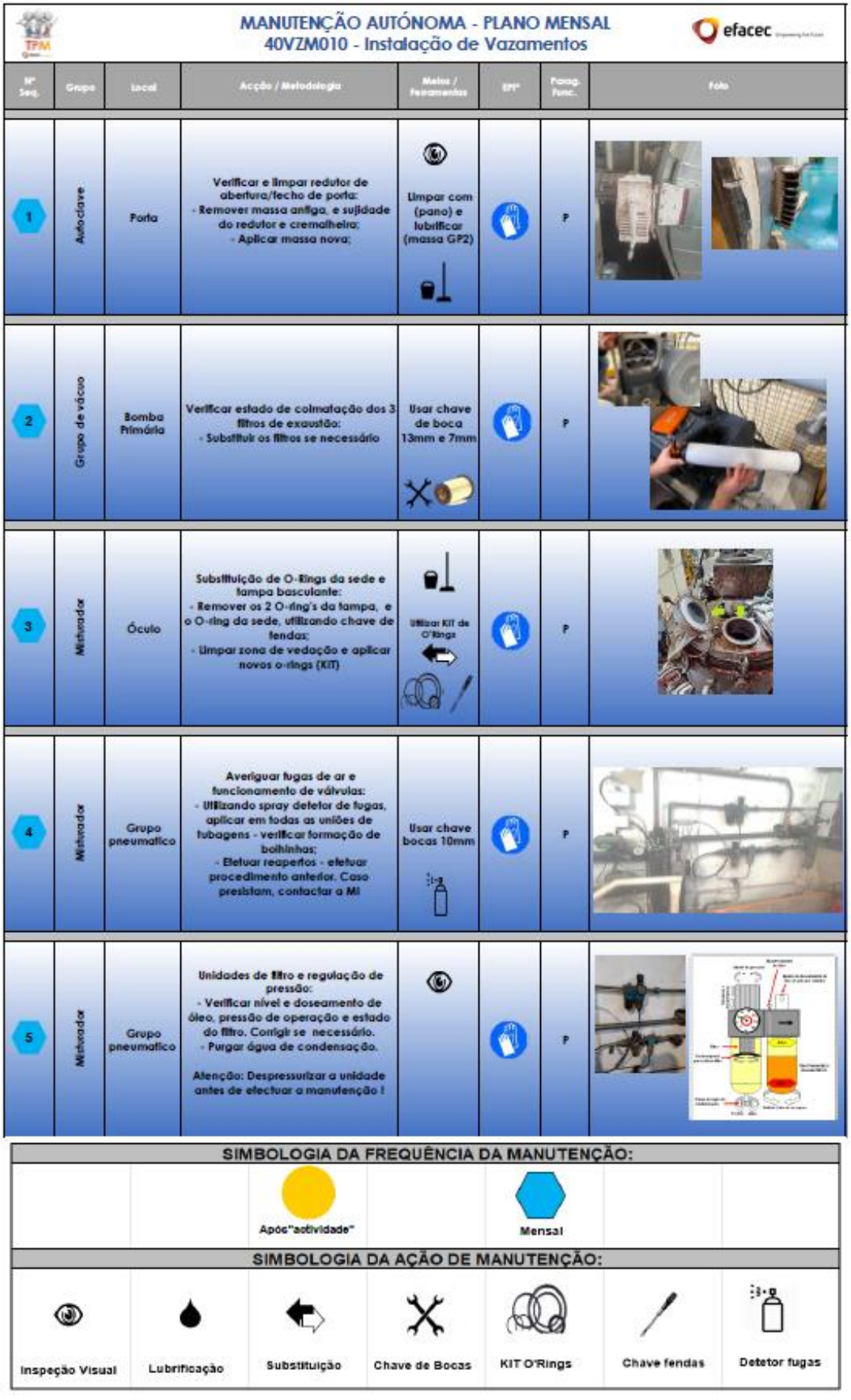
Wiktorsson, M., Andersson, C., & Turunen, V. (2018). Leading towards high-performance manufacturing - Enabling indicators in early R&D phases ensuring future KPI outcome. Procedia Manufacturing, 25, 223–230. https://doi.org/10.1016/j.promfg.2018.06.077

Wilke C. O. (2019), “Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures”, O’Reilly, 1st Edition.

Yepez P., Alsayyed B., & Ahmad R. (2019), “Intelligent assisted maintenance plan generation for corrective Maintenance”, Manufacturing Letters, 21, 7–11.

Zonta T., Costa C. A. D., Righi R. D. R., Lima M. J. D., Trindade E. S. D, & Li G. P. (2020), “Predictive maintenance in the Industry 4.0: A systematic literature review”, Vol 150, 106889. https://doi.org/10.1016/j.cie.2020.106889

APPENDIX A: Old AM manual for 40VZM010



MANUTENÇÃO AUTÓNOMA - PLANO MENSAL
40VZM010 - Instalação de Vazamentos

efacec

Nº Seq.	Grupo	Local	Acção / Metodologia	Meios / Ferramentas	EPI	Perag. Func.	Foto
1	Autoclave	Porta	Verificar e limpar redutor de abertura/fecho de porta: - Remover massa antiga, e sujidade do redutor e cremalheira; - Aplicar massa nova;	Limpar com (pano) e lubrificar (massa GP2)		P	
2	Grupo de vácuo	Bomba Primária	Verificar estado de colmatação dos 3 filtros de exaustão: - Substituir os filtros se necessário	Usar chave de boca 13mm e 7mm		P	
3	Misturador	Óculo	Substituição de O-Rings da sede e tampa basculante: - Remover os 2 O-ring's da tampa, e o O-ring da sede, utilizando chave de fendas; - Limpar zona de vedação e aplicar novos o-rings (KIT)	Utilizar KIT de O'Rings		P	
4	Misturador	Grupo pneumatico	Averiguar fugas de ar e funcionamento de válvulas: - Utilizando spray detetor de fugas, aplicar em todas as uniões de tubagens - verificar formação de bolhinhas; - Efetuar reapertos - efetuar procedimento anterior. Caso persistam, contactar a MI	Usar chave bocas 10mm		P	
5	Misturador	Grupo pneumatico	Unidades de filtro e regulação de pressão: - Verificar nível e doseamento de óleo, pressão de operação e estado do filtro. Corrigir se necessário. - Purgar água de condensação. Atenção: Despressurizar a unidade antes de efectuar a manutenção !			P	

SIMBOLOGIA DA FREQUÊNCIA DA MANUTENÇÃO:

Após"actividade" | Mensal

SIMBOLOGIA DA AÇÃO DE MANUTENÇÃO:

Inspeção Visual | Lubrificação | Substituição | Chave de Bocas | KIT O'Rings | Chave fendas | Detetor fugas

APPENDIX B: Record of attendance at training

Academy efacec

REGISTO DE PRESENÇAS

Formador: Celso Manuel P Teixeira ☐ Formador Externo ☑ Formador Interno | nº colaborador: 201

Curso/Acção: TPM Vazamento de araldite Local: Arroteia Código*: 6 - Técnica

Duração (h): 00:30 Data: 31/mar/21 Horário: 15:00

Objectivos: Formar operadores e chefias para realizar um conjunto de actividades simples e planeadas com o objectivo de manter o equipamento em boas condições de funcionamento, aumentando o seu conhecimento tecnico e incutir responsabilidade.

Conteúdo: Executar o plano de manutenção primaria, identificar partes da maquina onde intrevir, saber quais os produtos a utilizar e como utilizar em condições de segurança.

Nº Colab.	NOME COMPLETO (EM MAIÚSCULAS)	UN/Empresa	RÚBRICA
2708	Rui David de Sá Rodrigues Farias	DT	Rui
4184	Ricardo Emanuel Ribeiro Loureiro	DT	Loureiro
0007	Joaquim Armando Araújo Ferreira	DT	[illegible]

01.000EFACEC-07040001-001-001-EN-07

* Códigos: 1 - Comportamental; 2 - QAS; 3 - Gestão e Administração; 4 - Linguas Estrangeiras; 5 - Informática; 6 - Técnica

DATA: 31/mar/21

ASSINATURA DO FORMADOR: [signature]

DGERT ENTIDADE FORMADORA CERTIFICADA

APPENDIX C: Clusters created

Tipo	Serialized item group	Search argument CLUSTER	Search argument ITEM	Descrição
EAT	EAT	EAT_MFP_SLD	EAT_MFP_SLD	Máquina Ferramenta Portátil - SOLDADURA
EAT	EAT	EAT_MFP_CIN	EAT_MFP_CIN	Máquina Ferramenta Portátil - CINTAGEM
EAT	EAT	EAT_MFP_CCDCF	EAT_MFP_CCDCF	Máquina Ferramenta Portátil - COR CRAV DESB CABO FIO
EAT	EAT	EAT_MFP_COR	EAT_MFP_COR	Máquina Ferramenta Portátil - CORTE
EAT	EAT	EAT_MFP_DES	EAT_MFP_DES	Máquina Ferramenta Portátil - DESBASTE
EAT	EAT	EAT_MFP_FF	EAT_MFP_FF	Máquina Ferramenta Portátil - FURAÇÃO E FIXAÇÃO
EAT	EAT	EAT_MFP_RA	EAT_MFP_RA	Máquina Ferramenta Portátil - REBITAR E AGRAFAR
EAT	EAT	EAT_MFP_IAE	EAT_MFP_IAE	Máquina Ferramenta Portátil - ILUMINAÇÃO E ACESS ELETRICOS
EAT	EAT	EAT_MFP_AL	EAT_MFP_AL	Máquina Ferramenta Portátil - ASPIRAÇÃO E LAVAGEM
EAT	EAT	EAT_MFP_SOPAQ	EAT_MFP_SOPAQ	Máquina Ferramenta Portátil - SOPRADOR AR QUENTE
EAT	EAT	EAT_MFP_PIN	EAT_MFP_PIN	Máquina Ferramenta Portátil - PINTURA
EAT	EAT	EAT_MFP_COMP	EAT_MFP_COMP	Máquina Ferramenta Portátil - COMPRESSOR
EAT	EAT	EAT_MFP_ACE	EAT_MFP_ACE	Máquina Ferramenta Portátil - ACESSÓRIOS
EAT	EAT	EAT_MFP_OUTROS	EAT_MFP_OUTROS	Máquina Ferramenta Portátil - OUTROS
EAT	EAT	EAT_AE_GAN C	EAT_AE_GAN C	Acessório de Elevação - GANCHO C
EAT	EAT	EAT_AE_EST	EAT_AE_EST	Acessório de Elevação - ESTROPO
EAT	EAT	EAT_AE_LINGA	EAT_AE_LINGA	Acessório de Elevação - LINGA
EAT	EAT	EAT_AE_MAN	EAT_AE_MAN	Acessório de Elevação - MANILHA
EAT	EAT	EAT_AE_GAR	EAT_AE_GAR	Acessório de Elevação - GARRA
EAT	EAT	EAT_AE_OLH	EAT_AE_OLH	Acessório de Elevação - OLHAIS
EAT	EAT	EAT_AE_PPPR	EAT_AE_PPPR	Acessório de Elevação - PORTA PALETES PONTE ROLANTE
EAT	EAT	EAT_AE_ARG	EAT_AE_ARG	Acessório de Elevação - ARGOLÕES
EAT	EAT	EAT_AE_OUTRO	EAT_AE_OUTRO	Acessório de Elevação - OUTROS
EAT	EAT	EAT_MH_CIL	EAT_MH_CIL	Equipamento Hidráulico - CILINDRO
EAT	EAT	EAT_MH_BOMB	EAT_MH_BOMB	Equipamento Hidráulico - BOMBA
EAT	EAT	EAT_MH_MANG	EAT_MH_MANG	Equipamento Hidráulico - MANGUEIRA HIDRAULICA
EAT	EAT	EAT_MH_VALV	EAT_MH_VALV	Equipamento Hidráulico - VÁLVULA
EAT	EAT	EAT_MH_ACES	EAT_MH_ACES	Equipamento Hidráulico - ACESSÓRIOS
EAT	EAT	EAT_MH_OUTRO	EAT_MH_OUTRO	Equipamento Hidráulico - OUTROS
EAT	EAT	EAT_EPI/C_LV_HOR	EAT_EPI/C_LV_HOR	Equip Prot Indiv/Coletiva - Linha Vida Horizontal
EAT	EAT	EAT_EPI/C_LV_VER	EAT_EPI/C_LV_VER	Equip Prot Indiv/Coletiva - Linha Vida Vertical
EAT	EAT	EAT_EPI/C_VI	EAT_EPI/C_VI	Equip Prot Indiv/Coletiva - Vara Isolante
EAT	EAT	EAT_EPI/C_T	EAT_EPI/C_T	Equip Prot Indiv/Coletiva - Terras
EAT	EAT	EAT_EPI/C_DAT	EAT_EPI/C_DAT	Equip Prot Indiv/Coletiva - Detetor Ausência Tensão
EAT	EAT	EAT_EEPT_ESCA	EAT_EEPT_ESCA	Escadas/Escadotes/Plataformas de Trabalho - ESCADA
EAT	EAT	EAT_EEPT_ESCO	EAT_EEPT_ESCO	Escadas/Escadotes/Plataformas de Trabalho - ESCADOTE
EAT	EAT	EAT_EEPT_PT	EAT_EEPT_PT	Escadas/Escadotes/Plataformas de Trabalho - PLATAFORMA TRABALHO
EAT	EAT	EAT_EEPT_AND	EAT_EEPT_AND	Escadas/Escadotes/Plataformas de Trabalho - ANDAIME
EAT	EAT	EAT_RMM	EAT_RMM	Recursos de Medição e Monitorização
EAT	EAT	EAT_FC_SC	EAT_FC_SC	Ferramentas de Corte - SERRA CIRCULAR
EAT	EAT	EAT_FC_F/PL	EAT_FC_F/PL	Ferramentas de Corte - FRESA/PORTA-LÂMINAS
EAT	EAT	EAT_FC_SA	EAT_FC_SA	Ferramentas de Corte - SISTEMA DE APERTO
EAT	EAT	EAT_FM	EAT_FM	Ferramentas Manuais
EAT	EAT	EAT_ML_PAL	EAT_ML_PAL	Meios Logísticos - PALETE DE TRANSPORTE COM OLHAIS
EAT	EAT	EAT_ML_CMMM	EAT_ML_CMMM	Meios Logísticos - CARROS/MESAS DE TRABALHO OU MOVIMENTAÇÃO DE MATERIAIS
EAT	EAT	EAT_ML_CAVELETES	EAT_ML_CAVELETES	Meios Logísticos - CAVALETE
EAT	EAT	EAT_ML_PP	EAT_ML_PP	Meios Logísticos - PORTA PALETES
EAT	EAT	EAT_ML_MESAELV	EAT_ML_MESAELV	Meios Logísticos - MESA ELEVATÓRIA
EAT	EAT	EAT_ESP	EAT_ESP	Equipamentos Auxiliares Trabalho Específicos
EAT	EAT	EAT_ESP	EAT_ESP_IMP	Equipamentos Auxiliares Trabalho Específicos - IMPRESSORA
Equipamento	EMC	EMC_EMP	EMC_EMP	EMPILHADOR
Equipamento	EMC	EMC_PPE	EMC_PPE	PORTA PALETES ELÉTRICO
Equipamento	EMC	EMC_REB	EMC_REB	REBOCADOR
Equipamento	EMC	EMC_STACK	EMC_STACK	STACKER ELÉTRICO
Equipamento	ELEVCARG	ELEV CARG_PR	ELEV CARG_PR	PONTE ROLANTE
Equipamento	ELEVCARG	ELEV CARG_PORT	ELEV CARG_PORT	PÓRTICO/SEMI-PÓRTICO
Equipamento	ELEVCARG	ELEV CARG_LANÇA	ELEV CARG_LANÇA	LANÇA
Equipamento	ELEVCARG	ELEV CARG_MONOCA	ELEV CARG_MONOCA	MONOCARRIL
Equipamento	ELEVCARG	ELEV CARG_DIFER	ELEV CARG_DIFER	DIFERENCIAL
Equipamento	ELEVCARG	ELEV CARG_BALAN	ELEV CARG_BALAN	BALANCEIRO
Equipamento	ELEVCARG	ELEV CARG_CRU/AR	ELEV CARG_CRU/AR	CRUZETA/ARANHA DE VÁCUO
Equipamento	ELEVCARG	ELEV CARG_OUTRO	ELEV CARG_OUTRO	OUTROS EQUIP. ELEVAÇÃO CARGA
Equipamento	PLATELEV	PLAT ELEV_TESOURA	PLAT ELEV_TESOURA	PLAT ELEV - TESOURA
Equipamento	PLATELEV	PLAT ELEV_FUSO	PLAT ELEV_FUSO	PLAT ELEV - FUSO
Equipamento	PLATELEV	PLAT ELEV_ART	PLAT ELEV_ART	PLAT ELEV - ARTICULADA
Equipamento	PLATELEV	PLAT ELEV_TELESC	PLAT ELEV_TELESC	PLAT ELEV - TELESCÓPICA E MASTRO VERTICAL
Equipamento	PLATELEV	PLAT ELEV_MCAR	PLAT ELEV_MCAR	PLAT ELEV - MONTA-CARGAS
Equipamento	PLATELEV	PLAT ELEV_DOC	PLAT ELEV_DOC	PLAT ELEV - DOCAGEM
Equipamento	GAS	GAS_ARMAZ./DIST.	GAS_ARMAZ./DIST.	CENTRAL E REDE DE GAS
Equipamento	GAS	GAS_POSTOS	GAS_POSTOS	POSTO DE GAS
Equipamento	GEN	GENERICO	"Descrição do equipamento"	"Descrição do equipamento"

APPENDIX D: New AM Manual Template

efacec	MANUAL DE MANUTENÇÃO AUTÓNOMA	Cluster(s)/equipamento(s): Números de série: UN(s): Cód. Documento:	TN "Frequência"

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
		Aconselha-se verificação sempre que se efetue o carregamento da bateria	chave de bocas AAA123 - BBB345	P	
				P	
				P	
				P	
			chave de bocas Martelo Roquete AAA123 - BBB345	P	

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	Duração estimada (min):

Link para video de execução:	Spares/Cons. necessários:	
Manual do equipamento:	Código	Descrição
	AAA123	BBB345

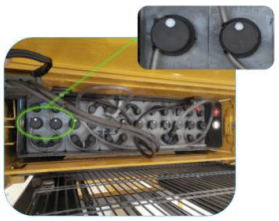
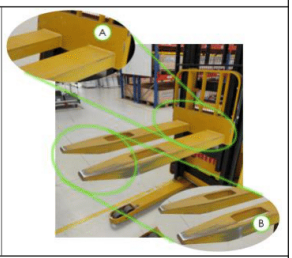
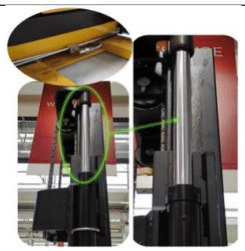
Nota:
1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança;
2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template:

SIMBOLOGIA DA FREQUÊNCIA DA MANUTENÇÃO:							
 Dependente do evento	Turno	Diário	 Semanal	 Quinzenal	 Mensal	 Trimestral	 Semestral
SIMBOLOGIA DA AÇÃO:							
 Inspeção Visual	 Lubrificação	 Substituição	 Ferramentas	 Limpeza			

APPENDIX E: AM Manual – Stackers

efacec	**MANUAL DE MANUTENÇÃO AUTÓNOMA**	**Cluster(s)/equipamento(s):** EMC - Stacker **Números de série:** 17968; 17961; 17966; 17957; 17963; 18003; 17969; 17953; 17965; 17959; 17954; 17958; 17951; 18005; 17952; 17964; 17960; 18004; 17967; 17955; 17949; 18006; 17956; 18007; 17962; 17950; 0098 **UN(s):** Geral **Cód. Documento:**	W Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
1	Bateria	Após carregar a bateria, verificar se os flutuadores brancos indicadores de nível de água estão visíveis. Caso não estejam, ligar ao dispensador de água destilada automático para repor o nível. ⚠ **Aconselha-se verificação sempre que se efetue o carregamento da bateria**	👁 - -	P	
2	Garfos de carga	Verificar se os garfos têm fissuras (zona A) e se as extremidades (zona B) estão alinhadas (paralelas).	👁 - -	P	
3	Sistema de elevação de carga	Avaliar o estado de tensão das correntes de elevação. Estas devem estar igualmente tensionadas, não apresentando folga ou tensão exagerada.	👁 - -	P	
4	Sistema de elevação de carga	Verificar a integridade dos tubos e cilindros hidráulicos, segundo os seguintes passos: 1. Elevar os garfos ao máximo. 2. Procurar por fugas, fissuras ou cortes, em especial na zona do mastro.	👁 - -	P	
5	Garfos de carga	Baixando os garfos ao mínimo, verificar na grade de encosto da carga (zona A) e dos garfos (zona B): 1. Estabilidade (se está solta). 2. Integridade (se está fissurada ou partida).	👁 - -	P	

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):** 02:30

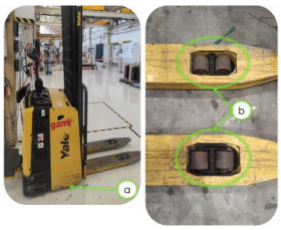
Link para video de execução: https://efacecpws.sharepoint.com/:v:/s/ManutenoIndustrialTransversalWebSite/EXUOMiUDfBFKlmnCDGkYVL0By1OhTyimQfwE4ZseEA3bng?e=gnSam5	**Spares/Cons. necessários:** Código	Descrição
Manual do equipamento:		
Nota: 1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança; 2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.		
Código do template: 01.000EFACEC-10010059-008-000-PT-00		

efacec

MANUAL DE MANUTENÇÃO AUTÓNOMA

Cluster(s)/equipamento(s): EMC - Stacker
Números de série: 17968; 17961; 17966; 17957; 17963; 18003; 17969; 17953; 17965; 17959; 17954; 17958; 17951; 18005; 17952; 17964; 17960; 18004; 17967; 17955; 17949; 18006; 17956; 18007; 17962; 17950; 0098
UN(s): Geral
Cód. Documento:

W
Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
6	Rodas	Através de movimentações do equipamento, verificar se: 1. A roda motriz (a) e as rodas de apoio (b) rodam sem impedimentos. 2. Se existem oscilações no movimento.	 - -	F	
7	Sistema de travagem e emergência	Em funcionamento, verificar operacionalidade da: 1. Travagem de serviço (largar o acelerador). 2. Travagem de emergência (acionar botão de emergência). ⚠ **Recomenda-se a realização desta atividade diariamente, no arranque do turno, ou antes de utilização.**	 - -	F	
-	-	-	- - -	-	-
-	-	-	- - -	-	-
-	-	-	- - -	-	-

Legenda da simbologia Ação — Inspeção Visual; Substituição; Lubrificação; Ferramentas; Limpeza

Duração estimada (min): 02:30

Link para video de execução:
https://efacecpws.sharepoint.com/:v:/s/ManutenoIndustrialTransversalWebSite/EXUOMiUDfBFKlmnCDGkYVL0By1OhTyimQfwE4ZseEA3bng?e=gnSam5

Spares/Cons. necessários:

Código	Descrição

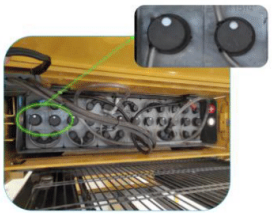
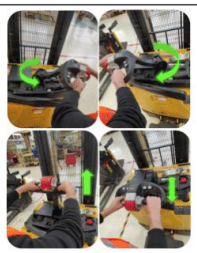
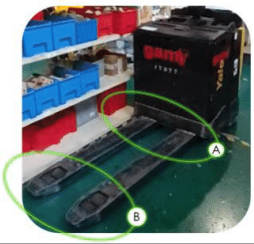
Manual do equipamento:

Nota:
1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança;
2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template: 01.000EFACEC-10010059-008-000-PT-00

APPENDIX F: AM Manual - Electric Pallet Truck

efacec	**MANUAL DE MANUTENÇÃO AUTÓNOMA**	**Cluster(s)/equipamento(s):** EMC - Porta-Paletes **Números de série:** 1573; 17977; 17900; 17971; 27565 **UN(s):** Geral **Cód. Documento:**	W Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
1	Bateria	Após carregar a bateria, verificar se os flutuadores brancos indicadores de nível de água estão visíveis. Caso não estejam, ligar ao dispensador de água destilada automático para repor o nível. ⚠ **Aconselha-se verificação sempre que se efetue o carregamento da bateria**	👁 - -	P	
2	Comando e acionamento	Movimentar o guiador em todas as direções de modo a verificar se existe algum impedimento do movimento.	👁 - -	P	
3	Garfos de carga	Verificar: 1. Se os garfos têm fissuras (zona A). 2. Se as extremidades (zona B) estão alinhadas (paralelas).	👁 - -	P	
4	Plataforma de apoio e barreiras laterais	Verificar se: 1. A plataforma de apoio está firme, colocando-se em cima da mesma e confirmar que ela não toca no chão. 2. As barreiras laterais rodam sem impedimentos e bloqueiam na posição de funcionamento (posição da ilustração).	👁 - -	P	
-	-	-	- - -	-	-

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):** 01:30
Link para video de execução: https://efacecpws.sharepoint.com/:v:/s/ManutenoIndustrialTransversalWebSite/EfIM30fI-F9FtoO1ZeLV_WYBV3SG_SQMF_JQWvcLWZeu9Q?e=gvhk25							**Spares/Cons. necessários:** Código / Descrição
Manual do equipamento:							
Nota: 1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança; 2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.							
Código do template: 01.000EFACEC-10010059-008-000-PT-00							

efacec	**MANUAL DE MANUTENÇÃO AUTÓNOMA**	**Cluster(s)/equipamento(s):** EMC - Porta-Paletes **Números de série:** 17977; 17900; 17971; 27565 **UN(s):** Geral **Cód. Documento:**	W Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
5	Comandos e acionamentos	Verificar o correto funcionamento dos comandos, atuando-os separadamente: 1. Buzina. 2. Acelerador. 3. Botão de emergência do guiador. 4. Sobe/Desce.	👁 - -	F	
6	Rodas	Através de movimentações do equipamento, verificar se: 1. A roda motriz (a) e as rodas de apoio (b) rodam sem impedimentos. 2. Se existem oscilações no movimento.	👁 - -	F	
7	Sistema de travagem e emergência	Em funcionamento, verificar operacionalidade da: 1. Travagem de emergência (acionar botão de emergência). 2. Travagem de serviço (largar o acelerador). ⚠ **Recomenda-se a realização desta atividade diariamente, no arranque do turno, ou antes de utilização.**	👁 - -	F	
-	-	-	- - -	-	-
-	-	-	- - -	-	-

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):** 01:30

Link para video de execução: https://efacecpws.sharepoint.com/:v:/s/ManutenoIndustrialTransversalWebSite/EfIM30fI-F9FtoO1ZeLV_WYBV3SG_SQMF_JQWvcLWZeu9Q?e=gvhk25

Spares/Cons. necessários:

Código	Descrição

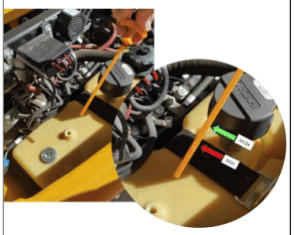
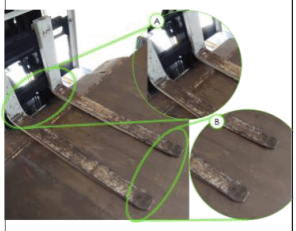
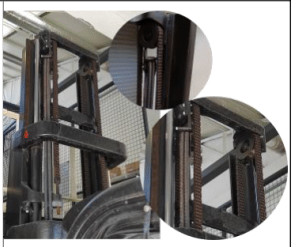
Manual do equipamento:

Nota:
1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança;
2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template: 01.000EFACEC-10010059-008-000-PT-00

APPENDIX G: AM Manual - Forklift

efacec	**MANUAL DE MANUTENÇÃO AUTÓNOMA**	**Cluster(s)/equipamento(s):** EMC - Empilhador **Números de série:** 17757; 17934; 17933; 17936; 17938; 17922; 17763; 17939; 18056; 17929; 17925; 17916; 17924; 18060; 17761; 17918; 17923; 17917; 17932; 17992; 17921; 17937; 17940; 17926; 17935; 17931; 17930; 17765; 18058; 8875 **UN(s):** Geral **Cód. Documento:**	W Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
1	Grupo Hidráulico	1. Verificar o nível de óleo no depósito hidráulico, através da vareta graduada. O nível deve estar entre o mínimo e o máximo representados na vareta. 2. Verificar a integridade dos tubos hidráulicos, procurando por fugas, fissuras ou cortes. 3. Limpar manchas de óleo resultantes da actividade.	Pano de limpeza -	P	
2	Grupo capot / bateria	Após carregar a bateria, verificar se os flutuadores brancos indicadores de nível se encontram vísiveis, seguindo os seguintes passos: 1. Abrir o vidro de trás. 2. Destravar comandos manuais. 3. Destravar a trava do capot e levantá-lo. 4. Verificar se os flutuadores estão visíveis. Caso não estejam, ligar ao dispensador de água destilada automático para repor o nível. 5. Fechar o capot e o vidro, certificando que estão bem fechados.	- -	P	
3	Pneus	Verificar: 1. Nível de desgaste dos pneus. O limite mínimo de desgaste é o marcado na ilustração. 2. A integridade dos pneus, procurando por rasgos ou não conformidades.	- -	P	
4	Sistema de elevação de carga	Verificar: 1. Se os garfos têm fissuras (zona A). 2. Se as extremidades (zona B) estão alinhadas ou com desgaste.	- -	P	
5	Sistema de elevação de carga	Avaliar o estado de tensão das correntes de elevação. Estas devem estar igualmente tensionadas, não apresentando folga ou tensão exagerada.	- -	P	

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):** 05:30

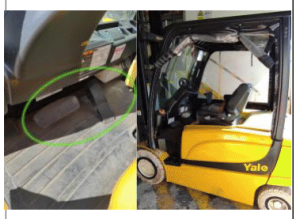
Link para vídeo de execução:	**Spares/Cons. necessários:**	
https://efacecpws.sharepoint.com/:v:/s/ManutenoIndustrialTransversalWebSite/EWY0RIgkLn9KnrNUXRsVVCAB0R4N3KqmYQpuuIRobpBDwA?e=mydZBn	**Código**	**Descrição**
Manual do equipamento:		
Nota: 1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança; 2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.		
Código do template: 01.000EFACEC-10010059-008-000-PT-00		

efacec

MANUAL DE MANUTENÇÃO AUTÓNOMA

Cluster(s)/equipamento(s): EMC - Empilhador
Números de série: 17757; 17934; 17933; 17936; 17938; 17922; 17763; 17939; 18056; 17929; 17925; 17916; 17924; 18060; 17761; 17918; 17923; 17917; 17932; 17992; 17921; 17937; 17940; 17926; 17935; 17931; 17930; 17765; 18058; 8875
UN(s): Geral
Cód. Documento:

W
Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
6	Sistema de elevação de carga	Elevar os garfos ao máximo e verificar a integridade dos tubos e cilindros hidráulicos, procurando por fugas, fissuras ou cortes, em especial na zona do mastro.	 - -	P	
7	Sistema de elevação de carga	Baixar os garfos e verificar na grade de encosto da carga (zona A) e dos garfos (Zona B): 1. Estabilidade (se está solta). 2. Integridade (se está fissurada ou partida).	 - -	P	
8	Geral	Verificar: 1. Estado dos pedais. 2. Integridade exterior do equipamento, tal como lonas rasgadas ou vidros picados.	 - -	P	
9	Geral	Verificar se as escovas e limpa-para-brisas: 1. Estão operacionais. 2. Apresentam algum desgaste ou anomalia que condicione a sua função.	 - -	P	
10	Luzes	Verificar correto funcionamento da sinalização luminosa: 1. Luzes frontais; 2. Luzes de presença; 3. Luzes Stop; 4. Luz de marcha-atrás; 5. Pirilampo.	 - -	P	

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	Duração estimada (min): 05:30

Link para video de execução:
https://efacecpws.sharepoint.com/:v:/s/ManutenoIndustrialTransversalWebSite/EWY0RIgkLn9KnrNUXRsVVCAB0R4N3KqmYQpuuIRobpBDwA?e=mydZBn

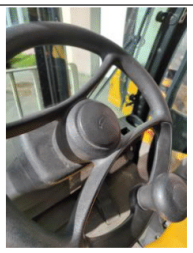
Manual do equipamento:

Spares/Cons. necessários: Código	Descrição

Nota:
1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança;
2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template: 01.000EFACEC-10010059-008-000-PT-00

efacec	**MANUAL DE MANUTENÇÃO AUTÓNOMA**	**Cluster(s)/equipamento(s):** EMC - Empilhador **Números de série:** 17757; 17934; 17933; 17936; 17938; 17922; 17763; 17939; 18056; 17929; 17925; 17916; 17924; 18060; 17761; 17918; 17923; 17917; 17932; 17992; 17921; 17937; 17940; 17926; 17935; 17931; 17930; 17765; 18058; 8875 **UN(s):** Geral **Cód. Documento:**	W Semanal

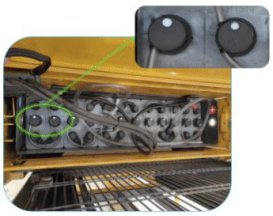
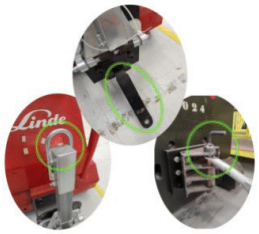
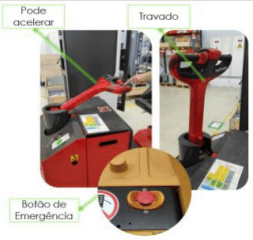
Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
11	Geral	Verificar correto funcionamento da sinalização sonora: 1. Buzina; 2. Buzina de marcha atrás;	 - -	P	
12	Geral	Verificar o devido funcionamento e se ouve algum ruído anómalo de: A - Painel de comandos manual 1) Movimentação vertical; 2) Inclinação da torre; 3) Movimentação lateral. 4) Movimentar equipamento para a frente e para trás B - Painel digital - Sentido da marcha, conta horas, velocidade de trabalho, se está parqueado ou não.	 - -	F	
13	Geral	1. Verificar se o cinto de segurança prende corretamente e se possui rasgos ou cortes. 2. Com a máquina ligada, testar o funcionamento do botão de emergência. ⚠ **Recomenda-se a realização desta atividade diariamente, no arranque do turno, ou antes de utilização.**	 - -	P/F	
-	-	-	- - -	-	-
-	-	-	- - -	-	-

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):** 05:30

Link para video de execução:	**Spares/Cons. necessários:**	
https://efacecpws.sharepoint.com/:v:/s/ManutenoIndustrialTransversalWebSite/EWY0RlgkLn9KnrNUXRsVVCAB0R4N3KqmYQpuuIRobpBDwA?e=mydZBn	**Código**	**Descrição**
Manual do equipamento:		
Nota: 1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança; 2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.		
Código do template: 01.000EFACEC-10010059-008-000-PT-00		

APPENDIX H: AM Manual - Rebocador

efacec	**MANUAL DE MANUTENÇÃO AUTÓNOMA**	**Cluster(s)/equipamento(s):** EMC - Trator de Reboque **Números de série:** 18024; 18025; 0024; 0578 **UN(s):** Geral **Cód. Documento:**	W Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
1	Bateria	Após carregar a bateria, verificar se os flutuadores brancos, indicadores do nível de água, estão visíveis. Caso não estejam, ligar ao dispensador de água destilada automático para repor o nível. ⚠ **Aconselha-se verificação sempre que se efetue o carregamento da bateria**	👁 - -	P	
2	Sistema de reboque	Verificar a integridade dos ganchos de reboque, procurando por fissuras e assegurando que estão bem fixos.	👁 - -	P	
3	Rodas	1. Verificar a integridade dos pneus, procurando por rasgos ou não conformidades. 2. Em funcionamento, movimentar o equipamento para ver se existem oscilações do movimento.	👁 - -	P/F	
4	Pedal de homem morto/Tapete e botão de paragem	1. Em movimento, verificar se a máquina pára quando: 1a. Se larga o pedal de homem morto. 1b. Se deixa de pressionar o tapete. 2. Verificar o correto funcionamento do botão de paragem, no guiador.	👁 - -	F	
5	Sistema de travagem	Em funcionamento, verificar operacionalidade da: 1. Travagem de serviço em ambos os sentidos (largar acelerador). 2. Travagem de emergência (acionar botão de emergência). ⚠ **Recomenda-se a realização desta atividade diariamente, no arranque do turno, ou antes de utilização.**	👁 - -	F	

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):** 01:30

Link para video de execução: https://efacecpws.sharepoint.com/:v:/s/ManutenoIndustrialTransversal/EUsTWPkXSvdOjboCRAa6VAEB-2JSVnRzrY3ZXxeg9uCSXw?e=1cNJXE

Manual do equipamento:

Nota:
1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança;
2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template: 01.000EFACEC-10010059-008-000-PT-00

Spares/Cons. necessários:	
Código	**Descrição**
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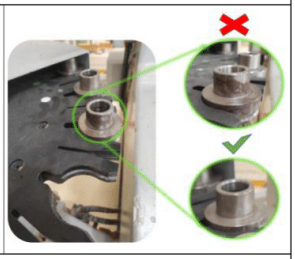
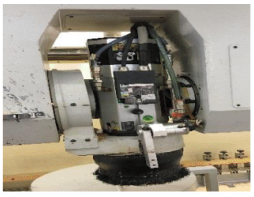
-	-

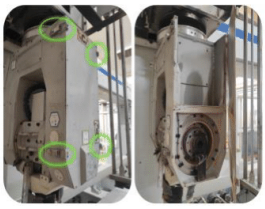
APPENDIX I: AM Manual – Bermaq 10M337

efacec	MANUAL DE MANUTENÇÃO AUTÓNOMA	**Cluster(s)/equipamento(s):** 10M337 **Números de série:** 10M337_00 **UN(s):** TRF **Cód. Documento:**	TN Turno

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
1	Mesas de trabalho e gabarits	Recorrendo a aspiração manual, efetuar limpeza de: 1. Mesa de trabalho do equipamento; 2. Gabarits. **Nota:** Ter cuidado para não aspirar espferas e o´rings de vedação.	 Tubo de aspiração -	P	
2	Carrossel Porta Ferramentas	Utilizando panos de limpeza e esfregão, limpar os cones porta-ferramentas. **Nota:** Aquando da substituição/introdução de um novo cone no carrossel deve também ser efectuada esta ação.	 Panos de Limpeza Esfregão -	P	
3	Cabeça principal	Limpeza da superficie de encaixe dos cones porta-ferramentas.	 Panos de Limpeza -	P	
4	Cabeça principal	Descarregamento da pressão de ar comprimido do spindle (fim do dia de trabalho).	 - -	P	
5	Botão de emergência	Verificar o correto funcionamento de: 1. Botão de emergência do Painel de controlo; 2. Botão de emergência auxiliar; 3. Tapetes de segurança.	 - -	P	

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):**	
Link para video de execução:							**Spares/Cons. necessários:**	
Manual do equipamento:							**Código**	**Descrição**
Nota: 1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança; 2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.							-	-
Código do template: 01.000EFACEC-10010059-008-000-PT-01							-	-

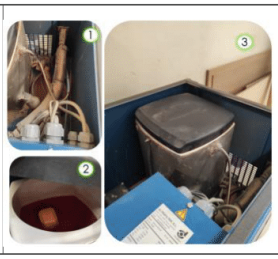
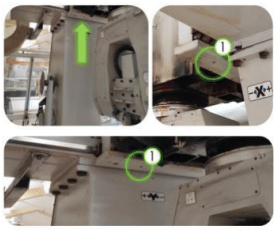
efacec	**MANUAL DE MANUTENÇÃO AUTÓNOMA**	**Cluster(s)/equipamento(s):** 10M337 **Números de série:** 10M337_00 **UN(s):** TRF **Cód. Documento:**	TN Turno

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
6	Cabeça principal	Remover a blindagem frontal e aspirar o interior da campânula (aspiração manual).	 Tubo de aspiração -	P	
7	Sistema de Aspiração	No sistema de aspiração, verificar: 1. Integridade; 2. Existência de obstruções. Caso se verifiquem, desapertar uma das extremidades e desobstruir.	 Tubo de aspiração -	P	
8	Área envolvente	Na área envolvente realizar limpeza: 1. Geral; 2. Componentes mecânicos (elementos de transmissão, esteiras porta-cabos, percursos dos eixos).	 Panos de Limpeza Tubo de aspiração -	P	
-	-	-	- - -	-	-
-	-	-	- - -	-	-

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):**

Link para video de execução:	**Spares/Cons. necessários:** Código	Descrição
Manual do equipamento:	-	-
Nota: 1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança; 2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.	-	-
Código do template: 01.000EFACEC-10010059-008-000-PT-01	-	-

efacec	**MANUAL DE MANUTENÇÃO AUTÓNOMA**	**Cluster(s)/equipamento(s):** 10M337 **Números de série:** 10M337_00 **UN(s):** TRF **Cód. Documento:**	W Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
1	Unidade de arrefecimento	Verificar: 1. Se a temperatura da água indicada no controlo do termostato é aproximadamente a determinada como referência: 20º; 2. Se a pressão da bomba é a mesma que a pressão nominal (Pnom) indicada na placa de caracteristicas: 4,7bar. **Nota:** é admissível uma tolerância de 10%	 - -	P	
2	Unidade de arrefecimento	Verificar: 1. Integridade da tubagem; 2. O nível do líquido de refrigeração. Pode ser verificado no painel de comandos da unidade ou diretamente no depósito. Deve estar a minimo 50%; 3. Se a tampa do depósito ficou corretamente fechada (ilustração).	 - MI10CS0047 - Líquido refrigeração	P	
3	Tinas óleo	Remover o excesso de óleo nas tinas da seguinte forma: 1. Desapertar parafusos (na ilustração). 2. Remover a tina. 3. Remover o excesso de óleo.	 Panos de Limpeza Chave UMBRACO 3	P	
4	Calibrador de ferramentas	Calibrar o calibrador de ferramentas seguindo os passos indicados na instrução específica, presente no equipamento.	 - -	P/F	
-	-	-	- - -	-	-

Legenda da simbologia	Ação	Inspeção Visual	Substituição	Lubrificação	Ferramentas	Limpeza	**Duração estimada (min):**

Link para video de execução:	**Spares/Cons. necessários:**	
Manual do equipamento:	**Código**	**Descrição**
	MI10CS0047	Líquido de refrig.
	-	-
	-	-
	-	-
	-	-
	-	-
	-	-
	-	-

Nota:
1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança;
2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template: 01.000EFACEC-10010059-008-000-PT-01

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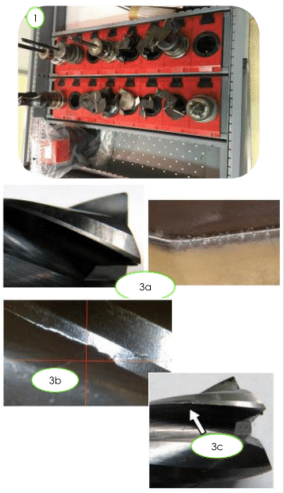
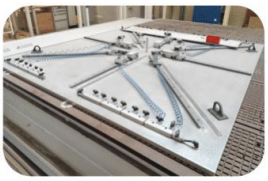
MANUAL DE MANUTENÇÃO AUTÓNOMA

Cluster(s)/equipamento(s): 10M337
Números de série: 10M337_00
UN(s): TRF
Cód. Documento:

W – Semanal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
5	Bomba óleo Smart2	Verificar a existência de fugas ou presença de bolhas de ar. Caso se verifiquem seguir o indicado na nota de rodapé.	- -	P	
6	Ferramentaria	1. Limpar ferramentas e porta-laminas; 2. Verificar se as ferramentas estão afiadas, analisando a existência e conformidade do gume de corte; 3. Os problemas mais tipicos em lâminas são danos devido a desgaste e abrasão. Então, é necessário verificar se as lâminas estão: a) Queimadas; b) Danificadas; c) Lascadas. Caso se verifique, deve-se rodar a lamina/gume de corte ou substituir.	Pano de Limpeza Chaves torx Lâminas -	P	
7	Gabarits	Verificar, nos gabarits: 1. Conformidade de vedação (interface mesa/gabarit e componentes do gabarit); 2. Bom funcionamento de patins e elementos móveis; 3. Integridade e legibilidade de escalas; 4. Integridade dos componentes.	- -	P	
8	Circuito Pneumático	Na unidade de filtragem e regulação de pressão do ar: 1. Pressão do ar, cerca de 8 bar; 2. Limpeza do filtro.	- -	P	

Legenda da simbologia Ação — Inspeção Visual; Substituição; Lubrificação; Ferramentas; Limpeza

Duração estimada (min):

Link para video de execução:

Manual do equipamento:

Spares/Cons. necessários:

Código	Descrição
-	-
-	-
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-	-
-	-

Nota:
1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança;
2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template: 01.000EFACEC-10010059-008-000-PT-01

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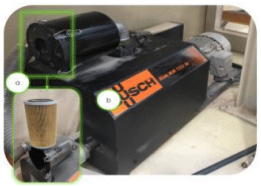
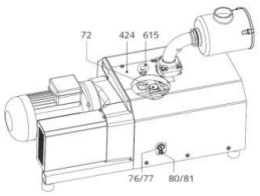
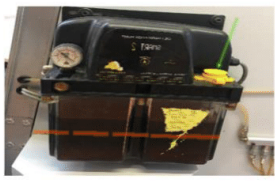
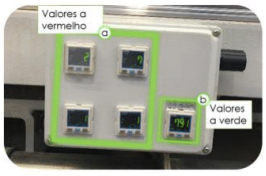
MANUAL DE MANUTENÇÃO AUTÓNOMA

Cluster(s)/equipamento(s): 10M337
Números de série: 10M337_00
UN(s): TRF
Cód. Documento:

M
Mensal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação Ferramentas Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
1	Bombas Vácuo	Limpar: a. Filtros, com recurso a aspiração; b. Carcaça exterior do grupo, com recurso a panos de limpeza.	Panos de Limpeza Aspiração manual -	P	
2	Bombas Vácuo	Verificar nível do óleo de óleo no visor. Caso seja necessário repor: 1. Retirar o olhal de transporte e a tampa (424); 2. Remover a válvula de escape de ar (72); 3. Encher com óleo lubrificante novo até que o visor do depósito (76) esteja como o indicado na figura; 4. Voltar a inserir a válvula de escape de ar com o anel de vedação na válvula; 5. Voltar a montar a tampa do cilindro (424) e colocar o parafuso com olhal de transporte.	MI10CS0117 - Óleo vácuo RO300W -	P	 
3	Bomba Óleo Smart2	Verificar o nível de óleo no depósito. O nível deve ser reposto sempre que estiver abaixo de metade do depósito.	- MI10CS0111 - Óleo Fuchs RENEP	P	
4	Bombas Vácuo Busch - Caixas de comando (Manómetros)	Ligar sistema de vácuo e verificar valores obtidos: 1. Se os valores do retângulo a) estiverem a vermelho - nível conforme (sistema em vácuo); 2. Se o valor do retângulo b) estiver a verde - nível conforme.	- -	F	

Legenda da simbologia Ação — Inspeção Visual — Substituição — Lubrificação — Ferramentas — Limpeza

Duração estimada (min):

Link para video de execução:

Manual do equipamento:

Spares/Cons. necessários:

Código	Descrição
MI10CS0117	Óleo vácuo RO300W
MI10CS0111	Óleo Fuchs RENEP
-	-
-	-
-	-
-	-
-	-
-	-

Nota:
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2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template: 01.000EFACEC-10010059-008-000-PT-00

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MANUAL DE MANUTENÇÃO AUTÓNOMA

Cluster(s)/equipamento(s): 10M337
Números de série: 10M337_00
UN(s): TRF
Cód. Documento:

M
Mensal

Nº Seq.	Área/Local	Acção / Metodologia	Simbologia ação / Ferramentas / Spares/Consumíveis	Parag./ Func.	Fotos/Ilustrações
5	Unidade de arrefecimento	Com a unidade desligada: 1. Limpar a unidade, tanto interior como exterior, eliminando o pó existente, com recurso a panos de limpeza e aspiração manual. 2. Verificar se o medidor de caudal, ao cortar o caudal de líquido, alarma corretamente, garantindo assim a vida útil do motor de fresagem. Para cortar o caudal fecha-se lentamente a torneira do líquido de refrigeração, aparecendo o alarme no ecrã de controlo CNC.	 Pano de Limpeza Aspiração manual -	P	 
6	Unidade de arrefecimento	Limpar o filtro de água seguindo os seguintes passos: 1. Fechar os passadores indicados na figura; 2. Remover o copo; 3. Aspirar.	 Aspiração manual -	P	
7	Lábio do despoeir.	1. Verificar a integridade; 2. Colocar pó de talco na zona assinalada na figura, entre borrachas, para reduzir atrito de deslocamento.	 - Pó de talco	P	
8	Guias e fusos dos eixos	1. Verificar se as guias e fusos dos eixos se encontram desobstruídas. 2. Lubrificar manualmente na zona indicada na figura com o spray.	  - MI10CS0014 - Spray WD-40	P	
9	Painel controlo	Verificar se: 1. Legibilidade e integridade dos botões do painel de controlo; 2. Funcionalidade e iluminação dos indicadores.	 - -	F	

Legenda da simbologia Ação — Inspeção Visual; Substituição; Lubrificação; Ferramentas; Limpeza

Duração estimada (min):

Link para video de execução:

Manual do equipamento:

Nota:
1. Para a execução das tarefas/ações, os colaboradores deverão usar os Equipamentos de Protecção Individual previamente definidos pela Organização, sejam eles genéricos ou específicos das tarefas/ações, assim como também cumprir todas as regras de Segurança;
2. Se surgir alguma anomalia no decurso da realização das actividades, reportar, de acordo com o tipo de equipamento industrial em BAAN - efsoc9500m000 ou Plataforma de gestão de EMCs.

Código do template: 01.000EFACEC-10010059-008-000-PT-01

Spares/Cons. necessários:

Código	Descrição
MI10CS0014	Spray WD-40
-	Pó de talco
-	-
-	-
-	-
-	-
-	-
-	-