FACULTY OF ENGINEERING OF THE UNIVERSITY OF PORTO

Improvement of the Production Flow through the Implementation of a Provisioner in a Paint Production Unit

Maria Teresa Carreira Alves



Master in Mechanical Engineering - Production Management

FEUP's Supervisor: Prof. Xavier Andrade

Company's Supervisor: Eng. Joana Oliveira Monteiro

July 30, 2026

© Maria Teresa Carreira Alves, 2026

Resumo

A crescente pressão para melhorar a eficiência operacional e a competitividade industrial tem levado as organizações a procurar soluções que permitam utilizar melhor os recursos disponíveis e reduzir atividades que não acrescentam valor ao produto final. Neste contexto, a presente dissertação foi desenvolvida na área de enchimento do setor C1 da *Corporação Industrial do Norte, S.A.* (CIN), tendo como principal objetivo melhorar o fluxo produtivo através da implementação da função de Aprovisionador.

O trabalho iniciou-se com uma análise detalhada da situação existente, recorrendo à observação direta das operações, a estudos Day in Life Of (DILO), Sequence Charts e análises de produtividade. Esta fase permitiu identificar várias atividades realizadas pelos operadores de enchimento que provocavam interrupções frequentes das operações produtivas e aumentavam o tempo dedicado a atividades de valor não acrescentado.

Com base nos resultados obtidos, foi desenvolvida, normalizada e implementada a função de Aprovisionador, responsável pela preparação e disponibilização de materiais, pelo apoio aos setups, pela recolha e cintagem de paletes e pela realização de atividades auxiliares associadas ao processo de enchimento. Esta função permitiu transferir parte das atividades dos operadores de enchimento para o Aprovisionador, contribuindo para uma maior concentração nas tarefas produtivas e para uma melhor organização do trabalho.

Após a implementação da solução proposta, foram repetidos os estudos realizados na fase inicial, de forma a avaliar o seu impacto. Os resultados demonstraram uma redução das atividades de valor não acrescentado de 32.7% nas máquinas de enchimento manual, 28.2% nas máquinas automáticas e 26.0% nas semi-automáticas. Verificaram-se ainda reduções significativas nos tempos de setup, atingindo 33.3% nos set ups de Marca, 22.9% nos setups de Embalagens e 41.2% nos setups de Produto Intermédio. Adicionalmente, a produtividade aumentou 34% na área de enchimento e 43.3% no setor C1, superando o objetivo inicial de alcançar um aumento superior a 5%, sem comprometer a capacidade diária de produção.

Conclui-se que a implementação do Aprovisionador contribuiu para melhorar a organização das operações de enchimento, reduzir desperdícios e aumentar a produtividade do setor. Os resultados obtidos demonstram que a adoção de um operador dedicado a atividades de suporte é uma solução eficaz para melhorar o desempenho operacional em ambientes industriais com características semelhantes.

Abstract

The increasing pressure to improve operational efficiency and industrial competitiveness has led organisations to seek solutions that enable a better utilisation of available resources and reduce activities that do not add value to the final product. In this context, the present dissertation was developed in the filling area of sector C1 at *Corporação Industrial do Norte, S.A.* (CIN), with the main objective of improving the production flow through the implementation of a Provisioner.

The work began with a detailed assessment of the existing situation, based on direct observation of operations, Day in Life Of (DILO) studies, Sequence Charts and productivity analyses. This phase made it possible to identify several activities performed by filling operators that caused frequent interruptions to production operations and increased the time dedicated to non-value-added activities.

Based on the results obtained, the role of the Provisioner was developed, standardised and implemented. The Provisioner became responsible for material preparation and supply, setup support, pallet collection and strapping, as well as other auxiliary activities associated with the filling process. This role enabled part of the operators' activities to be transferred to a dedicated worker, allowing filling operators to focus more on productive tasks and contributing to a better organisation of work.

Following the implementation of the proposed solution, the studies carried out during the initial phase were repeated in order to evaluate its impact. The results showed a reduction in non-value-added activities of 32.7% in manual filling stations, 28.2% in automatic machines and 26.0% in semi-automatic machines. Significant reductions in setup times were also achieved, reaching 33.3% for Brand setups, 22.9% for Container setups and 41.2% for Intermediate Product setups. Additionally, productivity increased by 34% in the filling area and by 43.3% in sector C1, exceeding the initial objective of achieving an increase greater than 5%, without compromising daily production capacity.

It can therefore be concluded that the implementation of the Provisioner contributed to improving the organisation of filling operations, reducing waste and increasing sector productivity. The results obtained demonstrate that the adoption of an operator for support activities constitutes an effective solution for improving operational performance in industrial environments with similar characteristics.

Acknowledgements

The completion of this dissertation marks the culmination of a very important stage of my academic and personal journey. Throughout this path, I have had the privilege of receiving the support, guidance and friendship of several people, to whom I would like to express my sincere gratitude.

First and foremost, I would like to thank Engineer Joana Oliveira Monteiro for all her support and guidance throughout this semester. Her constant availability, encouragement, trust and daily support were fundamental to the development of this project.

I would also like to thank Professor Xavier Andrade for his availability throughout this work and for the valuable contributions that helped improve this dissertation.

I would like to give a special thank you to the entire filling team of sector C1 at CIN — Carlos Barbosa, Ismael Teixeira, Rui Calege, João Bento, Paulo Costa, Bruno Vale, Nuno Trindade and Hugo Lopes — for their collaboration, availability and support throughout the internship. They welcomed me exceptionally well, always willing to answer questions, share their knowledge and make this experience even more rewarding. I leave with many great memories from these past months.

To all my friends, from FEUP and beyond, thank you for being by my side throughout this journey and for making the most demanding moments much easier and lighter. To Margarida and Daniela, in particular, who accompanied me throughout the entire internship, thank you for your friendship and companionship. You truly made a difference. These past few months and this experience would not have been the same without either of you.

To my entire family, I would like to express a very special thank you. To all my grandparents, aunts, uncles and amazing cousins, thank you for all the love, support and encouragement you have given me throughout every phase of my life. I am incredibly fortunate to have each and every one of you by my side celebrating every achievement with me.

Finally, my deepest gratitude goes to my parents and my siblings. Thank you for putting up with me every day, for supporting me through the most difficult moments and for always believing in me. None of this would have been possible without your love, patience and unconditional support. This achievement is as much yours as it is mine.

To all of you, my sincere thank you.

Maria Teresa Carreira Alves

Contents

1 Introduction **1**
- 1.1 Project Motivation and Objectives . . . 1
- 1.2 Company Presentation . . . 2
- 1.3 Adopted Methodology . . . 4
- 1.4 Dissertation Structure . . . 4

2 Literature Review **6**
- 2.1 Lean Logistics Support Concepts . . . 6
  - 2.1.1 Junjo . . . 7
  - 2.1.2 Mizusumashi . . . 7
- 2.2 Key Performance Indicators . . . 8
- 2.3 Lean Thinking . . . 9
  - 2.3.1 Lean Principles . . . 10
  - 2.3.2 The seven wastes . . . 11
- 2.4 Lean Tools . . . 12
  - 2.4.1 5S . . . 12
  - 2.4.2 Day in Life Of . . . 13
  - 2.4.3 Pareto Chart . . . 13
  - 2.4.4 Single-Minute Exchange of Die . . . 14
  - 2.4.5 Visual Management . . . 14
  - 2.4.6 Overall Equipment Effectiveness . . . 14
  - 2.4.7 Standard Work . . . 15

3 Current State Overview **17**
- 3.1 Layout of the Filling Area . . . 17
- 3.2 Filling Process Overview . . . 18
- 3.3 Filling Equipment Characterization . . . 19
- 3.4 Current Operational Challenges . . . 23

4 Proposed Solutions and Operational Improvements **27**
- 4.1 Operational Performance Studies . . . 28
  - 4.1.1 Productivity Studies . . . 28
  - 4.1.2 Strapex Operational Study . . . 31
- 4.2 Implementation and Standardisation of the Provisioner Role . . . 33
  - 4.2.1 Day in Life Of and Value-Added Analysis . . . 33
  - 4.2.2 Setup Improvements . . . 36
  - 4.2.3 Strapping Workload Study . . . 40
  - 4.2.4 Filling Schedule Compliance Analysis . . . 45

4.2.5 Human Resource Allocation Scenario Analysis 47
4.2.6 Daily Filling Schedule Analysis 49
4.2.7 Double Pallet System 52
4.2.8 Provisioner Role Standardisation 53

5 Analysis and Comparison of Results **56**
5.1 Impact on Operator Activities 56
5.2 Impact on Setup Operations 57
5.3 Impact on Productivity of the Sector 58

6 Conclusions and Future Work **61**
6.1 Conclusions 61
6.2 Future Work 62

References **63**

A Gantt Chart **65**

B C1E Plant Layout **66**

C Swimlane Process Map **67**

D Strapex Machine **68**

E Productivity Studies - Template Sheets **70**

F Tamping Mechanism **72**

G Day in Life Of - Template Sheet **74**

H Data obtained from the DILOs performed **75**

I Sequence Chart - Template Sheet **78**

J Data Recorded for the Strapping Study **79**

K Results obtained for the Filling Schedule Study **81**

L Human Resource Allocation per Number of Simmultaneous Machines **83**

M Provisioner's Compliance Rate - Template Sheet **87**

N Reconstruction of the Daily Schedules of Days 29 and 30 of April **88**

O Double Pallet Floor Marks - Before and After Reinforcement **91**

P Provisioner's Priority Study **92**

Q Final Standard Work Sheet **94**

List of Figures

1.1 CIN headquarters' plant layout . . . 3

3.1 Automatic filling machines operating in the Filling Area (C1E) area . . . 19
3.2 Manual Filling Station . . . 22

4.1 Comparison of setup activities before and after the application of Single-Minute Exchange of Die (SMED) principles . . . 38
4.2 Daily strapping workload between January and March . . . 41
4.3 Daily strapping workload and contribution of the ME-30 and ME-60, between January and March . . . 42
4.4 Contribution of the ME-30 and ME-60 to the total strapping workload . . . 43

5.1 Weekly productivity evolution for the overall Central Plant (C1) sector . . . 59
5.2 Weekly productivity evolution for the C1E filling area . . . 59

A.1 Gantt Chart . . . 65

B.1 C1E Plant Layout . . . 66

C.1 Swimlane Process Map . . . 67

D.1 Strapex Machine . . . 68
D.2 Strapex Machine . . . 69

E.1 Productivity Study for 1 operator . . . 70
E.2 Productivity Study for 2 operators . . . 71

F.1 Tamping mechanism . . . 72
F.2 Manual Filling Station Layout while using this tamping mechanism . . . 73

G.1 DILO Template Sheet . . . 74

H.1 Example of graphical outputs obtained from the DILO analysis performed on the ME-53 . . . 75
H.2 Example of graphical outputs obtained from the DILO analysis performed on a manual filling station . . . 76
H.3 Example of graphical outputs obtained from the DILO analysis performed on the ME-61 . . . 77

I.1 Sequence Chart Template Sheet . . . 78

J.1 Example of the Strapping Time Record 79
J.2 Excerpt from the Strapping Time Table 80

M.1 Provisioner's Compliance Rate Template Sheet 87

N.1 Day 29 - Before 88
N.2 Day 29 - After 89
N.3 Day 30 - Before 89
N.4 Day 30 - After 90

O.1 Before Reinforcement 91
O.2 After Reinforcement 91

P.1 Provisioner's Priority Study - Example 1 92
P.2 Provisioner's Priority Study - Example 2 92
P.3 Provisioner's Priority Study - Example 3 93

Q.1 Standard Work Document (Page 1) 94
Q.2 Standard Work Document (Page 2) 95

List of Tables

3.1 Types of setup 20

4.1 Productivity results for automatic machines 29
4.2 Productivity results for semi-automatic machines 29
4.3 Productivity results for manual filling operations 29
4.4 Operational analysis of the 4 Liters (L) packaging process 32
4.5 Distribution of Value-Added (VA) and Non-Value-Added (NVA) activities by machine category 34
4.6 Estimated annual distribution of operator activities before and after the Provisioner implementation 35
4.7 Average setup duration before the implementation of the Provisioner 37
4.8 Estimated impact of the ME-61 valve replacement improvement 39
4.9 Economic value of the setup time saved 39
4.10 Evaluation of strapping integration feasibility 44
4.11 Productivity results with and without integrated strapping 44
4.12 Summary indicators of schedule deviations 47
4.13 Theoretical Reduction in Filling Duration 49
4.14 Provisioner Compliance Rates 51
4.15 Effective Reduction Applied According to the Number of Simultaneous Machines 51

5.1 Impact of the Provisioner on the distribution of operator activities 57
5.2 Average setup duration before and after the Provisioner implementation 57

K.1 Filling schedule compliance analysis (Part I) 81
K.2 Filling schedule compliance analysis (Part II) 82

L.1 Two-machine operational scenarios 83
L.2 Three-machine operational scenarios 84
L.3 Four-machine operational scenarios 85
L.4 Five-machine operational scenarios 86

List of Acronyms

C0	Raw Material Warehouse
C1	Central Plant
C1E	Filling Area
C1F	Manufacturing Area
C2	*Nováqua*
C4	Varnish Production Unit
C5	Diluent Production Unit
C6	Fillers and Putties Production Unit
C8	Industrial Range Production Unit
CIN	*Corporação Industrial do Norte, S.A.*
DILO	Day in Life Of
E	Container
ERP	Enterprise Resource Planning
FEUP	Faculty of Engineering of the University of Porto
h	hours
KPI	Key Performance Indicators
L	Liters
L/m-h	Litres per Man-Hours
M	Brand
min	minutes
NVA	Non-Value-Added
OEE	Overall Equipment Effectiveness
PI	Intermediate Product
s	seconds
S7	Solid Raw Materials Weighing Facility
S10	Liquid Raw Materials Weighing Facility
SMED	Single-Minute Exchange of Die
TPS	Toyota Production System
VA	Value-Added
WIP	Work In Progress

Chapter 1

Introduction

The present dissertation was developed at *Corporação Industrial do Norte, S.A.* (CIN), as part of the Master's program in Mechanical Engineering at the Faculty of Engineering of the University of Porto (FEUP).

The work focuses on the project titled *Improvement of the Production Flow through the Implementation of a Provisioner in a Paint Production Unit* and was carried out over a period of four months in the Central Plant (C1) of CIN. This sector, operating under the Operations Department, combines both production and filling activities. For the purpose of this dissertation, particular attention was given to filling operations, where the production flow was analyzed and improved to enhance efficiency and productivity.

This chapter introduces the context of the dissertation by explaining the motivations behind the project, outlining its primary objectives and providing a description of CIN as the host company. Additionally, it presents the adopted methodology used throughout the development of the study and concludes with an overview of the structure of the dissertation.

1.1 Project Motivation and Objectives

In modern production environments, maintaining a smooth and reliable production flow is essential to meet market demand efficiently while sustaining high levels of productivity and competitiveness. Interruptions caused by material shortages, delays, or mismanagement directly impact the overall performance of the production process, generating waste and reducing operational efficiency.

It was identified that operators frequently interrupted their primary activities to perform auxiliary and organizational tasks that did not directly contribute to the filling process, such as searching for the correct packaging materials or collecting finished pallets from the end-of-line area. Consequently, operators were often forced to leave their workstations, increasing Non-Value-Added (NVA) activities and reducing the efficiency of the filling process.

To address these challenges, this dissertation proposes the development and implementation of a Provisioner within the filling team of sector C1 of CIN, using lean tools, in order to reduce waste.

Rather than introducing an additional operator, the proposed approach consists of reallocating one of the existing team members to a dedicated logistical support role. The main objective of this function is to support the filling operations by assuming responsibility for several external and logistical tasks, allowing filling operators to remain focused on the machine operation itself. These responsibilities include supplying the required materials to the filling stations, supporting setup preparation activities and transporting completed pallets to the finished product area. By reducing the need for operators to leave their workstations during production, the proposed function aims to improve workflow organisation, reduce NVA activities and increase the overall productivity of the sector. Therefore, the proposed solution seeks to improve productivity through a more efficient allocation of existing human resources rather than through an increase in workforce size.

Within this context, the study aims to analyse the operational needs of the filling area and to define and standardise the responsibilities that can be integrated into the role of the Provisioner.

As a measurable outcome, the initiative targets an increase of approximately 5% in the overall productivity indicator of the analysed area. This productivity indicator is calculated based on the ratio between the total volume filled and the total man-hours assigned to the operation.

1.2 Company Presentation

CIN is a Portuguese company specialized in the development, production, and commercialization of paints, varnishes, and related coating products. Founded in 1917, the company has accumulated more than a century of experience in the coatings industry, establishing itself as a reference manufacturer in both the Iberian Peninsula and international markets.

CIN has held the leading position in the Portuguese paint market since 1992 and became the leader in the Iberian Peninsula in 1995, following the integration of the Valentine brand. Over the years, the company has expanded its international presence and currently operates several production facilities across Europe and Africa, including Portugal, Spain, France, Italy, the Netherlands, Angola, and Mozambique.

CIN's business is organized into four main market segments:

- **Architectural/Decorative Coatings (58%)**: Paints and varnishes used in the construction sector for professional and domestic applications.
- **Industrial Coatings (23%)**: Coating solutions for industrial materials such as metal, wood, plastic and glass.
- **Protective Anticorrosion Coatings (12%)**: Products designed to protect metal and concrete structures exposed to aggressive environments.
- **Yachting and Marine Coatings (7%)**: Coatings developed for maritime applications, including boats and yachts.

These segments allow the company to address a wide range of applications, including construction, industrial finishing, infrastructure protection and maritime environments.

The headquarters of CIN are located in Maia where the main liquid paint manufacturing plant, the Research & Development Center, and the central distribution facility are situated. The facility is organized into several production units and support areas, described as follows:

- **Raw Material Warehouse (C0)** – Central storage area where raw materials are received and distributed to the different production units.
- **Solid Raw Materials Weighing Facility (S7)** – Area where solid raw materials are weighed prior to being supplied to production.
- **Liquid Raw Materials Weighing Facility (S10)** – Responsible for the preparation and weighing of liquid raw materials.
- **Central Plant (C1)** – Responsible for the production of the general product range. This unit is divided into two main areas: production and filling operations. The present dissertation focuses specifically on the filling area of this plant.
- ***Nováqua* (C2)** – Dedicated to the production of water-based paints.
- **Varnish Production Unit (C4)** – Responsible for the manufacturing of varnish products.
- **Diluent Production Unit (C5)** – Produces diluents used in various paint formulations.
- **Fillers and Putties Production Unit (C6)** – Focused on the production of fillers and surface preparation materials.
- **Industrial Range Production Unit (C8)** – Dedicated to coatings for industrial applications.

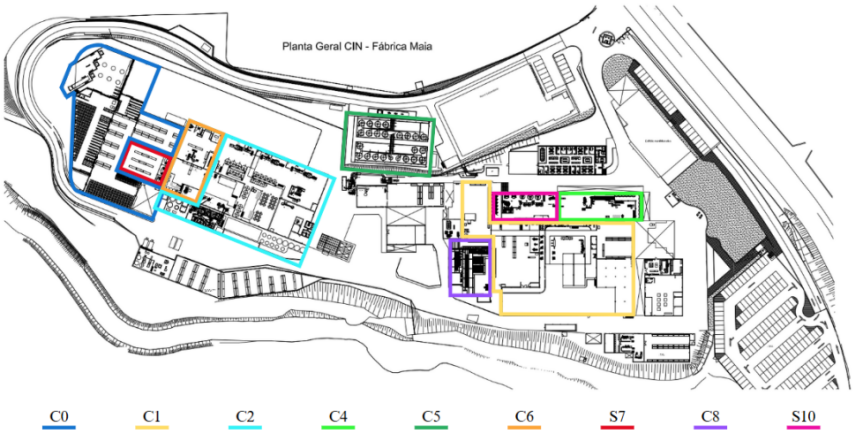


Figure 1.1: CIN headquarters' plant layout

1.3 Adopted Methodology

This project followed a structured approach aimed at understanding the current functioning of the filling area in sector C1, identifying improvement opportunities and evaluating their impact on the organization and productivity of the filling operations. The adopted methodology was a pre-post intervention study which combined direct observation of the production environment, operational analysis, productivity studies and practical implementation of improvement measures adapted to the operational reality of the sector.

To support the development of the project, a planning schedule was defined in order to organize the different phases of the work throughout the duration of the internship. Appendix A presents a Gantt chart illustrating the main phases of the project.

The first stage of the project consisted of a detailed observation phase carried out through several visits to the factory floor. During this phase, the general functioning of the filling area, the operators' tasks and the procedures associated with each filling process were analysed in order to better understand the operational dynamics of the sector. These observations made it possible to identify the main operational difficulties and inefficiencies affecting the filling operations.

Based on the problems identified throughout the observation phase, several operational and productivity studies were developed with the objective of improving the organization and productivity of the sector. As these studies were carried out, some operational difficulties became increasingly evident and were progressively evaluated as potential activities to be integrated into the Provisioner role.

Taking into account both the problems identified and the results obtained throughout the different studies, a standard work procedure was developed in order to define and standardize the responsibilities associated with the Provisioner function within the filling area.

After the definition of the standard work procedure, the Provisioner role started to be progressively introduced to the filling operators in order to ensure that all workers were familiar with the responsibilities and operational objectives associated with this function. The proposed role was then evaluated over a four-week period, during which adjustments and adaptations were introduced whenever necessary in order to ensure the feasibility of the developed procedure within the operational reality of the sector.

Finally, the studies initially performed before the implementation of the Provisioner were repeated under the new operating conditions, this time with the Provisioner actively supporting the filling operations. The obtained results were then compared in order to evaluate the impact of the implemented changes on the productivity and organization of the filling area.

1.4 Dissertation Structure

This dissertation is organised into six chapters.

In addition to this Introduction, Chapter 2 presents the literature review, where the main theoretical concepts and methodologies related to process improvement are discussed.

Chapter 3 analyses the current state of the production section under study, describing the different filling processes, identifying the problems observed, and analysing the main sources of waste.

Chapter 4 presents the solutions developed for the problems identified during the analysis of the filling area, including both the proposed implementation of the Provisioner and the additional studies carried out throughout the period of the internship.

Chapter 5 analyses and compares the performance of the production system before and after the implementation of the proposed solution, evaluating the impact on productivity and operational efficiency.

Finally, Chapter 6 presents the main conclusions of the study and proposes potential developments for future work.

Chapter 2

Literature Review

This chapter presents the theoretical concepts and methodologies that support the development of this dissertation. Since the main objective of the project is to improve the productivity of sector C1 through the implementation of a Provisioner, the literature review focuses on Lean Manufacturing principles, internal logistics support concepts and performance evaluation methodologies related to production flow improvement.

The chapter begins by presenting Lean logistics support concepts associated with material replenishment and production support activities. The role of the Provisioner developed in this project is not commonly described in the literature as a distinct operational function, but its responsibilities are closely related to existing Lean internal logistics concepts. For this reason, particular attention is given to the *junjo* and *mizusumashi* systems, whose objectives and operating principles present strong similarities with the support activities performed by the Provisioner.

Subsequently, Key Performance Indicators (KPI) are introduced as important tools for monitoring and evaluating operational performance within manufacturing systems.

Then, the chapter introduces the fundamental principles of Lean Thinking that support the improvement approach followed throughout this dissertation and the several Lean tools and methodologies relevant to the analysis developed in this work, namely 5S, Day-In-Life-Of, Pareto Charts, Single-Minute Exchange of Die, Visual Management, Overall Equipment Effectiveness (OEE) and Standard Work.

2.1 Lean Logistics Support Concepts

Lean Manufacturing principles emphasize the importance of creating continuous flow and reducing NVA activities throughout production systems (Kaizen Institute, 2024a). Within this context, internal logistics assumes a critical role in ensuring the efficient supply of materials, components and information to production lines while minimizing operational interruptions and unnecessary movement waste (Coimbra, 2013).

Despite the relevance of logistics support activities within Lean environments, the literature does not provide a specific or standardized definition for a Provisioner. Different terminologies

are used in both literature and industrial practice to describe logistics support functions within production environments, including terms such as *line feeder*, *internal logistics operator*, *water spider* and *mizusumashi* (Perloiro, 2020; BOOST 4.0 Project, 2020; Wang, 2013; Coimbra, 2013). Although these concepts differ in scope and application, they generally share the objective of supporting production flow through material replenishment and logistics assistance activities (Coimbra, 2013; BOOST 4.0 Project, 2020).

Among the Lean concepts most closely associated with this type of logistics support function are the concepts of *junjo* and *mizusumashi*, both related to internal logistics flow and production support operations (Coimbra, 2013).

2.1.1 Junjo

The term *junjo* is commonly associated with sequenced delivery systems within Lean production environments (Coimbra, 2013). In this approach, materials and components are delivered according to the exact production sequence in which they will be used, instead of being replenished exclusively according to stock consumption as in traditional kanban systems (Coimbra, 2013).

According to Coimbra, the *junjo* system operates through sequenced picking lists that allow the logistics operator to prepare and deliver materials in the precise order required by production. This methodology contributes to improved synchronization between logistics and production activities while reducing unnecessary operator movement and the amount of material stored near the workstation (Coimbra, 2013).

The literature also highlights that *junjo* systems are particularly advantageous in production environments with high product variety and frequent production changes, where material organization and sequencing become increasingly important (Coimbra, 2013). By supplying materials according to the production sequence, the system contributes to a more organized and stable production flow (Coimbra, 2013).

2.1.2 Mizusumashi

The *junjo* and *mizusumashi* concepts are closely connected within Lean internal logistics systems. While *junjo* focuses on the synchronization and sequenced delivery of materials according to production requirements, the *mizusumashi* is typically responsible for physically executing these logistics flows through standardized supply routes and replenishment cycles (Coimbra, 2013).

The *mizusumashi* system, also commonly referred to as the "water spider" system, represents one of the main operational approaches used to support internal logistics flow in Lean environments (Coimbra, 2013; Kaizen Coach, 2024; Velaction Continuous Improvement, 2024). The term describes a dedicated logistics operator responsible for supplying and transporting materials, supporting production flow through standardized routes and fixed supply cycles (Coimbra, 2013).

According to Coimbra, the *mizusumashi* operates between supermarkets and production lines using predefined routes with fixed cycle times, ensuring the continuous replenishment of materials and the collection of empty containers and production information. The main objective of this

system is to centralize logistics-related tasks in a dedicated operator, allowing production operators to remain focused on value-added activities (Coimbra, 2013).

Several authors and Lean practitioners describe the *mizusumashi* as a key element in reducing operational interruptions and unnecessary movement waste within production systems (Kaizen Coach, 2024; Velaction Continuous Improvement, 2024; Flexpipe, 2024). By ensuring that materials, containers and auxiliary resources are continuously available near the workstation, the system contributes to improved flow stability, reduced waiting times and increased productivity (Coimbra, 2013; 6Sigma, 2024).

Additionally, the *mizusumashi* concept is strongly associated with standardized work practices, including predefined routes, fixed replenishment cycles and standardized logistics tasks (Velaction Continuous Improvement, 2024; 6Sigma, 2024). This standardization contributes to greater process predictability, improved operational consistency and reduction of variability within production support activities.

This interpretation is reinforced by Perloiro (Perloiro, 2020), who defines the *mizusumashi* as an "internal logistics operator" responsible for supplying products, materials and information to workstations according to production requirements, while simultaneously preventing operators from being interrupted by non-value-added activities and unnecessary movement waste. Similarly, research related to production logistics describes the "internal logistics operator" as responsible for picking and moving materials throughout the shopfloor in order to support manufacturing operations (Wang, 2013).

Studies related to Lean logistics and assembly line replenishment also describe comparable functions using the term "line-feeding operator" (BOOST 4.0 Project, 2020), where logistics operators are responsible for supplying materials directly to the point of use, collecting empty containers and ensuring the continuity of production flow through standardized replenishment circuits. Although different terminology is used, these functions present strong similarities regarding material supply, logistics support and reduction of production interruptions (Perloiro, 2020; BOOST 4.0 Project, 2020; Wang, 2013).

While the provisioner function developed in this project does not directly correspond to a single specific Lean concept described in the literature, several of its operational principles are closely related to the concepts previously presented, particularly regarding workstation supply, reduction of operator displacement, support of production flow and reduction of non-value-added activities.

2.2 Key Performance Indicators

KPI are metrics used to evaluate the performance of processes and organizations, supporting decision-making based on objective and measurable data. In management contexts, KPI function as reference indicators that allow managers to monitor progress toward specific goals and assess whether operational activities are aligned with organizational objectives (Bartolucci et al., 2026; Marr, 2012).

KPI play an important role in performance management systems by providing measurable information that helps organizations track results, identify deviations, and implement corrective actions when necessary. These indicators also enable comparisons between current and past performance, as well as benchmarking against other organizations or internal targets, supporting continuous improvement initiatives (Setiawan and Purba, 2020).

Depending on their application, KPI can be classified into different categories, such as operational, financial or strategic indicators. In manufacturing environments, operational KPI are particularly relevant, as they support the monitoring of production performance, process efficiency and operational stability (Pinto, 2009).

Several operational KPI are commonly used in manufacturing systems to evaluate different dimensions of performance. In Lean manufacturing environments, production systems are typically monitored through multiple indicators associated with productivity, quality, equipment performance and process efficiency (Ante et al., 2018; Ndlela et al., 2020).

Since manufacturing performance is multidimensional, organizations often combine different KPI in order to obtain a broader understanding of operational performance and identify improvement opportunities within production systems (Ante et al., 2018).

A widely used indicator in manufacturing environments is the OEE, which combines availability, performance and quality into a single metric. OEE provides a global perspective of equipment utilization and allows organizations to identify productivity losses associated with machine stoppages, reduced operating speed and quality defects (MOUHIB et al., 2024; Ndlela et al., 2020).

Indicators associated with productivity, lead time, downtime and process efficiency are also highly relevant in manufacturing environments, particularly within Lean production systems (Ante et al., 2018).

By providing clear and measurable information about process performance, KPI help organizations monitor their operations and ensure that activities remain aligned with strategic objectives (Pinto, 2009).

2.3 Lean Thinking

Lean Thinking is a management philosophy focused on improving organizational performance through the systematic elimination of waste and the creation of value for the customer. Womack and Jones, 2003 describe lean as an approach that seeks to maximize value while minimizing the resources required to deliver products or services. In this context, waste is defined as any activity that does not add value from the customer's perspective.

The origins of Lean Thinking can be traced back to earlier industrial management approaches developed during the beginning of the twentieth century, particularly Scientific Management proposed by Frederick Taylor and the Ford Production System introduced by Henry Ford. Taylor's approach focused on work standardization, task optimization and productivity improvement through systematic process analysis, while Ford implemented large-scale mass production systems based on standardized products and continuous flow (Lean Enterprise Institute, 2024a).

Although these production models significantly improved industrial productivity, they were highly dependent on large production batches, high inventory levels and limited product variety. Following the economic difficulties experienced after the Second World War, Japanese manufacturers began adapting these concepts to their own industrial reality, focusing on flexibility, waste reduction and process efficiency (Lean Enterprise Institute, 2024a).

In this context, the Toyota Production System (TPS) emerged in Japan and was largely shaped by the work of Taiichi Ohno (Melton, 2005; Lean Enterprise Institute, 2024a). Unlike traditional mass production systems, TPS focused on continuous flow, reduction of non-value-added activities and continuous improvement through the concept of *Kaizen*. This production philosophy challenged the dominant Western manufacturing model based on large-scale standardized production and complex planning systems (Melton, 2005; Lean Enterprise Institute, 2024a).

At its core, Lean Thinking aims to achieve more efficient operations by using fewer resources, including less effort, time, space, and materials, while still delivering exactly what customers require (Womack and Jones, 2003). By focusing on the entire value stream rather than on isolated processes, organizations are able to identify inefficiencies and improve the overall performance of the production system (Pinto, 2009). Studies conducted by the Lean Enterprise Research Centre indicate that, in many manufacturing environments, only a small proportion of activities actually add value to the final product, while a significant share of operations consists of non-value-added tasks (Melton, 2005). This highlights the significant potential for improvement through waste elimination.

The implementation of Lean principles has been widely associated with several operational benefits, including reduced lead times, lower inventory levels, improved process robustness, and better knowledge management (Melton, 2005). Although Lean Thinking originated in the automotive industry, its principles have since been successfully applied across a wide range of sectors, including manufacturing, supply chain management, and service industries (Pinto, 2009).

Several decades later, these production principles were reintroduced and popularized in Western industry through the concept of Lean Thinking, particularly after the publication of the work by Womack and Jones, who formalized Lean as a management philosophy focused on value creation and waste elimination (Womack and Jones, 2003; Lean Enterprise Institute, 2024a).

More broadly, Lean can be understood as both a philosophy and a practical approach to organizational management. It begins with the identification of customer value and continues through the continuous improvement of processes and workflows. Through ongoing experimentation and learning, organizations adopting Lean practices seek to progressively reduce waste, improve process flow, and enhance product or service quality (Institute, 2023).

2.3.1 Lean Principles

As said before, Lean Thinking focuses on maximizing value for the customer while minimizing waste in processes. This approach is based on five fundamental principles that guide organizations in improving efficiency and reducing non-value-adding activities and that according to (Womack and Jones, 2003) are defined as follows:

- **Specify Value:** Value must be defined from the perspective of the final customer. Only activities that contribute directly to what the customer is willing to pay for should be considered valuable.
- **Identify the Value Stream:** The value stream includes all the steps required to bring a product from raw material to the final customer. By mapping these steps, it becomes possible to identify and eliminate activities that do not add value.
- **Create Flow:** Once waste has been removed, the remaining value-adding activities should occur in a continuous and efficient flow without interruptions, delays, or bottlenecks.
- **Establish Pull:** Production should be driven by actual customer demand. In a pull system, products are produced only when required, preventing overproduction and excess inventory.
- **Pursue Perfection:** Lean encourages continuous improvement, where organizations constantly seek to reduce waste, improve processes, and move closer to perfect value delivery.

2.3.2 The seven wastes

In section 2.3 we defined waste as any activity that does not add value to the final product or service. In Lean philosophy, these activities are called *muda*, a Japanese term used to describe actions that consume resources and time without creating value. As a result, they increase operational costs and make products or services more expensive than necessary (Pinto, 2009).

According to Taiichi Ohno, there are seven main types of waste that can be found in any production process (Womack and Jones, 2003; Melton, 2005):

- **Overproduction:** Producing more items than required or producing them earlier than needed.
- **Waiting:** Periods of time when people, materials, or equipment are waiting for the next step in the process.
- **Transportation:** Unnecessary transport of materials and products between process stages.
- **Over-processing:** Performing more work that does not add more value to the product
- **Inventory:** Stacks of parts waiting to be completed or finished products waiting to be shipped.
- **Defects:** Production of defective items that require rework or must be discarded.
- **Motion:** Unnecessary movement of workers during the production process.

Although the traditional Lean approach defines seven main categories of waste, several authors later proposed the inclusion of an eighth waste associated with the underutilization of people (Womack and Jones, 2003; Wahab et al., 2013). This waste refers to situations where employees' knowledge, skills and improvement potential are not fully utilized within the organization. It

includes aspects such as poor task allocation, uneven workload distribution, lack of employee involvement in continuous improvement activities and failure to leverage workers' experience and problem-solving capabilities (Wahab et al., 2013).

2.4 Lean Tools

2.4.1 5S

The concept of 5S originated in Japan and was developed during the 1960s b y Sakichi Toyoda, Kiichiro Toyoda and Taiichi Ohno as part of the development of lean production practices. The main objective of this tool is to create a clean and organized workplace that supports efficiency and promotes a culture of continuous improvement within organizations (Oliveira et al., 2017).

The 5S methodology refers to a set of workplace organization practices aimed at reducing waste and improving the performance of both people and processes. This approach focuses on maintaining optimal workplace conditions by promoting organized, clean, and efficient working environments. As a result, it contributes to improved productivity, operational efficiency, and overall process performance (Pinto, 2009).

The methodology is composed of five sequential steps, each represented by a Japanese term that describes a specific workplace practice. According to (Oliveira et al., 2017) they are described as follows:

- **Seiri (Sort)** – This step involves identifying and removing unnecessary items from the workplace. Only the materials, tools, and equipment required to perform the tasks should remain available, eliminating clutter and reducing waste.
- **Seiton (Set in Order)** – After unnecessary items are removed, the remaining tools and materials must be organized efficiently. Each item should have a designated place, allowing for quick identification and easy access, which helps reduce time losses and improve workflow efficiency.
- **Seiso (Shine)** – This step focuses on cleaning and maintaining the workplace. Regular cleaning contributes to a safer working environment and allows potential problems in equipment or products to be detected more easily.
- **Seiketsu (Standardize)** – In this stage, standards and procedures are established to ensure that the first three steps are consistently applied. Standardization helps maintain workplace organization and supports the long-term effectiveness of the methodology.
- **Shitsuke (Sustain)** – The final step focuses on maintaining discipline and ensuring that the 5S practices are continuously followed. This often involves regular audits and monitoring activities to guarantee the sustainability of the methodology.

The implementation of the 5S methodology provides several benefits for organizations, particularly by improving workplace organization, reducing wasted time and space, increasing operational efficiency, and supporting the development of a culture of continuous improvement (Oliveira et al., 2017).

2.4.2 Day in Life Of

Day in Life Of (DILO) is an observational analysis tool used to understand how employees spend their working time throughout a typical shift. The method consists of continuously monitoring an operator and recording the activities performed, their duration, and their sequence. This approach provides a detailed representation of actual work practices and enables a comprehensive understanding of how daily tasks are executed (ToolsHero, 2024; DMAIC, 2024).

The data collected during a DILO study can be used to analyse the distribution of time across different activities and identify inefficiencies within a process. In particular, the method is frequently applied to distinguish between Value-Added (VA) and NVA activities, quantify sources of waste, and identify interruptions, waiting periods, or unnecessary movements that negatively affect operational performance (ToolsHero, 2024; DMAIC, 2024).

Within Lean Manufacturing and continuous improvement initiatives, DILO studies support process analysis by providing objective information about how resources are utilized. The insights obtained can be used to redesign workflows, redistribute responsibilities, standardize work methods, and develop improvement actions aimed at increasing productivity and operational efficiency (ToolsHero, 2024; DMAIC, 2024).

2.4.3 Pareto Chart

Pareto Charts are quality improvement tools used to identify and prioritize the factors that contribute most significantly to a given problem. The method is based on the Pareto Principle, commonly referred to as the 80/20 rule, which suggests that a relatively small number of causes are often responsible for the majority of observed effects. By highlighting these critical causes, Pareto analysis enables organizations to focus improvement efforts on the areas with the greatest potential impact (Larson and Whitney, 2025; Kaizen Institute, 2024b).

A Pareto Chart combines a bar chart with a cumulative percentage line. The bars represent the frequency or impact of each category and are arranged in descending order, while the cumulative line indicates the proportion of the total effect accounted for by the categories considered. This representation facilitates the identification of the "vital few" causes responsible for the largest share of a problem and supports data-driven decision making.(Larson and Whitney, 2025).

Within Lean Manufacturing and continuous improvement projects, Pareto Charts are widely used during problem-identification and root-cause analysis activities. By distinguishing the most significant sources of waste, defects, or inefficiencies from less relevant issues, the method helps improvement teams prioritize actions and allocate resources more effectively (Kaizen Institute, 2024b; Larson and Whitney, 2025).

2.4.4 Single-Minute Exchange of Die

Single-Minute Exchange of Die (SMED) is a Lean methodology developed by Shigeo Shingo within the TPS with the objective of reducing setup and changeover times (Oliveira et al., 2017; Kaizen Institute, 2024c). The methodology focuses on minimizing machine downtime during production changes, contributing to improved flexibility, reduced lead times and lower inventory levels.

The SMED approach is based on the distinction between two types of setup operations: internal operations, which can only be performed while the machine is stopped, and external operations, which can be executed while the machine is still operating (Oliveira et al., 2017; Kaizen Institute, 2024c). One of the main objectives of SMED is to progressively convert internal activities into external activities, thereby reducing equipment stoppage time during changeovers.

Additionally, SMED emphasizes process standardization and the definition of standardized setup procedures, allowing organizations to reduce variability and improve operational consistency (Oliveira et al., 2017). According to the Kaizen Institute (Kaizen Institute, 2024c), reducing setup times also enables companies to operate with smaller production batches, increasing production flexibility and improving responsiveness to customer demand.

The implementation of SMED has enabled many companies to significantly reduce changeover durations, improving productivity, reducing waste and supporting smoother production flow (Kaizen Institute, 2024c).

2.4.5 Visual Management

Visual Management is a Lean Management approach that aims to improve operational efficiency by making information visible, clear, and easy to understand within the workplace. By using visual elements such as boards, signals, charts, and standardized markings, it allows workers to quickly understand the current state of operations and identify potential problems. According to (Pinto, 2009), visual management supports the improvement of processes by making activities more logical, intuitive, and transparent.

Several authors highlight that visual management facilitates communication and promotes faster problem identification. Hall describes visual management as a form of communication that relies on visual cues rather than verbal instructions, enabling workers to monitor the status of operations and react quickly to deviations (Hall, 1987).

2.4.6 Overall Equipment Effectiveness

OEE is a Key Performance Indicator used to evaluate the overall performance of a production system or equipment. Originally developed within the framework of Total Productive Maintenance, OEE aims to measure how effectively manufacturing resources are utilized by considering the main sources of production losses (Pinto, 2009; Oliveira et al., 2017).

The OEE metric provides a global perspective of equipment performance by integrating three fundamental components: Availability, Performance and Quality (MOUHIB et al., 2024). By

combining these elements into a single indicator, OEE allows organizations to identify inefficiencies, monitor equipment reliability, and support continuous improvement initiatives within manufacturing systems. Additionally, comparing expected and actual OEE values can help organizations detect operational problems, improve maintenance strategies, and reduce production losses. (Oliveira et al., 2017)

OEE is calculated as the product of three performance factors, as shown in Equation (2.1).

$$OEE = Availability \times Performance \times Quality \tag{2.1}$$

Where, according to (MOUHIB et al., 2024):

- **Availability** measures the proportion of scheduled production time during which the equipment is operating. It considers losses associated with machine stoppages, such as equipment failures and setup activities. It is computed as in Equation (2.2)

$$Availability = \frac{Total\ Time - Downtime}{Total\ Time} \tag{2.2}$$

- **Performance** evaluates whether the equipment is operating at its theoretical maximum speed, considering minor stops and reduced operating speed, as represented in Equation (2.3).

$$Performance = \frac{Processed\ Quantity \times Theoretical\ Cycle\ Time}{Operating\ Time} \tag{2.3}$$

- **Quality** represents the proportion of good units produced in relation to the total production, as shown in Equation (2.4).

$$Quality = \frac{Processed\ Quantity - Defective\ Quantity}{Processed\ Quantity} \tag{2.4}$$

By analysing these three components, OEE provides a structured way to identify the main sources of productivity losses and supports decision-making aimed at improving equipment utilization and overall production efficiency (MOUHIB et al., 2024).

2.4.7 Standard Work

According to Pinto, 2009, process standardization is a fundamental principle of Lean Thinking, ensuring that tasks are performed consistently across operators and shifts. Standard work defines the best-known method for executing an activity, specifying the sequence of operations, the tools to be used, and the procedures to follow. By establishing clear and shared guidelines, it reduces variability, increases process stability, and creates a baseline for continuous improvement.

Standardization also plays a key role in ensuring quality, as consistent methods lead to more predictable and reliable outcomes. In Lean, standard work is typically structured around three

core elements: *cycle time*, *work sequence*, and *Work In Progress (WIP)*, which together support a stable and continuous production flow (Pinto, 2009).

Historically developed by Ohno in the 1950s, standard work is defined by Jang and Lee as the degree to which operational rules and procedures are formalized and executed. The authors emphasize that teams should have autonomy to define rules that facilitate their work, provided that these rules ensure consistency and eliminate unnecessary variation. Because it prescribes the exact method for performing each task, standard work leaves little room for improvisation and is often used as a training tool for new operators (Oliveira et al., 2017).

Standard work is typically supported by several visual and operational tools used to document, communicate and maintain standardized procedures within production environments. According to the Lean Enterprise Institute (Lean Enterprise Institute, 2024b), common tools associated with standardized work include standardized work charts, work instruction sheets, process sequence diagrams and visual management aids. These tools help operators understand task sequences, required movements, cycle times and operational responsibilities, contributing to improved process consistency and reduction of variability (Lean Enterprise Institute, 2024b).

Additionally, standardized procedures are often complemented by visual support systems such as checklists, workflow diagrams and operational instructions displayed at the workstation. These resources facilitate training activities, improve communication between operators and support the sustainability of continuous improvement initiatives within Lean environments (Lean Enterprise Institute, 2024b).

The benefits of standard work include variability reduction, cost reduction through waste elimination, improved quality by minimizing operator-dependent differences, increased worker involvement by shifting the focus from individual error to system design, and the creation of a solid foundation for continuous improvement. As stated in Womack and Jones, 2003, standard work provides a precise description of each activity, including cycle time, task time, sequence, inventory levels, and operational standards.

Chapter 3

Current State Overview

The objective of this chapter is to characterize the current organization of the filling operations in the C1 sector at CIN's Maia production plant and identify the main inefficiencies affecting the department's performance.

To support this analysis, the chapter presents the layout of the filling area, the overall filling process and the operational characteristics of the different filling systems currently in use. Additionally, the main operational challenges identified throughout the observation phase are analysed and discussed, providing the foundation for the improvement studies and proposals developed in the following chapters.

3.1 Layout of the Filling Area

Sector C1 is composed of two interconnected operational areas: the Manufacturing Area (C1F) and the Filling Area (C1E). These areas operate sequentially, as the overall workflow depends on the coordinated execution of both stages. The paint is initially produced in the tanks of the C1F area and subsequently filled into the corresponding containers by the C1E team, according to the production plan.

The first floor of the building is primarily dedicated to C1F operations, where the mixing tanks and most production equipment are located. The ground floor corresponds mainly to the C1E filling area, although several C1F machines are also installed on this level.

Appendix B presents the layout of the C1E floor, highlighting the main functional zones and equipment installed in the area.

- **Daily Kaizen area** — Dedicated space where daily meetings are held to analyse the previous day's productivity and production results, align the operational plan for the current day and discuss improvement opportunities and operational concerns.
- **Strapping and finished product zone** — Area where completed pallets are strapped and temporarily stored, organized and stored before shipment preparation.

- **Packaging material area** — Staging area where containers and lids are placed after being prepared by the packaging team. The materials are organized by filling machine, allowing operators to quickly identify and access the required materials during setup operations.
- **Automatic filling machines** — ME-35, ME-36 and ME-53.
- **Semi-automatic filling machines** — ME-30, ME-60 and ME-61.
- **Two Manual filling stations**.

Overall, the layout and equipment distribution within the C1E area provide an overview of how the filling operations are organized throughout the department and help contextualize the processes and inefficiencies analysed in the following sections.

3.2 Filling Process Overview

In order to better understand the operational dynamics of the C1E filling area, a swimlane-styled process map was developed to represent the overall filling process.

The resulting map, presented in Appendix C, synthesizes the operational flow from production planning to shipment preparation.

The C1E filling area is composed of a team of six operators responsible for executing the filling operations across the different filling systems within the department. Although operators may occasionally rotate between machines according to production requirements, they are generally associated with specific types of filling operations based on their experience and training.

The process begins with the weekly production plan which is defined by the team leaders from C1E and C1F. Based on the planned production requirements, the packaging team prepares the necessary labels and separates the required packaging material for each filling order.

Simultaneously, the paint manufacturing process is initiated in the C1F section. After manufacturing, the product is submitted to quality control before being released for filling operations. Following product approval and the availability of the corresponding containers and lids in the Packaging Material Area, setup activities are initiated.

These activities include gathering materials, adjusting the machines according to the containers dimensions, performing cleaning procedures when required and conducting operational verification tasks before production startup.

During filling operations, containers are palletized continuously as they are produced. For containers below 4 Liters (L), operators must first assemble the cardboard boxes and place the filled containers inside them. The boxes then pass through the Strapex machine, where adhesive tape is automatically applied before palletization (see Appendix D for an illustration of the equipment). For containers above 4 L, this secondary packaging operation is unnecessary, as the filled containers are placed directly onto pallets. However, some specific products of 4 L also require secondary cardboard packaging, which is not always performed simultaneously with the filling process itself, as discussed later in this dissertation.

After pallet completion, the pallets are transported to the strapping and finished product area, where they are strapped, if needed, and organized before shipment preparation. At the end of each filling order, operators verify whether additional products remain scheduled for production. If no further filling operations of the same product are planned, machine cleaning procedures are initiated.

This initial process analysis provided a global understanding of the operational workflow and served as the basis for the subsequent studies developed throughout this dissertation.

3.3 Filling Equipment Characterization

As previously mentioned, the C1E area includes three different types of filling systems: automatic, semi-automatic and manual. The following sections provide a more detailed characterization of each system in order to highlight their operational differences and specific requirements.

Automatic Filling Machines

The automatic filling systems operate according to the same general filling principle, although the ME-35 differs from the remaining two machines due to both its layout configuration and the nature of products processed.

The ME-35 is exclusively dedicated to water-based products and has a U-shaped layout configuration (illustrated in Figure 3.1a). In this machine, the feeding area, where empty containers are initially placed, is positioned close to the end-of-line. This arrangement significantly reduces operator displacement throughout the operation. In contrast, the ME-36 and ME-53 machines have a linear layout, requiring greater movement between the beginning and the end of the filling line, as shown in Figure 3.1b.



(a) ME-35 (b) ME-53

Figure 3.1: Automatic filling machines operating in the C1E area

These automatic systems are exclusively used for containers up to 4 L. During operation, empty containers are placed on the machine feeding table and automatically transported through

the conveyor system to the filling station, before continuing towards the end-of-line accumulation area.

Before each filling operation, setup activities must be performed on the machine depending on the product and packaging format being processed. There are three types of setup within the automatic machines: Brand (M), Container (E) and Intermediate Product (PI). Table 3.1 summarizes these three types of setup.

Table 3.1: Types of setup

Setup Type	**Description**
M	Change of brand between consecutive filling operations while maintaining the same product. This setup typically involves only control and verification activities. Since no machine adjustment or cleaning procedure is required, this is the shortest setup type.
E	Change of container size between consecutive filling operations. This setup requires mechanical adjustments to the machine in order to ensure correct positioning and filling accuracy according to the new packaging dimensions.
PI	Change of product between consecutive filling operations, requiring cleaning proceures before production restart. Depending on product compatibility, the cleaning level can vary between no cleaning, quick cleaning or thorough cleaning. In some cases, a packaging format or brand change may occur simultaneously, requiring additional machine adjustments associated with an E or M setup.

Consequently, setup duration varies significantly depending on the type of setup being performed and the cleaning and adjustment requirements associated with the product change.

Once production begins, operators are responsible for continuously supporting the operation throughout the filling process. Their tasks include replenishing empty containers and lids, monitoring the general operation of the equipment and palletizing the filled containers at the end-of-line. The operation is highly dependent on the uninterrupted execution of these activities, since the machine has to stop whenever the end-of-line accumulation area becomes full or it automatically stops whenever empty containers or lids are unavailable.

As these machines present the highest production rate within the C1E sector, maintaining workflow continuity becomes particularly important for ensuring productivity.

All automatic filling machines include an integrated Strapex machine for packaging operations once they frequently work with containers smaller than 4 L. In these situations, operators must first assemble the cardboard boxes before placing the filled containers inside them.

These automatic filling systems therefore provide high production capacity and elevated operational efficiency. However, their performance remains strongly dependent on continuous operator support throughout the filling process.

Semi-Automatic Filling Machines

Unlike the automatic filling systems, where containers are automatically conveyed through the filling line after being loaded onto the feeding table, the semi-automatic machines require continuous manual feeding throughout the entire operation, as each container must be manually positioned underneath the filling nozzle before the filling cycle can begin. As a result, the filling operation requires a higher level of operator involvement and is more sensitive to operator availability and movement throughout the operation.

Although all semi-automatic filling machines operate according to the same general principle, the ME-61 differs from the ME-30 and ME-60 due to its L-shaped layout. By reducing the distance between the feeding and palletizing areas, this configuration minimizes operator displacement and allows a single operator to manage the operation in most situations without significantly compromising productivity. In contrast, the ME-30 and ME-60 machines have a linear layout, requiring greater movement between the beginning and the end-of-line.

Due to the operating mode described above, the filling process requires continuous operator presence at the beginning of the line. If the same operator were also responsible for palletizing activities, the repeated displacement between both ends of the machine would interrupt the filling operation and significantly increase physical fatigue. For this reason, the ME-30 and ME-60 machines typically operate with two operators.

The operator positioned at the beginning of the line is responsible for labeling the containers whenever necessary, positioning the empty containers underneath the filling nozzle, initiating the filling process and placing the lids on the filled containers. Meanwhile, the second operator remains at the end-of-line, removing filled containers from the accumulation area, palletizing them and relocating completed pallets.

The semi-automatic systems are considerably more versatile regarding packaging capacity and are used for a wide range of container sizes, ranging from small containers between 2 and 5 L to large drums of up to 200 L. Although smaller containers may occasionally be filled on these machines, this situation is relatively uncommon and usually restricted to limited production quantities. Unlike the automatic filling systems, the semi-automatic machines do not include an integrated Strapex unit for packaging operations. Therefore, whenever containers requiring cardboard packaging are filled, either a second operator must be assigned to perform the packaging activities or the filled containers must be temporarily stored on pallets and packaged later in a separate operation.

Setup operations also involve machine adjustments according to the containers dimensions being processed and may require cleaning procedures depending on the compatibility between consecutive products.

From an operational perspective, the semi-automatic machines provide significant flexibility regarding containers' size and product types. However, this flexibility comes at the cost of greater manual intervention.

Manual Filling Stations

The manual filling stations differ significantly from the automatic and semi-automatic systems, as the filling operation is performed entirely through direct operator intervention rather than through an integrated filling machine.

The setup preceding the filling operation also differs significantly from the remaining filling systems. In addition to placing the mobile paint tank under agitation and gathering the corresponding containers to be filled, operators must collect the weighing scale used to control the filling quantity, the tamping equipment required to seal the lids and the label support structure whenever manual labeling is necessary. Right before operation begins, the mobile paint tank is positioned on an elevated platform located in the manual filling area. Below this tank, a smaller intermediate tank is installed in order to regulate the paint flow supplied to the containers during filling. This layout can be seen in Figure 3.2.



Figure 3.2: Manual Filling Station

The filling operation itself is controlled manually throughout the entire process. Initially, the operator allows a certain quantity of paint to flow from the mobile tank into the intermediate tank. The container is then positioned underneath the filling valve and placed on top of the weighing scale, allowing the operator to continuously monitor the weight and manually stop the filling process once the target quantity is reached.

After filling, the operator places the lid on the container, seals it using the tamping equipment and palletizes the finished container. This sequence is repeated individually for each container throughout the operation.

Similarly to the semi-automatic filling systems, the manual filling stations provide considerable operational flexibility regarding containers' capacity and product types. However, due to the entirely manual nature of the operation, these stations generally present lower production cadence and require greater operator effort throughout the filling process.

Despite the high level of manual intervention required during production, setup activities in the manual stations are generally simpler and faster than those associated with the automatic and semi-automatic systems. Since the mobile tanks and intermediate tanks are removed after each operation and transported to the washing area by the logistics operator, the filling station itself does not require extensive cleaning procedures between consecutive products.

Additionally, multiple intermediate tanks are normally available within the department, allowing subsequent filling operations to begin without waiting for the cleaning process of the previous tank to be completed.

Despite their lower production cadence, the manual filling stations play an important role in allowing the department to handle a wide variety of products and containers within the department. However, these operations remain highly dependent on repetitive manual handling and continuous operator movement during operation.

The operational differences between the automatic, semi-automatic and manual filling systems significantly influence productivity levels, setup duration, operator allocation and material handling requirements throughout the department. These characteristics also contribute directly to several inefficiencies identified during the analysis phase, discussed in the following section.

3.4 Current Operational Challenges

The analysis of the filling operations within the C1E section revealed several inefficiencies affecting productivity, workflow continuity and resource allocation. Although the department includes different filling systems with distinct operational characteristics, many of the identified issues were transversal to the entire filling process.

The following sections present the main operational challenges identified throughout the observation phase and their impact on the daily operation of the department.

Inefficient Operator Allocation

One of the main inefficiencies identified during the analysis phase was related to the number of operators allocated to each filling machine.

In several situations, two operators were assigned to the same filling operation without a proportional increase in production output. Although the presence of a second operator may reduce operator movement and physical effort in certain situations, productivity levels often decreased due to the increase in labor input.

This issue became particularly relevant considering the limited number of operators available within the C1E area. Allocating additional operators to filling machines without a significant productivity gain reduced the workforce available for other operational activities that could generate greater added value within the department.

Consequently, a detailed productivity study was conducted in order to determine under which conditions the use of one or two operators would be operationally justified.

Excessive Simultaneous Filling Operations

In addition to the inefficient allocation of operators within individual filling machines, difficulties were also identified regarding the overall distribution of operators across simultaneous filling operations.

The C1E area has a total of six operators, meaning that the number of filling machines operating simultaneously must be adjusted according to the available workforce and support capacity. However, during the observation phase, operator distribution was frequently performed without clearly defined criteria regarding the number of filling operations that could realistically occur simultaneously.

As a result, situations frequently occurred in which nearly all available operators were allocated directly to filling machines, leaving insufficient support capacity for external activities.

As the number of active filling machines increased, the workload associated with these support activities also increased significantly. During the initial implementation phase, the provisioner frequently experienced difficulties managing all operational requirements simultaneously.

This situation led to delays in setup preparation, accumulation of pallets awaiting strapping and increased operator movement throughout the department.

Overall, the absence of a structured evaluation of feasible operational scenarios contributed to situations in which the operational workload exceeded the department's effective support capacity.

Strapping Operations and Workload Distribution

The workload associated with strapping activities varied significantly depending on the daily production schedule and on the number of completed pallets requiring strapping throughout the shift. During periods of lower production activity, the existence of a permanently dedicated strapping operator appeared disproportionate to the effective workload generated by the activity.

These observations motivated the development of a study aimed at quantifying the real workload associated with pallet strapping operations and evaluating whether the permanent allocation of an operator exclusively dedicated to this task was operationally justified.

Filling Schedule Instability

During the observation period, considerable instability was identified in the execution of the filling schedule.

Although a weekly filling plan is prepared every Friday to organize the production activities for the following week, the schedule was rarely executed as initially defined.

Frequent changes to the planned production sequence were observed throughout the week, mainly due to the introduction of urgent filling orders requiring immediate prioritization, as well as communication and coordination issues between different production sectors, which occasionally resulted in materials or products not being available at the scheduled filling time.

These constant adjustments reduced production predictability and made it considerably more difficult to organize filling operations efficiently. Since operators were often unable to anticipate upcoming filling orders, setup preparation activities became less efficient and ongoing setups frequently had to be interrupted or modified in response to changing production priorities.

As a result, additional time was spent reorganizing operations, adapting machine setups and coordinating activities between production, filling and packaging teams in order to respond to continuously changing production requirements.

Material Availability

The instability of the filling schedule also had a direct impact on material availability within the department.

Since packaging materials and labels are prepared according to the weekly production plan, frequent deviations from the planned sequence increased the probability of materials not being available when required for filling operations. In situations where products initially scheduled for later periods needed to be filled earlier due to urgent production requests or replanning activities, the corresponding packaging materials had often not yet been fully prepared by the packaging team. Consequently, operators were frequently forced to wait for materials, interrupt setup activities or perform additional coordination tasks before production could begin.

Packaging Operations

As discussed previously, for containers below 4 L, operators are required to assemble cardboard boxes, place the filled containers inside them and subsequently pass the boxes through the Strapex machine before palletization.

Although these activities are necessary to ensure packaging conformity, they do not directly contribute to the filling process itself and represent an additional operational workload associated with the operation.

A specific inefficiency was identified in certain 4 L filling operations. These products are usually filled in the manual stations, which do not include an integrated Strapex system. Therefore, the containers are frequently filled first and only packaged into cardboard boxes afterwards.

As a result, filled containers accumulate temporarily in an intermediate area awaiting subsequent packaging and palletizing operations.This operational sequence generates additional handling activities, increases waiting time and creates non-value-added tasks after the filling process itself has already been completed.

Setup Issues

Another recurrent inefficiency identified during setup operations was associated with tank agitation activities. According to the production requirements specified in the shop order, certain products must remain under agitation for a defined period before the filling operation can begin.

Ideally, the agitation process should be initiated immediately at the beginning of the setup procedure, allowing operators to perform the remaining setup activities while the product is mixing. However, during the observation phase, it was frequently verified that operators only initiated tank agitation during the later stages of setup preparation.

As a result, several setup activities were completed before the mandatory agitation period had elapsed, generating unnecessary waiting time before production startup and increasing total setup duration.

Chapter 4

Proposed Solutions and Operational Improvements

Following the analysis of the current state presented in Chapter 3, several operational studies and improvement initiatives were developed to address the main inefficiencies identified in the C1E filling area.

The analyses performed during the initial phase of the project revealed that a significant portion of operators' working time was being consumed by NVA activities. In addition, the allocation of operators to filling machines was often based on empirical decisions rather than on objective productivity criteria, leading to situations of inefficient resource utilisation.

Several studies were therefore conducted under real production conditions, including productivity studies, operational scenario evaluations, DILO studies, setup analyses, and workload assessments related to strapping operations. These studies provided operational support for the implementation of a new organizational model centered around the Provisioner.

The proposed improvements focus not only on increasing productivity, but also on improving workflow stability, reducing setup-related interruptions, standardizing operational practices, and ensuring a more efficient distribution of responsibilities between filling operators and support functions.

This chapter is divided into two main sections: Operational Performance Studies and Implementation and Standardisation of the Provisioner Role. The first section presents studies that are not directly related to the implementation of the Provisioner but that contributed to improving the overall productivity and operational performance of the filling area. The second section focuses on the development and implementation of the Provisioner role, presenting the analyses and studies conducted throughout the internship to support its organisation and integration into daily operations.

4.1 Operational Performance Studies

This section presents two operational studies conducted within the C1E filling area. The first evaluates the relationship between operator allocation and productivity across the different filling systems, while the second analyses the packaging and palletising process associated with 4 L containers. Together, these studies provided important insights into resource utilisation and workflow organisation, supporting the identification of opportunities to improve operational performance.

4.1.1 Productivity Studies

During the initial observation phase, it was identified that the number of operators assigned to the filling machines was not always aligned with the actual operational requirements of each process, often resulting in inefficient resource allocation without a clear productivity benefit.

To better understand the impact of operator allocation on operational performance, several productivity studies were conducted across the different filling systems operating in the C1E area. One of the project's objectives was to evaluate the productivity achieved with one and two operators for each packaging size range on every filling machine. The main purpose was to determine under which operating conditions one or two operators should be assigned to each machine type in order to ensure efficient resource utilisation.

Methodology

The analyses were carried out under normal production conditions for automatic, semi-automatic and manual filling operations.

For each study, the operating time, produced quantity, operator tasks and unplanned stoppages were recorded using standardised productivity worksheets, presented in Appendix E. Productivity was measured in Litres per Man-Hours (L/m-h), calculated as the ratio between the total volume filled, in Liters (L), and the product of the operating time, in hours (h), and the number of operators assigned to the operation, as shown in Equation 4.1. This metric allowed the comparison between one-operator and two-operator scenarios.

$$\text{Productivity} = \frac{\text{Total Volume Filled (L)}}{\text{Operation Time (h)} \times \text{Number of Operators}} \tag{4.1}$$

The analyses were grouped according to machine type and packaging volume range.

Automatic Machines

Table 4.1: Productivity results for automatic machines

Machine	Volume Range (L)	1 Operator (L/m-h)	2 Operators (L/m-h)
ME-36 / ME-53	0–1	743	557
	2–5	2560	1646
ME-35	0–1	685	495
	2–5	2851	1629

Semi-Automatic Machines

Table 4.2: Productivity results for semi-automatic machines

Machine	Volume Range (L)	1 Operator (L/m-h)	2 Operators (L/m-h)
ME-61	2–5	626	405
	10–20	2121	1267
	20–30	771	674
ME-60	2–5	434	313
	10–20	2874	2274
ME-30	2–5	–	737
	10–20	–	2112

Manual Filling Operations

Table 4.3: Productivity results for manual filling operations

Volume Range (L)	1 Operator (L/m-h)	2 Operators (L/m-h)
0–2	128	–
2–5	960	–
10–20	1760	1624
20–30	1020	1455

Discussion

The results obtained demonstrate that operator productivity depends strongly on the machine type, layout configuration and operational workload associated with each filling process. Since productivity is expressed in L/m-h, to maintain the same productivity level, production output would need to increase proportionally to the additional labour employed. Therefore, the allocation of extra operators is only justified when the resulting increase in output compensates for the increase in labour utilisation.

For automatic machines, the results clearly show that operating with a single operator consistently achieves higher productivity values than operating with two operators.

For semi-automatic machines, the results were more dependent on machine layout and operational requirements. The ME-61, due to its L-shaped configuration, showed consistently higher productivity with one operator, particularly for middle-range volumes. The reduced operator displacement associated with this layout allows a single operator to efficiently perform feeding, monitoring, and palletising activities without requiring additional support.

For the ME-30 and ME-60, previous analyses and operational discussions developed within the sector had already indicated that the allocation of two operators was generally more appropriate due to the layout and workload associated with these machines. Both machines require continuous manual feeding at the beginning of the line, meaning that the filling operator must remain close to the infeed area throughout the operation. At the same time, filled containers must be palletised at the end of the line. Consequently, operating these machines with a single operator would require frequent interruptions of the filling process to perform palletising activities. Since both machines have a linear layout, these interruptions would also involve considerable operator movement between the beginning and the end of the line. For this reason, productivity studies with a single operator were not conducted for the ME-30, as this operating condition was not considered suitable for normal production.

In the case of the ME-60, additional productivity studies were conducted to validate these previous observations. Although the results showed slightly higher productivity values with one operator, the difference between one and two operators was not significant enough to justify a standardised allocation rule based exclusively on productivity. Furthermore, many of the products typically filled on the ME-60 require rapid availability immediately after approval, making the completion time of the filling operation particularly important. Therefore, the allocation of a second operator remains operationally justified, both to support palletising and auxiliary handling activities and to ensure the responsiveness required by the production system.

For manual filling operations, the influence of packaging volume became considerably more significant. For smaller packaging volumes, productivity studies with two operators were not conducted because preliminary observations showed that the presence of a second operator would only interfere with the filling process due to the reduced workspace and the simplicity of the operation itself.

As the packaging size increased, the productivity difference between one and two operators became progressively smaller and, for the volume range between 20 and 30 L, productivity values were even higher with two operators.

In these larger volume ranges, the filling operation requires the use of a larger tamping mechanism (illustrated in Appendix F). When a single operator performs the operation alone, considerable time is spent moving away from the filling position, walking around the tamping mechanism, collecting the filled container, palletising it, and returning to the filling position. This sequence requires approximately 8 to 10 seconds (s) per container, creating a significant cumulative impact on both productivity and operator fatigue. This layout can be seen in Figure F.2.

As a result, for larger packaging volumes, the decision regarding the allocation of a second operator becomes increasingly dependent on physical workload intensity and service-level re-

quirements rather than productivity values alone. Under these operating conditions, assigning a second operator cannot be considered excessive whenever sufficient resources are available.

Overall, the results demonstrate that increasing the number of operators assigned to a filling operation does not necessarily result in a proportional increase in output. In most cases, the productivity gains achieved by adding a second operator were considerably smaller than the corresponding increase in labour utilisation, indicating diminishing returns associated with additional staffing. These findings provide objective guidelines for workforce allocation within the filling area, helping to identify situations where a second operator adds value and those where the same resource can be more effectively utilised in another filling operation or in support activities such as the Provisioner role.

4.1.2 Strapex Operational Study

During the initial observations carried out in the filling area, a specific operational issue was identified in the filling process of 4 L containers requiring secondary packaging in boxes. Unlike the remaining filling operations, these products were frequently processed in two separate stages, generating additional transportation, intermediate storage, and handling activities.

In the first stage, the operator performed the filling operation and palletised the containers temporarily as a standard pallet. Once the pallet was completed, the operator transported it to an intermediate storage area using a pallet truck and then returned to the machine to continue the filling process.

The second stage only occurred later, when another operator became available to retrieve the intermediate pallet and place the containers into boxes in order to form the final pallet configuration.

This workflow resulted in several additional NVA activities associated with pallet transportation, temporary storage, and subsequent pallet retrieval. Therefore, a study was conducted to better understand the operational impact of this process.

Methodology

The study was divided into two separate analyses: the filling operation itself and the subsequent packaging and palletising operation. For both analyses, the observed tasks and corresponding execution times were recorded under normal production conditions considering the same pallet configuration.

This observed pallet consisted of 96 containers distributed across 4 layers. Between each layer, a cardboard separation sheet was placed, resulting in a total of 3 cardboard sheets per pallet. After the filling operation, the 96 containers were packed into 48 boxes, with 2 containers placed in each box. The boxes were then palletised in four layers, with anti-slip sheets placed between consecutive layers to ensure pallet stability.

The results obtained are presented in Table 4.4.

Table 4.4: Operational analysis of the 4 L packaging process

Filling Operation	Packaging and Palletising Operation
Observed tasks: • Filling containers; • Organising containers on the pallet; • Placing cardboard separation sheets. **Observed times:** • 6 min per layer of 24 containers; • 15 s to place each cardboard separation sheet. **Total time:** 25 min/pallet	**Observed tasks:** • Retrieving and labelling boxes; • Forming boxes; • Placing containers inside; • Sealing boxes; • Palletising. **Observed times:** • 60–70 s to form 4 boxes; • 20–30 s to palletise 4 boxes; • 10–30 s for anti-slip sheets. **Total time:** 17–22 min/pallet

Discussion

The results demonstrate that the time required to package and palletise the containers is largely compensated by the filling time itself whenever both operations are performed simultaneously. In contrast, when filling and packaging are performed separately, the makespan associated with the process may effectively double and can even exceed this value depending on the duration for which the pallet remains in the intermediate storage area. These findings indicate that separating filling and packaging activities introduces significant operational waste, increasing material handling requirements, workflow interruptions and overall process time.

For this reason, the allocation of a second operator during these filling operations becomes operationally advantageous. While one operator remains focused on the filling operation, the second operator can simultaneously perform the packaging and palletising activities, allowing the complete operation to be finalised within the approximately 25 minutes (min) required for the filling process itself.

This approach eliminates intermediate pallet storage, reduces NVA activities, improves workflow continuity, and prevents the accumulation of unfinished work after production.

4.2 Implementation and Standardisation of the Provisioner Role

In parallel with the operational performance studies, several analyses were conducted specifically to support the implementation and structuring of the Provisioner within the filling area.

The objective of these studies was to evaluate the operational feasibility and impact of introducing this support function. Through the redistribution of external tasks, the role of the Provisioner aimed to improve workflow continuity, reduce machine interruptions, support setup preparation activities, and increase productive operating time.

The studies presented in this section focus directly on the development, validation, and standardisation of this function. The studies presented in this section focus directly on the development, validation, and standardisation of this function. These analyses include DILO studies to identify activities that could be transferred to the Provisioner, setup improvement studies based on the SMED methodology to reduce machine downtime, a strapping workload evaluation to assess the distribution time associated with this activities, a filling schedule compliance analysis to evaluate the stability of the production plan, human resource allocation analysis to assess workforce requirements under different operating conditions, a daily filling schedule analysis to evaluate the impact of operating with or without a Provisioner, the development of the double pallet system and the development of a standard work sheet to support the implementation of the role.

Together, these studies provided the foundation for the implementation of a more structured and efficient operational model for the C1E filling area.

4.2.1 Day in Life Of and Value-Added Analysis

Before defining the responsibilities of the Provisioner, it was necessary to understand how operators distributed their time throughout the shift and which activities contributed most significantly to their workload. Therefore, a DILO study was conducted to classify operators' activities according to whether the filling machine was producing or not producing. VA activities corresponded to all tasks performed by the operator while the filling machine remained in operation, meaning that these activities did not interrupt the production process. In contrast, NVA activities corresponded to tasks that required the filling machine to stop during production, such as replenishing lids or containers when the machine stopped due to a lack of materials.

The main objectives of the study were to quantify the proportion of VA and NVA activities performed by operators, determine which NVA activities consumed the largest share of their working time, evaluate their suitability for reassignment to the Provisioner and estimate the potential benefits associated with the implementation of this role.

Methodology

The DILO analyses were conducted across the different filling systems operating in the C1E sector, including automatic, semi-automatic and manual filling machines.

For each observation, a single operator was monitored during the initial part of the workday and all activities performed were recorded using a standardised DILO worksheet. The recorded information included the task description, start time, end time and any relevant operational observations. An example of the data collection sheet used during the study is presented in Appendix G.

After data collection, all recorded activities were classified into three categories: VA, NVA and NVA that could potentially be covered by the Provisioner and integrate its tasks.

For each DILO, pie charts were developed to evaluate the distribution of VA and NVA activities, while Pareto charts were used to identify the tasks that consumed the largest proportion of operator time. Appendix H presents one example, conducted on each machine category, of the graphical outputs obtained.

The results consistently revealed that a substantial proportion of operators' working time was dedicated to NVA activities. Across the examples presented, the NVA activities accounted for between 53% and 63% of the observed time. Within this share, between 18% and 24% of the operators' working time corresponded to activities that could potentially be reassigned to the Provisioner, thereby allowing operators to dedicate a greater proportion of their time to filling-related activities. Furthermore, the Pareto analyses showed that material handling activities represented the largest source of operational waste in all cases, accounting for between 14.6% and 19.4% of the observed activities. This finding highlighted the potential benefit of introducing a support role responsible for ensuring material availability at the filling stations.

To obtain a broader representation of the sector, the results were subsequently aggregated according to machine category. Table 4.5 presents the average distribution of VA and NVA activities for each category.

Table 4.5: Distribution of VA and NVA activities by machine category

Machine Category	**VA (%)**	**NVA (%)**	**NVA Potentially Covered by Provisioner (%)**
Automatic	36.6	42.3	21.1
Semi-automatic	36.6	45.7	17.7
Manual	46.8	29.1	24.1

Automatic and semi-automatic machines presented the highest proportion of NVA activities, with 63.4% of the observed time, while manual operations showed the highest percentage of VA work among the analysed categories.

To better understand the potential impact of the Provisioner, historical data regarding the annual utilisation time and setup durations of each filling machine were extracted from the internal Enterprise Resource Planning (ERP). The activity distributions obtained through the DILO analyses were then applied to these annual operating times in order to estimate the annual amount of time dedicated to VA and NVA activities by filling operators.

A hypothetical scenario was subsequently evaluated in which all transferable NVA activities were performed by the Provisioner instead of the filling operators. Under this assumption, the annual distribution of operator activities was recalculated to estimate the potential reduction in NVA work that could be achieved through the implementation of the Provisioner.

Table 4.6 compares the estimated annual distribution of operator activities before and after the implementation of the Provisioner. It should be noted that the activities transferred to the Provisioner are not eliminated from the process; rather, they are reassigned from the filling operators to a dedicated support role.

Table 4.6: Estimated annual distribution of operator activities before and after the Provisioner implementation

Machine	Before Provisioner			After Provisioner			NVA Reduction (%)
	Total (h)	VA (h)	NVA (h)	Total (h)	VA (h)	NVA (h)	
Manual	867.1	406.1	461.0	658.5	406.1	252.4	45.2
ME-53	275.1	100.7	174.3	217.1	100.7	116.4	33.2
ME-35	164.9	60.3	104.5	130.1	60.3	69.8	33.2
ME-36	91.6	33.5	58.1	72.3	33.5	38.8	33.2
ME-30	358.5	131.2	227.3	295.0	131.2	163.8	27.9
ME-60	147.3	53.9	93.3	121.1	53.9	67.3	27.9
ME-61	429.7	157.3	272.5	353.6	157.3	196.3	28.0
Total	**2334.2**	**943.0**	**1391.0**	**1847.7**	**943.0**	**904.8**	**35.0**

The results indicate that the implementation of the Provisioner would significantly reduce the amount of NVA work performed by filling operators. Overall, annual NVA activities are estimated to decrease from 1391.0 h to 904.8 h, corresponding to a reduction of approximately 35%.

The largest reduction is estimated for the manual filling stations, where annual NVA activities decrease from 461.0 h to 252.4 h, representing a reduction of approximately 45%. For the automatic filling machines, the estimated reduction in NVA activities is approximately 33%, while for the semi-automatic filling machines the estimated reduction is approximately 28%.

Although the total amount of VA work remains unchanged, the reduction in NVA activities decreases the total time required from filling operators, increasing the proportion of time dedicated to value-adding activities and improving the overall efficiency of the filling operation.

Discussion

The DILO study provided the first quantitative evidence supporting the need for a Provisioner within the filling area. Rather than being primarily occupied with machine operation, operators were found to spend a significant proportion of their working time performing supporting activities required to sustain the production flow.

The results suggest that the main opportunity for improvement does not lie in modifying the filling process itself, but rather in reorganising how auxiliary activities are distributed among the

workforce. By assigning logistical and material-handling activities to the Provisioner, filling operators can remain focused on production activities while support tasks are performed in parallel. This reduces operational interruptions, improves workflow continuity and minimises machine idle time associated with operators leaving their workstations to perform auxiliary tasks.

Although the filling process itself remains unchanged, this redistribution of responsibilities is expected to increase the proportion of time devoted to value-adding activities and consequently improve overall productivity. Furthermore, the identification of material availability and material-handling activities as the most time-consuming NVA tasks provided a clear basis for defining the future responsibilities of the Provisioner. Consequently, the findings of this study served as the foundation for the development and standardisation of the Provisioner role presented in the following sections.

4.2.2 Setup Improvements

Since setup activities represent unavoidable production interruptions, reducing setup duration was identified as an important opportunity to improve the operational efficiency of the filling area.

This subsection is divided into two parts. First, Sequence Charts and SMED analyses were used to study the existing setup procedures and identify activities that could be reassigned to the Provisioner. Subsequently, a specific improvement implemented on the ME-61 machine is presented, together with an assessment of its operational and economic impact.

4.2.2.1 Sequence Charts and SMED analyses

Setup operations represent unavoidable periods of production interruption and therefore have a direct impact on machine availability and overall operational efficiency. Since one of the main objectives of the Provisioner is to support filling operators by performing logistical and preparation activities, it became important to understand how setup time was being distributed and which activities could potentially be reassigned.

For this reason, a detailed analysis of the different setup processess was conducted using Sequence Charts and the principles of the SMED methodology. The objective of this study was to identify the activities that contributed most to setup duration, distinguish between internal and external tasks and evaluate the potential contribution of the Provisioner in reducing setup-related inefficiencies.

Methodology

Several setups were observed under normal production conditions before the implementation of the Provisioner. The analysis included the three setup categories identified in the sector: M, associated with brand changes that only require control and verification activities; E, associated with container format changes that require machine adjustments; and PI, associated with product changes requiring cleaning operations and therefore typically representing the longest setup durations.

For each setup, several Sequence Charts were completed in order to record all activities performed throughout the changeover process. The worksheet used to gather these data included the task description, execution time, task category and its classification as either an internal or external activity. An example of the Sequence Chart used during the study is presented in Appendix I.

The setup observations allowed the determination of the average duration associated with each setup category. The results obtained are presented in Table 4.7.

Table 4.7: Average setup duration before the implementation of the Provisioner

Setup Type	**Average Duration (min)**
M	6.5
E	18
PI	42

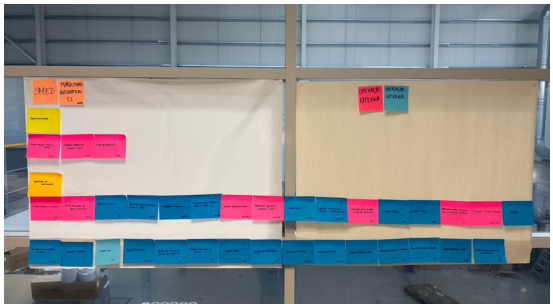
As expected, PI setups presented the longest durations due to the cleaning operations required when changing product. E setups showed intermediate durations, mainly associated with equipment adjustments necessary to accommodate different packaging dimensions. M were the shortest setups, as they generally involve only control and verification activities without requiring cleaning procedures or machine adjustments.

Following the collection of these observations, a SMED workshop was organised with the participation of several filling operators from the sector. During this session, the Sequence Charts developed throughout the study were reviewed and all setup activities were organised according to the order in which they were being performed at the time.

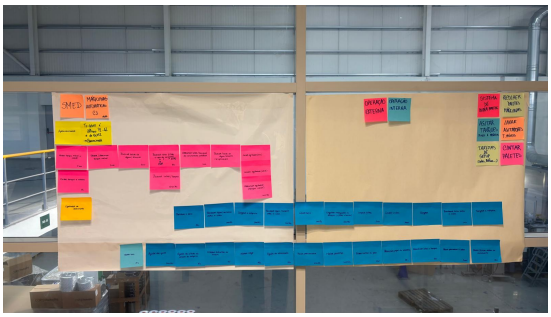
The objective of the workshop was to critically analyse the existing setup procedures and identify opportunities to reduce setup duration through a better distribution of responsibilities between the filling operator and the Provisioner.

As illustrated in Figures 4.1a and 4.1b, activities were classified as either internal or external, represented in blue and pink, respectively. Internal activities require machine stoppage and therefore had to be performed by the filling operator. External activities, on the other hand, can be carried out while the machine remained available for production, making them suitable candidates for reassignment to the Provisioner.

Based on this analysis and the discussions carried out during the workshop, several setup activities were reorganised and reassigned, resulting in a new standard setup sequence. The proposed method aims to ensure that external activities are prepared in advance by the Provisioner, allowing the filling operator to focus exclusively on internal setup activities and reducing the overall setup duration.



(a) Setup sequence - Before



(b) Setup sequence - After

Figure 4.1: Comparison of setup activities before and after the application of SMED principles

Discussion

The Sequence Chart analysis and subsequent SMED workshop provided a structured approach for reviewing setup activities and identifying improvement opportunities within the filling sector.

The study revealed that a significant number of activities performed during setups corresponded to external tasks that did not require direct operator intervention. These included preparing the product tank by starting the agitator, cleaning the agitator, collecting the solvent bucket required for cleaning operations, and retrieving the materials required for the filling process, such as containers, lids, and labels. By transferring these activities to the Provisioner and defining a new standard setup sequence, it became possible to establish a more efficient distribution of responsibilities between both functions.

The participation of the operators throughout the SMED workshop was particularly valuable, as it enabled the identification of practical improvement opportunities based on their daily experience and knowledge of the process.

The setup durations presented in this section represent the baseline situation before the implementation of the proposed changes. Following the implementation of the new setup methodology and the introduction of the Provisioner, the setup durations were measured again and compared with these baseline results. The outcomes of this comparison are presented and discussed in Chapter 5.

4.2.2.2 ME-61 Valve Replacement Improvement

During the internship, an improvement opportunity was identified in the setup procedure of certain products filled on the ME-61 machine.

It was observed that operators spent a considerable amount of time cleaning the filter valve during the setup process. Due to the location and geometry of the component, this activity was difficult to perform and contributed significantly to the overall setup duration.

To address this issue, it was proposed to keep a clean valve available near the machine. Under this new method, the operator simply replaces the valve during the setup, while the removed valve is subsequently cleaned outside of the workstation by a free operator and prepared for future use.

Although this improvement was not directly developed as part of the SMED workshop, it follows the same principle of converting an internal activity into an external one.

A pilot implementation of this improvement was carried out on the ME-61. The setup duration was reduced from 29 min to 19 min, corresponding to a reduction of approximately 34.5%.

In order to estimate the potential impact of this improvement beyond the pilot implementation, a historical analysis was performed using production data extracted from the internal ERP.

All filling operations associated with this type of product were identified for 2025 and for the first semester of 2026. The number of corresponding setups was then determined and multiplied by the average setup duration previously observed on the ME-61, allowing the cumulative setup time for these products during the selected time intervals to be estimated. The reduction obtained during the pilot implementation (34.5%) was subsequently applied in order to estimate the potential impact of the proposed improvement.

The results are presented in Table 4.8.

Table 4.8: Estimated impact of the ME-61 valve replacement improvement

Period	**Setups**	**Before (h)**	**After (h)**	**Reduction (h)**
2025	28	11.67	7.64	4.02
2026 - 1st Semester	39	16.25	10.65	5.60

The results indicate that the improvement would have reduced setup time by approximately 4.0 h during 2025. An even greater benefit was estimated for the first semester of 2026, where the reduction reached 5.6 h.

This increase is primarily explained by the higher production volume of these products observed during 2026, resulting in a greater number of setups and consequently a larger cumulative benefit from the proposed improvement.

The work centre cost associated with the ME-61 was obtained from the internal ERP of the company and corresponds to €62.5 per operating hour, including the labour required to operate the machine. Based on this value, the economic value of time saved (€) associated with the estimated setup time reduction was calculated and is presented in Table 4.9.

Table 4.9: Economic value of the setup time saved

Period	**Time Saved (h)**	**Economic Value of Time Saved (€)**
2025	4.02	251.25
2026 - 1st Semester	5.60	350.22
Total	9.62	601.47

The analysis demonstrates that even small reductions in individual setup duration can translate into significant cumulative benefits when applied repeatedly throughout the year.

4.2.3 Strapping Workload Study

At the beginning of the internship, it was common practice to allocate one operator almost exclusively to pallet strapping activities during several production periods. However, it was unclear whether the workload associated with these operations actually justified the permanent allocation of an operator. For this reason, a study was conducted to quantify the strapping workload within the filling area.

This subsection begins by quantifying the overall strapping workload within the sector and assessing whether a dedicated strapping operator is justified. Subsequently, following concerns raised by the filling operators regarding the workload assigned to the Provisioner, alternative ways of reducing this workload were explored. Since the ME-30 and ME-60 filling machines already operate with a second operator, the possibility of integrating end-of-line pallet strapping into the responsibilities of this operator was investigated. Besides reducing the amount of strapping work assigned to the Provisioner, this approach could also eliminate NVA idle time by performing strapping activities during the filling cycle. Finally, the feasibility of this approach and its impact on operational productivity are evaluated.

4.2.3.1 Current State

Initially, several strapping operations were directly observed in order to determine the average strapping time associated with different packaging configurations. The recorded times were classified according to the packaging code, the number of containers per pallet, and the strapping configuration applied to the pallet.

An example of the data collection sheets and the database developed to consolidate the average strapping times for each packaging configuration are presented in Appendix J.

Using the developed database, all filling operations carried out between January and March were extracted and associated with their corresponding packaging configurations in order to estimate the total daily strapping workload during this period. This estimated daily strapping workload between January and March is presented in Figure 4.2.

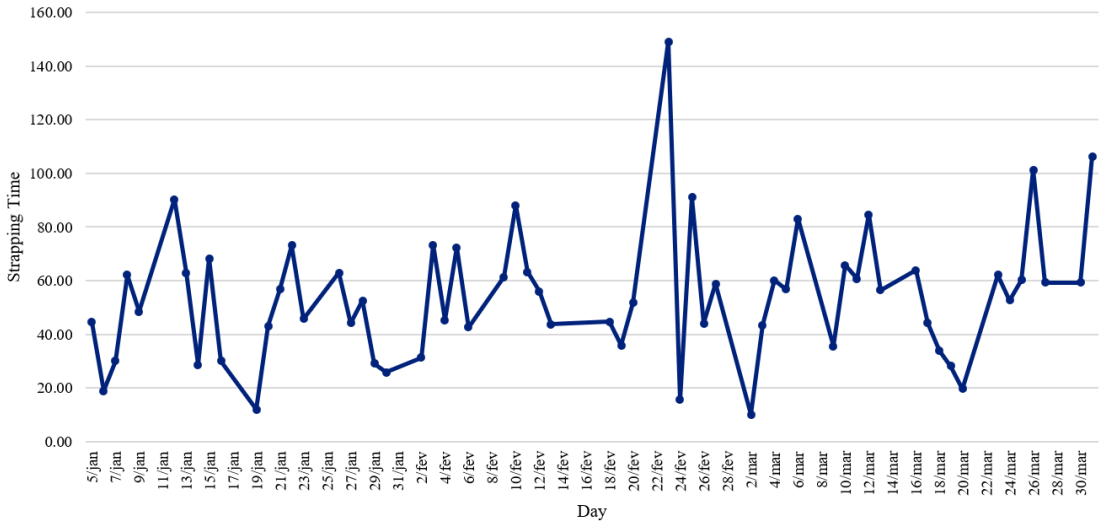


Figure 4.2: Daily strapping workload between January and March

The analysis revealed considerable variability in the daily strapping workload. The highest recorded values reached approximately 145, 106, and 101 min, while the lowest values were approximately 10, 12, and 16 min. Despite this variability, the estimated average daily strapping workload during this period was approximately 51 min per day.

However, this first analysis presented some limitations. Since the study was conducted retrospectively and during a period in which not all filling operations were directly monitored, some strapping times were not accounted for. Additionally, the analysis also included night-shift production, introducing additional variability into the results.

For this reason, a second and more controlled analysis was conducted during the week of 20 to 24 April, to validate the previous results. During this period, all filling operations and corresponding strapping activities performed exclusively during the day shift were directly monitored, allowing a more accurate estimation of the real operational workload. This second analysis resulted in an average daily strapping workload of approximately 44 min per day, a value that is relatively close to the average of 51 min per day obtained from the January to March analysis.

The results obtained demonstrate that, although strapping represents an important operational activity, the workload does not appear sufficiently high or consistent to justify the permanent allocation of an operator exclusively for this task. Instead, the activity can be integrated into the normal responsibilities of the Provisioner without creating a significant operational constraint.

4.2.3.2 Integration of Strapping Operations in the ME-30 and ME-60

As discussed previously, concerns were raised regarding the workload assigned to the Provisioner. In response, an opportunity to reduce the amount of strapping activities under its responsibility was explored. The ME-30 and ME-60 filling machines were selected for further analysis because they typically generate a high number of pallets and already require a second operator.

This created an opportunity to increase the utilisation of this operator while simultaneously reducing the strapping workload assigned to the Provisioner.

For this reason, a proposal was developed to install a shared strapping machine at the end of these filling lines. Rather than purchasing new equipment, an existing strapping machine available in another production area, where it was no longer being used, was relocated for this purpose. Under this configuration, pallet strapping would be performed directly by the second operator immediately after pallet completion, integrating this activity into the filling workflow.

Before evaluating the feasibility of this proposal, it was first necessary to quantify the contribution of the ME-30 and ME-60 machines to the overall strapping workload within the filling area.

For this purpose, a historical analysis was conducted using the strapping records collected between January and March. For each day included in the dataset, the total strapping time was compared with the portion specifically associated with pallets produced on the ME-30 and ME-60 machines.

Figure 4.3 presents the daily strapping workload observed throughout the analysed period, together with the contribution associated with the ME-30 and ME-60 machines. Red markers identify days in which more than 30 pallets originated from these two machines, while green markers indicate days where neither the ME-30 nor the ME-60 performed filling operations.

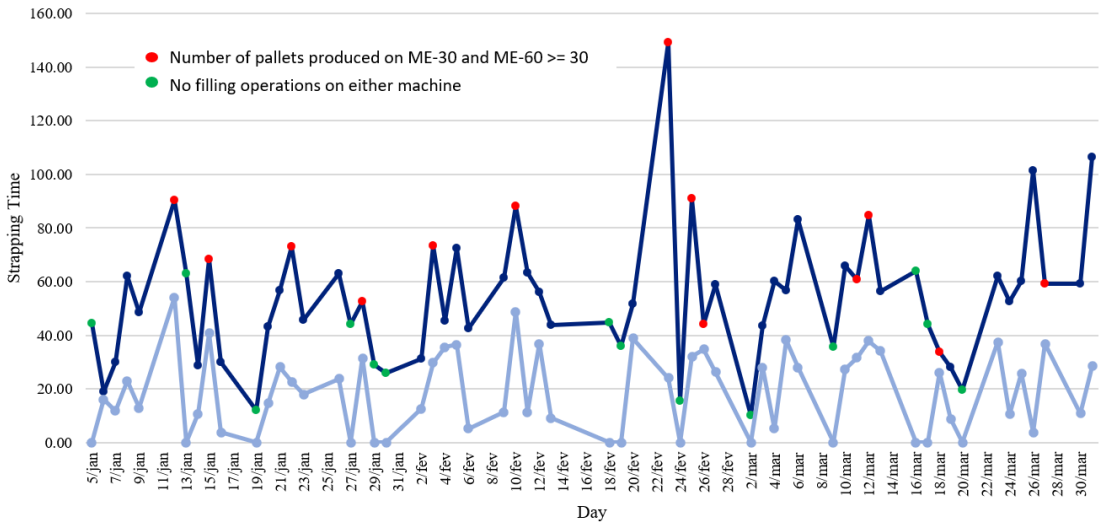


Figure 4.3: Daily strapping workload and contribution of the ME-30 and ME-60, between January and March

The results show that the strapping workload associated with the ME-30 and ME-60 follows a similar behaviour as the total daily strapping workload. Periods with higher overall strapping requirements tend to coincide with increased activity on these machines, indicating that they represent a significant contributor to the total amount of pallet strapping performed within the filling

area. This relationship is particularly evident on the days highlighted in red, where a high number of pallets produced by the ME-30 and ME-60 is associated with peaks in the total strapping workload.

To quantify this contribution, the following pie chart, presented in Figure 4.4, was developed.

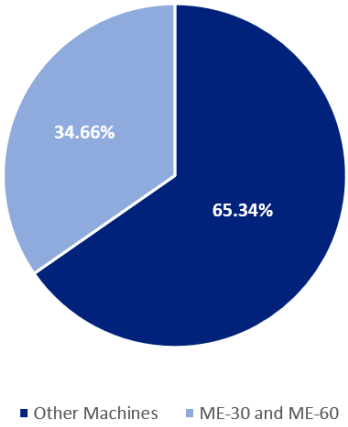


Figure 4.4: Contribution of the ME-30 and ME-60 to the total strapping workload

The analysis revealed that approximately 35% of the total strapping workload during the analysed period was associated with pallets produced on the ME-30 and ME-60 machines. Consequently, the implementation of the proposed solution would have the potential to remove approximately one third of the strapping activities currently assigned to the Provisioner. As a result, the Provisioner would be able to dedicate a greater proportion of its time to activities such as setup support and pallet transportation, reinforcing the effectiveness of the proposed operational model.

Evaluation of Strapping Integration into Filling Operations

Following the identification of the potential benefits associated with transferring part of the strapping workload from the Provisioner to the filling operators, a series of studies were conducted on the ME-30 and ME-60 filling machines.

The initial objective was to compare productivity levels when the second operator assigned to these machines performed only palletizing activities and when the same operator also performed the strapping operations at the end of the line. However, during the first observations it became evident that this approach was not feasible for all products. In some cases, the second operator was unable to simultaneously perform palletizing and strapping activities while maintaining the normal operation of the filling process. The operator was required to work under significant time pressure and the filling machine had to be temporarily stopped due to product accumulation at the end of the line.

As a result, before conducting the productivity comparison, it became necessary to establish a criterion capable of distinguishing between feasible and non-feasible operating conditions.

The criterion adopted was based on the relationship between the time required to fill all the containers of one pallet and the time required by the second operator to complete all activities associated with that pallet.

The total workload assigned to the second operator was then determined as the sum of the palletizing time and the strapping time required for one pallet. The integration of strapping activities was considered feasible whenever the time required to perform palletizing and strapping was lower than the time required to fill all the containers of that pallet, as described in Equation (4.2).

$$T_{palletizing} + T_{strapping} \leq T_{filling} \tag{4.2}$$

If this condition was not satisfied, the operator would be unable to keep pace with the filling process, leading to the progressive accumulation of unfinished work and potential interruptions to production.

Table 4.10 summarizes the results obtained for the operating conditions analysed.

Table 4.10: Evaluation of strapping integration feasibility

Machine	**Product Code**	**Palletizing + Strapping Time (min/pallet)**	**Filling Time (min/pallet)**	**Feasibility**
ME-30	Product A C6	7.4	6.0	Not Feasible
	Product B 16	5.1	2.8	Not Feasible
	Product C 04	7.4	10.3	Feasible
ME-60	Product D 20	4.3	5.5	Feasible

The analysis demonstrated that only one of the observed ME-30 operating conditions and the ME-60 operating condition satisfied the proposed criterion. In the remaining cases, the combined palletizing and strapping workload exceeded the time available during pallet production, making the integration of strapping activities impractical.

Consequently, only the operating conditions classified as feasible were selected for the subsequent productivity studies. These studies aimed to quantify the productivity gains that could be achieved within the sector.

Table 4.11 summarizes the results obtained for the analysed operating conditions.

Table 4.11: Productivity results with and without integrated strapping

Machine	**Product Code**	**Operating Method**	**Time (min)**	**Productivity (L/m-h)**
ME-30	Product C 04	Without Integrated Strapping	57	454.7
		With Integrated Strapping	47	551.4
ME-60	Product D 20	Without Integrated Strapping (Obs. 1)	29	1365
		Without Integrated Strapping (Obs. 2)	34	1165
		With Integrated Strapping	23	1721.0

For Product C 04 on ME-30, the results showed an increase in productivity from 454.7 L/m-h to 551.4 L/m-h. Throughout the observation, the operator was able to perform the strapping activities without disrupting the filling process. Furthermore, sufficient available time remained to carry out other support activities, including supplying lids, replenishing empty containers and assisting the first operator whenever necessary. No significant product accumulation was observed, confirming that sufficient time was available for the operator to perform both palletizing and strapping activities without affecting the filling process. Additionally, in this particular filling operation, 45 min of the strapping workload were removed from the Provisioner's responsibilities. At the same time, the movement of 18 finished pallets to a temporary storage area awaiting strapping was eliminated, reducing unnecessary material handling and removing a potential safety risk associated with the accumulation of non-strapped pallets.

The same analysis was conducted on the ME-60 for Product D 20. For this machine, two observations were conducted under the existing operating method, in which strapping activities were performed by the Provisioner. In the first observation, the operation required 29 min, resulting in a productivity of 1365 L/m-h. In the second observation, the same quantity was completed in 34 min, corresponding to a productivity of 1165 L/m-h.

Although both observations presented similar productivity levels, a significant difference was identified regarding the waiting time between the completion of production and the execution of the strapping activities. In the first observation, the completed pallets remained waiting for approximately 45 min before being strapped by the Provisioner. In the second observation, this waiting time was reduced to only 8 min.

These results reveal a considerable variability in the time that completed pallets remain in the production area awaiting strapping. Since the execution of this activity depends on the availability of the Provisioner, delays may occur whenever other operational priorities arise. Consequently, finished pallets may accumulate temporarily within the filling area, increasing WIP inventory and requiring additional storage space until the strapping operation can be performed.

When strapping activities were incorporated into the responsibilities of the second operator, the operation required only 23 min, corresponding to a productivity of 1721.0 L/m-h. More importantly, the waiting time associated with the availability of the Provisioner was completely eliminated, since pallets were strapped immediately upon completion.

These observations suggest that integrating strapping activities into the filling operation not only has the potential to increase productivity but also eliminates the variability associated with pallet waiting times. As a result, finished pallets can be processed immediately upon completion, reducing temporary inventory accumulation and making the operation less dependent on the availability of the Provisioner.

4.2.4 Filling Schedule Compliance Analysis

During the initial observation phase, it became evident that the weekly filling schedule was rarely followed as originally planned. This issue has a significant impact on the implementation

of the Provisioner, since the effectiveness of the Provisioner depends strongly on the ability to anticipate upcoming filling operations and prepare materials, packaging, and setups in advance.

When the daily production plan changes frequently throughout the day, the Provisioner loses the ability to organise future operations efficiently, leading to a more reactive workflow and increasing the occurrence of interruptions and unplanned activities within the filling area.

For this reason, an analysis was conducted to evaluate the compliance rate of the weekly filling schedule.

Methodology

Over a period of six weeks, all filling operations performed each day were manually recorded directly on printed versions of the weekly filling schedule.

For each production day, information was collected regarding the number of planned filling operations, the number of planned fillings completed on the scheduled day, the total number of fillings performed, and the number of priority filling requests. These priority requests included *stock-out* products, corresponding to products that had run out of stock, *commitment* products, referring to products with previously agreed delivery dates, and urgent filling requests introduced during the day that were not originally included in the production plan and therefore required immediate adjustments to the filling schedule.

Based on these records, the filling schedule compliance rate was calculated for each day as the ratio between the number of fillings completed on the day originally specified in the weekly schedule and the total number of fillings performed, regardless of whether they had been planned for that day or not, as shown in Equation (4.3):

$$Compliance\ Rate = \frac{Fillings\ Completed\ on\ the\ Planned\ Day}{Total\ Fillings\ Performed} \times 100 \tag{4.3}$$

The results obtained are presented in Appendix K and demonstrate a very low level of compliance between the planned and actual production schedules. During the six-week observation period, the highest compliance rate observed was only 58.33%, highlighting the difficulty of maintaining adherence to the planned filling schedule.

In addition to the daily compliance rate, a complementary analysis was performed to evaluate the nature of the observed schedule deviations. For each filling operation, it was verified whether the operation was completed on the planned day, anticipated relative to the original schedule, delayed to a later date or introduced as an urgent request not included in the initial weekly plan. Based on this classification, summary indicators were calculated to quantify the main sources of schedule instability. This indicators are presented in Table 4.12.

Table 4.12: Summary indicators of schedule deviations

Indicator	Percentage
Anticipated Fillings	52.0%
Delayed Fillings	16.7%
Urgent Fillings Not Included in the Weekly Plan	4.3%

From an operational perspective, anticipated fillings create significant organisational challenges. Since these operations are executed before their planned date, the associated packaging materials, labels, lids and auxiliary components are often not yet available at the filling station or prepared for use. As a result, operators must spend additional time locating the required materials and, when these are unavailable, the filling operation may be placed on hold until the materials arrive.

Urgent filling requests create similar difficulties. In addition to requiring immediate material preparation, these requests are often introduced during the course of the production day, forcing sudden changes to the filling sequence and generating additional setup activities that were not originally planned.

These findings are particularly relevant for the implementation of the Provisioner role as the effectiveness of the Provisioner depends heavily on the ability to anticipate future operations and prepare the required materials in advance. Therefore, frequent schedule changes, especially those associated with anticipated and urgent fillings, reduce the ability of the Provisioner to operate proactively.

Consequently, improving schedule stability should be regarded as a key enabler for maximising the benefits of the proposed operational model. In addition to improving the effectiveness of the Provisioner, greater schedule adherence would facilitate the advance preparation of materials, reduce productivity losses associated with searching for unavailable components, minimise operational interruptions and contribute to reducing the unnecessary inventory generated by delayed fillings.

4.2.5 Human Resource Allocation Scenario Analysis

The implementation of the Provisioner requires the reallocation of human resources within the filling area, with one of the six available operators becoming dedicated to support activities rather than filling operations. As a result, only five operators remain available to operate the filling machines. It therefore became necessary to evaluate whether the different combinations of machines operating simultaneously within the C1E area could be operated with the available workforce.

This analysis became particularly relevant following the schedule compliance study, which revealed frequent changes to the production plan, a high number of anticipated fillings and the regular introduction of urgent production requests. Under these conditions, periods with several

simultaneous filling operations became increasingly common, often creating pressure to reassign the Provisioner to filling activities in order to meet production requirements.

The main objective of this study was to create a structured operational reference capable of supporting production planning decisions and preventing situations where the number of simultaneous filling operations exceeds the effective operational capacity of the filling area. The analysis therefore focused on identifying the combinations of simultaneously operating machines that could be supported while maintaining one operator permanently assigned to the Provisioner role.

Methodology

The analysis considered several combinations of simultaneous filling operations grouped according to the number of active machines: 2, 3, 4 or 5 machines operating simultaneously.

For each scenario, the required workforce was determined using the recommended operator allocation established in the productivity studies and the operational constraints associated with each machine type. Operator qualification constraints were also considered and incorporated into the scenario evaluation.

The complete set of operational scenarios developed during this analysis is presented in Appendix L. The appendix includes all combinations of 2, 3, 4 and 5 simultaneous filling operations together with the corresponding workforce requirements.

Discussion

The results demonstrate that the operational feasibility of simultaneous filling operations becomes increasingly constrained as the number of active machines increases.

All two-machine scenarios were considered operationally feasible while maintaining the Provisioner. Even the most demanding configuration, involving the simultaneous operation of the ME-30 and ME-60, remains feasible without requiring the Provisioner to support filling activities.

Most three-machine scenarios also remain operationally feasible. The only exception involves the simultaneous operation of three automatic machines, which is currently infeasible due to the limited number of operators qualified to operate automatic filling equipment.

A significant increase in operational constraints was observed in the four-machine scenarios. Several combinations already require all available filling operators, leaving no operational flexibility within the sector. Scenarios involving both the ME-30 and ME-60 were identified as particularly critical due to their higher workforce requirements.

The five-machine scenarios clearly demonstrate the limitations of the proposed operating model. Most combinations require six or seven operators, exceeding the personnel available when one operator is dedicated to the Provisioner. Consequently, only one of the analysed five-machine scenarios was considered operationally feasible, highlighting the difficulty of maintaining five simultaneous filling operations while preserving the Provisioner.

The development of these scenario tables therefore provides an important operational planning tool. By clearly identifying feasible and infeasible machine combinations, it supports more realistic production planning decisions and helps prevent situations that exceed the operational capacity of the filling area.

Furthermore, the analysis reinforces the importance of maintaining the Provisioner exclusively dedicated to support activities, since redirecting the Provisioner to filling operations compromises setup anticipation, material preparation, workflow stability and the overall effectiveness of the proposed operational model.

4.2.6 Daily Filling Schedule Analysis

Following the analysis of the hypothetical operational scenarios, an additional study was conducted to evaluate whether the implementation of the Provisioner could negatively affect the daily production capacity of the filling area. This analysis was motivated by the recurrent perception that, during periods of high workload, all available operators were required to perform filling activities, leading team leaders to temporarily assign the Provisioner to a filling machine. Consequently, the support activities associated with the role were not performed, reducing the expected benefits of the proposed operating model.

The objective of this study was therefore to assess whether the same number of filling operations could be completed while maintaining one operator permanently assigned to the Provisioner role.

4.2.6.1 Numerical Analysis

To perform this analysis, the expected reductions in filling duration for each machine category were calculated. These reductions were obtained by comparing the total time required to complete a filling operation, including both setup and production activities, with the estimated time required when the tasks transferred to the Provisioner were removed from the operator's workload. This resulted in the theoretical reductions present in Table 4.13. Machines ME-30 and ME-60 were excluded from this analysis since they normally operate with two operators and the support activities associated with the Provisioner can already be performed by the second operator.

Table 4.13: Theoretical Reduction in Filling Duration

Machine Type	Theoretical Reduction
Manual Filling Stations	21%
ME-30	0%
ME-60	0%
ME-61	12%
Automatic Machines	10%

The theoretical reductions presented in Table 4.13 assume that all activities assigned to the Provisioner are successfully performed whenever required. However, in practice, the Provisioner may not be able to support all machines simultaneously, particularly when several filling operations are occurring at the same time.

To account for this limitation, a compliance analysis was conducted. During several production days, all support activities associated with the role were recorded and classified according to whether they required Provisioner intervention and whether that intervention was effectively provided. The activities were then grouped according to the number of machines operating simultaneously. The template sheet used to collect this data is presented in Appendix M.

For each operating scenario, the compliance rate was calculated as the ratio between the number of required support activities that were effectively performed and the total number of activities requiring Provisioner intervention. Therefore, the compliance rate represents the percentage of required support activities that were successfully completed.

This analysis was initially intended to determine Provisioner compliance rates for operating scenarios involving two, three and four simultaneously running machines based on direct observations. However, because the study was conducted during the final stage of the internship, it was only possible to collect a sufficient number of observations for the two-machine scenario.

For this operating condition, approximately 90% of the activities requiring Provisioner support were performed by the Provisioner, resulting in an observed compliance rate of 90%. This indicates that most of the support activities assigned to the role were successfully completed.

Given the limited number of observations available for scenarios involving three and four simultaneous machines, the corresponding compliance rates were estimated based on the increase in workload associated with these operating conditions. Moving from two to three machines represents an increase of approximately 50% in the Provisioner's workload. Therefore, the compliance rate was estimated by dividing the observed two-machine compliance rate by 1.5, resulting in an estimated value of 60%.

Similarly, operating four machines simultaneously represents an approximate 100% increase in workload compared with the two-machine scenario. Under the same assumption, the compliance rate was estimated by dividing the observed compliance rate by 2, resulting in 45%. For simplicity and to avoid an unjustified level of precision, this value was rounded to 50%.

It should be noted that these estimates represent conservative assumptions. In practice, the increase in workload is not strictly proportional to the number of machines operating simultaneously, since some filling operations require significantly less support than others. For example, filling operations involving containers with a capacity below 4 L do not require pallet strapping, thereby reducing the Provisioner's workload. Consequently, the estimated compliance rates for the three and four-machine scenarios are likely to underestimate the actual performance that could be achieved in practice.

As the purpose of these compliance rates was to support a conservative evaluation of the proposed operating model, the use of lower estimated values was considered preferable to adopting optimistic assumptions.

Table 4.14 summarizes the compliance rates adopted for each operating scenario.

Table 4.14: Provisioner Compliance Rates

Operating Scenario	**Compliance Rate**
2 Machines	90%
3 Machines	60%
4 Machines	50%

The effective reduction applied to each filling operation was calculated by multiplying the theoretical reduction associated with the machine type by the corresponding Provisioner compliance rate. The resulting reductions used throughout the simulation are presented in Table 4.15.

Table 4.15: Effective Reduction Applied According to the Number of Simultaneous Machines

Machine Type	**4 Machines**	**3 Machines**	**2 Machines**
Manual Filling Stations	11%	13%	19%
ME-30	0%	0%	0%
ME-60	0%	0%	0%
ME-61	6%	7%	11%
Automatic Machines	5%	6%	9%

These effective reductions were subsequently used to adjust the duration of each filling operation during the simulation of the selected production days.

4.2.6.2 Practical Discussion

To evaluate the practical impact of the Provisioner on daily production capacity, two production days were selected for detailed analysis. These days were intentionally chosen because no Provisioner had been assigned, due to the perception that all available operators were required to perform filling activities. Only five operators were available during both days, meaning that a maximum of four operators could be allocated to filling activities if one operator was assigned to the Provisioner role.

For each day, the original production schedule was reconstructed using the recorded start and finish times of each filling operation. The duration of each filling was then adjusted according to the expected reduction associated with the Provisioner and the corresponding compliance rate. Finally, the sequence of filling operations was reorganized whenever necessary to ensure that no more than four operators were simultaneously assigned to filling activities, while maintaining one operator dedicated to the Provisioner. The detailed scheduling tables for both analysed production days, including the original schedules and the corresponding schedules adjusted to account for the Provisioner implementation, are presented in Appendix N.

The analysis of the 30th of April demonstrated that the perceived shortage of operators was primarily caused by an uneven distribution of filling operations throughout the day rather than by an actual lack of available workforce. On this day, eleven filling operations were completed during the day shift, eight of which were concentrated in the morning period. This resulted in several periods where all available operators were simultaneously assigned to filling activities, leaving no operator available to perform the Provisioner tasks.

However, the simulation showed that it was only necessary to postpone a single filling operation from the morning period to the afternoon period in order to eliminate all situations requiring more than five filling operators simultaneously. This adjustment would allow the Provisioner to be maintained throughout the day without reducing the total number of filling operations completed.

A similar analysis was performed for the 29th of April, leading to equivalent conclusions. This production day presented a more challenging scenario than the 30th of April, as a higher number of filling operations were scheduled and completed. Nevertheless, by introducing minor adjustments to the sequence of filling operations, it was possible to maintain the Provisioner while respecting the workforce limitations of the sector and completing the same number of filling operations.

It should also be noted that, during part of the day, an additional operator from C1F was temporarily assigned to support the filling operation on the ME-60 machine. Consequently, periods involving five operators corresponded to four filling operators and one manufacturing operator, meaning that the Provisioner could still be maintained without exceeding the available workforce in the filling area. Only the periods involving six operators simultaneously corresponded to the utilisation of all five filling operators together with the additional manufacturing operator, leaving no operator available to be the Provisioner.

Under the proposed schedule for this day, the final filling operation would have been completed at 17h06min, representing only a marginal extension beyond the normal shift end. Considering the operational reality of the sector, this difference was considered negligible, particularly because any remaining filling time could easily be absorbed by the subsequent shift.

Overall, the results suggest that the implementation of the Provisioner does not necessarily reduce the daily production capacity of the filling area. In both analysed scenarios, it was possible to complete the same number of filling operations while maintaining one operator dedicated to the Provisioner role, requiring only minor adjustments to the sequencing of production activities.

These findings indicate that the perceived need to reassign the Provisioner to filling operations is often more closely related to the distribution and scheduling of filling activities throughout the day than to actual workforce limitations. Consequently, a more balanced allocation of filling operations may allow the Provisioner to be maintained without compromising production output, while still preserving the operational benefits associated with the support activities performed by the role.

4.2.7 Double Pallet System

The double pallet system corresponds to a visual management practice previously implemented in the sector in 2024 through floor markings near the end of the filling lines. However,

over time, these markings became degraded and the practice gradually lost consistency among operators. For this reason, the floor markings were reinforced during the project in order to recover the use of this standard and strengthen its visibility on the shop floor.

The objective of the double pallet system is to reduce the number of times the filling operator needs to leave the machine after completing a pallet. Without this system, the operator would have to interrupt the filling operation each time a pallet was completed in order to remove it and place a new empty one. By keeping a second empty pallet available at the end of the line, the operator can continue the filling process with fewer interruptions and fewer movements away from the workstation.

This practice also supports the implementation of the Provisioner. Ideally, the Provisioner should collect completed pallets whenever possible, allowing filling operators to remain focused on machine operation. However, since the Provisioner may be occupied with higher-priority tasks, it is not realistic to assume that every completed pallet will always be removed immediately.

In this context, the double pallet system creates a larger time window for the Provisioner to collect completed pallets before the operator is forced to interrupt the process. If the Provisioner is not available, the filling operator may still need to remove the pallet, but the frequency and urgency of these interruptions are reduced compared to operating with only one pallet.

Therefore, the double pallet system is beneficial both with and without Provisioner intervention. When the Provisioner is available, it improves pallet removal coordination and supports continuous machine operation. When the Provisioner is unavailable, it still reduces operator movement and provides greater flexibility at the end of the filling line.

In the specific case of the ME-53, the original floor markings only defined one pallet position for the 4 L configuration and one pallet position for the 0.75 L configuration. As part of this improvement, an additional pallet position was marked for each of these packaging formats, allowing the double pallet system to be applied regardless of whether the machine is filling 4 L or 0.75 L containers. The condition of the double pallet floor markings before and after reinforcement is presented in Appendix O.

4.2.8 Provisioner Role Standardisation

The studies presented throughout this chapter made it possible to identify the activities that could be reassigned to the Provisioner and to assess the potential operational benefits associated with its implementation. However, simply identifying these activities was not sufficient to guarantee the success of the role.

In practice, the Provisioner is frequently required to respond to multiple requests simultaneously, making it difficult to perform all support activities at the same time. Therefore, it became necessary to establish a clear set of priorities to ensure that the role consistently focuses on the activities that generate the greatest benefit to the filling operations.

For this reason, a study was conducted to analyse how the Provisioner allocated time throughout the day, identify situations where filling operators were still performing Provisioner-related activities and define a standardised working method for the role.

Methodology

The Provisioner was monitored throughout several working days and all activities performed during the shift were recorded together with their respective start and finish times. Special attention was given to situations where tasks that should normally fall under the responsibility of the Provisioner were performed by filling operators instead. These situations were considered particularly relevant, as they often indicated either an inadequate prioritisation of tasks or a conflict between simultaneous requests.

Based on these observations, Gantt charts were developed to represent the chronological distribution of activities performed during each observation period. The charts enabled the identification of situations where lower-priority activities were being performed while more critical support activities remained unattended.

Representative examples of the Gantt charts developed during the study are presented in Appendix P.

The analysis revealed several situations where filling operators performed activities that would theoretically fall under the responsibility of the Provisioner. Examples included setup support activities being carried out by operators while the Provisioner performed pallet strapping and organization tasks (Appendix P.1), operators collecting materials and shop orders while the Provisioner was occupied with packaging activities (Appendix P.2), and the preparation of future filling operations taking priority over support activities required by ongoing production (Appendix P.3).

These observations demonstrated that the effectiveness of the Provisioner role depends not only on the activities assigned to it, but also on the priorities adopted throughout the day. Activities directly associated with preventing machine stoppages, supporting setups and preparing upcoming filling operations were found to generate the greatest benefit, whereas tasks such as pallet organisation and strapping operations could often be postponed without significantly affecting production. Consequently, the establishment of a clear hierarchy of priorities became a fundamental requirement for the standardisation of the role.

Definition of Priority Rules

As the primary objective of the Provisioner is to maximise the amount of time that filling operators remain focused on machine operation, activities directly associated with preventing machine stoppages and supporting setup execution were assigned the highest priority level.

The resulting hierarchy was defined as follows:

1. Support ongoing setups;
2. Collect and transport finished pallets;
3. Strapping pallets;
4. Perform other NVA activities according to the sector's needs.

The priority rules established were incorporated into a standard work document for the Provisioner role. This document defines the responsibilities, operating principles and task hierarchy associated with the function.

The standardisation process consolidated the findings obtained from all the studies above into a single operational reference. By clearly defining the responsibilities of the role, the standard work document reduces ambiguity regarding task ownership and facilitates a more consistent execution of the function.

Furthermore, the document serves as a training and communication tool, ensuring that all operators share a common understanding of the Provisioner's responsibilities and priorities.

The resulting standard work document is presented in Appendix Q.

Discussion

The observations performed during this study demonstrated that the effectiveness of the Provisioner depends not only on the activities assigned to it, but also on the prioritisation criteria adopted throughout the day.

The study showed that the main challenge associated with the role is not the quantity of work assigned to it, but rather deciding which activities should take priority when competing requests arise. Without a clear hierarchy of priorities, lower-priority activities may be performed while tasks with a greater impact on production continuity remain unattended.

For this reason, the priority rules established through the Gantt chart analysis were designed to provide a structured decision-making framework for the role. By clearly defining which activities take precedence over others, the standard work seeks to ensure that the Provisioner's efforts are consistently directed towards preventing machine stoppages and supporting filling operations.

The resulting standard work document provided the foundation for the implementation phase of the project and served as the reference used during the subsequent validation of the Provisioner role.

Chapter 5

Analysis and Comparison of Results

Following the development, standardisation and implementation of the Provisioner presented in the previous chapter, the proposed work method was applied within the filling area under real operating conditions.

Several results associated with the development and validation of the Provisioner were already presented throughout Chapter 4. The purpose of this chapter is therefore to consolidate the most relevant performance indicators and evaluate the overall impact of the implemented changes on the operation.

To achieve this, new DILO studies and Sequence Charts were conducted after implementation. These analyses focused on evaluating changes in the distribution of VA and NVA activities, as well as the setup times achieved when the Provisioner was active. In addition, productivity indicators were analysed in order to assess the overall impact of the proposed operating model.

The results obtained after implementation are presented and compared with the baseline situation described in Chapter 4, providing a comprehensive assessment of the effectiveness of the Provisioner and the associated improvement measures.

5.1 Impact on Operator Activities

To evaluate the impact of the new work organisation on operator activities, additional DILO studies were conducted after the implementation of the Provisioner. The observations were performed under the same operating conditions as those described in Chapter 4, allowing a direct comparison between the situations before and after implementation.

Table 5.1 summarizes the results obtained for each machine category before and after the implementation of the Provisioner.

Table 5.1: Impact of the Provisioner on the distribution of operator activities

Machine Category	**VA Before (%)**	**NVA Before (%)**	**VA After (%)**	**NVA After (%)**
Manual	46.8	53.2	64.2	35.8
Automatic	36.6	63.4	54.5	45.5
Semi-automatic	36.6	63.4	53.1	46.9

Overall, the results demonstrate a consistent improvement in the distribution of operator activities across all machine categories. In every case, the proportion of time dedicated to VA activities increased following the implementation of the Provisioner, indicating a more effective use of operator time within the filling area. Relative to the initial situation, NVA activities were reduced by 32.7% in manual filling stations, 28.2% in automatic machines and 26.0% in semi-automatic machines.

The most significant improvement was observed in the manual filling stations, where VA activities increased from 46.8% to 64.2%. Automatic and semi-automatic machines also showed positive results, with VA activities increasing to 54.5% and 53.1%, respectively.

These improvements were primarily achieved through the transfer of material-handling and logistical activities to the Provisioner, including material collection, material storage and pallet handling tasks. By removing these responsibilities from the filling operators, the need to leave the workstation during production was reduced, resulting in fewer interruptions and a higher proportion of time dedicated to value-adding activities. The results therefore demonstrate that the implemented work organisation contributed directly to the reduction of NVA activities within the filling area.

5.2 Impact on Setup Operations

Following the implementation of the Provisioner, the external activities identified during the SMED workshop were transferred to the Provisioner. As a result, setup durations were reduced across all setup types.

Table 5.2 summarizes the average setup durations observed before and after the implementation of the Provisioner role for each setup type.

Table 5.2: Average setup duration before and after the Provisioner implementation

Setup Type	**Before Provisioner (min)**	**After Provisioner (min)**	**Reduction (%)**
M	6.0	4.0	33.3
E	17.5	13.5	22.9
PI	42.5	25.0	41.2

The greatest improvement was observed in PI setups, where the average setup duration decreased by 41.2%. This result was expected, since PI setups are the setup type in which the

Provisioner provides the greatest level of support, performing a larger share of the external activities.

The reduction in setup duration resulted from the transfer of several preparation and support activities to the Provisioner, including agitator cleaning, tank preparation, material collection and diluent retrieval. By performing these activities externally and in parallel with ongoing production, the amount of machine downtime required during setup operations was significantly reduced.

Overall, the results demonstrate that the implementation of the Provisioner contributed to a faster execution of setup operations and reduced the time during which filling equipment remained unavailable for production. Furthermore, the observed reductions across all setup categories indicate that the proposed work organisation can be applied consistently to different setup scenarios within the filling area.

5.3 Impact on Productivity of the Sector

To assess the overall impact of the project on operational performance, an analysis of productivity evolution throughout the internship period was conducted.

Within the company, productivity indicators are typically monitored at sector level, with the overall productivity of sector C1 being calculated jointly for both the C1F and C1E sectors. Since the Provisioner was implemented exclusively in the filling area, the productivity evolution of C1E was analysed separately from the overall C1 indicator.

This analysis aimed to determine whether the productivity improvements observed at sector level were also reflected in the filling area, where the impact of the proposed work method was expected to be greatest.

A total of 24 weeks of productivity data were analysed. Rather than directly comparing the productivity values observed at the beginning and end of the internship period, linear trendlines were used to evaluate the overall productivity evolution. This approach was considered more representative, as it takes into account all observations and reduces the influence of atypical weeks.

Figure 5.1 presents the productivity evolution of the overall C1 sector, while Figure 5.2 shows the corresponding results for the C1E filling area.

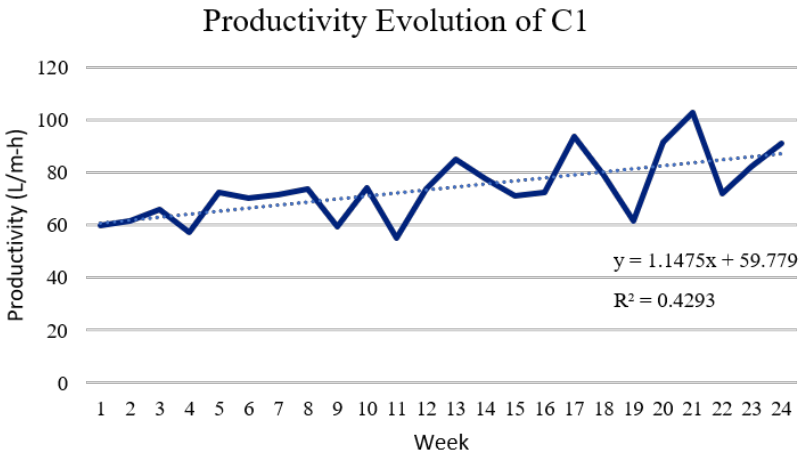


Figure 5.1: Weekly productivity evolution for the overall C1 sector

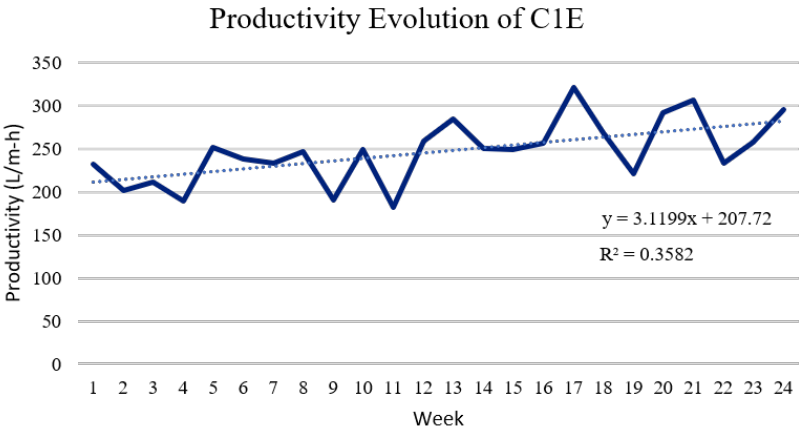


Figure 5.2: Weekly productivity evolution for the C1E filling area

For the overall C1 sector, the productivity trend was represented by the linear trendline shown in Equation (5.1):

$$y = 1.1475x + 59.779 \tag{5.1}$$

with a coefficient of determination of $R^2 = 0.4293$.

Similarly, the productivity trend for the filling area, C1E, was represented by the linear trendline presented in Equation (5.2):

$$y = 3.1199x + 207.72 \tag{5.2}$$

with a coefficient of determination of $R^2 = 0.3582$.

In both equations, x corresponds to the week number and y corresponds to the productivity value expressed in L/m-h. The R^2 values indicate the goodness of fit of the linear regression models.

Using these trendlines, the estimated productivity at the beginning and end of the 24-week period was calculated. The results indicate that the productivity of the C1 sector increased from 60.9 L/m-h to 87.3 L/m-h, corresponding to an estimated increase of 43.3%.

Similarly, the productivity of the filling area increased from approximately 210.8 L/m-h to 282.6 L/m-h, corresponding to an estimated increase of 34.0%.

These results suggest that the productivity gains achieved in the filling area contributed positively to the overall productivity increase of sector C1. Since the improvement measures developed during this project were implemented exclusively in C1E, this finding indicates that the changes introduced in the filling area supported the overall performance improvement observed at sector level.

It should be noted that the observed productivity evolution cannot be attributed exclusively to the implementation of the Provisioner. Instead, it reflects the combined impact of the different improvement initiatives developed throughout the project, including the reorganisation of operator activities, setup improvement measures and machine-specific improvements. Together, these initiatives contributed to a more efficient production flow and improved utilisation of both labour and equipment resources.

Nevertheless, the positive trend observed in the filling area is consistent with the expected impact of the implemented measures. The reduction of NVA activities allowed operators to dedicate a greater proportion of their working time to production tasks, while the reduction of setup durations increased equipment availability. Combined with the remaining improvement initiatives implemented during the project, these measures contributed to the productivity gains observed throughout the study period.

Chapter 6

Conclusions and Future Work

The main objective of this dissertation was to improve the production flow of the filling area in sector C1 of CIN through the implementation of a Provisioner dedicated to supporting filling operations. The results obtained suggest that this objective was largely achieved. The productivity improvements observed throughout the project exceeded the initial target of a 5% productivity increase, demonstrating the positive impact of the implemented measures on the operational performance of the filling area.

6.1 Conclusions

The analyses performed throughout the project revealed that filling operators were frequently required to interrupt their primary activities in order to perform logistical and support tasks. These interruptions reduced the proportion of VA work, increased operator movement and contributed to longer setup durations and lower operational efficiency.

To address these issues, a Provisioner role was developed and standardised to centralise support activities and assist filling operators. The proposed operating model was supported by several complementary studies, including productivity analyses, workload evaluations, filling schedule assessments and operational scenario analyses. These studies not only supported the definition of the Provisioner's responsibilities but also provided a broader understanding of the factors affecting the performance of the filling area.

Following implementation, the results demonstrated that the proposed operating model generated significant operational benefits. The DILO analyses showed an increase in VA activities across all machine categories, while setup durations were significantly reduced through the transfer of external activities to the Provisioner. Additional improvements, such as the integration of selected strapping activities into filling operations and the improvement of the ME-61 setup procedure, further contributed to improving the overall productivity of the sector.

The analyses also demonstrated that maintaining one operator permanently assigned to the Provisioner role does not necessarily reduce the daily production capacity of the filling area, as previously assumed.

The positive impact of the implemented measures was further reflected in the productivity indicators. During the internship period, the filling area presented a productivity increase of approximately 34%, while the overall productivity of sector C1 increased by approximately 43.3%. Furthermore, the objective of achieving a productivity improvement greater than 5% in the filling area was successfully exceeded.

Overall, the results obtained demonstrate that the Provisioner represents an effective approach for improving workflow organisation, reducing NVA activities and increasing operational efficiency. The standardisation and implementation of this function provided a practical and sustainable solution to several of the operational challenges identified in the filling area, creating a foundation for continued improvement in the future.

6.2 Future Work

Despite the positive results achieved, several opportunities for future work were identified. Firstly, the Provisioner compliance analysis should be extended in order to obtain a larger dataset, particularly for scenarios involving three and four simultaneous filling operations. This would allow the compliance rates used in the operational simulations to be validated through direct observation and provide a more accurate assessment of the Provisioner's performance under different workload conditions.

Another relevant opportunity involves improving the stability of the weekly filling schedule. Since frequent deviations from the production plan were identified as one of the main challenges to the proactive execution of the Provisioner role, reducing schedule variability could further enhance the effectiveness of the proposed operating model and increase the benefits associated with advance preparation and setup support activities.

Additionally, future work should include the training of operators to perform the Provisioner. Expanding the number of trained operators would increase workforce flexibility, facilitate the integration of the role into the daily operation of the sector and support the long-term sustainability of the proposed work organisation.

Finally, the applicability of the Provisioner concept could be evaluated in other production areas of the factory. Future work could therefore assess the operational characteristics of these areas and evaluate the feasibility and potential benefits of implementing a similar role, contributing to a broader improvement of production flow across the factory.

References

6Sigma (2024). *What is the Role of the Waterspider in Lean Manufacturing?* Accessed: 2026-05-20. URL: https://6sigma.com/what-is-the-role-of-the-waterspider-in-lean-manufacturing/.

Ante, Giorgio, Francesco Facchini, Giorgio Mossa, and Salvatore Digiesi (2018). "Developing a Key Performance Indicators Tree for Lean and Smart Production Systems". In: *IFAC-PapersOnLine* 51.11, pp. 13–18. DOI: 10.1016/j.ifacol.2018.08.227.

Bartolucci, B., F. Frasca, C. Bertolin, and A. M. Siani (2026). "KPIs as catalyst for energy-efficient building renovation under EU regulations". In: *Environmental & Sustainability Indicators*.

BOOST 4.0 Project (2020). *Line Feeding Processes and Internal Logistics in Assembly Systems*. Tech. rep. Horizon 2020.

Coimbra, Eduardo (2013). *Kaizen in Logistics and Supply Chains*. McGraw-Hill Education.

DMAIC (2024). *Day in the Life of (DILO)*. URL: https://www.dmaic.com/wiki/day-in-the-life-of-dilo/ (visited on 06/28/2026).

Flexpipe (2024). *The Role of the Water Spider in Lean Manufacturing*. Accessed: 2026-05-20. URL: https://www.flexpipeinc.com/ca_en/role_of_waterspider-2/.

Hall, R. W. (1987). *Attaining Manufacturing Excellence*. Homewood, Ill. : Dow Jones-Irwin.

Institute, Lean Enterprise (2023). *Understanding Lean Thinking and Practice Fundamentals*.

Kaizen Coach (2024). *Mizusumashi*. Accessed: 2026-05-20. URL: https://www.kaizen-coach.com/lean-dictionary/mizusumashi.

Kaizen Institute (2024a). *Compreender Lean Manufacturing: Guia*. Accessed: 2026-05-20. URL: https://kaizen.com/pt/insights-pt/compreender-lean-manufacturing-guia/.

— (2024b). *Pareto Chart: Focusing Improvement Efforts*. URL: https://kaizen.com/insights/pareto-chart-improvement-efforts/ (visited on 06/28/2026).

— (2024c). *SMED: Reduce Changeover and Boost Efficiency*. URL: https://kaizen.com/insights/smed-reduce-changeover-boost-efficiency/ (visited on 05/22/2026).

Larson, Jeremy and Eric Whitney (2025). "Pareto Charts, Scatter Plots, and Bubble Charts". In: *Current Problems in Pediatric and Adolescent Health Care* 55, p. 101804. DOI: 10.1016/j.cppeds.2025.101804.

Lean Enterprise Institute (2024a). *A Brief History of Lean*. URL: https://www.lean.org/explore-lean/a-brief-history-of-lean/ (visited on 05/22/2026).

— (2024b). *Standardized Work*. URL: https://www.lean.org/lexicon-terms/standardized-work/ (visited on 05/22/2026).

Marr, B. (2012). *Key Performance Indicators: The 75 measures every manager needs to know*. Financial Times.

Melton, T. (2005). "THE BENEFITS OF LEAN MANUFACTURING What Lean Thinking has to Offer the Process Industries". In: *IChemE*.

MOUHIB, Z., M. GALLAB, S. MERZOUK, A. SOULHI, and B. ELBHIRI (2024). "Towards a generic framework of OEE monitoring for driving effectiveness in digitalization era". In: *Elsevier*.

Ndlela, Thobekile et al. (2020). "Overall Equipment Effectiveness: Systematic Literature Review and Overview of Different Approaches". In: *Applied Sciences* 10.18, p. 6469. DOI: 10.3390/app10186469.

Oliveira, J., J. Sá, and A. Fernandes (2017). "Continuous Improvement through "Lean Tools": An Application in a Mechanical Company". In: *Procedia Manufacturing* 13, pp. 1082–1089.

Perloiro, Madalena (2020). "Implementation of the Mizusumashi Concept in a Ceramics Factory". MA thesis. Instituto Superior Técnico, Universidade de Lisboa.

Pinto, J. P. (2009). *Pensamento Lean: A filosofia das organizações vencedoras*. Lidel.

Setiawan, I. and H. H. Purba (2020). "A Systematic Literature Review of Key Performance Indicators (KPIs) Implementation". In: *JOURNAL OF INDUSTRIAL ENGINEERING MANAGEMENT RESEARCH*.

ToolsHero (2024). *Day in the Life Of (DILO)*. URL: https://www.toolshero.com/quality-management/day-in-the-life-of-dilo/ (visited on 06/28/2026).

Velaction Continuous Improvement (2024). *Water Spider (Mizusumashi)*. Accessed: 2026-05-20. URL: https://www.velaction.com/water-spider-mizusumashi/.

Wahab, Amelia Natasya Abdul, Muriati Mukhtar, and Riza Sulaiman (2013). "A Conceptual Model of Lean Manufacturing Dimensions". In: *Procedia Technology* 11, pp. 1292–1298. DOI: 10.1016/j.protcy.2013.12.327.

Wang, Yuan (2013). "RFID-enabled Real-time Production Planning and Scheduling in Lean Manufacturing". PhD thesis. The University of Hong Kong.

Womack, J. P. and D. T. Jones (2003). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. Free Press.

Appendix A

Gantt Chart

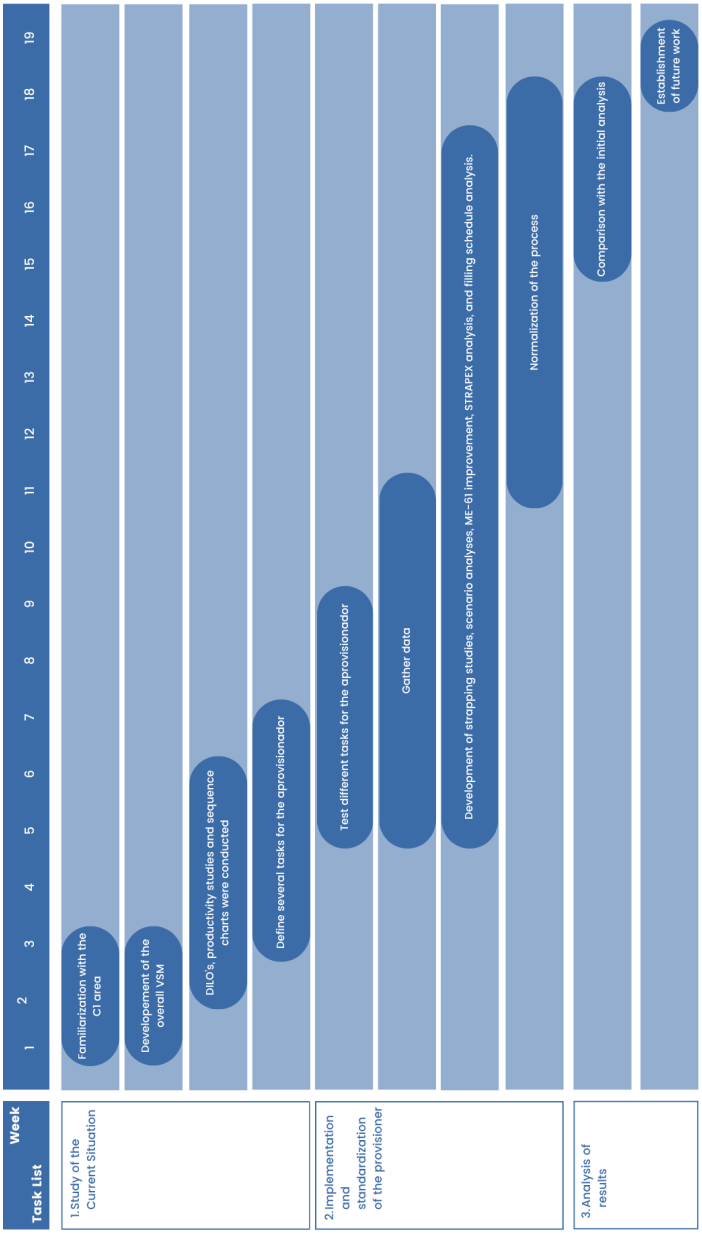


Figure A.1: Gantt Chart

Appendix B

C1E Plant Layout

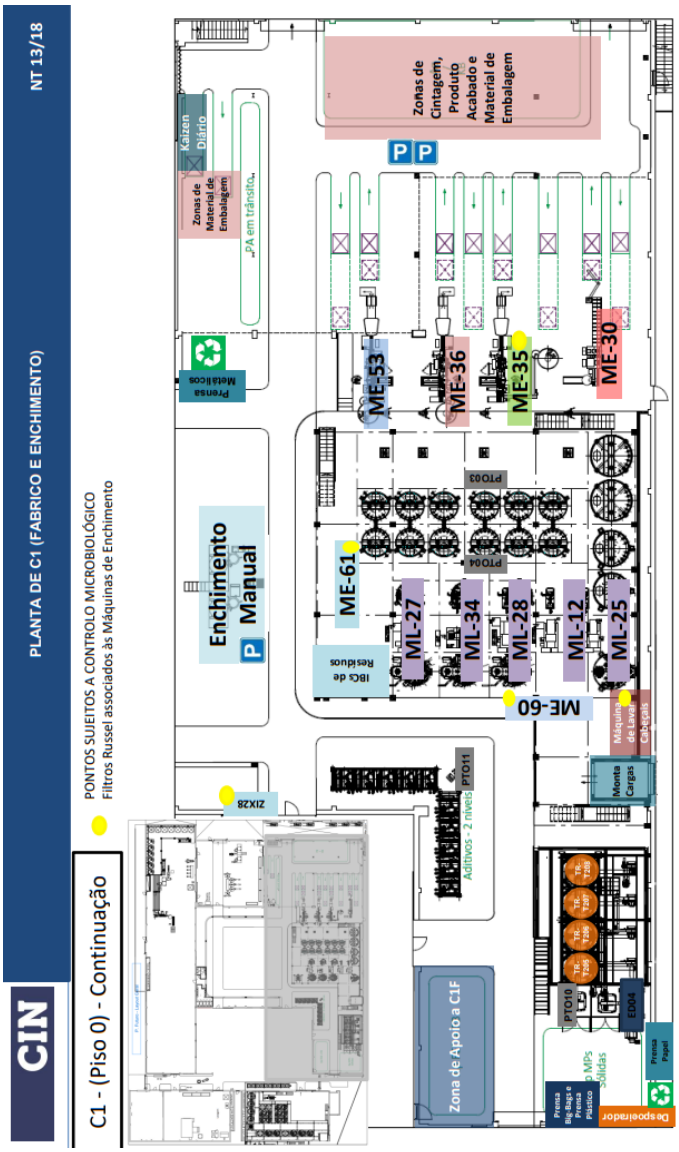


Figure B.1: C1E Plant Layout

Appendix C

Swimlane Process Map

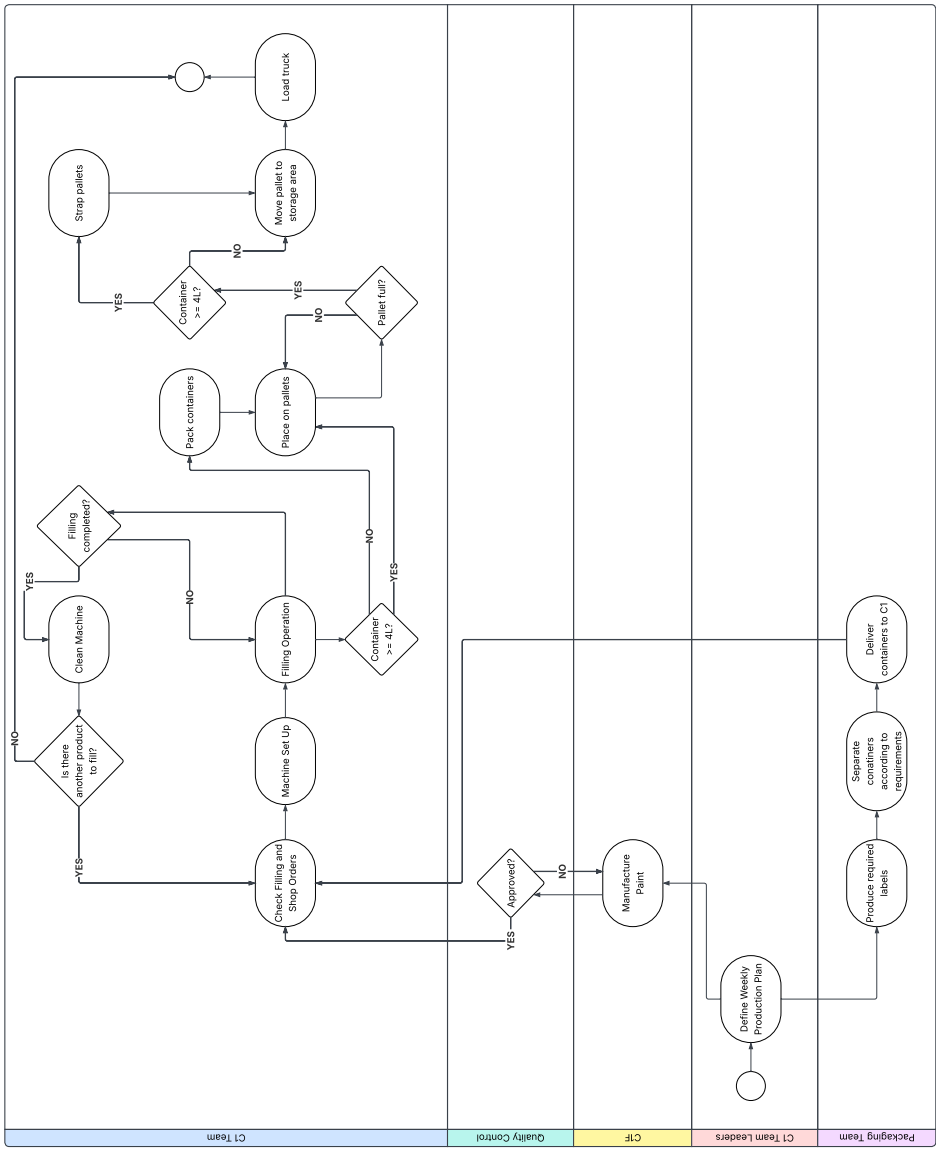


Figure C.1: Swimlane Process Map

Appendix D

Strapex Machine



Figure D.1: Strapex Machine



Figure D.2: Strapex Machine

Appendix E

Productivity Studies - Template Sheets

CIN **PRODUCTIVITY STUDY**

Product		Paint Weight	
FO:		Number of Manual Labels	
Number of Filled Cans		Base / Overall	

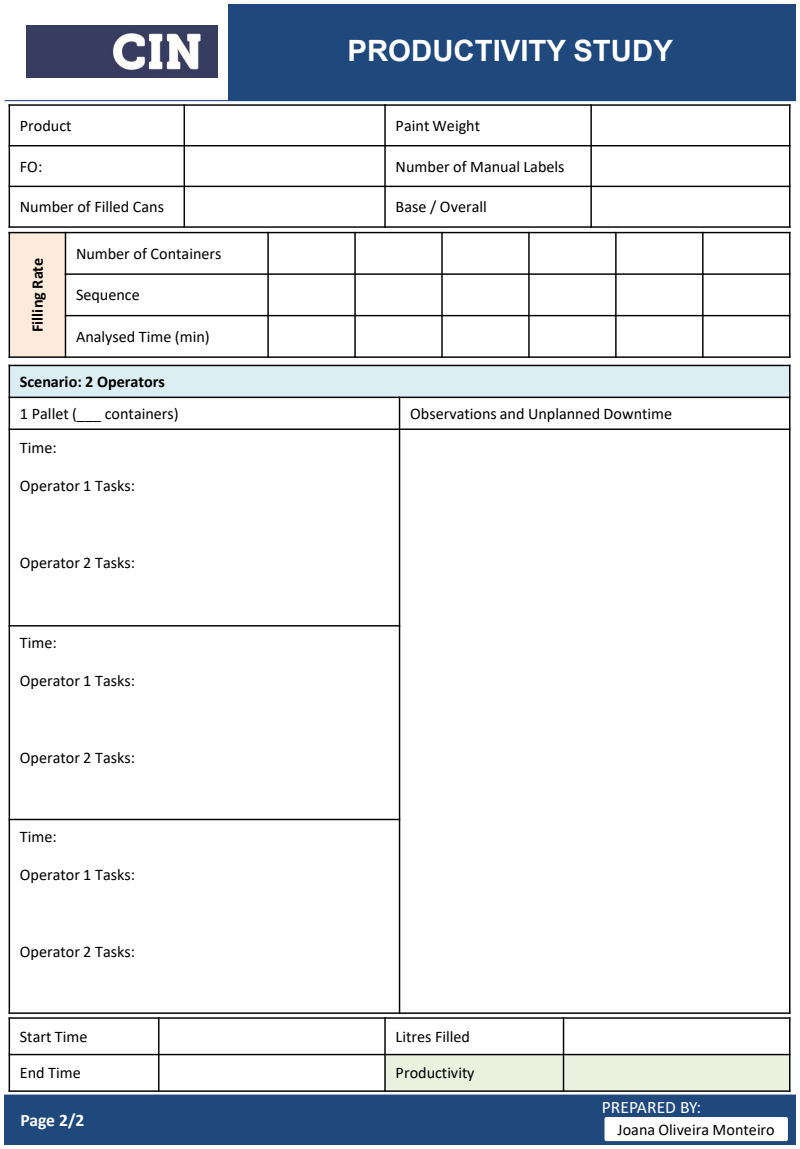
Filling Rate	Number of Containers						
	Sequence						
	Analysed Time (min)						

Scenario: 1 Operator	
1 Pallet (___ containers)	Observations and Unplanned Downtime
Time: Stops for palletising + number of cans + duration: • • •	
Time: Stops for palletising + number of cans + duration: • • •	
Time: Stops for palletising + number of cans + duration: • • •	

Start Time		Litres Filled	
End Time		Productivity	

Page 1/2 PREPARED BY: Joana Oliveira Monteiro

Figure E.1: Productivity Study for 1 operator



CIN

PRODUCTIVITY STUDY

Product		Paint Weight	
FO:		Number of Manual Labels	
Number of Filled Cans		Base / Overall	

Filling Rate							
	Number of Containers						
	Sequence						
	Analysed Time (min)						

Scenario: 2 Operators	
1 Pallet (___ containers)	Observations and Unplanned Downtime
Time: Operator 1 Tasks: Operator 2 Tasks:	
Time: Operator 1 Tasks: Operator 2 Tasks:	
Time: Operator 1 Tasks: Operator 2 Tasks:	

Start Time		Litres Filled	
End Time		Productivity	

Page 2/2

PREPARED BY:
Joana Oliveira Monteiro

Figure E.2: Productivity Study for 2 operators

Appendix F

Tamping Mechanism



Figure F.1: Tamping mechanism



Figure F.2: Manual Filling Station Layout while using this tamping mechanism

Appendix G

Day in Life Of - Template Sheet

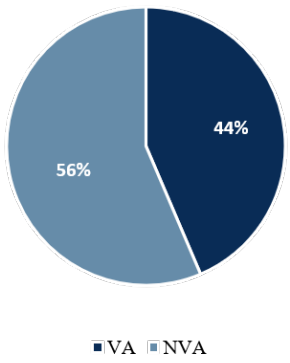
DILO - Day In Life Of _____ __/__/___

#	Activity Description	Start Time	End Time	Observations	VA / NVA
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

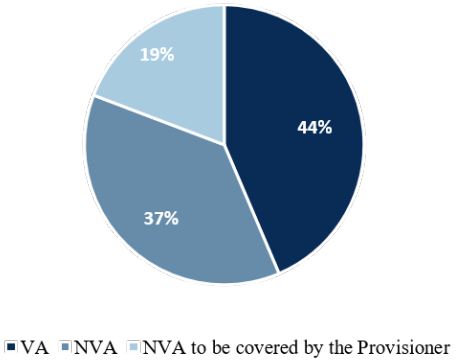
Figure G.1: DILO Template Sheet

Appendix H

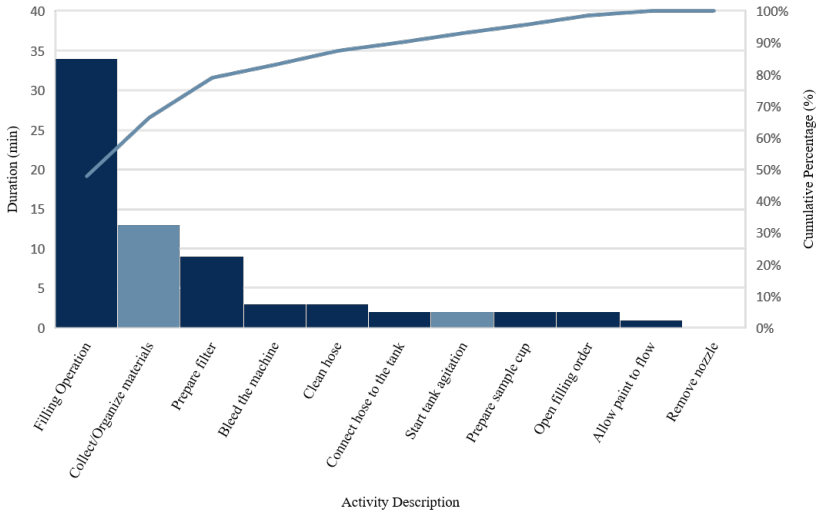
Data obtained from the DILOs performed



(a) Distribution of VA and NVA activities

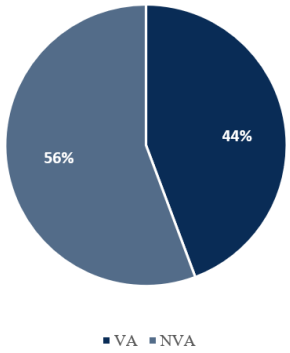


(b) NVA potentially covered by the Provisioner

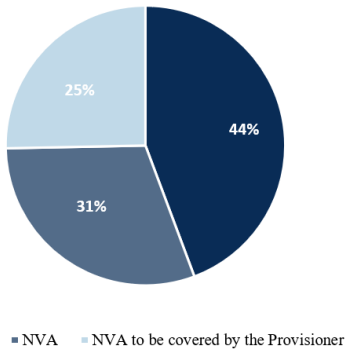


(c) Pareto analysis of operator activities

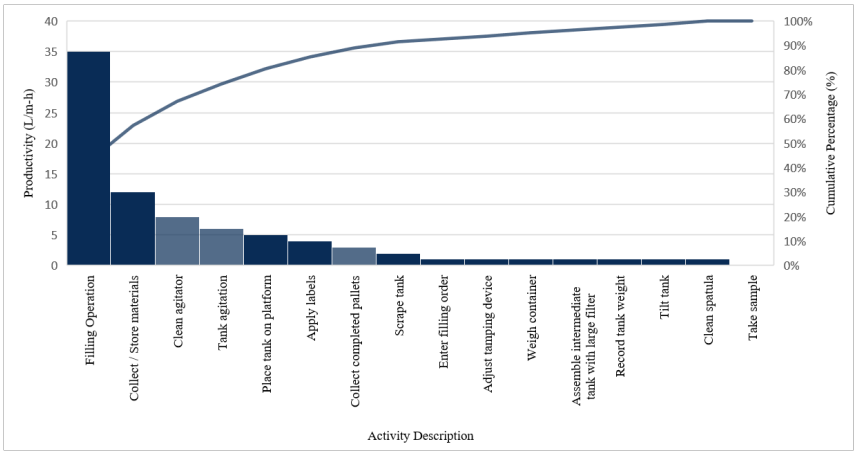
Figure H.1: Example of graphical outputs obtained from the DILO analysis performed on the ME-53



(a) Distribution of VA and NVA activities

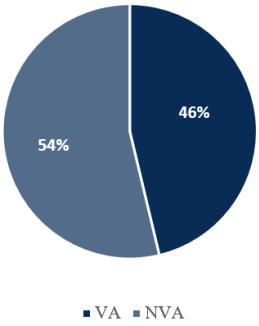


(b) NVA potentially covered by the Provisioner

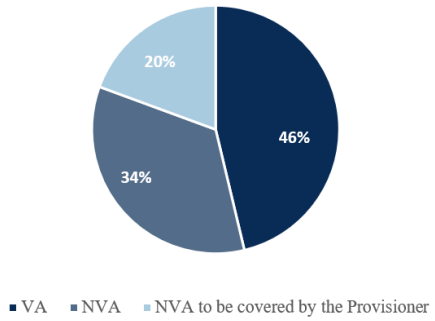


(c) Pareto analysis of operator activities

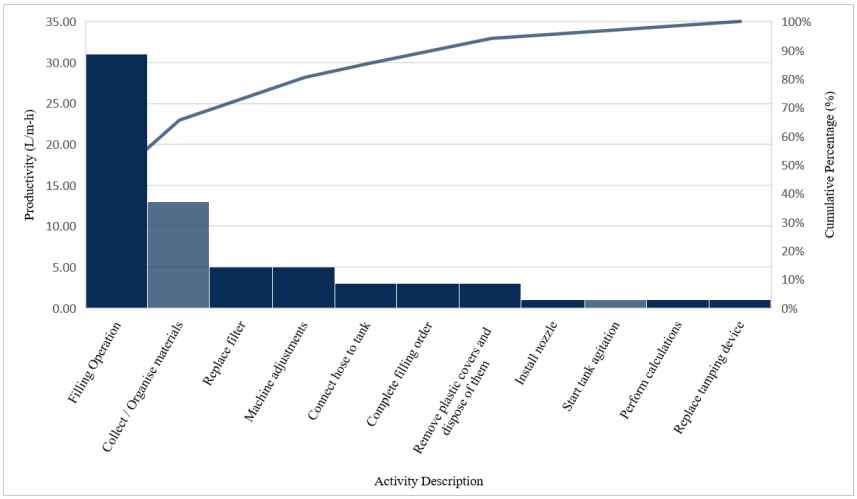
Figure H.2: Example of graphical outputs obtained from the DILO analysis performed on a manual filling station



(a) Distribution of VA and NVA activities



(b) NVA activities covered by the Provisioner



(c) Pareto analysis of operator activities

Figure H.3: Example of graphical outputs obtained from the DILO analysis performed on the ME-61

Appendix I

Sequence Chart - Template Sheet

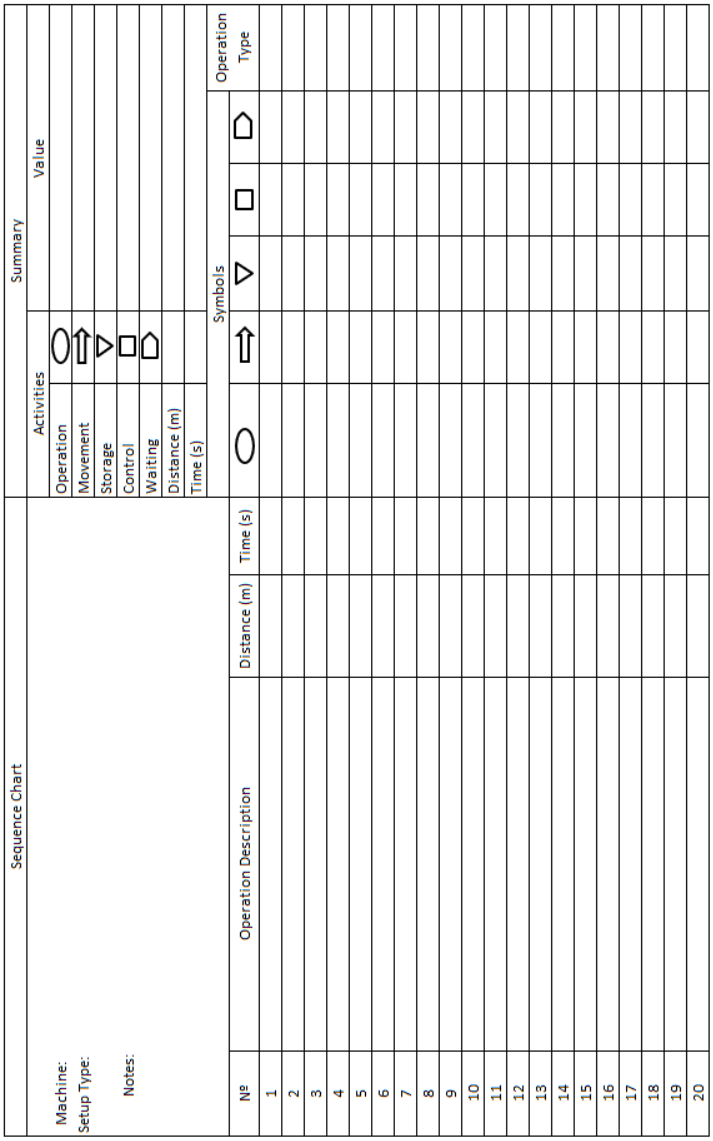


Figure I.1: Sequence Chart Template Sheet

Appendix J

Data Recorded for the Strapping Study

72 containers per pallet

	Average (s)			
STRAPPING	151.5	**Product**	17685 0503 05	
	1 horizontal strap around each layer (passing underneath the handles of the corner containers) + corner protectors	**Packaging**	L-QST05	
		Palletising		**Time (s)**
		Quantity per pallet	72	162.5
		Number of layers	3	
		Units per layer	24	
		Product	89200 8801 04	
		Packaging	PIA04-V5	
		Palletising		**Time (s)**
		Quantity per pallet	72	140.5
		Number of layers	3	
		Units per layer	24	

Figure J.1: Example of the Strapping Time Record

Containe	Pallet ID	Time	Nr of containers per palle
AC200-V1	PALLET-EXP	171	4
ACN04-RL	PALLET-EUR	173.8	96
AV200-V1	PALLET-EUR	130	2
CP208	PALLET-EUR	**11**	2
LBC10-N	PALLET-EUR	48.0	24
L-CFO04	PALLET-EUR	173.8	96
L-CLO04-B	PALLET-EUR	173.8	96
LCM05	PALLET-EUR	150.2	96
LGC04	PALLET-EUR	150.2	96
LMC20-V1	PALLET-EXP	45.1	24
LMC20-V1	PALLET-EUR	36.7	22
LMC21	PALLET-EUR	36.7	22
LMC25	PALLET-EUR	36.66	22
LME04	PALLET-EUR	173.82	96
LMU05-N	PALLET-EUR	150.15	96
LMU15	PALLET-EUR	65.00	33
LMU25-V1	PALLET-EUR	37.0	16
LMV04	PALLET-EUR	173.82	96
LMV10	PALLET-EUR	87.67	44
L-PSD04	PALLET-EUR	173.82	96
L-QST05	PALLET-EUR	151.5	72
L-SNF04	PALLET-EUR	173.82	96
L-TTS10	PALLET-EUR	87.7	44
LVC20-V2	PALLET-EUR	36.7	22
LVM25	PALLET-EXP	36.66	24
LVM25	PALLET-EUR	36.66	22
PI005-V4	PALLET-EUR	150.15	96
PIA04-V4	PALLET-EUR	150.2	96
PIA04-V5	PALLET-EUR	150.2	96
PIA20-V4	PALLET-EUR	36.66	22
PIC04-V4	PALLET-EUR	150.2	96
PIC20-V4	PALLET-EUR	36.7	22
PICC5-V4	PALLET-EUR	150.2	96
PIE15-V4	PALLET-EUR	65.0	33
PIE20-V3	PALLET-EUR	36.7	22
PIE20-V3	PALLET-EXP	36.7	24
PIS20-V3	PALLET-EUR	36.7	22

Figure J.2: Excerpt from the Strapping Time Table

Appendix K

Results obtained for the Filling Schedule Study

Table K.1: Filling schedule compliance analysis (Part I)

Date	Planned	Completed as Planned	Total Performed	Urgent	Compliance Rate (%)
23/Mar	4	0	8	3	0.00
24/Mar	10	1	10	3	10.00
25/Mar	18	3	15	6	20.00
26/Mar	13	0	11	5	0.00
27/Mar	15	1	10	4	10.00
30/Mar	12	7	12	3	58.33
31/Mar	12	4	14	7	28.57
01/Apr	19	6	12	4	50.00
02/Apr	6	3	13	5	23.08
06/Apr	8	1	9	3	11.11
07/Apr	10	3	7	3	42.86
08/Apr	17	2	5	3	40.00
09/Apr	9	0	7	2	0.00
10/Apr	6	1	8	3	12.50
13/Apr	9	3	10	3	30.00
14/Apr	12	2	7	4	28.57
15/Apr	13	2	8	4	25.00
16/Apr	13	4	10	0	40.00
17/Apr	11	3	8	3	37.50
20/Apr	7	4	10	5	40.00
21/Apr	10	4	11	1	36.36

Table K.2: Filling schedule compliance analysis (Part II)

Date	Planned	Completed as Planned	Total Performed	Urgent	Compliance Rate (%)
22/Apr	11	2	8	1	25.00
23/Apr	18	4	16	7	25.00
24/Apr	11	1	14	4	7.14
27/Apr	15	4	12	4	33.33
28/Apr	16	3	11	4	27.27
29/Apr	10	2	11	3	18.18
30/Apr	8	0	11	3	0.00

Appendix L

Human Resource Allocation per Number of Simmultaneous Machines

Table L.1: Two-machine operational scenarios

Scenario	Description	Required Operators
1	Manual, Manual	2
2	Automatic, Manual	2
3	Automatic, Automatic	2
4	ME-61, Manual	2
5	ME-61, Automatic	2
6	ME-60, Manual	3
7	ME-60, Automatic	3
8	ME-60, ME-61	3
9	ME-30, Manual	3
10	ME-30, Automatic	3
11	ME-30, ME-61	3
12	ME-30, ME-60	4

Table L.2: Three-machine operational scenarios

Scenario	Description	Required Operators
1	Automatic, Manual, Manual	3
2	Automatic, Automatic, Manual	3
3	Automatic, Automatic, Automatic	3*
4	ME-61, Manual, Manual	3
5	ME-61, Automatic, Manual	3
6	ME-61, Automatic, Automatic	3
7	ME-60, Manual, Manual	4
8	ME-60, Automatic, Manual	4
9	ME-60, Automatic, Automatic	4
10	ME-60, ME-61, Manual	4
11	ME-60, ME-61, Automatic	4
12	ME-30, Manual, Manual	4
13	ME-30, Automatic, Manual	4
14	ME-30, Automatic, Automatic	4
15	ME-30, ME-61, Manual	4
16	ME-30, ME-61, Automatic	4
17	ME-30, ME-60, Manual	5
18	ME-30, ME-60, Automatic	5
19	ME-30, ME-60, ME-61	5

*Operationally infeasible due to lack of trained operators for simultaneous automatic machine operation.

Table L.3: Four-machine operational scenarios

Scenario	Description	Required Operators
1	Automatic, Automatic, Manual, Manual	4
2	Automatic, Automatic, Automatic, Manual	4*
3	ME-61, Automatic, Manual, Manual	4
4	ME-61, Automatic, Automatic, Manual	4
5	ME-61, Automatic, Automatic, Automatic	4*
6	ME-60, Automatic, Manual, Manual	5
7	ME-60, Automatic, Automatic, Manual	5
8	ME-60, Automatic, Automatic, Automatic	5*
9	ME-60, ME-61, Manual, Manual	5
10	ME-60, ME-61, Automatic, Manual	5
11	ME-60, ME-61, Automatic, Automatic	5
12	ME-30, Automatic, Manual, Manual	5
13	ME-30, Automatic, Automatic, Manual	5
14	ME-30, Automatic, Automatic, Automatic	5*
15	ME-30, ME-61, Manual, Manual	5
16	ME-30, ME-61, Automatic, Manual	5
17	ME-30, ME-61, Automatic, Automatic	5
18	ME-30, ME-60, Manual, Manual	6
19	ME-30, ME-60, Automatic, Manual	6
20	ME-30, ME-60, Automatic, Automatic	6
21	ME-30, ME-60, ME-61, Manual	6
22	ME-30, ME-60, ME-61, Automatic	6

*Operationally infeasible due to lack of trained operators for simultaneous automatic machine operation.

Table L.4: Five-machine operational scenarios

Scenario	Description	Required Operators
1	Automatic, Automatic, Automatic, Manual, Manual	5*
2	ME-61, Automatic, Automatic, Manual, Manual	5
3	ME-61, Automatic, Automatic, Automatic, Manual	5*
4	ME-60, Automatic, Automatic, Manual, Manual	6
5	ME-60, Automatic, Automatic, Automatic, Manual	6
6	ME-30, Automatic, Automatic, Manual, Manual	6
7	ME-30, Automatic, Automatic, Automatic, Manual	6
8	ME-60, ME-61, Automatic, Manual, Manual	6
9	ME-60, ME-61, Automatic, Automatic, Manual	6
10	ME-60, ME-61, Automatic, Automatic, Automatic	6
11	ME-30, ME-61, Automatic, Manual, Manual	6
12	ME-30, ME-61, Automatic, Automatic, Manual	6
13	ME-30, ME-61, Automatic, Automatic, Automatic	6
14	ME-30, ME-60, Automatic, Manual, Manual	7
15	ME-30, ME-60, Automatic, Automatic, Manual	7
16	ME-30, ME-60, Automatic, Automatic, Automatic	7
17	ME-30, ME-60, ME-61, Manual, Manual	7
18	ME-30, ME-60, ME-61, Automatic, Manual	7
19	ME-30, ME-60, ME-61, Automatic, Automatic	7

*Operationally infeasible due to lack of trained operators for simultaneous automatic machine operation.

Appendix M

Provisioner's Compliance Rate - Template Sheet

Date _____

	Task	Level of Priority	Start Time	End Time	Performed by APV? (Y/N)	Required APV Task? (Y/N)	Observations	Nr of Fillings
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Figure M.1: Provisioner's Compliance Rate Template Sheet

Appendix N

Reconstruction of the Daily Schedules of Days 29 and 30 of April

Note: IDs highlighted in red correspond to priority operations whose original scheduling was maintained. IDs highlighted in yellow indicate operations whose scheduling was adjusted during the reconstruction process.

Start Time	End Time	Active IDs	Active Machines	Operators
8:45	9:08	1	ME30	2
9:08	9:35	1 + 2	ME30 + Manual	3
9:35	9:41	1 + 2 + 3	ME30 + Manual + ME61	4
9:41	9:55	2 + 3	Manual + ME61	2
9:55	10:25	2 + 3 + 4	Manual + ME61 + ME30	4
10:25	10:29	2 + 4	Manual + ME30	3
10:29	11:28	2 + 4 + 5	Manual + ME30 + ME61	4
11:28	11:29	2 + 4	Manual + ME30	3
11:29	11:37	4	ME30	2
11:37	12:23	4 + 6	ME30 + ME61	3
12:23	12:24	4 + 6 + 7	ME30 + ME61 + Manual	4
12:24	12:27	4 + 6	ME30 + ME61	3
13:34	13:35	6 + 8	ME61 + ME30	3
13:35	14:16	6 + 8 + 9	ME61 + ME30 + Manual	4
14:16	14:37	6 + 8 + 9 + 10	ME61 + ME30 + Manual + ME60	6
14:37	14:42	6 + 9 + 10	ME61 + Manual + ME60	4
14:42	14:48	6 + 10	ME61 + ME60	3
14:48	14:56	6 + 10 + 11	ME61 + ME60 + Manual	4
14:56	15:03	10 + 11	ME60 + Manual	3
15:03	15:04	10 + 11 + 12	ME60 + Manual + ME30	5
15:04	15:05	10 + 11 + 12 + 13	ME60 + Manual + ME30 + ME61	6
15:05	15:08	10 + 12 + 13	ME60 + ME30 + ME61	5
15:08	16:05	10 + 12 + 13 + 14	ME60 + ME30 + ME61 + Manual	6
16:05	16:09	10 + 13 + 14	ME60 + ME61 + Manual	4
16:09	16:18	10 + 14	ME60 + Manual	3
16:18	16:46	10	ME60	2

Figure N.1: Day 29 - Before

Start Time	End Time	Active IDs	Active Machines	Operators
8:45	9:08	1	ME30	2
9:08	9:35	1 + 2	ME30 + Manual	3
9:35	9:40	1 + 2 + 3	ME30 + Manual + ME61	4
9:40	9:55	2 + 3	Manual + ME61	2
9:55	10:21	2 + 3 + 4	Manual + ME61 + ME30	4
10:21	10:29	2 + 4	Manual + ME30	3
10:29	11:10	2 + 4 + 5	Manual + ME30 + ME61	4
11:10	11:23	4 + 5	ME30 + ME61	3
11:23	11:37	4	ME30	2
11:37	12:23	4 + 6	ME30 + ME61	3
12:23	12:24	4 + 6 + 7	ME30 + ME61 + Manual	4
12:24	12:26	4 + 6	ME30 + ME61	3
13:34	14:16	6 + 8	ME61 + ME30	3
14:16	14:35	6 + 8 + 10	ME61 + ME30 + ME60	5
14:35	14:37	8 + 9 + 10	ME30 + Manual + ME60	5
14:37	14:48	9 + 10	Manual + ME60	3
14:48	15:02	9 + 10 + 11	Manual + ME60 + Manual	4
15:02	15:03	9 + 10	Manual + ME60	3
15:03	15:33	9 + 10 + 12	Manual + ME60 + ME30	5
15:33	16:04	10 + 12	ME60 + ME30	4
16:04	16:05	10	ME60	2
16:05	16:46	10 + 13 + 14	ME60 + ME61 + Manual	4
16:46	17:05	13 + 14	ME61 + Manual	2
17:05	17:07	14	Manual	1

Figure N.2: Day 29 - After

Start Time	End Time	Active IDs	Active Machines	Operators
8:56	9:00	1	ME35	1
9:00	9:14	1 + 2	ME35 + Manual	2
9:14	9:23	1 + 2 + 3	ME35 + Manual + ME60	4
9:23	9:49	1 + 2 + 3 + 4	ME35 + Manual + ME60 + ME61	5
9:49	10:20	1 + 3 + 4 + 5	ME35 + ME60 + ME61 + Manual	5
10:20	10:28	1 + 3 + 5	ME35 + ME60 + Manual	4
10:28	10:48	1 + 3	ME35 + ME60	3
10:48	11:03	3	ME60	2
11:03	11:47	3 + 6	ME60 + Manual	3
11:47	11:49	3 + 6 + 7	ME60 + Manual + ME53	4
11:49	11:58	6 + 7	Manual + ME53	2
11:58	12:14	7	ME53	1
12:14	14:13	7 + 8	ME53 + Manual	2
14:13	15:03	9	ME53	1
15:03	15:17	9 + 10	ME53 + Manual	2
15:17	16:36	10	Manual	1
16:36	16:43	10 + 11	Manual + Manual	2
16:43	16:54	11	Manual	1

Figure N.3: Day 30 - Before

Start Time	End Time	Active IDs	Active Machines	Operators
8:56	9:00	1	ME35	1
9:00	9:14	1 + 2	ME35 + Manual	2
9:14	9:42	1 + 2 + 3	ME35 + Manual + ME60	4
9:42	9:49	1 + 3	ME35 + ME60	3
9:49	10:23	1 + 3 + 5	ME35 + ME60 + Manual	4
10:23	10:41	1 + 3	ME35 + ME60	3
10:41	11:03	3	ME60	2
11:03	11:47	3 + 6	ME60 + Manual	3
11:47	11:48	3 + 7	ME60 + ME53	3
11:48	12:14	7	ME53	1
12:14	12:28	7 + 8	ME53 + Manual	2
12:28	14:00	7	ME53	1
14:00	14:13	4	ME53 + ME61	2
14:13	14:53	4 + 9	ME61 + ME53	2
14:53	15:03	9	ME53	1
15:03	15:11	9 + 10	ME53 + Manual	2
15:11	16:21	10	ME53 + Manual	2
16:21	16:36	-	-	0
16:36	16:50	11	Manual	1

Figure N.4: Day 30 - After

Appendix O

Double Pallet Floor Marks - Before and After Reinforcement

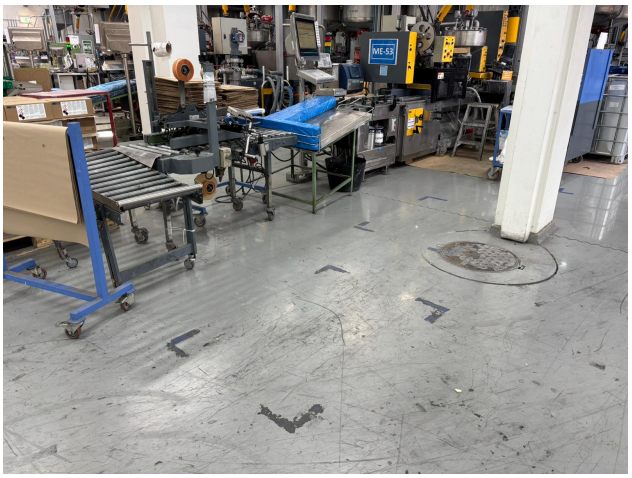


Figure O.1: Before Reinforcement



Figure O.2: After Reinforcement

Appendix P

Provisioner's Priority Study

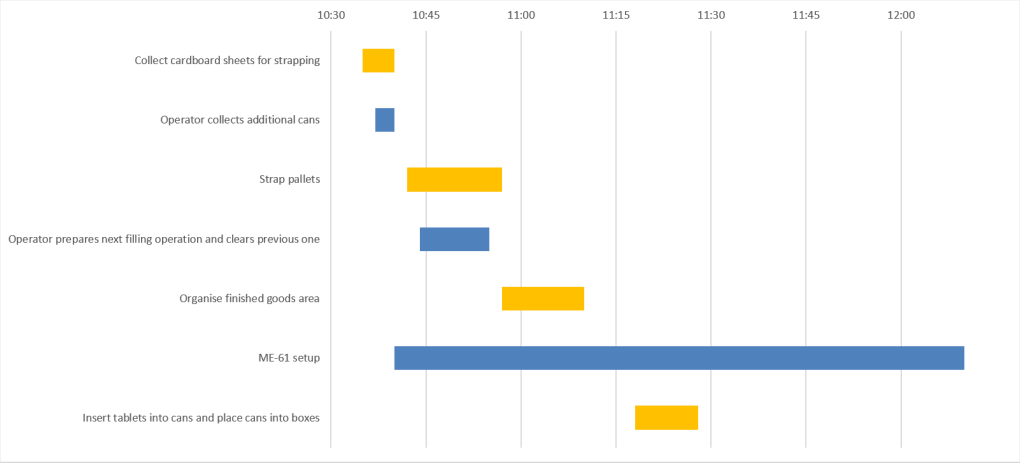


Figure P.1: Provisioner's Priority Study - Example 1

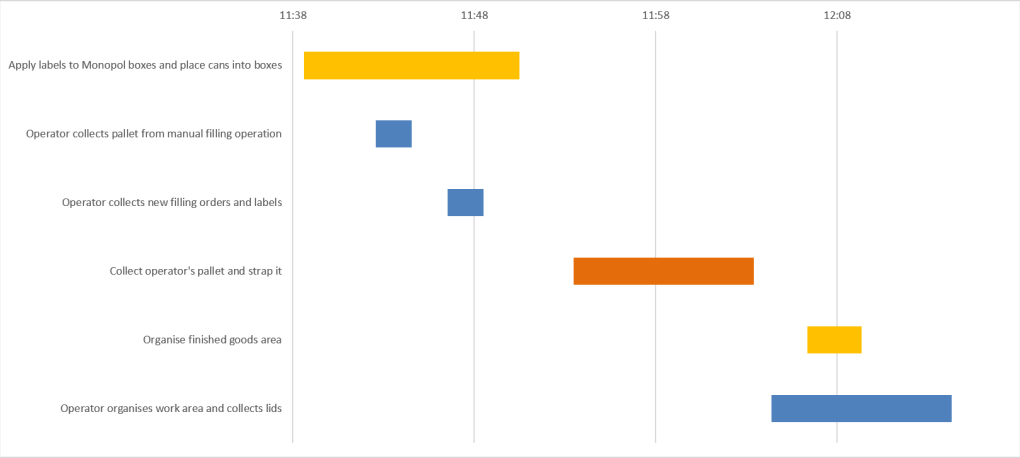


Figure P.2: Provisioner's Priority Study - Example 2

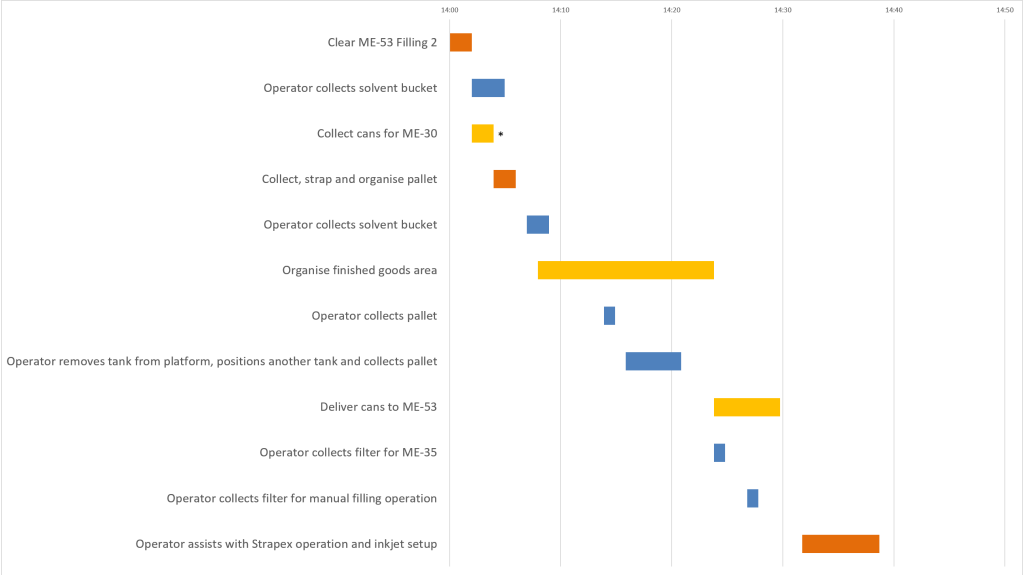


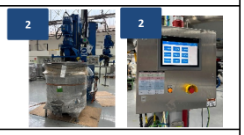
Figure P.3: Provisioner's Priority Study - Example 3

Appendix Q

Final Standard Work Sheet

CIN — **APROVISIONADOR C1 ENCHIMENTO**

Responsável:	Aprovisionador de Enchimento	**Setor:**	C1E	**NT xx/xx**
		Máquina:	Enchimento Manual e Máquinas	

Nº	**Atividade**	
	Preparação Set Up	
1	Início do dia: Chefe de equipa deve indicar o enchimento prioritário em termos de aprovisionamento. Durante o dia: Quando faltar uma palete para acabar um certo enchimento (e se houver um seguinte), pegar no próximo talão de enchimento e começar a prepará-lo.	
2	Dirigir-se à zona "TANQUES MÓVEIS APROVADOS" e colocar o tanque a agitar **(NT 43/14 - Agitação de produtos em tanques móveis)** ou, em caso de tanque fixo, dirigir-se ao PTO-03 ou 04, dependendo do tanque a encher e colocar a agitar (**NT 27/24 – Dump para enchimento).**	
3	Auxiliar no Set Up do enchimento, separar material pedido no Talão de Enchimento e transportar para o local de enchimento junto à plataforma ou junto à máquina de enchimento automática ou semiautomática. a) Buscar balde de água/diluente (se aplicável) b) Arrumar material do enchimento anterior (se aplicável) c) Colocar palete de embalagens dentro das respetivas marcações d) Colocar os rótulos no suporte para rótulos ou na mesa, se aplicável. e) Colocar as tampas junto à mesa da respetiva máquina. f) Colocar as caixas na mesa junto à Strapex (se aplicável) g) No caso das embalagens estarem numa palete fechada abrir o plástico **(NT 71/22 Abertura da maquia de palete de embalagens)** e retirar os cartões superiores. h) Recolher um frasco e etiqueta para retirar amostra de enchimento. Recolher também o filtro associado ao enchimento. **Nota:** Perceber antecipadamente se há produto a mais ou se o material não foi separado. Caso haja falta de algum material, comunicar à chefia.	

Página 2/3 | DATA: | ELABORADO/REVISTO: | APROVADO:

Figure Q.1: Standard Work Document (Page 1)

CIN **APROVISIONADOR C1 ENCHIMENTO**

Responsável:	Aprovisionador de Enchimento	**Setor:**	C1E	**NT xx/xx**
		Máquina:	Enchimento Manual e Máquinas	

Nº	**Atividade**	
	Preparação Set Up	
4	Enchimento de tambores de 200 litros: Separar os tambores e colocá-los em cima da/s palete/s (separar a quantidade pedida no talão de enchimento até ao máximo de 8 tambores).	
5	Parar a agitação dos tanques (consultar a norma **NT 43/14 - Agitação de produtos em tanques móveis)**.	
6	Colocar o tanque móvel na plataforma (ver norma **NT 16/20 – Colocação/Remoção de Tanques Móveis na Plataforma de Enchimento**) ou junto da máquina de enchimento. No caso de ser necessário retirar o tanque anterior, deixar o mesmo na zona para lavagem.	
	Tarefas Gerais	
8	Recolher paletes de produto acabado das linhas automáticas, semiautomática e manual e colocá-la na "ZONA DE PALETES PARA CINTAR". Garantir que é sempre deixada uma nova palete e que é usado o sistema de dupla palete.	
9	Ao não haver nenhum set up para auxiliar e nehuma palete por recolher, cintar as paletes (**NT 10/15 - Paletização e cintagem de paletes de produto acabado)** e colocá-las na zona de produto acabado dedicada a C1 **(NT 23/15 – Organização do cais nave central)**.	
10	Caso não haja nenhuma das tarefas acima mencionadas a realizar, poderá ajudar nas seguintes: a) Rotular latas ou caixas b) Empacotar latas com Strapex c) Auxiliar na paletização (se se justificar)	

Página 3/3	DATA:	ELABORADO/REVISTO:	APROVADO:

Figure Q.2: Standard Work Document (Page 2)