Improvement of the Goods Reception Process in the Glass Industry

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Abstract

The increasing innovation and technological evolution combined with the constant development of a company and the need to ensure a favorable competitive position, makes companies, more and more, feel obliged to optimize their processes. Therefore, this dissertation aims to analyze, map and improve the goods reception process at a glass industry company, since most of this process is poorly automated, leading to unnecessary time consumption and providing a higher probability of human error, which results in costs for the organization.

In order to frame the project within the glass industry company, the first step consists in describing the company and the structure of the entire process, identifying all the participants and their respective functions. During the process analysis and mapping the study method used was based on the identification of activities that do not add value to the process, as well as practices in which some of the waste that Lean philosophy tends to fight is found. For a good identification of these activities, the contact with the different participants of the process was fundamental. At the end of the project, a potential reduction of 89,40% in the gate house daily working time was identified, corresponding to a reduction of nine hours and fifty minutes, and a reduction of 70,58% in the general warehouse daily working time, which corresponds to a decrease of two hours.

Afterwards, different suppliers asked to quote their solutions of improvement for the goods reception process. Of the solutions proposed, one of them stands out since it has a payback period of only 1.03 years, which represents a very short period of investment return.

Resumo

A crescente inovação e evolução tecnológica aliada ao desenvolvimento constante de uma empresa e à necessidade de assegurar uma posição competitiva favorável, faz com que, cada vez mais, as empresas se sintam na obrigação de otimizar os seus processos. Desta forma, a presente dissertação objetiva a análise, o mapeamento e a melhoria do processo de receção de mercadorias numa industria vidreira, uma vez que a maior parte deste processo ainda se encontra pouco automatizada, levando ao consumo de tempo desnecessário e proporcionando uma maior probabilidade de se originarem erros humanos, o que se traduz em custos para a organização.

De forma a enquadrar o projeto na industria vidreira em questão, começa-se por descrever a empresa e a estrutura de todo o processo, referindo todos os intervenientes e respetivas funções. Durante a análise e mapeamento dos processos o método de estudo utilizado teve como base a identificação de atividades que não acrescentam valor ao processo, assim como práticas nas quais se verifiquem algum dos desperdícos que a filosofia *Lean* tende a combater. Para uma boa identificação destas atividades, o contacto com os vários intervenientes do processo foi fundamental. No final do projeto, identificou-se um potencial de redução do tempo de trabalho diário em 89,40% na portaria, correspondendo a uma redução de nove horas e cinquenta minutos, e em 70,58% no armazém geral, o que corresponde a uma diminuição de duas horas.

Posteriormente, contactou-se diferentes fornecedores para que estes apresentassem as suas propostas de melhoria para o processo de receção de mercadorias. Das soluções apresentadas, destaca-se uma delas, visto apresentar um *payback period* de apenas 1,03 anos, o que representa um período de retorno de investimento bastante baixo.

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Contents

Acronyms and Symbols

BH	Batch House
CI	Continuous Improvement
ERP	Enterprise Resource Planning
FTE	Full Time Equivalent
GH	Gate House
GW	General Warehouse
JIT	Just In Time
PO	Purchase Order
RM	Raw Material
TPS	Toyota Production System
TQM	Total Quality Management
VSM	Value Stream Mapping

List of Figures

List of Tables

Chapter 1

Introduction

The development of a company, as well as the constant innovation and technological evolution, results in an increasing need to sustain a favourable competitive position. To this end, it is crucial to consider the supply chain efficiency as one of the main factors influencing for the company's sustainability, in order to reduce internal costs and ensure customer satisfaction.

The process of goods reception, which is part of the supply chain, is essential for the proper performance of production, and the way this process is operated should be optimized. Even though it is understandable that in industrial companies the focus is on production efficiency, it is important to highlight that the improvement of support processes could also contribute to the overall organization success.

In this way, the present project, which approaches the optimization of the goods reception process, arises in the procurement department of BA Glass, SA, in order to ensure sustainable development and to maintain the competitive position of the organization.

This introductory chapter presents the company, the project background, the methodology followed to implement it and the structure of the present dissertation.

1.1 BA Glass Presentation

BA Glass, SA is a national company that develops, produces and commercializes glass recipients for the food, beverage, pharmaceutical and cosmetic industries, with a 108 years history.

Founded in 1912 by Raul da Silva Barbosa and Domingos de Almeida as "Barbosa & Almeida", it was dedicated only to selling glass bottles. Later, in 1930, it started its industrial activity, in which it specialized later, with the acquisition of a manufacturing unit in Campanhã. Afterwards, in 1947, with the introduction of automatic feeding and moulding technologies, the factory that until then operated with semi-automatic technologies significantly improved its production process.

In 1969, the production in Avintes plant began, where the headquarters of BA Glass, SA group was later established. It had two regenerative furnaces that reused heat and was a pioneer in the use of this technique in comparison with traditional methods of melting raw materials at the time.

To reinforce its leading position in the glass containers industry in Portugal, to grow in the Iberian market and to internationalize, BA Glass expanded its production capacity through acquisitions and construction of manufacturing units. In 1993 the company acquires CIVE (Companhia Industrial Vidreira, SA) located in Marinha Grande. During 1998, the plant in Villafranca de los Barros, Spain, is built. In the following year Vidriera Leonesa, SA is acquired and the plant in León, Spain, is installed. In 2008 the company acquires Sotancro, in Amadora, establishing the Venda Nova plant, which allows BA Glass to expand its client list once it started to include the pharmaceutical and cosmetic sectors. The expansion beyond the Iberian peninsula begins in 2012 with the acquisition of the Polish Warta Glass group, marking the group's expansion into Eastern Europe. In 2016, HNG Global in Gardelegen, Germany, is acquired, signalling the group's expansion into Central Europe. In the next year BA Glass expands its business into Southeast Europe through the acquisition of the Greek company Yioula, composed of four plants: one in Greece, another in Romania and two in Bulgaria (BAGlass, 2020). Figure 1.1 illustrates the distribution of BA Glass group's plants throughout Europe, as well as its warehouses.

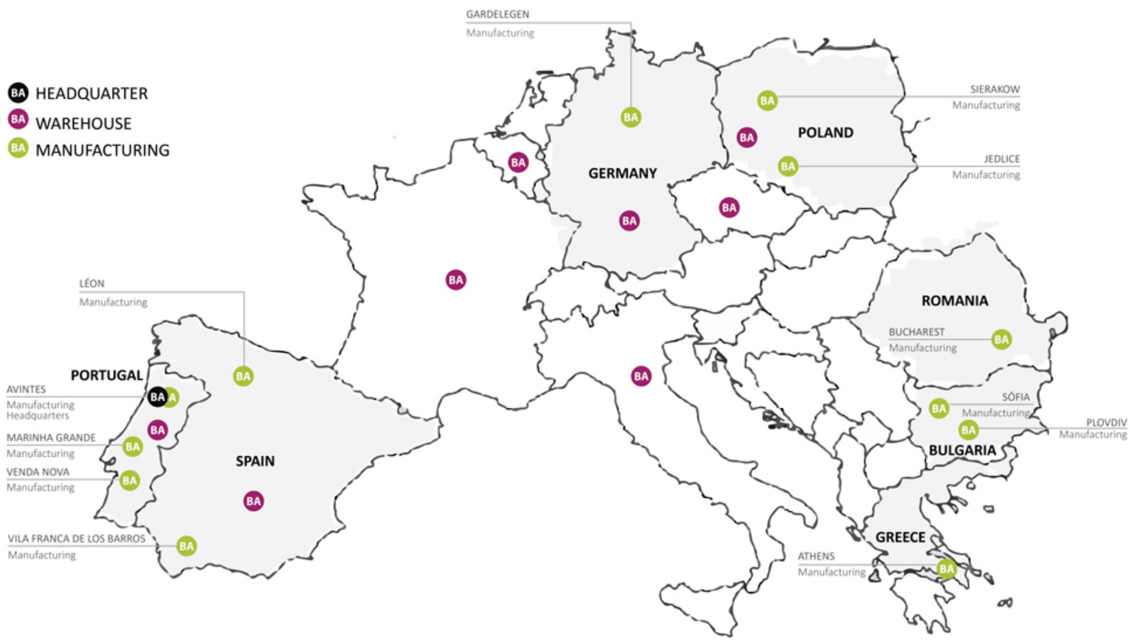


Figure 1.1: Location of BA Glass Group Plants and Warehouses (Source: BAGlass (2020))

1.2 Motivation of the Project

This project arises in a period of expansion of BA Glass Group, in which the supply chain becomes more and more complex, making crucial the continuous improvement of all organizational areas. With the increase of the number of factories and the growing internationalization of the company, a higher volume of sales is expected, which will have to be supported by a higher volume of production, which in turn will have an impact on the volume of goods to be received. As such, the goods reception process has to be in line with this growth in order to be able to receive all the goods needed for production. However, this process is still very manual, consuming unnecessary time and could lead to errors, which results in significant costs for the company. In this way, the optimization of the goods receipt process has become an object of study and special attention for the company, namely the way of entering the data into the system and also the simplification of the whole process.

This project is aimed at eliminating and filling the main weaknesses and gaps in the goods receipt process, reducing the time spent on it and consequently the costs and errors associated, in order to improve and standardize this process so that it could be implemented in the same way in the whole BA Glass Group.

1.3 Aim of the Project

The problem that the company aims to solve is related to the optimization of the goods reception processes, using Avintes plant as a pilot for tests and improvements to be implemented.

In order to ensure the improvement of these processes and their standardization, the following objectives for the project were established:

- Survey and mapping of AS-IS processes;
- Identification of the main problems and opportunities for improvement in the goods reception processes;
- Development of a TO-BE scenario with significant reduction of non-added value tasks in the process;
- Real time information in the system;
- Better data accuracy.

1.4 Methodology

Considering to the necessity to improve the company's goods receipt process, the methodology adopted in this dissertation begins by identifying the context, scope and objectives, as well as the processes with which this process is related. In this way, the current situation characteristics were identified, such as the functional areas involved and the associated systems.

Thereafter the AS-IS process is surveyed, by modeling the current flow of the process and analyzing the factors that affect its performance. The methodologies used during the process survey include observation and interaction with the process participants and measurement of the times of each task.

The following stage is the TO-BE process modeling, where possible improvement actions are studied for activities that do not add value to the process as well as for practices where some of the waste that the Lean philosophy tends to combat is identified, in order to select which of them should be adopted to improve the process performance. The main characteristics of the new process and the new model have been defined, and a flowchart has been developed for each process under analysis, in order to structure and summarize all the information crucial to the execution of the goods receipt process.

The last step concerns the contact with different suppliers, so each of them can present its solution to improve the goods reception process. In this way, it is possible to study which is the best proposal offered by them and to obtain the key characteristics previously defined at the lowest possible cost.

1.5 Dissertation Structure

The present dissertation is divided in five chapters. In this first chapter a brief presentation of the company is made, as well as a description of the proposed problem, the context and background of the project, the objectives established for it and the methodology used to solve the problem.

In the second chapter a theoretical approach of the concepts applied throughout the dissertation is presented. Firstly, aspects related to the reception of goods are reviewed, then lean thinking, namely its 5 principles, and the 7 types of *muda* as well as different lean tools useful for the project development.

The third chapter is dedicated to the description of the company's current goods receipt processes, concerning raw materials and non treated cullet. Afterwards the different problems identified in these processes are presented.

In the fourth chapter a description of the methodology adopted to approach the problem is made, and the different system components to be implemented are presented, in order to reduce the unnecessary time that exists in the whole process. Furthermore, a revision of the features of the different solutions offered by equipment suppliers are made.

The fifth chapter presents the results expected from the implementation of this project and the paybacks periods of each supplier suggestions calculation, in order to identify the most suitable one.

Lastly, the sixth chapter describes the dissertation conclusions and presents possible future work within the project.

Chapter 2

Bibliographical Review

This chapter contextualizes the main fundamentals and methodologies that will be approached in the development of this project. First of all, an overview of the reception process of goods is presented, since this is the principal focus of this project. Next, a reference to lean thinking is made, as well as the 7 *Muda*, that lean intends to fight. Finally, some lean tools that will be applied throughout this study, namely, continuous improvement, 5S methodology, standard work, value stream mapping and visual management are described.

2.1 Material Reception

According to Emmett (2011) material receipt is a set of operations aimed at verifying, in an orderly way, that the supplier has delivered the required product, in good condition, in the correct quantity, with the required quality and at the right time, and introduce this data into the system. The main activities that constitute this process are (Mulcahy, 1994):

- Schedule delivery of materials with suppliers;
- Unload the materials from the transporter vehicle;
- Confirm the product quantity;
- Check the product quality;
- Enter the product into the system;
- Transfer the product to the storage area.

Tompkins and Harmelink (2004) claim that absolute precision in the material reception is fundamental, because an error in this process will probably cause product storage in the wrong place.

Until a product has been physically unloaded, properly identified and placed in its respective location, it cannot be used. Therefore, a serious failure or break in the reception process could cause the accumulation of a substantial amount of material that is already in the company's possession but not ready for use yet. For this reason, reception performs a critical role insofar as its efficient performance conditions the quality and the entire warehouse operation.

Improving the effectiveness of this process requires teamwork between the vendor and the purchaser. Suppliers must load the vehicles in a way that facilitates the reception and the unloading by the company. So, Mulcahy (1994) says that Just In Time (JIT) strategy, new loading and unloading equipment and computers, bar codes and GPS are some developments that aim the improvement of the reception process.

2.2 Lean Thinking

Lean Thinking emerged in the Occident in the end of the 70s as an interpretation of Toyota Production System (TPS) by Taiichi Ohno. TPS's main objective is to increase productivity by continuously eliminating waste, based on the concepts of JIT and Automation (Ohno, 1988).

According to Dieste et al. (2019), Lean implementation aims to eliminate as much loss as possible from a production process, in order to use the least possible inventory, raw materials and Work In Progress (WIP). In this way it is possible to say that its major objective is to increase effectiveness and competitiveness by improving the sequencing of activities, ensuring a continuous operation of the process with minimum downtime, and also a better use of all resources.

As a result, with successive implementation of improvement actions, a company that adopts Lean philosophy will be able to get closer to the customers, improving its ability to respond to their needs (Womack and Jones, 2003).

Considering everything previously mentioned, Lean implementation is supported by the following 5 principles.

2.2.1 Specify Value

The value of the product offered is determined by the ultimate customer. In this way, a company must understand what represents value to the customers in order to focus on the waste elimination, that is, specifications that do not constitute value for them, offering a product at lower cost more efficiently (Womack and Jones, 2003).

2.2.2 Identify the Value Stream

The Value Stream is the sequence of all the actions that add the value specified to the customer. So this principle points to the concern of a company to find and eliminate the *mudas* (wastes) of the successive processes that constitute its value chain. The objective is to obtain an ideal value chain, free of *mudas*, that includes only activities that add value (Womack and Jones, 2003).

2.2.3 Flow

This principle is focused on making the value-creating steps flow in order to eliminate waiting time between machines or departments. Thus, the goal is that the product reaches the customer as soon as possible, consequently increasing his satisfaction level (Womack and Jones, 2003).

2.2.4 Pull

This principle stipulates that the company should let the customer, internal or external, since this could be any customer process within the value chain, pull the product from it instead of pushing it into the market, many times in unwanted quantities. This is characterized by the ability of supplying the customer with exactly what he wants, in the quantities and at the exact time he wants to receive it (Womack and Jones, 2003).

2.2.5 Pursue Perfection

The last principle represents the continuous improvement cycle that must be applied in the 4 previous principles, through the constant search for waste elimination. In this way, there is no end to the process of reducing time, space, costs and mistakes, which determine a better satisfaction of the customer's needs (Womack and Jones, 2003).

2.3 7 *Muda*

The application of the *muda* concept in the context of an industrial organization appeared with Taiichi Ohno at Toyota, because the Japanese had a serious disadvantage in the automotive industry compared to Europe and the United States.

Ohno presented a strategic solution to adopt in the company, which became the basis of TPS, in order to fight the mentioned disadvantage, focusing on the increase of production efficacy through the elimination of *muda*s.

Muda is any activity considered waste that consumes resources but does not create value and there are seven different categories of it (Ohno, 1988).

2.3.1 Overproduction

In accordance to Ohno (1988), overproduction means to produce earlier and in greater quantity than needed. This results in extra stock holding costs and costs associated to the production of parts that do not have demand, which could become obsolete, in detriment of a production wanted by market (Imai, 2012). In this way, unnecessary consumption of resources and raw materials, increased transport costs and energy consumption are caused.

This waste goes against the pull system and is usually related to the production of large lots, lack of confidence in suppliers, leading sometimes to higher productions lots than necessary to ensure that in the future all demand will be satisfied, and lack of confidence in the production process, planning the operations in advance in order to prevent interruptions and failures (Redeker et al., 2019).

2.3.2 Inventory

This waste is characterized by an excessive stock of raw materials, product in production or finished product, and, in most cases, this is the result of inadequate planning. It is mostly a financial problem, because of the capital needed to maintain these stocks. However, it also affects the quality of the inventory, since over time this may become deteriorated and the product may become obsolete (Imai, 2012).

In the opinion of Karlsson and Ahlstrom (1996), reducing the lots size can help reduce inventory and increase the organization's flexibility, but in this second case, the reduction of setup times becomes crucial.

According to Ohno (1988), this *muda* frequently serves to hide other problems that may exist, such as low quality, insufficient processes capacity, lack of communication, and others.

2.3.3 Defects

This *muda* is characterized by non-conforming products, that is, products that do not satisfy the quality standards. As a result, a rejection process is necessary, in which the products are sent to scrap or suffer rework. This process is marked as a waste of resources, like raw material, a multiple waste of time, once the reprocessing time and the time of each subsequent process that has been stopped are lost, and an increase in production costs.

Defects can be originated from situations such as machines failures or incorrect product design and can lead to a customer complaint (Imai, 2012).

2.3.4 Motion

Imai (2012) says that this *muda* is defined by the additional effort or displacement that a worker has to do when performing his work. It can be the result of an inadequate plant floor design, an inefficient workplace organization or the use of inappropriate tools.

2.3.5 Over-processing

Over-processing contains phases that do not add value and generates waste in obtaining products with characteristics that exceed the required.

This *muda* reflects problems that are based on an inefficient tool design and a product that contains specifications above those required to satisfy customers (Womack and Jones, 2003). It is also associated with the lack of standards and procedures to be applied in certain activities, inadequate tolerance and the wrong adjustments of the machines (Redeker et al., 2019).

2.3.6 Waiting

It corresponds to the downtime of the equipment or operators, that is, when they are unable to produce. This waiting time can be caused by lacking materials, information or tools (Ohno, 1988).

This waste is the result of an inefficient use of time, which usually involves flow problems and production excess and inventory (Redeker et al., 2019).

2.3.7 Transportation

This category of *muda* corresponds to the transport, short or long, of products between processes. Product transport does not generate value and, on the contrary, is a waste of time and increases the risk of product damage.

It can be caused by an inefficient plant floor layout characterized by excessive distance between the equipments where the subsequent processes are executed (Imai, 2012). Excessive transportation can also be related to overproduction, lack of route optimization and over-processing. This excessive transportation can cause an increase in lead times and, as a consequence, delivery failures (Redeker et al., 2019). According to Karlsson and Ahlstrom (1996) it is very difficult to eliminate 100% of the internal transport of products or components, however there are different ways to optimize it, such as changes in the plant layout and creation of circuits that ensure the efficiency of transport.

2.4 Lean Tools

2.4.1 Continuous Improvement

The existence of increasingly competitive markets forces companies to constantly improve their processes through Continuous Improvement (CI), in order to achieve a competitive advantage that allows them to distinguish from their competitors.

CI is defined as a culture of sustained improvement that focus on identifying opportunities to rationalize and standardize work, aiming at eliminating waste in all organizational systems and processes, and involving all participants in the organization, without making huge capital investments. The main objective of this ideology is to respond to the rapidly changing customer needs, desires and tastes, reducing costs and increasing quality and the service level (Singh and Singh, 2015).

Throughout the years, CI has been studied from many perspectives, which has made its approach evolve from traditional systems focused on manufacturing, centered on production lines to reduce waste and improve quality, to sophisticated methodologies that are widely used in the practice of Total Quality Management (TQM) programs nowadays, extending to the entire organization. The basic factor behind this evolution has been the ceaseless pursuit of improvement in organizations (Bhuiyan and Baghel, 2005). Haddas et al. (2014) believe that this evolution has introduced popular TQM concepts, empowering companies to develop better operational and strategic objectives, aligned with effectiveness and efficiency.

Bhuiyan and Baghel (2005) consider that in order to reap the maximum benefits from CI program, managers should implement CI at 3 different levels within the organization, namely: management, group and individual.

Despite the fact that CI has been known for decades, the failure rate is high, since two out of three CI initiatives do not produce the desired results. Although companies achieve significant improvements in the short term, the CI ultimately collapses. Weaknesses in information systems and methods of improvement, limited support and engagement from management, poor involvement, motivation and teamwork are some of the examples that can result in CI failure. In order to ensure that CI responds to the company's needs and expectations, it is necessary to hear the opinions of the different hierarchical levels, create mechanisms that build trust between them, empower workers to respond to deviations and make changes, and actively encourage, monitor and reward them for the appropriate use of CI methods (Lodgaard et al., 2016). According to Singh and Singh (2015) there are several reasons for organizations to invest in CI implementation, in particular:

- Necessity of change and remaining competitive;
- Improve the organization's work philosophy and the mentality of employees;
- Improve productivity and quality of services provided;
- Adjust stock levels and production time;
- Minimize investment in new technologies and maximize investment return;
- Reduce the impact of external factors such as competition, globalization and increase in raw material and energy costs.

Before adopting this strategy, it is fundamental to understand the current situation of existing processes, with the objective of finding opportunities for improvement. For this purpose, the processes mapping is a tool of high importance (Marriott, 2018).

2.4.2 Processes Mapping

In accordance with Marriott (2018), processes mapping, in a simple explanation, is a visual representation of the flow from one stage of a process to the next, defining with precision the person responsible, what is done, where and when it is done, for each stage of the process. This technique allows a better understanding of the processes in analysis, which in turn allows to detect opportunities to improve them. In this way, Nyemba and Mbohwa (2017) claim that process mapping allows to differentiate how a process is actually done from how it should be done.

This method consists of 3 main steps that are normally followed, the first one is the identification of the activities sequence of the process, the second one is the evaluation of the different steps to detect bottlenecks and redundancies, and the last one is the study of the best way to improve the process concerned and its flows (Nyemba and Mbohwa, 2017).

Due to the complexity of some processes, this approach should be a fundamental element for both process design and quality improvement (Marriott, 2018).

2.4.2.1 Value Stream Mapping

The lean tool for process mapping is Value Stream Mapping (VSM). This lean tool provides a schematic, visual and intuitive interpretation of the entire value chain of a certain process. It consists in a graphic and quantified representation of all the activities related to material and information flows, needed to produce a product or provide a service, from the moment of raw material arrival to the moment of delivery to the customer.

Mapping the value chain allows a macro view of the entire process and, simultaneously, an individual perspective of each operation. This allows identifying the material and information sequence and where is added value or not to the product, in order to develop improvement actions and eliminate waste. In this way, VSM is considered one of the most important tools in *muda* elimination.

Implementation of this tool consists in 4 fundamental steps. First of all it is necessary to identify the family of the products being studied, then analyze the current material and information flow for this family and build the current VSM, next it is essential to analyze it and design a future VSM with the intended improvements, and finally plan and implement these improvements. All these steps should be performed in a cyclical way in order to reduce the lead time to the customer and to try to achieve a lean value stream chain, that is, a chain free of any waste (Rother and Shook, 2003).

Thus, according to Abdulmalek and Rajgopal (2006), VSM is supported by 3 principles to characterize and understand all activities:

- **Valuable Activities** - all the steps in a process that add value to the product, that is, all the procedures for which customers are willing to pay;

- **No Valuable but Necessary Activities** - all the steps necessary to the process, but that customers are not willing to pay for. They can be considered waste and it is important, if possible, to remove them;

- **Waste** - all the actions that do not contribute to the product's value and, as a consequence, should be eliminated.

2.4.3 5S Methodology

5S is a group of defined practices to obtain and keep a clean and organized workplace, an increase in productivity and a reduction in waste. When well implemented, it provides numerous advantages in terms of organization, safety and efficiency (Imai, 2012).

It is usually the first lean tool implemented to facilitate the future application of other lean methods (Al-aomar, 2011).

The term 5S was originated in Japan and combines 5 Japanese words beginning with "S": *Seiri* (Sort), *Seiton* (Straighten), *Seiso* (Scrub), *Seiketsu* (Systematize) and *Shitsuke* (Standardize), where self-discipline (standardize) is the center of this concept, as shown in Figure 2.1.

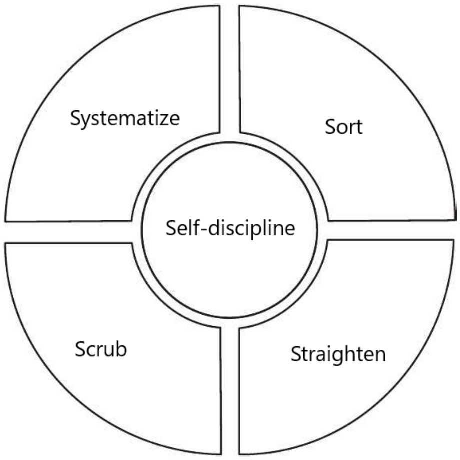


Figure 2.1: Relationship of the Five Steps of 5S (Source: Imai (2012))

2.4.3.1 *Seiri* (Sort)

The main objective of this S is the identification of unnecessary tools or materials and their elimination from the work area, keeping only the essential tools. These should be sorted according to the ones that are used more frequently and the ones that have less use (Imai, 2012).

2.4.3.2 *Seiton* (Straighten)

The basis of this S is to define a place for each item, considering its frequency and ergonomics of use. In this way, a place must be defined and identified for the essential items, in order to facilitate their use and storage, placing the most frequently used items as close as possible to the workplace, to eliminate unnecessary movements and minimize wasted time, which leads to an improvement in the efficiency of the process. This organization should be respected and supported by all in the use of the respective items (Imai, 2012).

2.4.3.3 *Seiso* (Scrub)

This S assumes that workplace, equipment and materials should be clean. It is also necessary to ensure their preservation, to facilitate the detection and prevention of anomalies, facilitating the verification of equipment performance and the execution of tasks.

The implementation of this is a starting point for improving safety at work and increasing the lifetime of tools and machines (Imai, 2012). All this because disorder, indiscipline, inefficiency, faulty production and accidents at work are the source of dust, dirt and waste. (Veres et al., 2018).

2.4.3.4 *Seiketsu* (Systematize)

This S aims to create procedures to standardize and integrate the previous 3S in the daily routines of the workers, in order to have always the same result of each activity. For this, visual aids (process documentation) should be used to create the norms of storage and cleaning (Imai, 2012), which should be communicative, clear and easy to understand (Veres et al., 2018).

This way, through these documents, the training of the operators and their involvement, it is ensured that the processes and instructions are executed according to the standards (Michalska and Szewieczek, 2007).

2.4.3.5 *Shitsuke* (Standardize)

This S has the objective of creating a discipline in all workers (self-control) in order to maintain the previous 4S and to avoid a return to old practices. For this purpose, audits of the workplaces should be made, in an early stage with greater frequency, until the preceding 4S become a daily habit (Imai, 2012).

2.4.4 Standard Work

The creation of a standard work arises as the precondition to the process of waste elimination, which is a crucial step of lean philosophy. Based on the requirements of the daily workers' operations, with the main objective of decreasing variability and inconsistency of execution, in order to have a basis from which to start the continuous improvement.

In fact, when several workers perform the same task it is probable that at least one of them will execute it differently. The elimination of variability then provides a credible and stable work base with which production can be planned, and a standard against which any improvement measures can be validated.

The norms are the reflection of the workers' requirements and should establish the most efficient method of executing a specific activity, promoting the elimination of invariability and execution inconsistency. The standards should include information about how to perform an activity in terms of movements, materials and times. The visual element in the creation of a norm is very important, since the use of images and key words facilitates the understanding and memorization of work instructions. The existence of these standards allows reducing costs, since it avoids rework due to quality defects, reduces training time for new employees and reduces work accidents.

Inherent to this methodology is the periodic audit to ensure compliance with the plan. The opportunity for operators to present possible improvements and alternatives to the process also arises here.

The work standardization serves as a comparative basis for the study of new ways to improve the process. In this way, from a continuous improvement perspective, it is assumed that there are always opportunities to generate more value. Initiatives such as the implementation of new practices can generate better results, and consequently, a new standardization is made and a new base process is defined (Liker and Meier, 2006).

According to Coimbra (2013) there are 5 essential steps for the creation of a standard work:

1. Define the process to be standardized;

2. Observe carefully and record the operator's movements and the time taken to execute the operations, and identify possible *muda* and difficulties;

3. Plan and implement improvement measures;

4. Uniform operator movements, cycle time and products in the manufacturing process and present them in visual form;

5. Consolidate and monitor implemented work standards.

Ismail et al. (2019) argue that standard work is defined by 3 distinct elements:

- **Standard Cycle Time** - time required for a station operator to complete each part, measured between the completion of two consecutive parts;

- **Standardized Work Sequence** - sequence in which the steps of each task are performed, reducing the cycle time variability;

- **Work in Progress Inventory** - minimum inventory required to sustain the production rhythm without down times.

2.4.5 Visual Management

As lack of communication is one of the main problems faced by many companies in their daily business, measures must be taken to fight it. In this way, Greif (1991) states that visual management is an important asset, since it is a powerful tool that allows to communicate more quickly and effectively within the company.

Its aim is to ensure that communication is performed in an intuitive, simple and objective way. This facilitates the identification of any failure and prevents undesirable situations, resulting like a process control. For that, signage, color codes, graphics and images that simplify the process of information sharing and interpretation are used. Imai (2012) presents some examples of the implementation of this tool, namely: the utilization of *kanbans*, floor markings and the use of light signals.

In conclusion, this tool helps in the identification and elimination of different *muda*, since it allows an easy and quick information interpretation, highlighting the discrepancies between the target and current realities, a fast response to problems and an efficient communication between all the stakeholders. This not only provides an increase in productivity for organizations, but also impacts costs, quality, delivery times and equipment reliability (Imai, 2012).

Chapter 3

Goods Reception at BA Glass

In this section, the key process of goods receipt will be described and classified in 2 different processes, reception of raw material and reception of non treated cullet. Each of these processes will be divided into 5 distinct stages. The first one is the purchase order creation process. The second is related to truck reception, with detailed description of all processes involved. The truck unloading stage is presented next. After this, the stage at which the truck leaves the factory is mentioned and finally the stage where the material data is introduced into the company's ERP is described. Some of the variants in the individual plants will also be mentioned, as the process is not entirely the same in all of them.

At the end of the chapter, the main problems identified during the entire process will be detailed with a critical analysis of them, considering the 7 types of *muda* described in lean, and the calculation of the number of daily hours that each operator spends with the whole goods receipt process will also be presented.

3.1 Planning and Production Process

Every BA Glass plant has its own production plan in order to produce all the required glass containers for the different customers. In this way, the production planning department is in permanent contact with customers, attempting also to follow the market needs, to ensure that production can satisfy all demands.

Based on all orders, a production plan is created for each BA plant, considering the type of glass container that each plant produces. For example, in Iberia plants, León and Marinha Grande factories produce white glass containers, Venda Nova plant is more targeted at spirit bottles and containers for food industry, and Villafranca de Los Barros and Avintes factories produce coloured glass containers, mainly green and amber.

The production process is divided into six distinct stages that occur throughout five zones: Composition and Fusion, Hot Zone, Cold Zone, Quality and Palletization and Finished Product Warehouse.

Stage 1 is where the raw materials are stored, and afterwards dosed and mixed in order to create the vitrified mass. The basis composition of glass containers is shown in Table 3.1. To obtain glass with the desired composition, raw materials such as sand, calcium carbonate, limestone and sodium sulfate are added, and cullet, which is glass from internal or external recycling, is also mixed.

Table 3.1: Glass Containers Composition

Element	% Total Composition
Silica (SIO_2)	70 - 72
Sodium (Na_2O)	12 - 14
Calcium (CaO)	9 - 11
Magnesium (MgO)	0 - 3
Aluminium (Al_2O_3)	1 - 2
Potassium (K_2O)	0 - 1

In stage 2 occurs the fusion of raw materials, which is processed in the furnaces, built in refractory material, at temperatures varying between 1500 and 1600ºC. Once the glass becomes liquid, it passes through a refining phase, in order to guarantee the thermal homogeneity of the whole melted mass and to obtain a quality product.

Stage 3 refers to the moulding of glass containers and is divided into two steps. In the first one, the glass is introduced into the starting mould to take the initial form, called pre-form. In the second one, the pre-form is transferred to the final mould, resulting in the product's final form.

In stage 4 the product re-firing and treatment of the surface are performed to thermally homogenize the glass mass, since during the moulding stage, the glass contacts the mould walls at relatively low temperatures, which makes the products' external surfaces much colder than the inside, so it is necessary to apply a heat treatment, the re-firing, to thermally homogenize the glass mass.

At stage 5 the products are transported to the automatic inspection machines that detect the defects in the items, eliminating the non-conforming products.

Finally, in stage 6 the glass containers are packaged at the end of the production lines, layered, on pallets and covered with plastic film, in order to protect all the products and facilitate their transportation. After packing, the pallets are transported to the finished product warehouses (Alves, 2012).

Figure 3.1 shows the production process of BA Glass factories, which includes all these stages.

3.2 Overview of the Current Goods Receipt Process

The project to develop is expected to be implemented in all BA Glass plants. Although there are some differences in the processes of the individual factories, which will be explained later, the process is practically the same in all of them. This way, only the process of Avintes plant will be described, once it is one of the factories that receives more trucks a day.

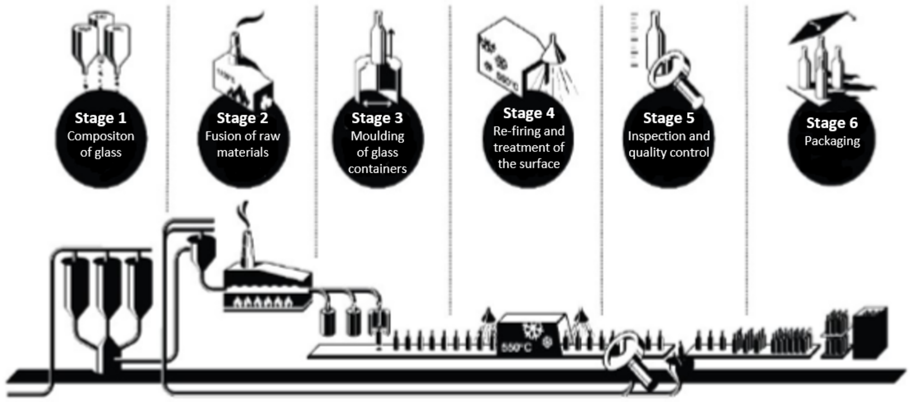


Figure 3.1: Production Process (Source: Alves (2012)) (adapted)

Between production planning and factory production process, the existence of the goods receipt process is imperative, since this process makes the connection between these two.

The material reception process is initiated in the procurement department, with the purchase order (PO) realization. The PO defines the quantities that each supplier will have to provide as well as the quantities that each transporter will have to deliver. PO is created by the central procurement replenisher and contains the delivery location, the requisition date and the list of requested products with the respective quantities. The supplier receives the PO by e-mail.

After receiving the PO, the supplier prepares the required order, with the requested products and their respective quantities. A delivery note is then issued which will accompany the goods to be transported to BA, and must contain the following information: supplier and purchaser data (company, address and tax identification number), goods description and their quantities, goods loading and unloading locations and date and time of the beginning of transport. Thus, the goods are ready to be transported and afterwards received at the plant.

When the truck arrives at gate house (GH) it is directed to the unloading place, but before heading to the respective location, the trucks have to be weighed. The material is unloaded depending on its type: raw material is unloaded in batch house (BH) and non treated cullet in BA distribution, and the goods must always be accompanied by the delivery note. Before unloading the truck, an inspection is made to the load and in case of significant non-conformities, the goods are immediately rejected. Batch house is the place where the silos that store the raw material are located and BA distribution is the designation of the plant location for unloading the non treated cullet.

Once the material is unloaded, the raw material and non treated cullet trucks are weighed again, leaving the plant afterwards. After weighing, a new record is created in the system and, based on this, the weekly delivery plan is updated by GH with the actual quantities of goods received.

At the next day, the general warehouse (GW) supervisor collects from GH all the documents related to the raw materials received in the previous day, to register them in the system, in order to update the stored quantities and signal to the financial department to account and pay the invoices issued by the suppliers. The goods are introduced manually in the system by truck and are entered into the SAP software using transaction MIGO, where the following information is entered: material arrival date, delivery note number, type of material, transport company and quantity.

The process described is shown in Figure 3.2, in which the main stages of the process are presented.

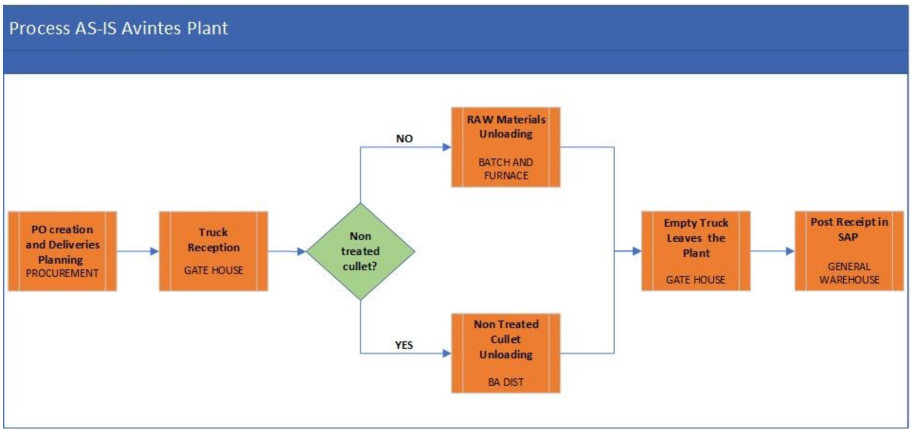


Figure 3.2: Main Stages of the Goods Reception Process

As seen in figure 3.2, the raw materials are divided into 2 distinct groups: raw materials and non treated cullet. Raw materials are all substances used in the production of glass containers, which are separated into large raw materials, used to form glass and in higher quantities, such as sand, cullet, soda and limestone, and other raw materials, that are used to refine the glass in terms of color, quality, etc., for example carbon, iron oxide and iron chromium. In this way, the suppliers of sand, soda, limestone and cullet are the most important raw material suppliers, since their products are indispensable to the glass production, and therefore their reception is daily and in large quantities. Concerning the other raw materials, their reception is less frequent, taking into account the production needs, and is realized in big bags, where each big bag contains approximately one ton. Non treated cullet concerns the cullet that does not come clean and, as such, still has to be subjected to a cleaning process before being used in the production of glass.

In the following sections each of the reception pathways for the 2 types of raw materials mentioned above will be described in detail.

3.2.1 Raw Material Receipt

The raw material receipt process is performed for all the raw material trucks that arrive to unload at the plant, and in Avintes this occurs, on average, 20 times a day.

3.2.1.1 Annual Purchase Order Creation and Deliveries Planning

For raw material, the PO is annual and all suppliers and transport companies are considered on it, defining the annual quantities that each supplier will have to provide as well as the annual quantities that each transporter will have to deliver. In this way the central procurement replenisher creates an annual PO per supplier with a correspondent line for each transport company, because for the same supplier there are different transport companies carrying out the goods transport. This is because, for some raw materials, BA is responsible for managing their transportation, not its suppliers, as is usual, and so BA can contract different transport companies for the same supplier, which is the case of soda, for example, where there are two different transport companies for the same supplier, as shown in the weekly plan of Figure 3.3.

This PO is created considering the needs of the plant's production in previous years, since the productions are very similar from year to year and, as such, the proportions of raw material required too. However, the quantity of cullet available causes the necessary quantities of the remaining raw materials to vary, the more cullet there is available, the less of the other raw materials will be needed.

On a weekly basis the central procurement replenisher creates a delivery plan, shown in Figure 3.3, in which the number of deliveries that will be received each day is entered, indicating the quantity that corresponds to each supplier and transport company, and sends it to the batch house supervisor and to gate house, for them to know what they will receive and when.

PROGRAMAÇÃO SEMANAL DE ENTREGAS

AVINTES

DIRECÇÃO DE LOGISTICA

Período: 06/04 a 10/04/2 SEMANA_ 15
Data: 02/04/2019

Quantidade em Toneladas

Produto	Código	Fornecedor	Pedido	Transportador	seg 06/04/20			ter 07/04/20			qua 08/04/20			qui 09/04/20			sex 10/04/20			sáb 11/04/20			Desvio		
					Prev	Ent	Dif	Prev	Ent	Dif	Prev	Ent	Dif	Prev	Ent	Dif	Prev	Ent	Dif	Prev	Ent	Dif	Ent	Dif	%
AREIA AMARELA	4130151	IMOSA - 35 ton	695179	PP (38t)	140		-140	105		-105	70		-70	70		-70	105		-105			0	0	-490	490
		ABRANFINAS	695180	Santos & Loureiro (35t)	210		-210	70		-70	105		-105	105		-105	105		-105			0	0	-595	595
				Completo FARIA (35t)	35		-35	35		-35			0			0			0			0	0	-70	70
					385			210			175			175			210						0	-665	665
CALCARIO	4107050	PARAPEDRA 30	695181	PP	30		-30	30		-30	30		-30	30		-30	30		-30			0	0	-150	150
		EUROCALCIO	695183	Transpataiense	30		-30	30		-30	30		-30	30		-30	30		-30			0	0	-150	150
CARBONATO DE SÓDIO	4107051	SAISA	695182	Transpataiense (29t)	58		-58	29		-29	29		-29	29		-29	29		-29			0	0	-174	174
				NHTRANS	27		-27	27		-27	27		-27	27		-27	27		-27			0	0	-135	135
					85		-85	56		-56	56		-56	56		-56	56		-56				0	309	309
ESCORIAS	4107061	CALUMITE	695184	Arniella			0			0			0	25		-25			0			0	0	-25	25
SULFATO DE SÓDIO	4107058	SAPEC	695253	Sapec 100%			0			0			0			0			0			0	0	0	0

Figure 3.3: Weekly Delivery Plan

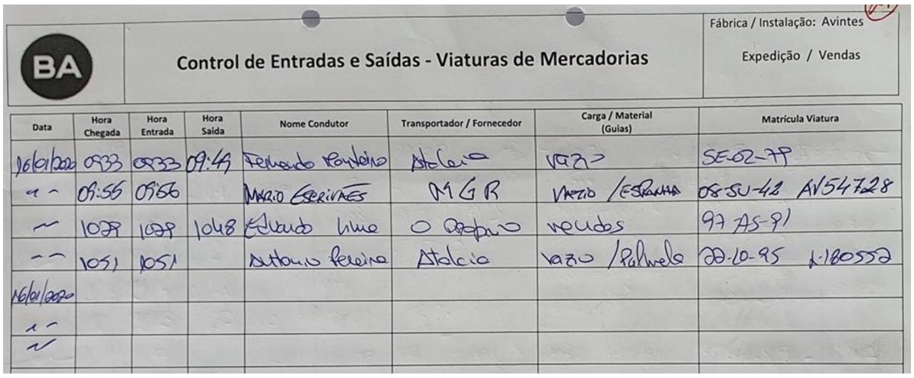
It should be noted that, in general, there are no deliveries during the weekend, so on Fridays and Mondays, the quantities to be received are normally greater than on the other weekdays. This weekly delivery plan is made according to the plant's production planning and the quantities received are subtracted from the annual quantities in the PO.

Besides receiving the PO, the supplier and the transport company also receive each week a plan of the deliveries that must be made in that week.

3.2.1.2 Truck Reception

When the truck arrives to gate house the appropriate register is made by hand on the BA internal sheet as shown in Figure 3.4. As can be seen, the arrival and entry times could be different. This is because often trucks have to wait at the entrance, since there is already another truck being weighed and therefore it is impossible to allow the entrance of another truck, as only one scale exists. So, in order not to disturb and to make movement in the plant easier, the truck waits at the entrance until it is allowed to enter.

The first thing to do after filling in the entry control form, is to inform the batch house operator, for him to authorize the truck's entry.



BA

Control de Entradas e Saídas - Viaturas de Mercadorias

Fábrica / Instalação: Avintes

Expedição / Vendas

Data	Hora Chegada	Hora Entrada	Hora Saída	Nome Condutor	Transportador / Fornecedor	Carga / Material (Guias)	Matrícula Viatura
16/01/2020	0933	0933	09:49	Fernando [illegible]	[illegible]	vazio	SE-02-79
〃	09:56	09:56		MARIO ESCRIVÃES	MGR	VAZIO / ESPANHA	08-SU-42 AV54728
〃	1029	1029	1048	Eduardo Lima	O [illegible]	[illegible]	97-AS-91
〃	1051	1051		António Ferreira	Atalcia	vazio / Palmela	20-10-95 L-180552
16/01/2020							
〃							
〃							

Figure 3.4: Entry and Exit Control - Goods Vehicles, where the date, the arrival, entry and departure times, the name, the transport company and supplier, the material, and the vehicle license plate are registered

If the entry is authorized a ticket is given to the truck driver, according to the material to be unloaded, as the example of a ticket for soda in the Figure 3.5. If the unloading is denied, the batch house operator will inform the driver how to proceed at the moment.

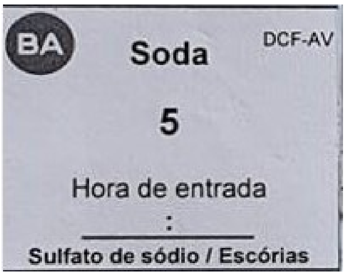


Figure 3.5: Ticket Example for Soda

After that, the full truck is weighed on the scale and a record is taken in the scale program, represented in the Figure 3.6, with the weighing value and the following information is filled in: vehicle license plate, transport company, supplier and code of the raw material (RM) that is being weighed, in this case the cullet.

Once all the information is recorded, the traffic light turns green and the truck driver goes to the material unloading place.

All this process takes approximately 5min per truck to execute.

3.2.1.3 Unloading

The truck goes to batch house and the following documents and information are collected: delivery note, CMR (international document on the cross-border land transport of goods, where the adjudication and processing of orders, responsibility for delay and the loss or damage of the goods transported are regulated), washing certificate (only for slag, sodium sulfate or other raw materials), analysis certificate with the humidity percentage and the stamp of the company that analysed the raw material and the date when the analysis was made, supplier weight (to compare with BA weight and check if there is much difference between them), and truck data, like vehicle license plate and transport company.

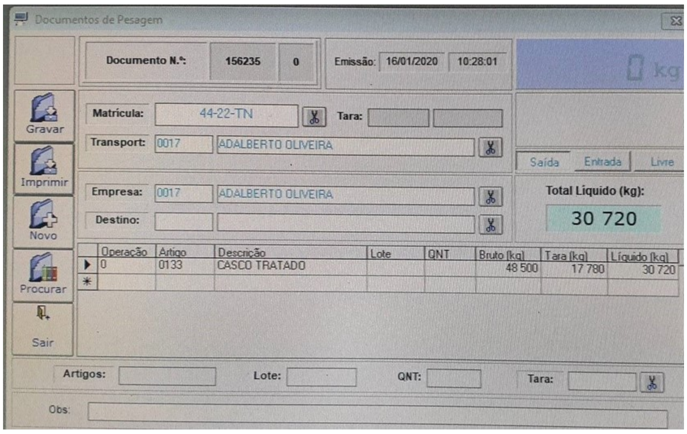


Figure 3.6: Scale Program Monitor

After that, a humidity analysis is made by a BH operator on a 5g sample of RM. If the RM humidity is within the intervals stipulated by BA, the RM is unloaded in the emptiest silo assigned to the particular RM. The maximum acceptable humidity to sand is 4,5% and to soda 0,5%, for values above these a new analysis is made on the same sample or on a sample from another part of the truck. If the new analysis still gives non conforming values, the operator calls the BH supervisor, who decides whether or not to reject the load.

After unloading the truck, the BH operator enters manually in the BH system all the data presented in the documents and gives the batch number to the truck driver to pass this information to GH, for those to record this information, in order to confirm on the following day that the data entered by BH and GH are in accordance.

The unloading of other raw materials is done by general warehouse supervisor and, after this, it is necessary to confirm that the quantity and quality are the same presented in the accompanying document. If it does not conform to the order, a complaint is made to the supplier.

Since the unloading is done by the truck driver, the BH operator spends 7min on this process. However, the truck unloading takes approximately 10min.

3.2.1.4 Empty Truck Leaves the Plant

After unloading, the truck is weighed on the scale again, but this time it is empty. During that time, the truck driver leaves the truck to deliver the documents that came from BH to GH and a weighing coupon is printed twice, one for the truck driver and other for BA. The documentation is separated, stamped and signed, handing the originals to the general warehouse and the rest to the truck driver. In this way the truck driver is allowed to leave the plant.

Thereafter the weekly plan of deliveries is updated by GH, according to the scale data, that is, with the BA weight, and it is shared with the central replenisher and the BH supervisor.

Every morning, GH sends a file to BH with all raw material trucks received on the previous day to compare with the data that BH operator filled in, to see if they are in accordance.

All this process takes approximately 3min per truck to execute.

3.2.1.5 Data Transfer to ERP

General warehouse supervisor collects daily the documents from gate house, that is, the previous day's documents, to enter all the raw material arrived on the day before into the enterprise resource planning (ERP) used in BA, which is SAP. These entries are all issued truck by truck.

With the PO number, general warehouse supervisor using the SAP transaction MIGO inserts the information bellow: arrival date, delivery note number, raw material, transport company and weight (for limestone the BA weight prevails and for the remaining raw materials the supplier weight prevails). Although the weekly delivery plan is updated with BA weight, the same does not occur with the weight that is entered into the system, since BA has agreements with the suppliers and, in the majority of cases, the supplier weight is entered into the system, in order to avoid problems with invoicing afterwards. However, this is one of the issues that this project intends to change, aiming to begin to enter into the system with BA weight at all times. Figure 3.7 presents the interface of MIGO transaction.

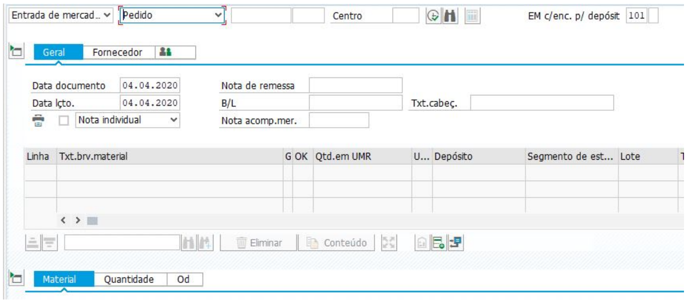


Figure 3.7: SAP Transaction MIGO Interface

General warehouse supervisor spends about 1min per truck to execute this process.

In Figure 3.8, the flowchart of this entire process is represented, where the green cells represent the main activities of the process and the red cells represent the activities where time is most wasted.

Although from a Japanese perspective none of the activities of the raw material reception process add value for the customer, they are essential for the production of the final product. Because of this, VSM of this process is presented in Appendix A, where value-added time (VA) and non-value added time (NVA) are classified in each of these activities in order to demonstrate the value that each of them added to the process itself and not to the final product. In this way, it can be observed that of the 26min that the process requires, 1,5min are non-value added time. In addition it can also be noted that the average lead time of the process is 35min. In this diagram it is also possible to see the cycle time of each stage as well as the number of operators required by each one.

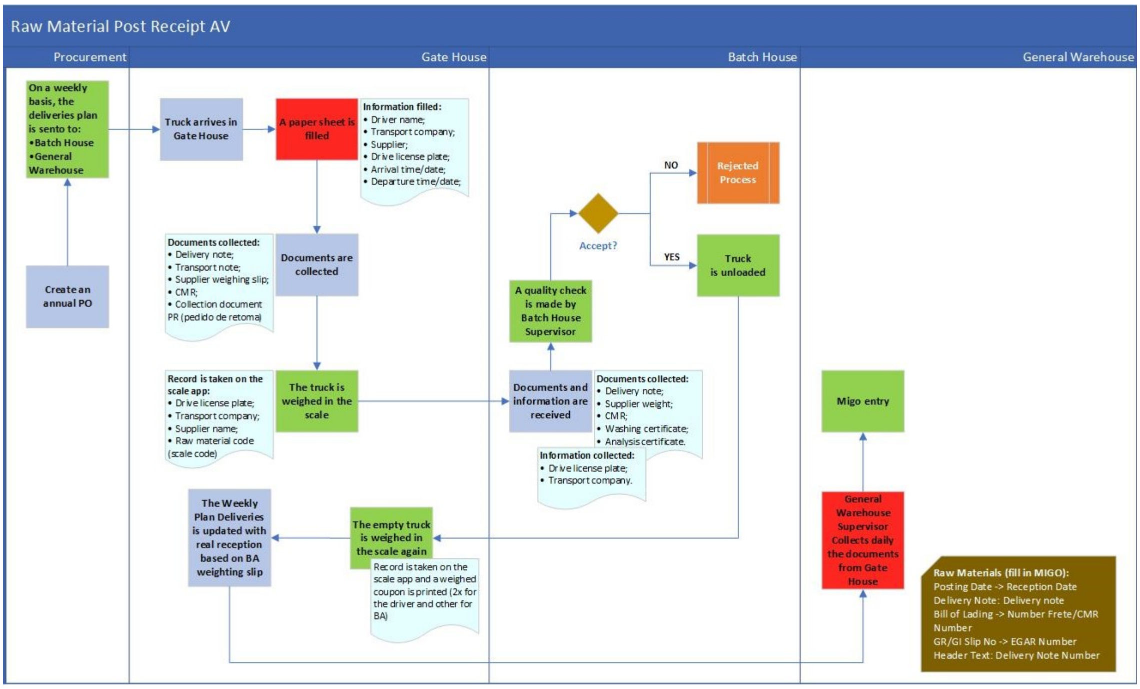


Figure 3.8: Raw Material Reception Process Flowchart

3.2.2 Non Treated Cullet Receipt

The non treated cullet receipt process is executed for all the non treated cullet trucks that arrive at the plant to unload, this occurs, on average, 50 times a day in Avintes.

The number of cullet reception is much higher compared to raw materials because, of the five plants in Iberia, only Avintes and Villafranca de Los Barros do cullet treatment, where after treated, a part is sent to the remaining plants. Furthermore, the cullet is the most important raw material for glass production as it is 100% recycled, leading to a significant reduction in energy and emissions costs. In this way, this material represents 50% to 70% of the raw material used in glass production.

3.2.2.1 Purchase Order Creation and Deliveries Planning

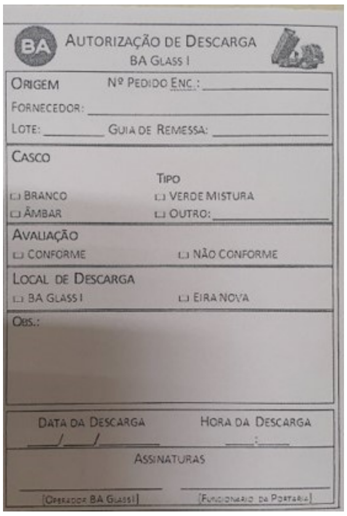
For cullet, the PO is created taking into account the production needs and the cullet which is generated in the plant by the production of defective glass containers, that is, the more defective products are produced more cullet will be generated, so the necessity to buy cullet reduces.

Each week the central procurement replenisher creates a delivery plan, in which the number of deliveries that will be received each day is entered, indicating the respective quantities and sends this plan to each one of the its suppliers and to the gate house.

3.2.2.2 Truck Reception

For each cullet truck that arrives at gate house, after filling in the entry control form (Figure 3.4), the documentation of the cullet to be unloaded is collected and it is checked if all the necessary documentation is available. The documents collected are the following: transport note, CMR, supplier weighing slip, eGAR document (legally mandatory note to be attached to the residues, therefore, as the cullet is scrap it is obligatory to have this document accompanying its transport in any case) and collection document.

If all documentation is present, an unloading authorization form is filled in by hand with the PO number, the supplier name, the delivery note number, the batch, the date and the signature, as shown in Figure 3.9.


BA AUTORIZAÇÃO DE DESCARGA
BA GLASS I

ORIGEM Nº PEDIDO ENC.: ______
FORNECEDOR: ______
LOTE: ______ GUIA DE REMESSA: ______

CASCO
TIPO
☐ BRANCO ☐ VERDE MISTURA
☐ ÂMBAR ☐ OUTRO: ______

AVALIAÇÃO
☐ CONFORME ☐ NÃO CONFORME

LOCAL DE DESCARGA
☐ BA GLASS I ☐ EIRA NOVA

OBS.:

DATA DA DESCARGA ___/___/______ HORA DA DESCARGA ___:___

ASSINATURAS
[OPERADOR BA GLASS I] [FUNCIONÁRIO DA PORTARIA]

Figure 3.9: Unloading Authorization Form

After that, the full truck is weighed on the scale and a record is taken in the scale program, with the weighing value and the information mentioned in the raw material reception process.

Once all the information is recorded, the traffic light turns green and the truck driver goes to the material unloading place.

All this process takes approximately 6min per truck to execute.

3.2.2.3 Unloading

The truck goes to BA distribution to be unloaded, but before a visual control is made to the cullet. In that control, if the cullet appears to have a lot of garbage, the delivery is rejected. If the cullet looks good, the operator authorises its unloading.

Since the unloading is done by the truck driver, the BA Distribution operator spends only 3min on this process. However, the truck unloading takes approximately 8min.

3.2.2.4 Empty Truck Leaves the Plant

After unloading, the empty truck is weighed on the scale again. During that time, the truck driver leaves the truck to deliver the unloading authorization form, previously signed by a BA operator and a GH employee, to GH and a weighing coupon is printed twice, one for the truck driver and other for BA. The documentation is recorded by hand in an internal system, Record of Cullet

Batches Received (Figure 3.10), then it is separated, stamped and signed, handing the originals to the general warehouse and the rest to the truck driver. In this way the truck driver is allowed to leave the plant.

Registo de Lotes de Casco Recepcionados 2020-01-15

Lote Nº	Guia de remessa	Hora Ent. hh:mm	Hora Saida hh:mm	Fornecedor	Cor	Insp. visual	Decisão	Responsável	Matricula	Quantidade kg	Observações
438	2005000028	09:21	00:00	VALORSUL	Verde	C	A	Anibal			03-TS-32
439	327033AL	09:23	00:00	ECOVIDRIO	Verde	C	A	Anibal	50-SZ-47		
440	2836131	09:23	00:00	LIPOR	Verde	C	A	Anibal	15-PM-25		
441	20610	09:29	00:00	ECOVIDRIO	Verde	C	A	Anibal			93-XR-12
442	2004000166	10:13	00:00	VALORSUL	Verde	C	A	Marlene	70-QU-12		
443	156	10:14	00:00	RESINORTE	Verde	C	A	Marlene			03-TS-26
444	2004000147	10:42	00:00	VALORSUL	Verde	C	A	Marlene	83-OX-98		
445	60200000188	10:42	00:00		Verde	C	A	Marlene	72-MI-34		BLUEOTTER
446	157149	10:43	00:00	SULDOURO	Verde	C	A	Marlene	79-CN-86		
447	327065AL	10:53	00:00	ECOVIDRIO	Verde	C	A	Marlene			5173 LCJ
448	7	11:10	00:00	GRAN CRUZ	Verde	C	A	Marlene	81-65-RI		
449	2836218	11:19	00:00	LIPOR	Verde	C	A	Marlene			72-XR-37
450	327150AL	11:43	00:00	ECOVIDRIO	Verde	C	A	Anibal			9777 JXF
451	510	11:43	00:00	ECOVIDRIO	Verde	C	A	Anibal			3647 LDT
452	157	11:44	00:00	RESINORTE	Verde	C	A	Anibal			90-XR-10
453	369	11:51	00:00	VALORMINHO	Verde	C	A	Anibal	59-RH-44		
454	157179	12:04	00:00	SULDOURO	Verde	C	A	Marlene	79-CN-85		
455	159	13:47	00:00	RESINORTE	Verde	C	A	Anibal			72-XR-37

Figure 3.10: Record of Cullet Batches Received

The weekly plan of deliveries is updated by gate house, according to the real receptions, that is, with the BA weight.

All this process takes approximately 4min per truck to execute.

3.2.2.5 Data Transfer to ERP

General warehouse supervisor collects daily the documents from gate house, that is, the previous day's documents, to enter all the cullet arrived on the day before into the system. In Avintes plant these entries are all issued truck by truck.

For non treated cullet entry it is necessary to close the eGAR documents, for this the GW supervisor needs to access the SILiAmb Site, put the respective cullet code and confirm all data. If all information is correct it is only necessary validate it, if not, the GW supervisor must correct the information and then validate it. Normally, it is necessary to correct the information to consider BA weights and not the suppliers declared weights, because, typically, they do not have scale and then they fill in incorrect values. SILiAmb is the ERP of the governmental repository of all disposed waste and the interface of this website is presented in Figure 3.11.

Figure 3.11: SILiAmb Website Interface

After that, the excel file "Cullet Recovery", that is presented in Figure 3.12, is filled. The waste accompanying document applicable is the eGAR document for Portuguese cullet and the delivery note for Spanish cullet, because cullet from Spain does not have an eGAR document. In this cases, the general warehouse supervisor only needs to sign the "Annex7" file to validate that the cullet was received.

BA Retoma de Casco/Cullet Recovery Ano/Year: 2020 Fábrica/Plant AV Total 37300,699

	Valorização de Casco/ Cullet Recovery					Produtor Resíduo/Waste Producer			Transportador/Transporter					
	Data/Date	Código LER/ European Waste List (EWL)	Documento de acompanhamento de resíduos aplicável/Applicable waste accompanying document	Quantidade/ Quantity (ton)	Tipo Operação/ Operation Type	NIF/VATIN	Nº SIRAPA (Only for Portugal)	Designação Social/ Social Designation	NIF/ VATIN	Designação/Designation	Entidades Gestoras*/ Management Entities*	País de Origem/ Country of origin	Data de saída/Departure date	Matrícula/ Licence Plate
64	28-02-2020	150107	329581	80,00	R12	[illegible]	0	SULDOURO	[illegible]	SULDOURO	SPV	Portugal	28-02-2020	
65	28-02-2020	150107	330482	25,36	R12	[illegible]	0	TRATOLIXO	[illegible]	TRANSPATAIENSE	SPV	Portugal	28-02-2020	
66	28-02-2020	150107	332780	32,62	R12	[illegible]	0	VALORMINHO	[illegible]	SANTOS & LOUREIRO	SPV	Portugal	28-02-2020	
67	28-02-2020	191205	226918	28,16	R12	[illegible]	0	VALORSUL	[illegible]	TRANSPATAIENSE	SPV	Portugal	28-02-2020	
68	28-02-2020	191205	330386	28,90	R12	[illegible]	0	VALORSUL	[illegible]	TRANSPATAIENSE	SPV	Portugal	28-02-2020	
69	28-02-2020	191205	342891	25,38	R12	[illegible]	0	VALORSUL	[illegible]	SANTOS & LOUREIRO	SPV	Portugal	28-02-2020	
70	28-02-2020	191205	342373	27,82	R12	[illegible]	0	VALORSUL	[illegible]	SANTOS & LOUREIRO	SPV	Portugal	28-02-2020	
71	28-02-2020	191205	343089	28,58	R12	[illegible]	0	VALORSUL	[illegible]	SANTOS & LOUREIRO	SPV	Portugal	28-02-2020	
72	28-02-2020	191205	343491	27,54	R12	[illegible]	0	VALORSUL	[illegible]	SANTOS & LOUREIRO	SPV	Portugal	28-02-2020	
73	28-02-2020	191205	343935	27,14	R12	[illegible]	0	VALORSUL	[illegible]	SANTOS & LOUREIRO	SPV	Portugal	28-02-2020	
74	28-02-2020	150107	328704	40,00	[illegible]	[illegible]	AFA00037083	RRI - RECOLHA RESIDU	[illegible]	COLHA RESIDUOS INDUSTR	Sucateiros/Scrapers	Portugal	28-02-2020	
75	28-02-2020	200102	225402	26,34	R12	[illegible]	0	SOGAMA	[illegible]	GABEIRAS MARTINEZ	Ecovidrio	Espanha	28-02-2020	R8110BDC/5173 JLC
76	28-02-2020	200102	17346	27,56	R12	[illegible]	0	ECOVIDRIO	[illegible]	TRANSPORTES MATOS	Ecovidrio	Espanha	28-02-2020	L-173427/10-SA-98
77	28-02-2020	200102	232	27,12	R12	[illegible]	0	ECOVIDRIO	[illegible]	TRANS AIOS	Ecovidrio	Espanha	28-02-2020	R 7684 BCP / 2046 HKY
78	28-02-2020	200102	23859	25,14	R12	[illegible]	0	ECOVIDRIO	[illegible]	TRANSPORTES MATOS	Ecovidrio	Espanha	28-02-2020	L-201067 / 50-SZ-47
79	28-02-2020	200102	20091	26,96	R12	[illegible]	0	ECOVIDRIO	[illegible]	GABEIRAS MARTINEZ	Ecovidrio	Espanha	28-02-2020	R 3487 BBJ / 7027 JXL
80	28-02-2020	200102	23758	26,22	R12	[illegible]	0	ECOVIDRIO	[illegible]	GABEIRAS MARTINEZ	Ecovidrio	Espanha	28-02-2020	C 03151 R/ 9777 JXF
81	28-02-2020	200102	33	26,28	R12	[illegible]	0	ECOVIDRIO	[illegible]	TR Y CANTERIA ANTONIO	Ecovidrio	Espanha	28-02-2020	1961 HRG
82	28-02-2020	200102	20839	28,00	R12	[illegible]	0	ECOVIDRIO	[illegible]	GABEIRAS MARTINEZ	Ecovidrio	Espanha	28-02-2020	R 9002 BBK/9809 JXF
83	28-02-2020	200102	9828	26,48	R12	[illegible]	0	ECOVIDRIO	[illegible]	GABEIRAS MARTINEZ	Ecovidrio	Espanha	28-02-2020	R 3487 BBJ / 7027 JXL

Figure 3.12: Excel File "Cullet Recovery"

Finally, after all this, the cullet is introduced in the system. For all this process the GW supervisor takes approximately 3min per truck.

For cullet arriving by boat at Leixões, before entering in ERP, it is necessary to search for the excel file with the respective boat name, then put the date of arrival and confirm the net weight of the different containers, because the entry of one cullet boat is made by joining several truck loads, since it comes to Leixões and then it is necessary to transfer it to Avintes. In this process the GW supervisor spends approximately 5min, depending on the number of loads that arrived in the previous day.

In Figure 3.13, the flowchart of this entire process is represented, where the green cells represent the main activities of the process and the red cells represent the activities where time is most wasted.

For the same reason as mentioned in the description of the previous process, the VSM of the non treated cullet reception process is presented in Appendix B, where value-added time (VA) and non-value added time (NVA) are classified in each of these activities in order to demonstrate the value that each of them added to the process itself and not to the final product. In this way, it can be observed that of the 24min that the process requires, 4,5min are non-value added time. In addition it can also be noted that the average lead time of the process is 35min. In this diagram it is also possible to see the cycle time of each stage as well as the number of operators required by each one.

Appendix C shows the layout of the Avintes plant, where the routes of both processes are highlighted. The blue one represents the pathway of the raw material reception process and the green one the pathway of the non treated cullet reception process.

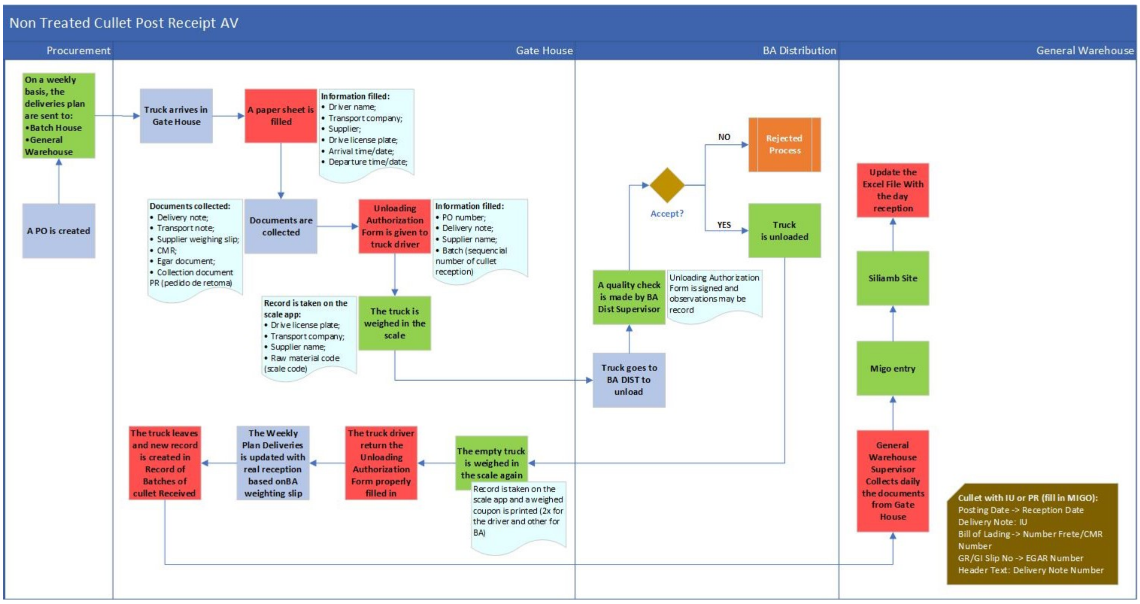


Figure 3.13: Non Treated Cullet Reception Process Flowchart

3.2.3 Process Variants in the Different Plants

Although the process is very similar in all BA plants, there are some particularities in some of them:

- Some plants do not register the raw material in the system on a daily basis, only on a weekly basis, as in Villafranca de los Barros and Venda Nova, or on a monthly basis, as in León;
- Some plants receive raw material by train, so in addition to the truck scale, there is also one for train wagons, as in the Plovdiv plant;
- In some plants, like Villafranca de Los Barros and Venda Nova, the truck weighing operation is performed in batch house and not in gate house;
- Regarding Iberia plants, only Avintes and Villafranca de Los Barros plants treat cullet, so in the remaining plants the process of non treated cullet does not exist.

3.3 Problem Identification

After an overview of the process of goods receipt and a more in-deph study of each constituent phase, it is possible to ascertain that there are several problems throughout this process, considering the seven types of *muda* described in lean.

- **Inventory** - As the general warehouse supervisor has to introduce all materials into the system manually and since this occupies most of his working time, he does not have time to inventory the material in stock. This could lead to obsolete material in the warehouse, since he cannot confirm whether the material in stock is the same as the system states it exists and if there is any material that no longer makes sense to have in stock. These obsolete parts are equivalent to money stopped and depreciated, since they could degrade over time;

- **Defects** - As all information is entered and filled in manually, for reasons such as distraction or incorrect transcription of information, incorrect data can be entered when filling in the files or when entering the goods, resulting in defects in the recorded information. This is quite serious, since it can cause complaints from suppliers, because the bills may remain pending due to the fact that the data is not in accordance with what was introduced in the system and, as a consequence, the supplier does not receive the money;
- **Motion** - Time that general warehouse supervisor spends every day in going to gate house to pick up the documents of the materials received on the previous day, in order to register them in the system;
- **Over-processing** - Since the same information is recorded several times and in different files there is an unnecessary repetition of information. This can be corroborated with Table 3.2, where the data collected in each step is shown, and with Table 3.3, where the number of times each information is collected is presented and whether it is relevant to the process or not. The fact that everything has to be filled in by hand is also a problem of over-processing of the process, since it leads to unnecessary consumption of human resources, which in turn leads to an increase in human resources costs. Therefore, time is also wasted when an operator has to search for errors caused by manual transcription of information and when gate house has to explain to the drivers how the trucks enter into the plant works and the procedures necessary to unload the material, which causes a waste of about 2min;

Table 3.2: Data Collected at Stages

	Data Collected
Truck Reception	Entry Control: date; arrival, entry and departure times; name; transport company and supplier; material; vehicle license plate Scale System: vehicle license plate; transport company; supplier; weight; material Unloading Authorization: PO; supplier; batch; delivery note; cullet type; cullet evaluation; unloading place; unloading date and time (for non treated cullet only) Documents: CMR; supplier weighing slip; eGAR document; collection document
Truck Unloading	Raw material: delivery note; CMR; washing certificate; analysis certificate; supplier weight; vehicle license plate; transport company
Truck Leaves the Plant	Raw material: coupon with BA weight; batch; delivery note; CMR Non treated cullet: unloading authorization; coupon with BA weight; delivery note; entry time; supplier; cullet colour; cullet inspection; BA operator; vehicle license plate
Data Transfer to ERP	-

Table 3.3: Number of Times Each Information is Collected Throughout the Process

Data	Raw Material	Non Treated Cullet	Important?
Date	1	2	Yes
Arrival Time	1	1	Yes
Entry Time	1	2	No
Departure Time	1	1	Yes
Driver Name	1	1	No
Transport Company	3	1	Yes
Supplier	2	3	Yes
Material Type	2	2	Yes
Vehicle License Plate	3	2	Yes
Weight	1	1	Yes
PO	1	1	Yes
Batch	1	1	Yes
Delivery Note	2	2	Yes
Material Evaluation	——	2	Yes
Unloading Place	——	1	Yes
Unloading Time	——	1	No
CMR	2	1	Yes
Supplier Weight	1	1	No
EGAR Document	——	1	Yes
Collection Document	——	1	Yes
Washing Certificate	1	———	Yes
Analysis Certificate	1	———	Yes
Coupon with BA Weight	2	2	No
Material Colour	——	1	No
BA Operator	——	1	No

- **Waiting** - As the deliveries have only the delivery day scheduled and not a specific time or interval, there are some hours of the day when the influx of trucks is high, making the operation slower and also causing the crowding of trucks outside the plant. This crowding mainly happens at the plant entrance, however, sometimes there are 1 or 2 trucks waiting to weigh/unload the material. The waiting times for these different situations are present in Table 3.4, where it is also possible to visualize the cycle time of each stage of the process, being important to mention that the cycle time refers to the time that is spent by the operators in each stage and not the time that the stage takes itself. All these waiting time significantly influences the efficiency of the second stage of the process (truck reception) as well as the cycle times of the several stages;

- **Transportation** - Internal transport necessary to move the materials, such as big bags, from the general warehouse to the factory. This would not happen if this material was unloaded in the respective user area.

Table 3.4: Cycle and Waiting Times of Stages

	Cycle Time	Waiting Time
Truck Reception	Raw material: 5min Non treated cullet: 6min	Usually between 5/7min, but can reach 20/30min if the plant is full
Truck Unloading	Raw material: 7min Non treated cullet: 3min	Usually between 10/15min
Truck Leaves the Plant	Raw material: 3min Non treated cullet: 3min	Usually about 5min
Data Transfer to ERP	Raw material: 1min Non treated cullet: 3min	———

3.4 Full Time Equivalent Calculation

Since the operators involved in each stage are not only responsible for the tasks relating to the receipt of raw materials, it is necessary to calculate their involvement in the process. For that, it is necessary to calculate the Full Time Equivalent (FTE) of this process for all the parts involved, in order to understand the percentage of workload that is occupied by this process in each place and also to know if the current number of operators is adequate to the needs.

An FTE is the number of hours worked by a full-time employee. Generally, this concept is used to convert the hours worked by several part-time employees into hours worked by full-time employees. However, the concept is also useful to compare the levels of employee involvement between the stages of a process, as a part of an analysis of the process (Bragg, 2019). This last description is the main use of FTEs in this project.

Considering the total hours required at each point of the process represented in Figure 3.14 and knowing that the number of full time working hours is 8, it is possible to state that:

- The GH FTE is 1,375, which means that, for an operator, the daily wotking time would not allow to do everything, since it would represent 137,50% of that time. This way it is possible to affirm that 2 operators are necessary in GH to execute all the tasks related to the reception of raw materials, and this is exactly what happens in Avintes plant. So, considering now that the total working time in GH is 16 hours, since there are two operators working at the same time, it is feasible to claim that 68,75% of their time is occupied with the reception of raw materials;

- The BH FTE is 0,2917, which means that 29,17% of BH operator working time is spent in the reception of raw materials;

- The BA distribution FTE is 0,3125, which means that 31,25% of BA Distribution operator time is spent in the reception of raw materials;

- The GW FTE is 0,3542, which means that 35,42% of GW supervisor time is spent in the reception of raw materials.

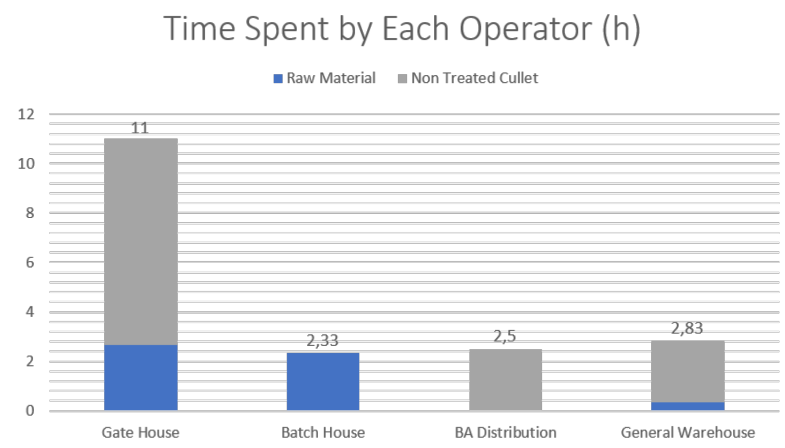


Figure 3.14: Time Spent by Each Operator

In this way, it can be claimed that the main overloaded by the raw materials receipt process are the GH operators, since they occupy more than 50% of their time with this process. The remaining operators have only an occupation of approximately 30% with this entire process.

It should also be pointed out that part of FTEs calculated are non-value added time. In GH this value is 0,4271FTE, which is equivalent to 3,42h, and in GW it is 0,1042FTE, which is equivalent to 50min.

Furthermore, it can also be verified by the graph in Figure 3.14 that the total number of hours used in the raw materials reception process is 18,66, which means that more than 2 FTEs have to be spent in this process, more specifically, 2,3325FTE. Thus it can be stated that the ideal number of operators in this process is 3, if it is possible that the operators also perform tasks not related to their respective place. Since 5 operators are currently associated with this process, it can also be claimed that this is not happening.

Chapter 4

Design of Improvements

This chapter presents the methodology followed throughout the development of this project, that is, the elements necessary for the implementation of a system that aims to improve the main opportunities identified for this in the goods receipt process. Each element is briefly described in order to understand the impacts and advantages of each one of them to help improve the current raw material reception process. After definition of the future system, an analysis of the equipment and software solutions of different suppliers is made to identify which better fits to the desired solution.

4.1 Project to Be Implemented

As mentioned in the previous section, the main problem with the goods receipt process is that all the information is entered manually, since this cannot only result in erroneous data entered, but also requires a lot of daily time for some of the process operators, namely the gate house operators and the general warehouse supervisor. So, in order to solve or reduce these issues, possible solutions that could be implemented were studied.

These solutions involve changing the process to be more automatic, in order to reduce the cycle time of the whole process and to save human resources, which can then occupy their time in other important activities of their work. Considering this, the project to be implemented is structured as follows:

4.1.1 Code Reader at the Plant Entrance

The scanner will read a code (bar code, QR code, etc.) that each truck driver will bring with him, either on paper or on mobile phone. This code will have the information about supplier, transport company and material, as well as the PO of the respective delivery. It will be generated by BA Glass and therefore sent to the supplier by the company. The remaining information, such as delivery note number, CMR number, supplier weight, EGAR document number (for the cullet) and truck license plate will be previously entered into an EDI (Electronic Data Interchange) system by the respective raw material supplier. The arrival date and time of the truck should also be automatically recorded in the system when the code is scanned in the reader.

When the code is read, the system will confirm if the order is scheduled to be delivered that day. If it is part of the daily delivery plan, the gate is opened and the truck can enter into the plant. Otherwise, the truck driver has to go to gate house, so that it can contact the supervisor of the place where the material will be unloaded (batch house or BA distribution) who in turn will or will not allow the entry of that truck. It should be noted that the system has to have a way of accepting a delivery manually, since once the respective supervisor allows the entry of a material that is not in the daily delivery plane, its information has to be introduced into the system.

4.1.2 Displays to Inform the Truck Driver

The display will inform the truck driver about the truck position on the scale, indicating if he should go forward or backward. It will also indicate the silo where the unloading should be done once the BH operator has selected it manually in the BH system.

Furthermore, it will also serve as a traffic light, displaying the red screen when the truck should be stopped in order to allow the weighing, and the green screen to inform that the truck can proceed since the weighing has already been completed.

This will help to make the process cleaner and to avoid wasting time passing this type of information person to person, by following a line more focused on visual management.

This display should have multi-language, as BA has suppliers and transport companies contracted throughout Europe, so truck drivers can be of different nationalities and it would be easier to transmit the information to them.

Two displays will be necessary, one at each side of the scale, since the truck has to be weighed at the entrance and exit and, as such, pass through the scale in both directions. So, the truck driver has to be informed of the truck position in both directions.

4.1.3 Cameras for an Automatic License Plate Reading

The cameras will be used to read the truck license plates automatically in order to weigh the trucks without the intervention of an operator. This is possible because when the truck license plate is read for the first time, that is, when the truck passes through the scale after entering and with the raw material loaded, a first weighing is made (gross weight), and to this weighing the system associates the license plate read by the camera placed at one of the scale ends. After that, when the truck passes through the scale again, this time before leaving the plant and empty, a new weighing is made (tare), and through another camera, placed at the other end of the scale, the license plate is read again. Thus, the system associates the same license plate to the two weighing and calculates the real amount of raw material the truck was transporting, subtracting the tare from the gross weight.

In this way, it is possible to calculate the real weight of raw material received without the intervention of an operator, which makes the gate house operator less overloaded and able to use his time in other activities of his job.

Moreover, these cameras will also allow a continuous view of the weighing area.

As explained above, two cameras will be necessary, one for each end of the scale.

4.1.4 Position Sensors

The sensors will ensure a correct positioning of the truck on the scale in order to guarantee that all trucks will assume the same position on the scale at all times. This will result in a better distribution of the truck weight on the scale, which will make the weighing performed more correctly and, consequently, closer to the real weight.

The sensitivity of these sensors allows the transmission of the forward and backward messages to the truck driver, since through them the scale system is able to detect if the truck position on the scale is the most correct and, considering this, to transmit on the display what is necessary to put the truck in the proper position, in case it is not yet in this one.

4.1.5 Electrovalves for Closing and Opening the Silos

Until now, the unloading of the large raw material soda and limestone is done by the truck driver, in which he inserts the hose in the tube of the silo and turns on the truck compressor, enabling the unloading of the raw material. However, before he starts the unloading, the BH operator has to give him the key of the silo where the unloading must be done.

In order to eliminate the wasted time of this transition, it is aimed to place in the silos a valve that opens automatically when the BH operator selects in the BH system the silo in which the unloading should be done. This information is shown on the display and the truck driver knows the silo where to unload, so when he arrives at the unloading area, he only has to put the hose in the respective silo and unload, since the electrovalve will already be open by order of the BH operator, so the truck driver does not need to get a key that allows him to make the unloading anymore. It should be noted that during this moment, the remaining electrovalves are blocked, so the unloading in any other silo is not allowed.

The electrovalves will only be needed for the large raw material soda and limestone silos, because only these are unloaded by cistern (unloading mode where the electrovalves must be applied).

4.1.6 Software

For all the requirements described previously to work, a software that interconnects all the constituent parts is required.

Thus, this software needs to communicate with the software of the scale already installed in the plant, since the sensors and displays have to be integrated in the existing scale and, as such, the software has to be compatible to allow this communication.

The software must also communicate with SAP, since the information collected by the code reader must be entered into SAP, as this is the software used in BA Glass. This communication must be via web service, because this is the mode of communication used in BA Glass for systems developed on different platforms to be compatible.

Additionally, a software that can communicate with the BH software is also required, since it will be necessary to transmit the information of the silo in which the raw material should be unloaded to the display, and this information is given by the BH operator, who manually selects the respective silo in the BH system. This communication is also necessary because the BH operator has to be able to approve the unloading and, after that, all the information collected by the code reader and the scale system has to be inserted in the system as a new material entry record.

Figure 4.1 represents the Avintes plant layout with the locations where each component described above must be placed detached. In green is represented the code reader placed at the end of the street where the trucks entrance to the plant is done ("Rua BA" in Figure C.1), in blue the displays at each end of the scale, in yellow the cameras for an automatic license plate reading, also one at each end of the scale, and in red the position sensors to be installed on the existing scale of the plant.

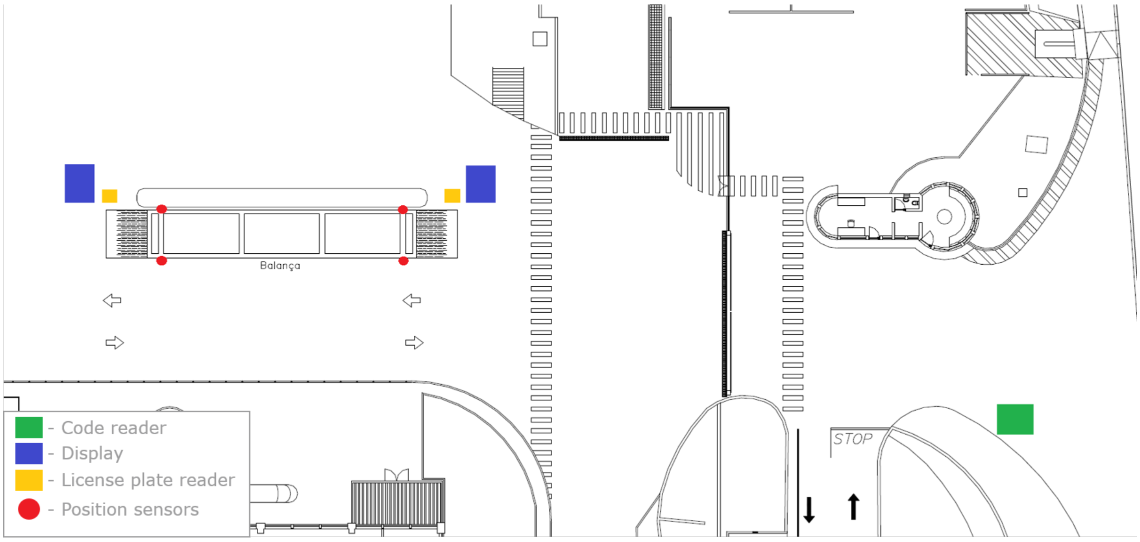


Figure 4.1: Location of Components at Avintes Plant

4.1.7 Visual Management

In addition to all technology mentioned, it would be interesting to implement a measure more focused on visual management. This would make transmission of information to the truck driver easier and would not require a BA operator to explain the procedures of the unloading process or how the truck entry into the plant is performed, since access to the plant for trucks is done through a road parallel to the plant employees' parking ("Rua BA" in Figure C.1) and not through the main road, in case these processes are unknown for the truck driver.

In terms of explaining the procedures of the unloading process, this implementation could involve placing signs inside the plant to inform where each unloading zone is located and to indicate the route to them, or tracing the routes to the different unloading zones on the floor. In this way the truck driver only has to follow the indications and does not have to stop to question the route to someone.

For the issue of explaining the specific entrance into the plant for trucks, the implementation could involve placing a sign outside the plant to indicate that entrance. With this, the truck drivers do not waste time turning around to enter through the correct access, since they did not try to enter into the plant incorrectly.

4.2 Suppliers' Solutions

In order to implement what was previously described, but not integrating the visual management section, different suppliers were contacted in order to present their quotes, so that it was possible to compare each other and decide which would be the best offer, considering all the requirements intended by BA Glass.

Until now, only 2 offers have been received, one from Balanças Marques and other from Cachapuz, which are described in the following sections:

4.2.1 Offer Number 1

Offer number 1 concerns the Balanças Marques offer, which consists in the characteristics bellow:

- 15 inch touchscreen self-service code reader;
- Display of 32 inches, 16:9 format and resolution 1920x1080, with automatic brightness adjustment. Besides all this, it also has 1 Ethernet port and 4 USB 2.0 ports. Furthermore, it has an internal ON/OFF control clock to save energy when not in use, as well as a ventilation system to control its internal temperature. In this display it will also be possible to provide visual indications to the truck driver of the actions he must perform, such as "forward" or "backward";
- 2MP colour camera equipped with a 3-9mm varifocal lens for an automatic license plate recognition, also providing a continuous view of the weighing zone;
- Position sensors installed on the scale, as can be seen in an example of their implementation in Figure 4.2;
- Software that enables the performance of the two weighing, the entrance one and the departure one, automatically and without the operator's intervention. It also allows the issuance of weighing reports, tickets and maps, as well as the weighing archive and photographs of them. In addition to all this, this software section also includes software development for specific functions, such as the interconnection with SAP and scale system.

Figure 4.2: Example of Balanças Marques Implementation for Position Sensors

The project for the implementation of this system, is represented in Figure 4.3. It should be noted that the location of each element is not mandatory, being only an idea for its implementation.

Considering all these elements it is possible to conclude that this offer approaches all BA Glass requests, except the one concerning the electrovalves to close and open the silos, so, in general, it is a good offer.

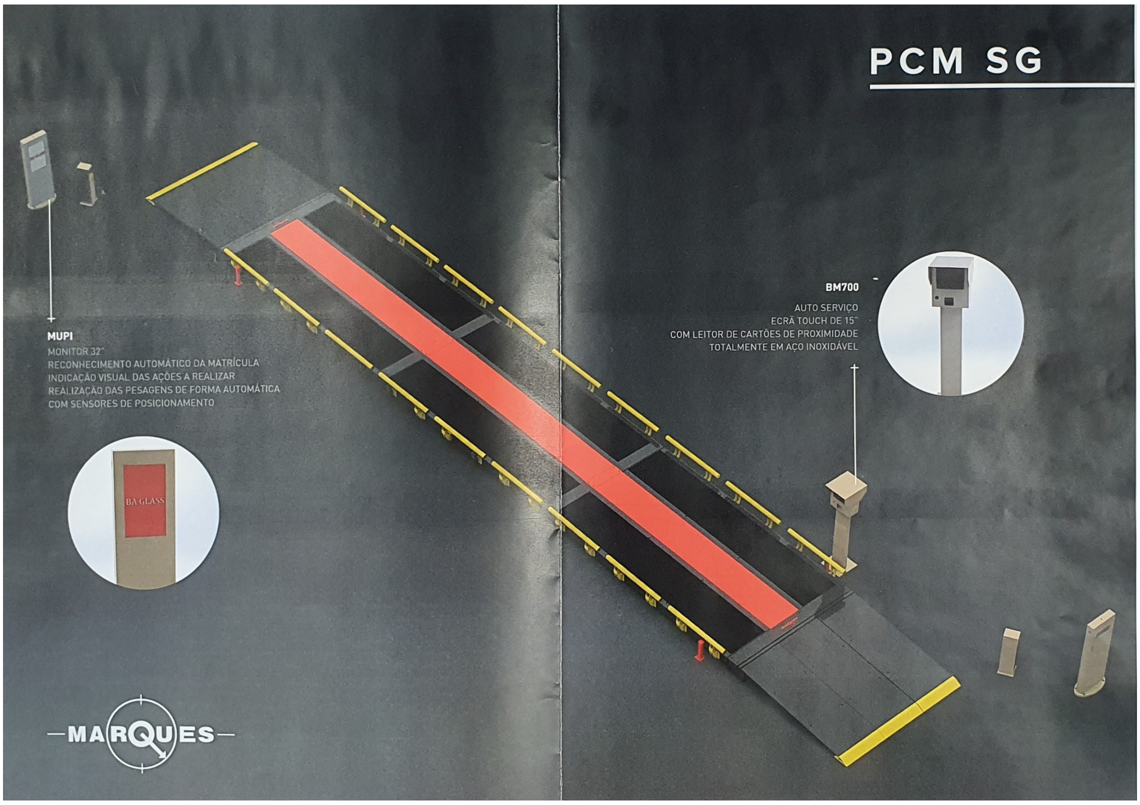


Figure 4.3: Project of Balanças Marques Offer

4.2.2 Offer Number 2

Offer number 2 concerns the Cachapuz offer that provides the following elements:

- Check-In kiosk designed to perform in extreme operating conditions and equipped with 10.4 inch touchscreen display, QR code reader, intelligent remote input/output unit, ethernet interface and, if needed, document collection zone. This kiosk is robust and is suitable for industrial use. An example of this element implementation can be seen in Figure 4.4;

Figure 4.4: Example of Cachapuz Implementation for Check-In Kiosk

- Informative display with RGB LED, visible area of 1280x128mm, which provides a maximum of 2 lines of 15 characters, and 160x32 pixels. It also includes an ethernet interface, an operating temperature between -20 and 60ºC, resistance to humidity between 10 and 90% and a 110º vision angle. Figure 4.5 shows an example of the implementation of this element;

Figure 4.5: Example of Cachapuz Implementation for Informative Display

- License plate reader system composed of 2MP IP camera, progressive scan with 1/2.7 inch and a 2.8-12mm motorized varifocal lens. This system also has a projection panel for led lighting in order to recognize license plates in darker environments. An example of the implementation of this component is represented in Figure 4.6;

Figure 4.6: Example of Cachapuz Implementation for License Plate Reader

- Transverse position control system with sensors incorporated into the scale, which is based on the principle of direct beam arrest and axial optics, with a detection range of 20m, and a maximum range of 28m. It also has a red and visible led light with a light point of 1100mm diameter, dispersion angle of approximately 5º and a wavelength of 645nm. This system also includes a control unit, which allows it to be connected to traffic lights already installed on the plant, for example. In Figure 4.7 is presented an example of implementation of this system;

Figure 4.7: Example of Cachapuz Implementation for Position Sensors

- Software that permits the management of users and access profiles, of entities and other master data, of multiple scales, assigning authorized weighing operations, and of operational and vehicle movement flows. It has web access for the registration and validation of operations in an operator assistance mode and also allows the real time control and monitoring of equipment, such as kiosks, license plate readers, IP cameras, traffic lights, barriers and position sensors. This software has a simple and oriented interface, is multi-language and enables integration with other software and automation systems, for example SAP, and it is also possible to define operating hours for it. In addition to all this, it is equally possible to define and control the number of vehicles in the plant, by operating place and material. The management of weighing operations is self-service via RFID (radio frequency identification) or other identification devices, providing the control of weighing deviations, by material, based on tolerances. Finally, with this software, it is possible to register operational logs, track the operations, send alerts and notifications by SMS and/or e-mail and issue operational reports, standard or customized;

- Automation system for an automatic unlocking of the unloading mechanism composed of a control unit, integrating PLC (Power Line Communication) sized to control the number of pneumatic silos currently installed. System also equipped with a control unit installed by pneumatic silo with button to start and stop the unloading, and a 3-colour light indicator. An example of this system is presented in Figure 4.8.

Figure 4.8: Example of Cachapuz Implementation for Unloading Automation System

As can be noted, this offer does not include, yet, BA Glass requirement for electrovalves to open and close the silos either. However, it includes an entire automation system for the unloading process which was not a BA requirement and seems somewhat dispensable at the moment. Moreover, the kiosk also seems a little dispensable to the intended solution, since the idea would be to have only the code reader, and therefore not all the other components involved, as well as the respective infrastructure.

In this way, in general, it can be stated that it is a good offer, possessing, however, some more components than the ones needed and requested.

In order to facilitate the interpretation of the two offers and the comparison between them, all BA Glass specifications for this project are summarized in Table 4.1, indicating whether or not each offer satisfies these conditions. In addition, the elements that each offer presents in excess of the mentioned requirements are also presented, as well as the investment required for each offer.

Table 4.1: Summary of Project Specifications

		Balanças Marques Offer	**Cachapuz Offer**
BA Glass Specifications	Code Reader	X	X
	Informative Display	X	X
	Automatic License Plate Reader	X	X
	Position Sensors	X	X
	Electrovalves to Open and Close the Silos	—	—
	Interconnection with the Existent Software	X	X
Extra Elements	Check-In Kiosk	—	X
	Unloading Process Automation	—	X
Necessary Investment for the Offer		€	€€

As can be observed and as previously mentioned, none of the offers presents the requirement of the electrovalves to close and open the silos in order to allow the load in them. Besides that, the Cachapuz offer provides 2 more elements than were requested.

From an overall perspective, it is possible to affirm that the Balanças Marques offer seems to be the best, since it covers the same required features as the Cachapuz offer, does not provide extra elements, presents a lower investment cost for the company and a more attractive design.

Chapter 5

Results

With the implementation of this project, it is expected that the goods reception process becomes more clean and organized, in order to eliminate errors in the data entry into the system, avoiding the manual registration of data, which besides avoiding these errors also reduces the overload of operators. Moreover, the registration in the system is done automatically and immediately after the material unloading, so it is not necessary to wait for the next day for entering this data in the system, which happens until today.

Since operators' overload is reduced with the project implementation, this means that process times are reduced too, as it is no longer necessary to fill paper sheets or excel files with data, neither to enter them manually into the system. This way, with implementation of the project, the cycle times would turn to the ones represented in Table 5.1. It is important to mention that these cycle times refer to the times that each operator spends on each task and not to the execution times of each step itself, and that these are estimated, since it was not possible to implement the project and, as a consequence, it was not possible to determine them.

Table 5.1: Future Cycle Time of Stages

	Cycle Time
Truck Reception	Raw material: 1min Non treated cullet: 1min
Truck Unloading	Raw material: 7min Non treated cullet: 3min
Empty Truck Weighing	Raw material: 0min Non treated cullet: 0min
Data Transfer to ERP	Raw material: 0min Non treated cullet: 1min

For the process itself, that is, the individual stages that compose it, it will consist in the same steps as the process before implementation. However, these will be changed in some aspects, as will be explained in the following sections.

5.1 Purchase Order Creation and Deliveries Planning

The weekly delivery plan is sent to gate house and, for raw materials, also to batch house by the central procurement replenisher. However, with the implementation of this project, the replenisher will no longer need to send this information, since the weekly delivery plan will be created in the system and, as such, any person who is authorized to access that information, can consult it directly in the system.

5.2 Truck Reception

This stage is characterized by wasting time filling manually an entry control paper sheet with different information and, for non treated cullet, an additional paper sheet is filled in to authorize the unloading. This way, with the code reader to be implemented, all the necessary information will be transferred directly to the system, so it is no longer necessary to fill in any data by hand.

In this stage, it is also necessary to insert some information in the scale system during the truck weighing. Nevertheless, with the installation of the license plate readers, the weighing will be done automatically, associating the information saved in the system before with the weighing done by the scale, through the truck license plate, so it is not necessary anymore to manually insert data in the scale system.

5.3 Unloading

At this stage the only change that will be noticed with the implementation of the project is that it is no longer necessary for BH operator to fill in an excel file with information, since this information will already be entered into the system from the beginning of the process, so it is not necessary this operator to write it again in an excel sheet. The BH operator will only have to approve the raw material unloading, depending on the result of the humidity test, and validate this in the BH system, where it is also recorded which percentage of humidity is measured and which operator has approved the unloading.

In this way, this stage is only influenced in the raw material reception process, since in the non treated cullet process the operator does not fill any information and also because the project to be implemented does not influence the material inspection time nor truck unloading time.

5.4 Empty Truck Leaves the Plant

At this stage gate house will no more be needed to weigh the truck, since with the implementations mentioned, the weighing will be automatic and, as such, without the intervention of an operator.

In addition, it will no longer be necessary to print the weighing slip, because the measured weight will immediately be recorded in the system and a notification will be sent to the respective supplier with the weighing value to provide them the BA weight. Considering the weighing of the raw material actually received, the weekly delivery plan will be automatically updated, so the operator does not need to do this anymore.

For the non treated cullet process, it will also not be necessary that the operator register in the Record of Batches of Cullet Received, because all the information will go directly to the system.

5.5 Data Transfer to ERP

In this step, for the raw material reception process, the GW supervisor will not have to enter anything in the system, as all data entry in the system will be done automatically.

Regarding the non treated cullet reception process, the GW supervisor will only need to enter the information manually on the SILiAmb website, since it is an external system and, as such, it is not possible to enter it automatically. The remaining data will be entered into the system automatically, like in raw material reception process.

5.6 Whole Process

Considering all the possible modifications of this project in the different steps of the process, in Figure 5.1 is presented the flowchart of the whole raw material reception process in the future situation. In this diagram it can be noted that the process has become more clean and organized, with a single data collection, which is automatic, and without any paper sheet or excel file to be filled.

Besides the flowchart of the whole process, the future VSM of the 2 individual reception processes are presented in Appendix D. Through these VSM it is possible to understand that with the implementation of this project, there is no longer non-value added time in goods reception processes, and that the overall time of the raw material reception process reduces by 5min and of the non treated cullet by 9min. This comparison of times, as well as the time saved in each process, is shown in Table 5.2.

Table 5.2: Comparison of Processing Times and Respective Saved Times

	Actual Processing Time	**Future Processing Time**	**Time Saved**
Raw Material	26min	21min	5min
Non Treated Cullet	24min	15min	9min

Moreover, it is also possible to note from the VSMs that the lead times of both processes are still 35min, since this project does not aim to improve these times. It is equally visible in this diagram the number of operators required in each stage of the process, and compared to the current process, there are stages that no longer require operators, which happens with both trucks weighing.

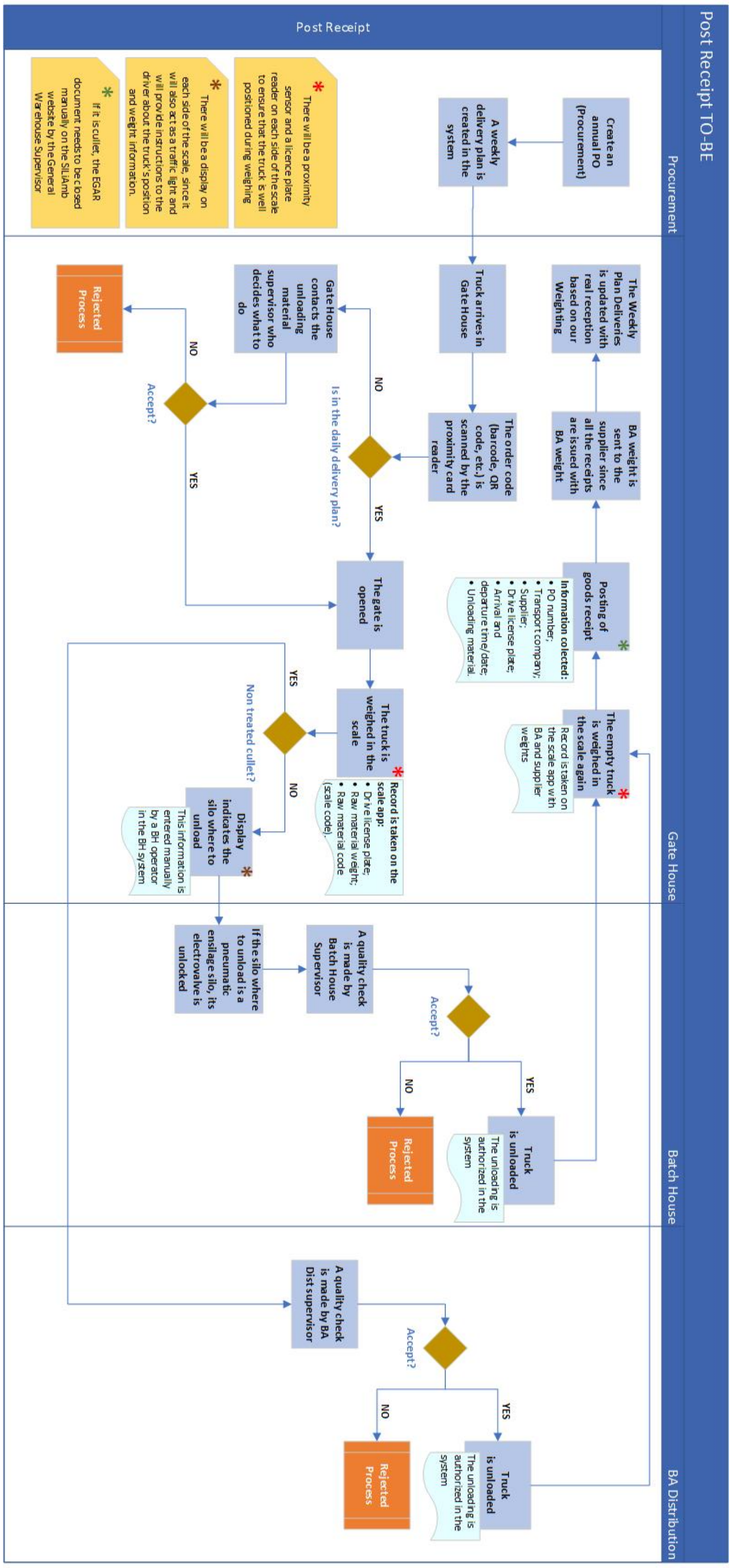


Figure 5.1: Goods Reception Process in the Future Situation Flowchart

5.7 Time Spent in the Process by Each Operator

In order to estimate the total time saved with the implementation of this project for each operator of the goods reception process, it was first calculated how much time each operator will have to spend on the task of this process after the project implementation. The total hours required by each operator for the reception process after the implementation of the project are represented in Figure 5.2.

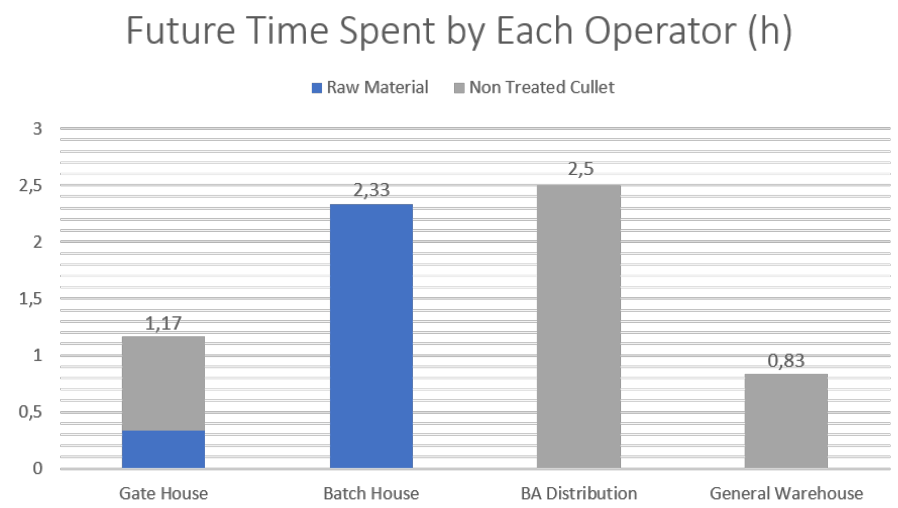


Figure 5.2: Required Time of Each Operator in Future Situation

Knowing that each operator works 8hours a day it is possible to state that with the implementation of this project:

- 14,58% of GH operator time will be spent in the reception of raw material and non treated cullet, which means a difference in working time occupation of 122.92%, corresponding to 9.83 hours saved in GH tasks related to this process. This indicates that the workload in GH for the goods receipt process was reduced in 89.40%. This way, since the time required for this process is reduced to only 1.17 hours, it means that only one operator is needed in GH, so one can be dismissed and the costs associated with it can be saved;

- 29,17% of BH operator time will be spent in the reception of raw material, which means that regarding BH working time occupation nothing happens with the project implementation, since the time needed for the goods reception process at this place is the same as before. This occurs because the time required by BH operator in this process is only related to the goods inspection, which is not influenced by the implementation of this system;

- 31,25% of BA distribution operator time will be spent in the reception of non treated cullet, which means that regarding BA distribution working time occupation nothing happens with the project implementation, since the time needed for the goods reception process at this place is the same as before. This occurs because the time required by BA distribution operator in this process is only related to the goods inspection, which is not influenced by the implementation of this system;

- 10,42% of GW supervisor time will be spent in the reception of raw material and non treated cullet, which means a difference in working time occupation of 25%, corresponding to 2 hours saved in GW tasks related to this process. This indicates that the workload in GW for the goods receipt process was reduced in 70,58%;

To calculate the total time saved for each operator, it is only necessary to subtract the values present in Figure 5.2 from those present in Figure 3.14. In order to simplify its interpretation, Table 5.3 presents all these values, that is, the current total times, the future situation total times and the total times saved. Furthermore, it is also possible to analyze in the same table the percentage reduction in the workload of each operator in the reception process of raw material and non treated cullet.

Table 5.3: Comparison of Operators' Total Times

	Current Total Time	**Future Total Time**	**Total Time Saved**	**Workload Reduction**
Gate House	11h	1,17h	9,83h	89,40%
Batch House	2,33h	2,33h	0h	0%
BA Distribution	2,5h	2,5h	0h	0%
General Warehouse	2,83h	0,83h	2h	70,58%

It can also be verified by the graph in Figure 5.2 that the total number of hours which will be required for the raw materials reception process is 6,8, which means that less than 1 FTE will be spent in this process, more specifically, 0,8538FTE. Thus it can be stated that the ideal number of operators in this process becomes 1, this if only one operator can perform all the tasks necessary for the process, so it would be interesting to do this analysis.

5.8 Payback Period

The payback period will be calculated for both offers previously described. However, to be possible to calculate this values, it is necessary to first present the costs that will be saved with the implementation of this project.

5.8.1 Saved Costs

The saved costs that will be most evident with the implementation of this system are the staff costs, since the time of the operators' workload in relation to this process will be reduced with this implementation. However, material costs, such as paper, can also be mentioned, but as they are a small amount and difficult to estimate, they will not be included in the payback period calculation.

In this way, the saved costs will be divided between costs actually saved, that is, costs that the company will no longer have after the project implementation, and internal costs saved, which is, costs that the company will continue to have, but that will be related to other processes and not to the goods receipt process.

The actually saved costs are related to the GH operator that can be dismissed, due to the reason that the necessary workload in GH for the goods reception process no longer justify the need of 2 simultaneous operators in GH during the day. These saved costs represent 48.26% of the current total costs, considering the daily hours that each operator spends with the goods reception process and not the number of daily hours that each operator works, since he has other tasks.

The internal costs saved are related to the time that can be reduced for GH and GW operators in relation to the goods receipt process. These saved costs represent the remaining 51.74% of the current total costs, considering once again the daily hours each operator spends with this process and not the number of daily hours each operator works.

An analysis of these values permits to deduce that the costs actually saved and the internal costs saved in the raw material and non treated cullet reception processes are practically the same, since their percentages are both close to 50%, although the internal costs saved have a relatively higher impact.

5.8.2 Payback Period Calculation

The payback period will be calculated considering only the costs actually saved with the project implementation, since only these costs will no longer be counted for the company, which will become a productivity profit.

For Balanças Marques offer, described in Section 4.2.1, the costs actually saved can cover 96.89% of the investment, resulting in a payback period of 1.03 years, which is very positive. It should be noted that this payback period was calculated only for Avintes plant, but considering that the project is implemented in all plants, because some elements, such as specific software development, have a total value considering all plants and not per plant, so this value was divided by the number of BA plants.

In relation to the Cachapuz offer, explained in Section 4.2.2, the costs actually saved cover only 33.87% of the investment, which represents a payback period of 2.95 years, which is also a good period, but much higher than the previous offer (higher by 1.92 years).

In both offers, the costs related to the number of electrovalves needed for Avintes plant have been considered through an estimate made considering this type of electrovalves inserted in other plants of the group, since there are BA plants that already have these electrovalves installed in silos.

In this way, considering the payback periods calculated, it can be stated that from the 2 offers for improving the raw materials reception process existing until now, the most favourable is the Balanças Marques offer with a payback of 1.03 years.

Chapter 6

Conclusion and Future Work

The main objective of the present project was to analyze and improve the process of goods receipt. As the BA Group is constantly expanding by acquiring new plants and increasing the production capacity of the existing plants, it is necessary to optimize this process and, consequently, standardize it in order to be able to accompany the evolution of the plants so that it is possible to receive all the raw materials needed for production.

In a first stage, the project presented as main challenge the survey of the current process, the identification of problems and the realization of suggestions for improvement, an activity that is quite complex, since it depends on many participants. During the project, there was a concern in analyzing all these participants, starting with the truck's reception and weighing in gate house, inspection and unloading of raw materials in batch house and BA distribution, thereafter and, at last, information entry in system in general warehouse. In this way, the major analysis tool used was the interaction with the people responsible for the different stages of the process, the observation of their different ways of working and the time measurement of each task required to be performed. The contact with the participants was crucial, not only to understand the functioning of each stage, but also to identify the problems and potential improvements for these. It became clear right from the beginning that reducing the time spent on daily activities is fundamental, especially in a company like BA, where plants produce 24 hours a day, 7 days a week, with no margin for interruptions in the flow of materials and information.

In a second stage, the main objective was to develop the process mapping, which was an essential step for the development of the project, once the process flow and the necessary resources were identified. For the process mapping the major tool was the development of the process flowcharts for the reception of raw materials and non treated cullet, not only for Avintes plant, but also for the five plants in Iberia.

Afterwards, for the several problems identified, an analysis was made of possible improvements to be adopted. Once these improvements had been defined, different suppliers were contacted in order to present an optimization project for the goods receipt process incorporating these improvements. However, due to the pandemic situation that the country suffered, and still continues to suffer, the suppliers' offers were presented much later than planned, and some of them have not been presented yet. In this way, all the results presented are estimated, since a decision was not yet taken nor a solution implemented, consequently the objectives concerning to the project implementation have not been achieved, at least at the moment. However, it can be stated that the offer of Balanças Marques stands out, since it presents a payback period of only 1.03 years, which represents a very low period of return on investment.

With the implementation of this project is expected a potential reduction of 89,40% in the gate house daily working time, corresponding to a reduction of nine hours and fifty minutes, and a reduction of 70,58% in the general warehouse daily working time, which corresponds to a decrease of two hours. Furthermore, it is also intended that it will be possible to record the information in real time after the second weighing, which is a great improvement compared to the current process since the probability of entering wrong information into the system is reduced to practically zero. Overall, it is expected to achieve a more clean and organized process with a single automatic collection of information and without any paper sheet or excel file to be filled, thereby creating an error-free process with a much lower workload than the current one.

From the viewpoint of the goods reception process, as future work, it would be interesting to analyze the possibility of the same person accumulating two or more functions, since the ones involved will only be occupied very partially with this process. In addition, it would also be beneficial to schedule an interval of delivery hours with the transport companies, and not just the day, in order to reduce the lead time of the process.

As future work, from a company perspective, it would be interesting to analyze the implementation of this project in the remaining plants, either in Iberia or in the remaining Europe, since the results expected at Avintes plant are very favorable. However, BA should consider that not all plants of the group have so many daily receptions of raw material as Avintes plant, so the results may not be as positive and, consequently, the implementation of this project not be the best solution. For those cases, it would be worthwhile to perform benchmarking between the plants of the group, in order to analyze the worst and best practices in each plant, with the objective of standardizing this process and obtaining the best results possible.

Another suggestion for future work would be to optimize the reception processes for the remaining materials, such as packaging material or consumables, in order to avoid errors in data entry in the system by the general warehouse supervisor. It should be noted that this project would be much simpler than the present one, since it would be enough to read a code, at the moment of its reception, through a tablet or similar, since these materials do not need to be weighed on the scale.

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Appendix A

Value Stream Mapping of Raw Material Reception AS-IS Process

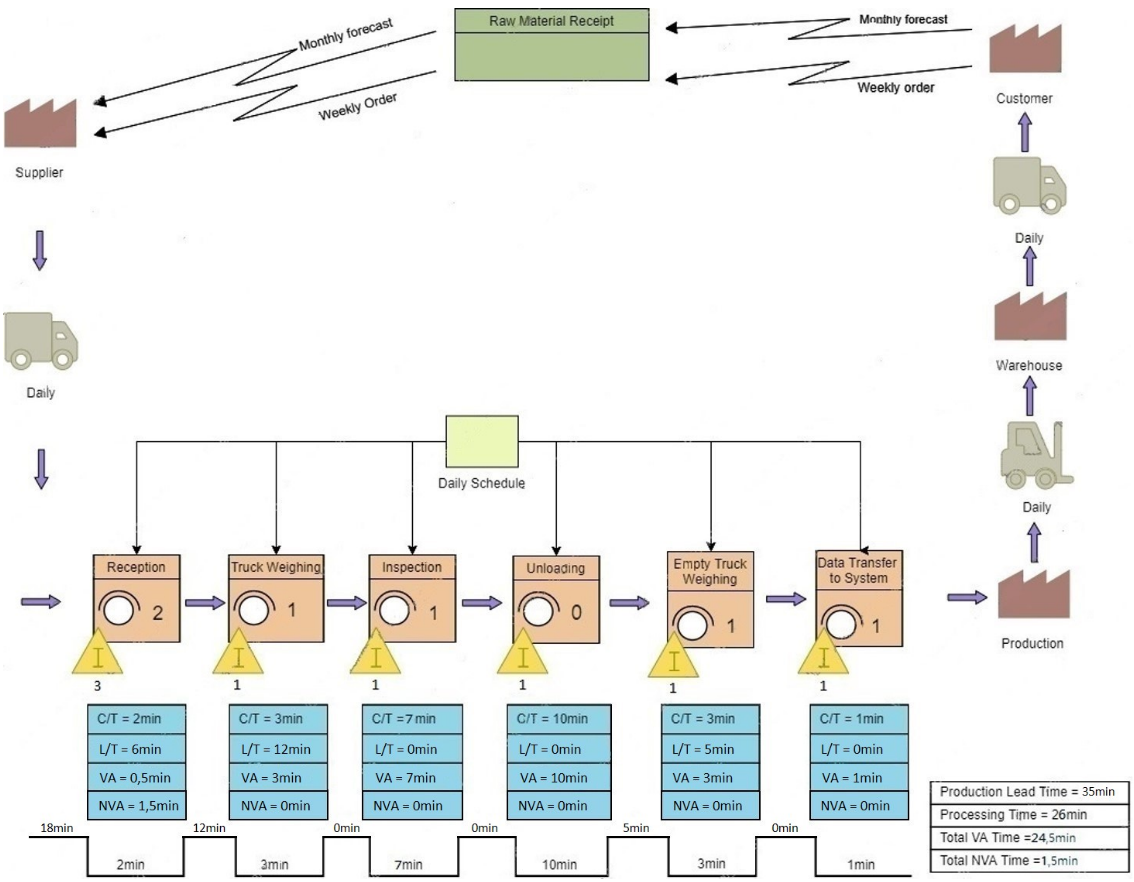

Figure A.1: VSM of Raw Material Reception Process

Appendix B

Value Stream Mapping of Non Treated Cullet Reception AS-IS Process

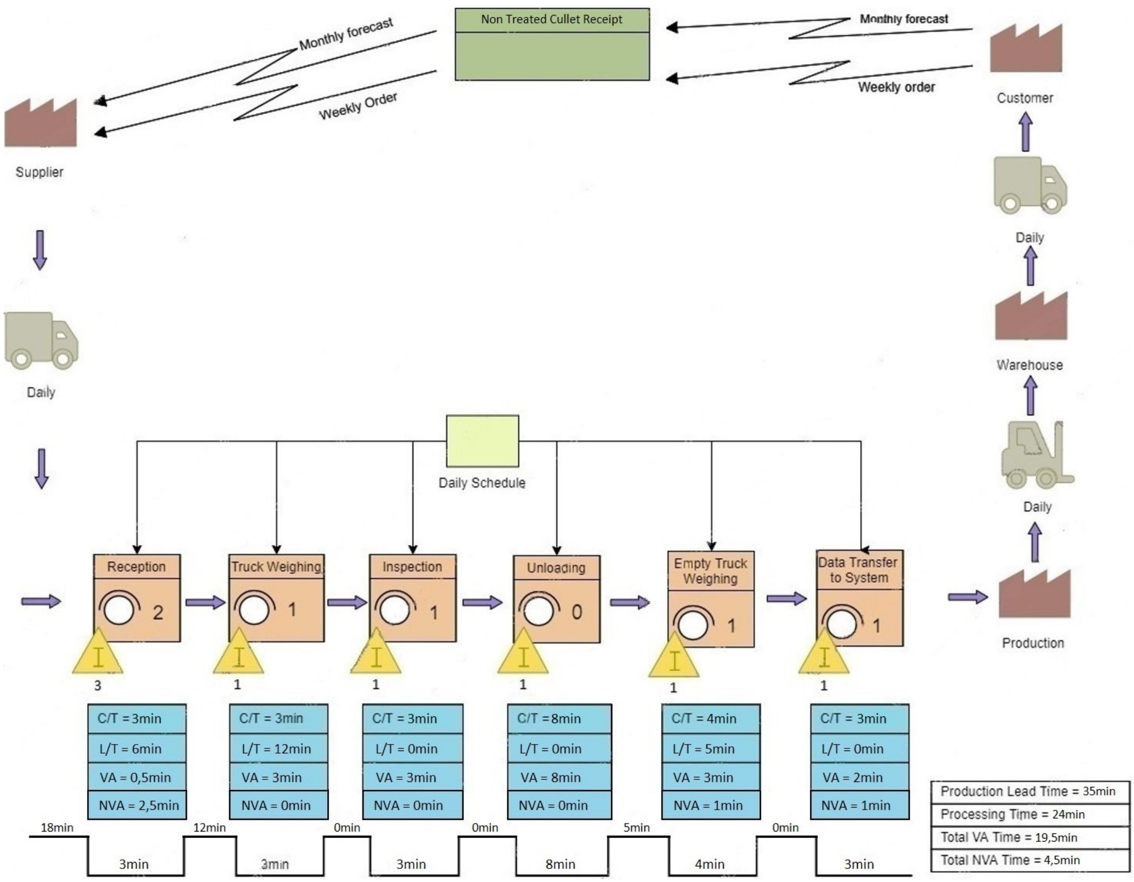

Figure B.1: VSM of Non Treated Cullet Reception Process

Appendix C

Avintes Plant Layout

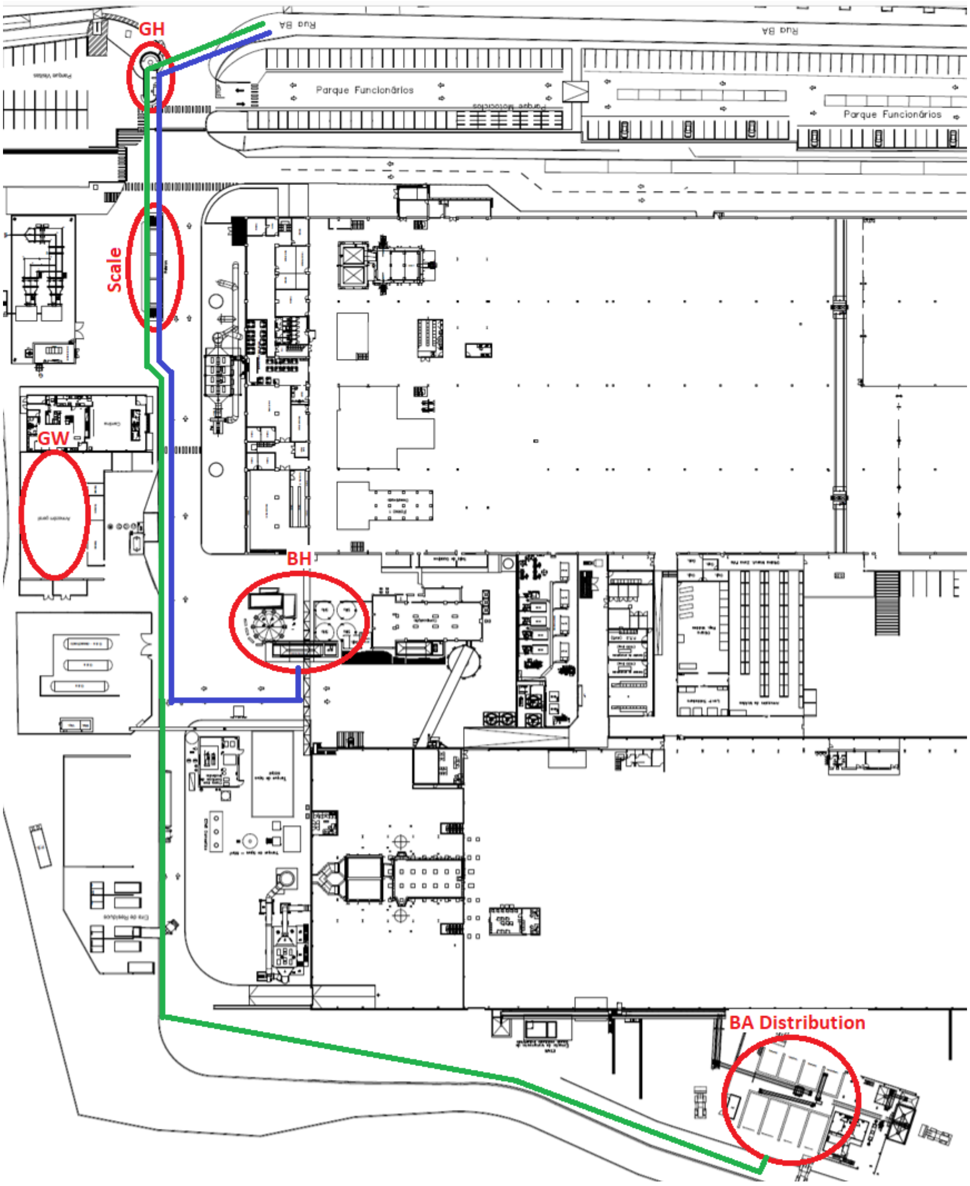

Figure C.1: Avintes Plant Layout with the 2 Routes Marked

Appendix D

Value Stream Mappings of TO-BE Process

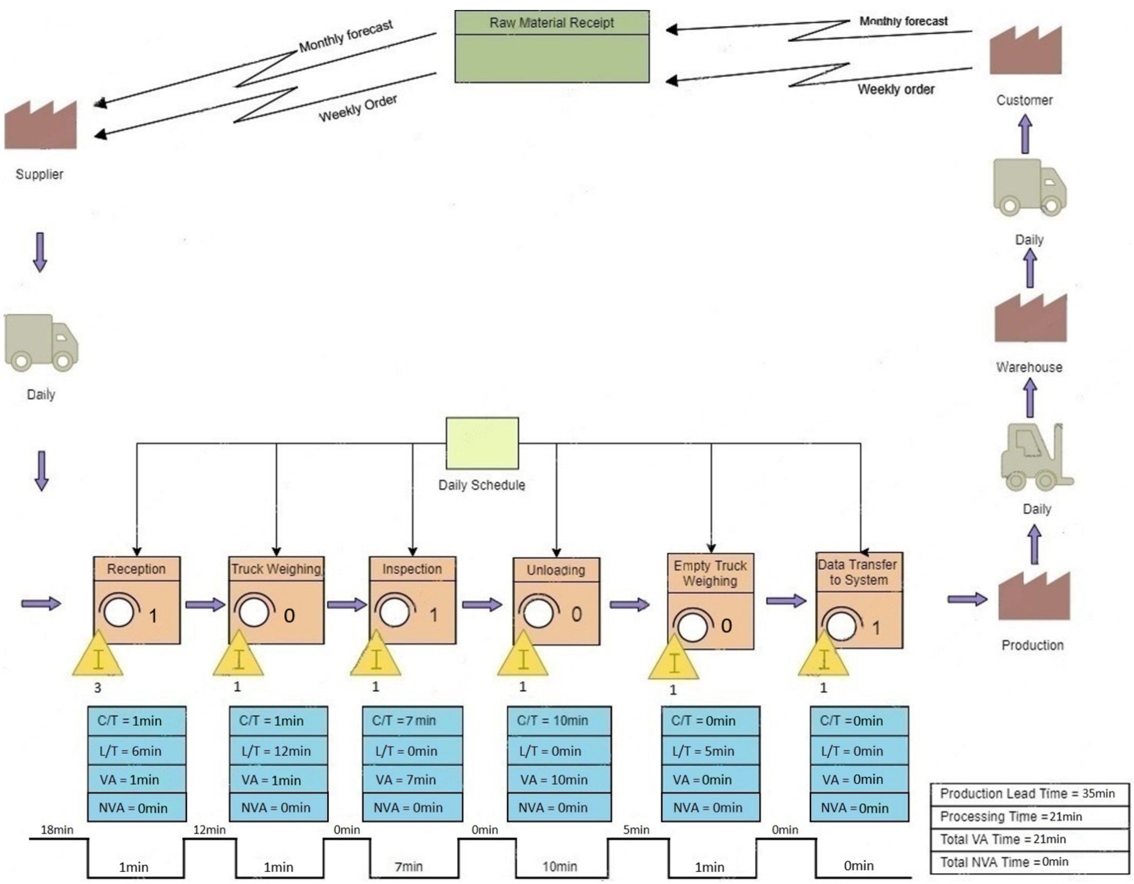

Figure D.1: Future VSM of Raw Material Reception Process

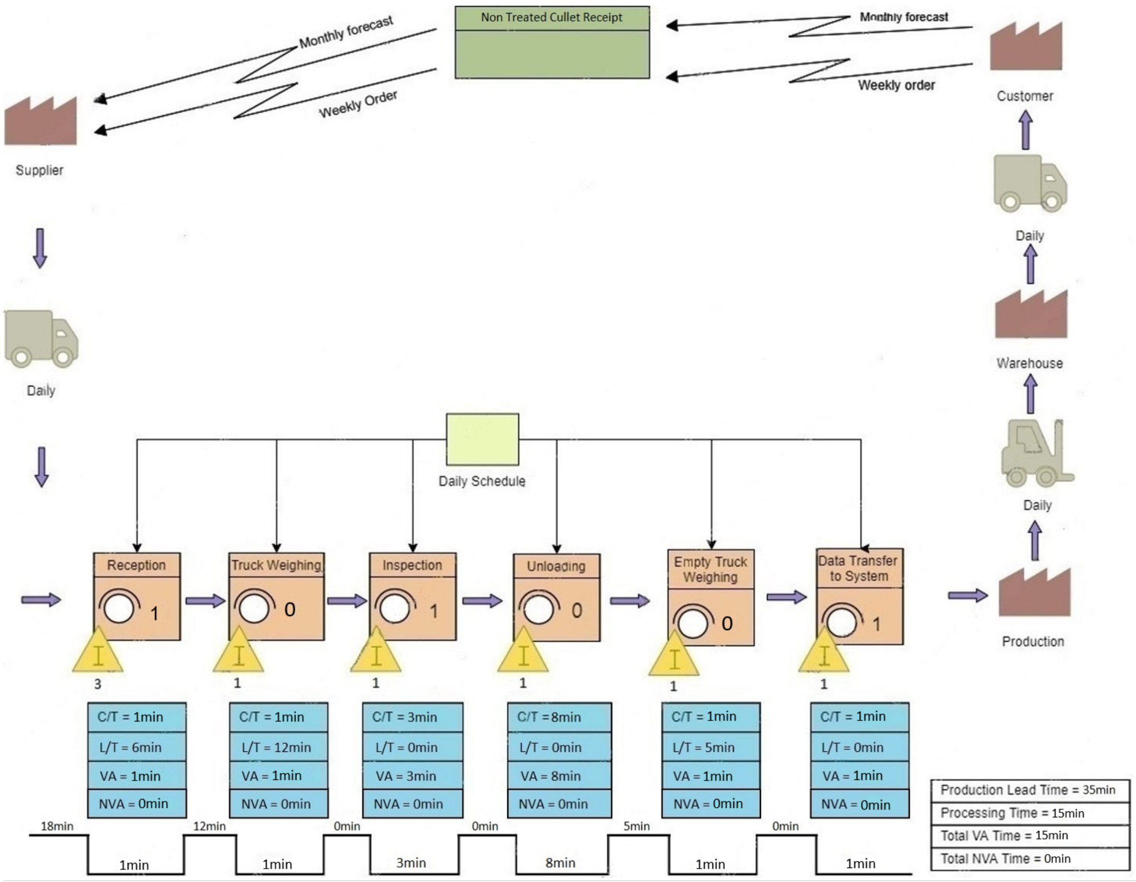

Figure D.2: Future VSM of Non Treated Cullet Reception Process