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Opportunities for Improvements and Framework for Ink Dispensing System Implementation

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BACHELOR'S THESIS

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Abstract

This thesis was made for Walki Oy in Pietarsaari. The company was in a situation of updating its ink supplier contract and was planning to implement a new ink dispenser system. The purpose was to investigate the possibilities for improvements in the ink production process, plan the layout for what the new ink dispensing system should look like, evaluate which of the two selected suppliers could offer the system that best suited Walki, and finally make a schedule that included all necessary steps to be able to transition from the old system to the implementation of the new one.

The work required the current process to be analyzed in detail to find what disrupted the workflow and what could cause hazards. Several LEAN methods were analyzed and another organization's ink dispensing system was investigated to provide inspiration. Visits of salespersons from both suppliers were also made to Walki to present what they had to offer.

The results consisted of a couple of improvement suggestions for an updated process, a new layout with the selected supplier's system, and a table that included all steps with a specific time for the transition process. While not everything was implemented in practice, the thesis provided a framework for the renewal process.

Language: English
Key Words: ink, production, change, LEAN, improvement

EXAMENSARBETE

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Titel: Möjligheter till förbättringar och grund för implementering av färgdispensersystem

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Abstrakt

Detta examensarbete utfördes åt Walki Oy i Jakobstad. Företaget höll på att uppdatera sitt avtal för leveranser av färger och planerade att ta i bruk ett nytt färgdispensersystem. Uppgiften gick ut på att undersöka möjligheter till förbättringar av färgframställningsprocessen, planera layouten för hur det nya färgdispensersystemet borde se ut, utvärdera vilken av två valda leverantörer som kunde erbjuda det system som passade Walki bäst och slutligen göra en tidsplan som inkluderade alla nödvändiga steg för att kunna övergå från det gamla systemet till implementeringen av det nya.

Arbetet krävde att den nuvarande processen analyserades i detalj för att hitta det som störde arbetsflödet och kunde orsaka faror. Flera LEAN-metoder analyserades och en annan organisations färgdispensersystem undersöktes för att ge inspiration. Besök av säljare från båda leverantörerna gjordes också till Walki för att presentera vad de hade att erbjuda.

Till resultaten hörde några förbättringsförslag till en uppdaterad process, en ny layout med den valda leveratörens system och en tabell som inkluderade alla steg med bestämd tid för övergångsprocessen. Även om allt inte implementerades i praktiken, gav examensarbetet en grund för förnyelseprocessen.

Språk: engelska
Nyckelord: färg, produktion, förändring, LEAN, förbättring

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Tiivistelmä

Tämä opinnäytetyö suoritettiin Walki Oy:lle Pietarsaaressa. Yhtiö oli päivittämässä värihankintojen sopimustaan, ja suunnitteli uuden värijakelulaitesysteemin käyttöönottoa. Tehtävänä oli tutkia väriprosessin parannusten mahdollisuuksia, suunnitella uuden värijakelulaitesysteemin ulkoasua, evaluoida mikä kahdesta valitusta toimittajasta pystyi tarjoamaan Walkille parhaiten sopivan systeemin, ja lopuksi tehdä aikataulu, joka sisälsi kaikki tarpeelliset vaiheet, jotta pystyttäisiin siirtymään vanhasta systeemistä uuden systeemin käyttöönottoon.

Työ vaati, että nykyistä prosessia analysoitaisiin yksityiskohtaisesti, jotta löydettäisiin se, mikä häiritsi työnkulkua ja aiheutti vaaroja. Useat LEAN-menetelmät analysoitiin ja toisen organisaation värijakelulaitesysteemiä tutkittiin, jotta saataisiin inspiraatiota. Molempien toimittajien myyjät kävivät myös Walkissa näyttämässä tarjoamiaan tuotteita.

Tuloksena ovat muutamia päivitetyn prosessin parannusehdotuksia, uusi ulkoasu valitun toimittajan systeemin mukaisesti ja taulukko, joka sisältää kaikki vaiheet siirtymäprosessin aikataulua huomioon ottaen. Vaikka kaikkea ei toteutettu käytännössä, opinnäytetyö antoi perustan uusimisprosessia varten.

Kieli: englanti
Avainsanat: väri, tuotanto, muutos, LEAN, parannus

Table of Contents

Appendicies

Appendix 1. Flexo plate storage room layout drawing

Appendix 2. Risk assessment and management table (in Finnish)

Appendix 3. The final layout presented by GSE

Appendix 4. The final layout presented by Inkmaker

1 Introduction

This bachelor's thesis was done for Walki Oy in Pietarsaari. The target company was in a situation of change regarding their ink supplier agreement and the idea of implementing a brand-new ink dispensing system came along to serve the purpose of producing sufficient amounts of ink for their printing production. The current method of producing and handling inks was seen as inefficient with room for improvement and needed to be analyzed in greater detail to give rise to new ideas.

1.1 Background

As of late 2021 Walki Oy in Pietarsaari is negotiating renewing agreements with their ink suppliers. Despite which supplier is chosen the ink series will anyhow change at Pietarsaari Plant. Flint Group is currently the main supplier of inks and the ingredients used for producing inks. Over 1650 recipes exist with numerous recipes with very minor differences therefore removal of recipes that have not been in use for years is necessary. Certain big volumes are dispensed by the system and many ingredients are kept in storage in the factory.

The current ink dispensing system is starting to get obsolete by today's standards, having been in use since 2007. Using old software and hardware, the system is not able to manage the recipes efficiently and handle the circulation of return inks optimally. The return inks are inks left over when a printing run is finished and must be used again to prevent unnecessary material waste and economical losses. The room where the ink dispensing system is located is hard to keep clean because of the layout, setup of containers, and the old sewerage system leading to the possibility of serious hazards for the products that need to meet food safety standards.

With the new ink supplier agreement, colors that have been dispensed in large volumes would instead be bought ready-made to be used directly by the printing machines and reduce the need for storage space in the factory when not needing separate ingredients for their production. The new ink dispensing system would be running on modern software, dispense the amounts necessary, utilize the return inks in one way or another, and have a layout to guarantee more functional changeover of containers and cleanliness. The layout of the new ink dispensing system has to be planned thoroughly and will require construction work to ensure work safety and ergonomy as well as optimal storage for purchased goods and return inks.

1.2 Purpose

The bachelor's thesis aims to provide opportunities for improvement for the whole layout and process involving the ink dispensing system, an evaluation of what ink dispensing system suits Walki Oy best, and a schedule for the tasks and construction work easy to follow. A well-planned ink dispensing system with well-thought-out storage of the concerned items facilitates the printing process, and guarantees a smoother material flow and better interaction between the workers in the department as a whole.

1.3 Goal

This work aims to provide the framework for the betterment of the area involving the ink dispensing system and that the updated ink dispensing system in its layout will work safely, efficiently, optimally, and most importantly meet the output needed for the target company's printing production.

1.4 Delimitation

This work only investigates the area and process the ink dispensing system is involved in with as little interaction with the other departments at Walki Oy as possible.

Mathematical calculations are not included in this thesis. The technical details and functionality of ink dispensing systems are described and analyzed in short and considered mainly in their entirety. The construction work included in the timetable needed for the renewal will not go into detail on the exact specifications of pneumatic, electrical, network, and water connections.

The ink supplier agreement process will not be included in this thesis and is instead handled between Walki management and the ink supplier. The technical person of the ink supplier has to be able to manage the ink formulation and software of the implemented ink dispensing system.

The final buying decision on the new ink dispensing system and what different add-ons will be needed is made by Walki management.

1.5 Target Company

Innovation and development are key concepts of Walki with a distinct ambition to produce zero waste and maintain efficient energy usage. As an international actor in the packaging industry and technical performance materials, Walki has segmented into three different business areas: Industrial Packaging, Consumer Packaging, and Engineered Materials providing sustainable solutions to customers specialized in their respective industries. The many different solutions are for instance: laminates used for packaging in the steel industry, products used in the imaging industry, protective apparel, food packaging and wraps for the paper industry. Walki's production plants are located in both Europe and Asia, spanning over 12 countries in total. In 2021, Walki's turnover was over 500 million euros and the production plants were 14 in total, with over 1400 employees. More than 80% of the products are made from renewable plant-based resources and 3000 pilot test runs are performed to try out new solutions in practice. The Pietarsaari Plant employs 195 people and the production capacity is 100.000 tons per year. (Kurula, Walki in brief, 2022), (Kurula, Walki Plants, 2021)

The name "Walki" originates from the early days of the Finnish paper industry when the Walkiakoski paper plant was founded in 1873 in Valkeakoski in Finland and the name started appearing on its paper products. Today's company Walki has its roots mainly in Finland and the UK. In 1930, the Paperituote plant was founded in Valkeakoski, and in 1964 Wisapak paper sack started its business in Pietarsaari. In 1954 the Clyde Paper Company in the UK started performing extrusion coating and later became Walki Garstang. Walki Group was formed in 2007 with CapMan as the owner. In 2018 Walki was acquired by One Equity Partners. (Kurula, Milestones - Walki, 2021)

Figure 1. Walki Oy Pietarsaari plant (Kurula, Walki Plants, 2021)

1.6 Disposition

The First Chapter serves as the introduction to this thesis.

The Second Chapter contains the theory of the concerned areas investigated in this thesis.

In the Third Chapter, the method used to put together this thesis is presented.

The Fourth Chapter presents an analysis of the current situation, regarding the current layout and process, ending up pointing out what areas require direct improvement.

The Fifth Chapter goes into the benchmarking process of two suppliers' ink dispensing systems to display their strengths and weaknesses.

In the Sixth Chapter, the results are presented of what the upcoming system would look like and work in practice. It ends with a discussion and suggestions for further improvement.

The Final Chapter serves as the discussion part where the thesis is reflected over.

2 Theory

This Chapter serves the purpose of presenting the theoretical standpoints of this thesis. The concept of ink dispensing and flexographic printing are described first. Later the improvement method LEAN and its subcategories Kaizen, Value-stream Mapping, 5S, and Just in time are brought up to the reader. Lastly, the Chapter ends with the concept of risk management and the purpose of an Occupational Health and Safety Management system.

2.1 Ink dispensing

Walki has built up a comprehensive library of recipes for producing the unique colors wanted by its customers and relies on a fully capable ink dispensing system to get the exact mixtures. The ink dispensing system itself consists of a dispensing unit and a setup of stations for the required ink ingredients. The system relies heavily on software for handling all color recipes and reporting available stock.

The colors printed on substrates can be categorized into spot colors and process colors. The spot colors are exactly defined colors with visual characteristics made from mixed ink and printed directly to the substrate. Something requiring lower amounts of ink and a specific appearance, such as a company logo, suits perfectly to be printed using spot colors. When printing using process colors dots are applied to the substrate to create a colored image. CMYK also referred to as the four-color process, is the most common method using cyan, magenta, yellow and black in different proportions. Printing with process colors is not limited to the four colors of CMYK others can also be used. Process colors are well suited for printing images with larger amounts of complex colors, such as paintings and photographs. (Pantone Europe, 2021)

The ink colors used in flexography printing production can either be bought ready-mixed from an ink supplier or produced by mixing different ingredients. Following a recipe with ingredients of the right proportions is essential to get the desired color with all of its technical and visual aspects. The needed ingredients included in the recipe are typically the following:

- water or solvents
- varnishes, binders, or hardeners – to give technical characteristics
- base colors – to give the right visual aspects

While the mixing can be performed manually it takes time and requires a great deal of work that can lead to varying quality results and potential waste. An ink dispensing system that operates automatically is an accurate and much faster method for ink production since it can dose the exact amounts of the ingredients. The ink dispensing unit's dispensing head contains pneumatic valves that are connected to the ingredients. Empty containers are placed under the dispensing head to be filled up and measured by a weighing scale. This is a so-called gravimetric system because it registers the dispensed amounts in kilograms. (Verbeek, Ink dispensing: the basics, 2021)

It is of high importance that the dispensing system only dispenses the type of ingredients it is designed for and that the ingredients only flow in their determined circulatory system. For example, an ink dispensing system designed to dispense water-based ingredients can not be used to dispense solvent-based ones. (GSE Dispensing, 2000)

The pumps that enable the transportation of the ingredients stored in the containers are placed on pump frames. Usually, the pump frames are placed directly behind the dispensing unit in a straight line with the containers aligned to it. The pump frames can alternatively be placed on a wall or at an angle. Generally, one of two types of pumps are used, either air-driven/pneumatic diaphragm pumps or electric pumps. The air-driven diaphragm pumps also contain a pulsation damper that absorbs flow pulsation generated by the pump. The tube system involved in the transportation of the ingredients is arranged in the following order: the suction tube starts deep down in the container and is connected to the pump. The next connection goes from the pump to the dispensing valve and the last connection goes from the dispensing valve returning to the same container. To prevent clogging inside the tube system the ingredients can be circulated automatically without being dispensed with an auto-circulation feature. Available in different models, the pumps may have filters and the containers themselves may contain mixers to maintain the quality along with level detectors. (GSE Dispensing, 2000), (Inkmaker, 2004)

Figure 2. Inkmaker M48. The current ink dispensing unit in use with stations seen in the background

The Inkmaker M48, seen in Figure 2, has a special design with the dispensing valves sitting on arms aligned in a circular shape with a metal shell cover at the rest position. The arms are controlled pneumatically and move to the middle when activated. In the middle, the dispensing valve is hooked and opened by a pneumatic actuator. (Inkmaker, 2004)

Cleaning of the dispensing valves is essential to prevent ingredients from drying inside and can be handled in several ways other than manual cleaning:

- In the Inkmaker M48, the valves are wet cleaned after the dispensing is finished. Washing fluid is pumped up from a washing tank and transported to the dispensing valves. (Inkmaker, 2004)

- In the Colorsat Compact 32 cleaning of the valves is performed with a plastic scraper. (GSE Dispensing, 2000)

The return inks that are left from a finished printing run can later be handled in two different ways:

- It can be left unaltered and used again when a printing job needs the exact color again
- Mathematical dispensing can be performed. The return ink is mixed with dispensed ingredients to get the desired color. As an example, if an orange spot color is needed then a specific amount of varnish and yellow can be dispensed and mixed with a red return ink adding up to the proportions of the orange spot color. (Verbeek, Effortlessly reusing press return inks for spot colour printing: a best-practice guide, 2021)

2.2 Flexographic printing

Walki Oy in Pietarsaari uses printing machines that utilize flexographic printing that works with liquid water-based inks. The inks are used to produce the desired different types of imagery on a variety of substrates, ranging from paper to plastics.

Far from a new type of printing method, flexographic printing was developed back in the 1890s and was the first printing method to use flexible plates. Despite not having the best success with water-based inks in its early days, as time passed and with new developments, the printing method has found usage in a wide variety of different industries and has been able to print on many substrates. The modern flexible printing plates often referred to as flexo plates, are made of rubber and have the print laser etched on them. (Jessie, 2018)

Four types of rollers are involved in the printing process: the fountain roller, the anilox roller, the roller that holds the flexo plate, and the impression roller, all featured in Figure 3. The fountain roller rotates in an ink reservoir and delivers the ink into the anilox roller's engraved cells. The engraved cells' depth allows for a specific thickness of ink. The anilox roller supplies the thickness of the ink to the flexo plate that has been placed on a plate cylinder roller. The substrate to be printed on rides between the plate cylinder roller and the impression roller. From pressure applied the ink is transferred over to the substrate resulting in a print. (Labelado, 2021)

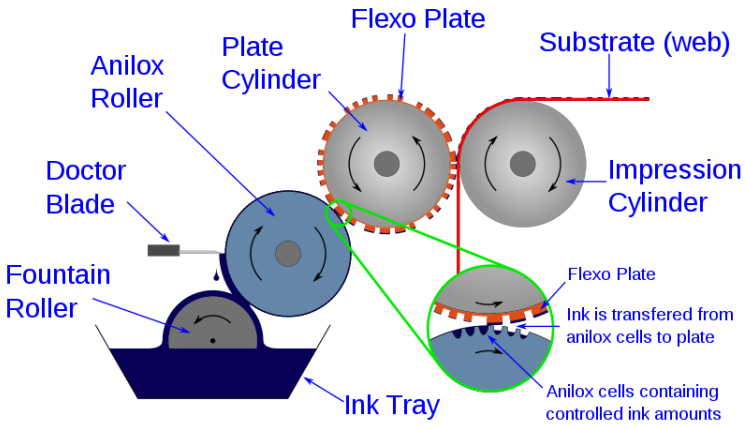

Figure 3. A typical flexographic printing diagram. (ECTran71, 2015). CC BY-SA 4.0

While one flexo plate is limited to delivering only one color to the substrate, the printing machines can have close to 10 stations for flexo plates for the substrate to pass through. Process printing/CMYK can be used as well as spot colors to achieve the image. (Jessie, 2018)

The printing abilities for water-based and solvent-based inks differ. The solvent-based inks work excellent at high printing speeds since they dry quickly onto the substrate. These types of inks contain on the other hand high levels of volatile organic compounds (VOCs) hazardous to the environment. The water-based inks contain lower levels of VOCs but are more limited compared to their counterpart because of their higher water content. Drying at a slower rate, the water-based inks are more challenging to use at higher printing speeds and on non-absorbent substrates. (Teachman & Felsberg, 2016)

2.3 LEAN

While the term “Lean” has been around for over 30 years, as a concept its history dates back to the quality and production philosophy that characterized the Japanese economy during the decades shortly after the second world war. The Japanese economy had been deeply wounded by the war and well-planned business strategies were needed for improvement. Taking inspiration from Western pioneers of quality work, Japan successfully regained its reputation for producing high-quality goods with great success, especially in the automotive and electronics industries. While often associated with Toyota and their Toyota Production System management philosophy, Lean is based on a variety of Japanese influences and not solely on the ideas of Toyota. Nowadays Lean is a concept that is extensively talked about in the corporate world. A rising number of companies strive to implement the management principles of Lean to create smooth workflows and to utilize all possible potential with efficient use of resources to deliver value to its customers. The Lean management principles have wide applicability that provides a great framework for systematically doing business to continue creating better results and identifying waste or other elements of work that do not bring value. To achieve all the expected outcomes of Lean require total commitment and understanding by the whole business hierarchy with dedicated leaders and motivated workers. (Sörqvist, 2013)

Kanbanize categorizes Lean management into five principles in a continuous cycle with customer needs central to them:

- To identify value and what specific actions add value to a product or service.
- Value-stream Mapping (this principle is described further in Chapter 2.5).
- To create an uninterrupted workflow.

- To create a “pull system”, where work is signaled when there is a need for it.

- Continuous improvement.

(Kanbanize)

2.4 Kaizen

The concept “Kaizen” means improvement and has applicability in several different areas ranging from the private personal life to the working life. Kaizen seen from the workplace point of view means to strive for ongoing continuous improvement by questioning conventional established working methods, reflecting on the organization’s current situation, critically analyzing what kind of changes could or should be made, and taking into consideration that even small changes can have a great impact in the long run when everyone in the organization is committed to their role. Kaizen can sort of be seen as the opposite approach to “innovation”. Taking the approach of innovation, the desire is usually to bring big changes for better results fast. Innovation may, however, be very costly, leaving the focus only on improving technology with only a few dedicated decision-makers resulting in short-lasting changes. (Imai, 1986)

2.5 Value-stream Mapping

A part of LEAN management, Value-stream Mapping is a useful tool for systematically mapping the current situation of a company's value-creating processes and giving birth to new ideas that will achieve further development. Seen from the perspective of bringing value to the customers and meeting their demands a value-stream map for the manufacturing steps of a product or the steps of a process set within a defined spectrum can be drawn out. The map may contain the flows of materials, the work adding value to the product, and all steps leading to the end. The made map will be analyzed with a specific value in mind to provide information on where and what type of actions should be taken. The spectrum of the map can vary from an analysis on a global level that includes customers and suppliers, down to analyzing how basic activities are performed in each step of a process since even those can generate losses. (Sörqvist, 2013)

2.6 5S

A well-organized workplace provides a safe working environment that can achieve the intended goals faster with a higher output and fewer mistakes. The 5S method is an improvement tool that underlines five steps necessary for the transition and maintenance of a healthy and organized workplace. These are categorized in the order:

- Sort – only the necessary objects related to the process are sorted out and stored in the needed amount at the workplace. These can for example be tools, components needed to manufacture a product or other objects needed in a certain process' operation.

- Set in order – the objects sorted out and deemed essential are systematically arranged in a spot with clear tags for their place. The objects can therefore be found easily and placed back in the same place after usage. When the defined places are known by everyone the objects are not gathered elsewhere resulting in unnecessary usage of space, more than necessary movement, or presenting a risk for work hazards, such as accidental slipping over gathered unorganized objects.

- Shine – the systematically arranged workplace must always be kept clean to continue its operations as effectively as possible. This also includes the objects.

- Standardize – the three previous steps are perfected with detailed schedules specifying what objects are concerned, how the storage system shall be arranged, maintenance of machines, and what areas are needed to be regularly cleaned.

- Sustain – the previous steps are followed in detail and maintained by everyone involved with the intention of never going back to an unorganized way of work. Continuous reporting facilitates this step.

(Hirano & Rubin, 1996)

2.7 Just in time

The planning philosophy Just in time, often referred to its abbreviation “JIT”, strives to produce and deliver goods in exactly the quantity and at the time they are needed. This requires a flexible production system that can withstand changes and imbalances.

JIT has its roots in the early 1970s and was first developed within Toyota manufacturing plants by Taiichi Ohno with the intention of meeting customer demand with as little delay as possible. The implementation of JIT and total commitment helped Toyota to successfully manage its challenges at the time resulting in great outcomes. (Institute for Manufacturing (IfM) - University of Cambridge, n.d.)

While originally generally focusing on the production of goods to meet customer demand, nowadays JIT targets improvement opportunities and to eliminate as much waste as possible. Possible actions to improve the organization’s business may include:

- To target direct problems and anything that does not add value
- To make layouts that require as minimal movement and relocation of components/products as possible.
- To create systems/flowcharts of processes to point out problems
- To consider the planning of simpler systems since they are generally easier to understand and manage
- Have quality control everywhere and preventive maintenance

In this context the term “waste” is seen in a broader sense and can be categorized into eight types:

- waste of motion
- overproduction
- waste from product defects
- waiting time, between each step in the process
- inventory waste, having excess inventory takes up more space and results in unnecessary spending of money

- transportation waste, such as unnecessarily moving certain resources.
- processing waste, this refers to adding more work, time, and effort to a product or service than wanted by the customer.
- Waste of human potential. While not included in the original Toyota Production System, over time, many have become aware of this type of waste. Those in the organization with the talent and extensive practical experience can easily be excluded from the decision-making process.

(Institute for Manufacturing (IfM) - University of Cambridge, n.d.), (Skhmot, 2017)

2.8 Risk assessment and management

To create and maintain safe working conditions all the harms and hazards are first identified and analyzed, then the risks of them are assessed, and lastly, actions are taken to mitigate the risks. The systematic activity comprised of the first two phases is known as "risk assessment" and the whole process as "risk management". The risk of an event is classified by how severe and likely they are to occur. The numerical value of the risk can be determined by the Table below, with a higher number presenting a greater risk that needs to be reduced immediately. (Työsuojelu.fi, 2021)

Table 1. Risk classification matrix. Modeled from (Työsuojelu.fi, 2021)

Probability	Minor consequences	Adverse consequences	Serious consequences
Unlikely	1 Negligible risk	2 Tolerable risk	3 Moderate risk
Possible	2 Tolerable risk	3 Moderate risk	4 Significant risk
Probable	3 Moderate risk	4 Significant risk	5 Intolerable risk

The assessment process gives a picture of the workplace's current situation regarding health and occupational safety and the needs for improvement and development. The responsibility to investigate hazards is based on the Occupational Safety and Health Act and is required by all employers, in every industry with any number of employees. The target area for the assessment should be well-defined and checklists make the reporting easier and more systematic. Risk assessment is continuous work and is of high importance in every type of change situation. (The Centre for Occupational Safety, u.d.)

2.9 Occupational Health and Safety Management system

Walki Pietarsaari follows an Occupational Health and Safety Management system and holds an ISO standard 45001:2018 for Occupational Health and Safety Management certificate. The planning of the layout will take Walki Pietarsaari's OH&S system into consideration. (Walki, 2021a)

The intention of an occupational health and safety management system, shortened to an OH&S system, is to set guidelines for an organization to manage risks and opportunities related to health and safety to deliver safe working conditions, and avoid injuries and poor health. Adopting an OH&S management system with an OH&S policy guiding actions can therefore benefit an organization in numerous ways, including fulfilling requirements mandated by law. While ISO 45001:2018 does not declare the exact specifications on how to tailor an OH&S management system to deliver precise results to the organization, the standard mainly focuses on the procedure to build one up and maintain it. The central concept of the ISO 45001:2018 is the PDCA cycle consisting of the steps:

- Plan – all risks, workplace-related as well as others, are evaluated and the procedures required to achieve the results in conformity with the organization's OH&S policy are defined.
- Do - the procedures are applied in practice.
- Check – all activities are controlled and the results are documented. They should all be in line with the OH&S policy and planned outcomes.
- Act – the results are attained and improved through actions.

(International Organization for Standardization, 2018)

The safety of Walki's personnel, visitors, suppliers, and others are all included in Walki's OH&S policy in all activities with emphasis on three principles:

- Say no to accidents – the vision is that all accidents are avoidable and safety has to be taken into consideration in every action. Close monitoring and reporting are therefore needed.

- Safety starts with me – safety can be tracked to individual actions and everyone is responsible to maintain a safe work environment for themselves and others concerned.

- Think before acting - awareness of the safety risks before performing a certain task is of great importance as well as evaluating if the current working methods need to be improved in terms of safety.

(Walki, 2021b), (Walki, 2021c)

3 Method

Firstly, the situation of the ink dispensing system's current position was analyzed thoroughly. Both the layout and the function of the ink dispensing system were investigated in practice with several visits to the facility to gain a deeper understanding of the situation. Interviews were conducted with the production manager, the supervisors of the printing production department, the ink dispensing system operator, and various employees who gave their points of view on the current system's problems and proposals for improvement.

As the next step, many different sources were studied to inspiration for implementing the new system with the best result possible. To gain further knowledge of both the working of the system as a whole and its technical aspects the sources of information ranged from improvement methods for systems, work safety planning, and the technical aspects of ink dispensing and printing production.

A field trip was taken along with the printing production supervisors on the recommendation from the production manager to his former employer Ab Rani Plast Oy to get a view of their modern ink dispensing system and solution for return ink storage.

Collected statistics of delivered ingredients and produced inks for the printing production were assessed to some extent to get a picture of the required size of the future storage spaces as well as the optimal amount of drums and IBCs (intermediate bulk containers) connected to the new ink dispensing system. Having overall minor influence, these are left out of this thesis.

After some time of systematic planning and investigation of the current system a flowchart of the process, a flowchart for value-stream mapping, and several suggestions for the upcoming layout of the future ink dispensing system were made.

In December the factory was visited first by the sales manager from IM Group, the organization Inkmaker belongs to, and then the sales engineer from GSE to get an insight into how the current system worked in practice at Walki Oy and see the advantages and disadvantages to then get an idea of improvement proposals for the future system.

After their respective visits, Inkmaker and GSE sent their sales quotations for their systems along with layout suggestions. Both candidates were compared point by point regarding their system specifications, price, software functionality, and service options.

Some more layout drawings were made in AutoCAD using the manufacturers' measurements to check the possibility of their respective ink dispensing systems being realizable in practice in the determined space at Walki Oy with designs altered from the ones originally presented by the manufacturers. After both candidates had presented an updated layout one of them was selected.

Finally, a construction schedule was made with a fixed set time for each work step taking into consideration the requirements of the future layout, improved work safety, and installation of the technical requirements of the upcoming ink dispensing system such as the supply of air, water, and electricity.

4 Analysis of the situation

This Chapter describes first the current layout and its functionality by going through the process. The current process is summarized by a flowchart along with a value-stream map including the points of interest. Lastly, the good parts of the current system are pointed out and then ending with the areas needing improvement.

4.1 The current layout

The layout of the process involving the ink dispensing system in its entirety can be seen in Figure 4.

Figure 4. Layout involving the ink production process

The layout can be categorized into the following areas seen in Figure 5.

- The consignment stock storage area (A)
- The ink dispensing system room (B)
- The flexo plate storage room (C)
- The small-batch return ink storage (D)
- The large-batch return ink storage (E)

Three printing machines are also involved and can be seen in Figure 4.

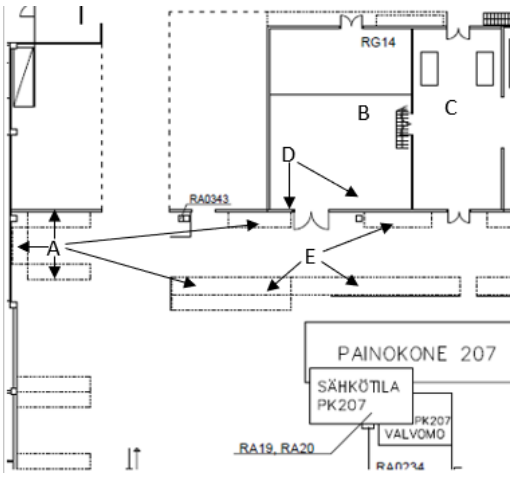

Figure 5. The listed areas displayed

A consignment stock consists of products located in the customer's inventory still owned by the supplier as long as they are stored. When put in use, the products are officially purchased. The ingredients held as consignment stock are those delivered by Flint Group in larger volumes that are in high demand to maintain the ink production volumes, such as colors, varnishes, and wax. Ingredients that affect the technical properties of the dispensed inks are consumed in lower volumes and are purchased directly and stored directly at the printing machines. The consignment stock of printing consumables at Walki Oy Pietarsaari was originally seen as a temporary solution for handling the storage of ingredients in larger volumes when switching to Flint Group as the main supplier since their warehouses were not conveniently accessible nearby, but because of unnecessary space usage that has been going on for over 10 years, it is planned to be ended and replaced soon by purchased ingredients in quantities with defined safety limits to not completely run out of stock.

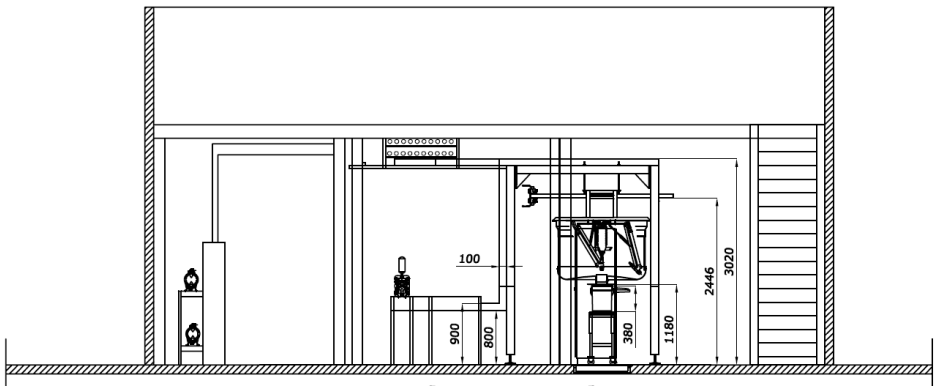

Figure 6. Sideview of the current Inkmaker system. The solid metal containers are not displayed.

The current system setup located in the ink dispensing system room with the Inkmaker M48 can be seen in Figure 6. The system has 32 stations available in total. The layout itself in terms of appearance and function has been largely the same since the year 2000. At that time a GSE Colorsat Compact 32 WB ink dispensing unit was put into use along with the current amount of stations. The Colorsat Compact unit was used until 2007 and swapped out for the current Inkmaker unit.

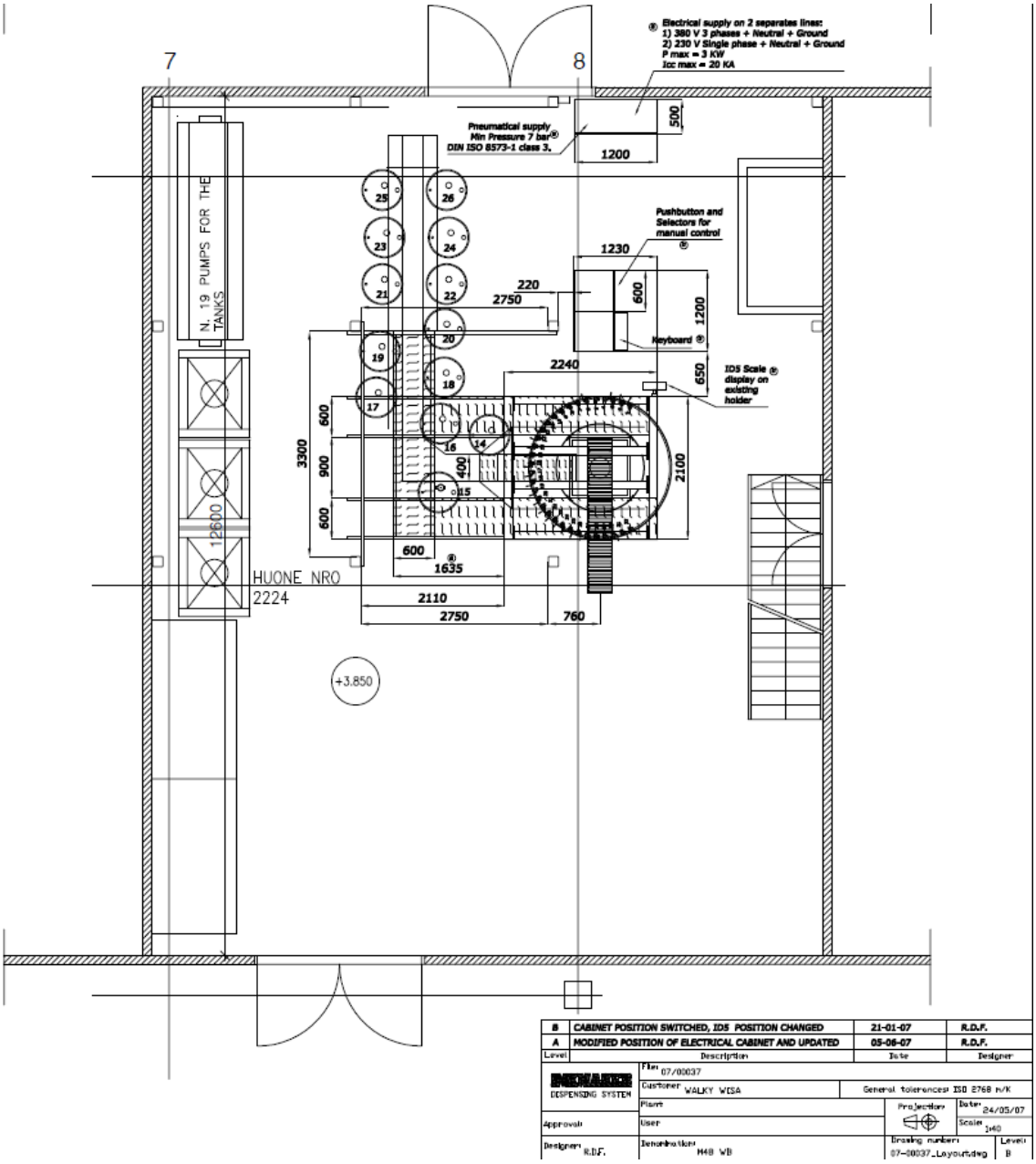

Figure 7. Top-down view of the current system's first floor

The first floor can be seen in Figure 7 and holds 13 stations made up of 200-liter drums, seen in Figure 8. The left-hand side holds the pumps connected to the stations on the second floor and a washing station for containers are located on the right-hand side. The second-floor houses 19 stations of solid containers of whom 2 hold 1500 liters and the rest 1000 liters on the left-hand side. A break room for the ink dispensing system operator is located on the second floor on the right-hand side. The first floor where the ink dispensing unit and return ink storage reside is 9.84 meters x 12.6 meters.

Figure 8. Stations on the first floor with the pumps seen in the background.

The second-floor houses the stations the ink is pumped to consisting of solid metal containers, which can be seen in Figure 9, and is 9.84 meters x 4.57 meters. The reasons that the ink dispensing system in its current form is pumping ink to the second floor are mainly because when it was designed it was at the time considered to be the best solution to save space, to separate the upper stations from the bottom ones when there were two different ink suppliers whose inks were placed to each floor respectively.

Figure 9. Stations on the second floor of solid containers of 1000 and 1500 liters

The door under the stairs, seen to the right in Figure 7, leads to the flexo plate storage room, but is blocked by a computer desk used by the operator and therefore inaccessible from the room housing the ink dispensing system. The room has filled its current function since 1999 and has in that time accumulated a wide variety of plates. Appendix 1 contains the layout drawing for the flexo plate storage room. The flexo plates are stored along with their print, so the design can be found if the same one is needed again in the printing production. The majority of them have on the other hand not been in use for a long time and are planned to be thrown away completely. The room has the dimension of 6.15 meters x 12.6 meters.

The storage for return inks is separated between a large-batch and a small-batch one. The return inks with volumes of 20 liters or lower will be stored in the small-batch storage in buckets and those of volumes between 20 to 200 liters in the large-batch storage in drums. The small-batch return ink storage is located in the bottom part of the ink dispensing system room and the large-batch one is on the outside.

All the ingredients in the consignment stock, as well as the return inks, both those of large and small batch type, are stored on shelves with three ledges, and the floor under it is also used as a storage space. Every of the mentioned items has pallets under them.

Three printing machines are available to perform the printing works: Printing machine 206, Printing machine 208 and Printing machine 210. Printing machine 210 is located in the spot that reads “Painokone 207”, as a printing machine named 207 was used there in the past.

4.2 The current process

When planning to make long-lasting, sustainable changes to a specific process to achieve the desired outcomes, in-depth analysis with a full understanding of how the current process works with all its associated steps and with a clear demarcation of what belongs to it with a well-defined beginning and end is necessary. When every step regarding the process is documented in a process flowchart everyone involved knows their role and objectives to reach the intended goal and avoid possible distractions that can lead to the creation of unnecessary waste. Any type of change can be marked out to indicate what kind of impact it may have on the steps involved and the current situation as a whole. The process flowchart also allows those who are completely unacquainted to get a faster understanding right from the start. (Oakland, 1993)

The ingredients used for the production of fresh inks (also called “virgin inks”) are colors, varnishes, and a certain type of wax that are all connected directly to the ink dispensing system and supplied only by Flint Group. Other types of ingredients, such as primers, overprint varnishes, and various other technical components are used directly at the printing machine to give the ink the right technical properties to produce the printing work. These are, for example, foam killers and pH increasers. Certain types of ready-made inks are also used on customer demand to print specific colors. The ingredients not connected to the ink dispensing system have a range of different suppliers.

Four types of different containers are used to store the fresh ingredients, while two types of containers are used for storing fresh inks. The fresh ingredients are stored in:

- IBCs (containing 800 kg or 1000 kg)
- Drums (containing 100 or 200 kg)
- Buckets (containing 20 or 25 kg)
- Plastic cans (containing 10 kg)

All ingredients used for the dispensing and ready-made ink are delivered in either IBCs or drums. Those that affect the technical properties come in smaller sizes.

Ink is dispensed only into 200-liter drums and 20-liter buckets. The drums that are used to store the fresh inks are the same ones first used to store fresh ingredients and connected to the ink dispensing system.

When a drum in the ink dispensing system is completely emptied it is washed out at the washing station and ready to use as storage of the fresh inks. The buckets used for the same purpose are bought brand new. When the drums are deemed unusable they are flattened with a drum crusher and taken for recycling along with the buckets and plastic cans. After the contents of the IBCs have been used the containers are shipped back to another company that will be responsible for the cleaning.

The ingredients used for dispensing are transported to the consignment stock part in the factory when they first arrive by a forklift. When a specific ingredient is needed it is then brought to the room that houses the ink dispensing system, the route seen in Figure 10, and then placed in a specific station so the contents can be used in the dispensing process.

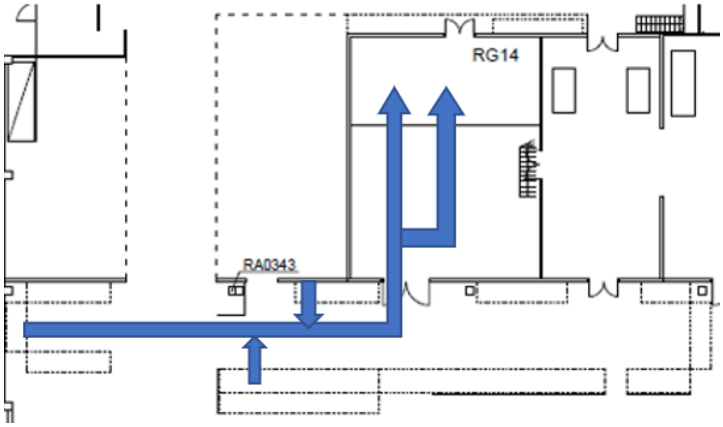

Figure 10. The flow of the ingredients from the consignment stock

The pallet with the desired ingredient is taken down from the shelf by a reach truck. The reach truck driver delivers the needed ingredient to the ink dispensing system room and places the pallet down on the floor. If the ingredient is stored in a 200-liter drum it is placed on a small movable platform and rolled to its station. If the ingredient is stored in an IBC it is put on a pallet jack and moved to the pumps connected to the solid containers to have all of its contents pumped out. The pallet is then returned to its original shelf position.

The ink dispensing system operator works day-time and prepares all the ink needed for a whole working day and is the one responsible for maintaining the whole return ink storage. The printing is done in three shifts from night to day. Ink is dispensed through the system from the demand of the printing machines' production schedules from the recipe, marked with a unique batch code printed that corresponds to the color for easy identification purposes. All of the colors that belong to the same printing work are placed on a pallet held by a pallet jack and moved outside by the operator.

The required ink is then taken to the printing machine by the printing machine workers needing it following the route seen in Figure 11 to either printing machine 206, printing machine 208, or printing machine 210.

Figure 11. Routes of the finished inks to the printing machines.

The unique batch codes used for the identification of the colors are categorized in codes consisting of 5 digits. The codes include darker and lighter shades of the same main color they belong to and are the following:

- Beginning with 2 – yellow and orange
- Beginning with 3 - red
- Beginning with 4 – blue
- Beginning with 5 - green
- Beginning with 6 - brown
- Beginning with 7 - black
- Beginning with 8 - violet
- Beginning with 9 - grey

Colors used in CMYK printing are specifically marked with a “4” at the beginning of their code. that refers to their usage in the four-color printing process. After the CMYK colors have been produced by the ink dispensing system they are never altered in any way with additional components. If the shade of the print wishes to be changed when using CMYK colors, then only the anilox roller is changed. The CMYK colors have therefore the extra digit to avoid the possibility of mixing and are stored separately from other inks.

The delivered ink is mixed carefully by a special mixer before use at the printing machine. The ink goes in and circulates through the printing machine and ends up in the same container it is stored in. The printing machines use the X Rite program throughout the printing process. Inside the printing machines, there is a camera that continuously reads the image quality achieved from the printing.

The X-rite program compares the produced print filmed by the camera with a reference image for how the print must be according to the customer's wishes. If deviations are observed, the machine stops completely, and then it is up to the machine operators to rectify the problem to achieve the desired print quality again. The various remedial methods can be to change the composition of the printing inks (such as adding water or other technical ingredients), to have repairs carried out on the printing machine itself, or to replace defective flexo plates or rollers. There are two workers per printing machine and if the ink runs out completely, the machine operator second in command is responsible for dispensing more ink.

When the printing run is finished and the specific color that has been used in the process is not needed at the moment, the return ink that is left over is brought to either the small-batch return ink storage or the large batch return ink storage through a route seen in Figure 12 from the respective printing machine. First, the return inks are placed on the same pallet and transported to the outside of the ink dispensing system storage room. The smaller ones stored in buckets are weighed on a special scale designated for the small-batch return inks and then the exact weight and planned storage space, determined by space available on the shelves, are registered on a computer located nearby. The larger-batch return inks do not have a scale assigned to them and their weight is determined approximately by the height the ink measures up to in the drum. The weight and storage space are registered on the same computer. The return inks are placed on a pallet and lifted by a truck to their storage space.

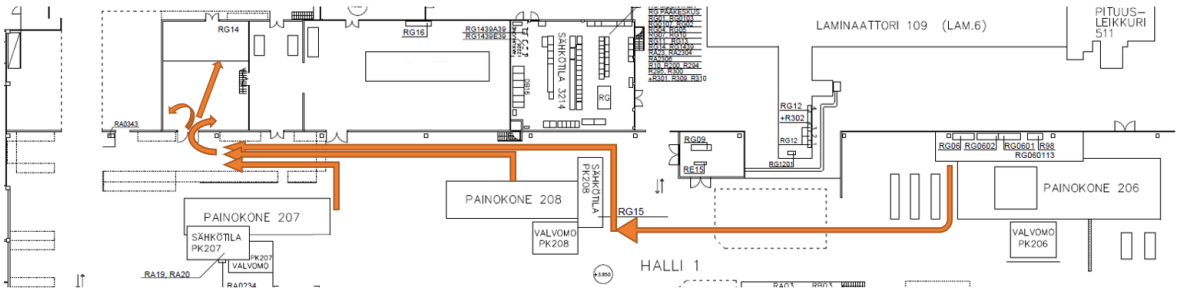

Figure 12. Routes of the return inks from the printing machines

When a new printing run comes the registered return inks are investigated in detail. If the same type of ink is needed again it can be used directly and possibly extra ink is dispensed to fulfill the amounts necessary for the printing run. While mathematical dispensing is available through the software it is seldom used.

The larger-batch return inks are more accurately measured when placed on the scale located under the dispensing head to dispense only sufficient amounts.

The current process can be summarized in a flowchart seen in Figure 13.

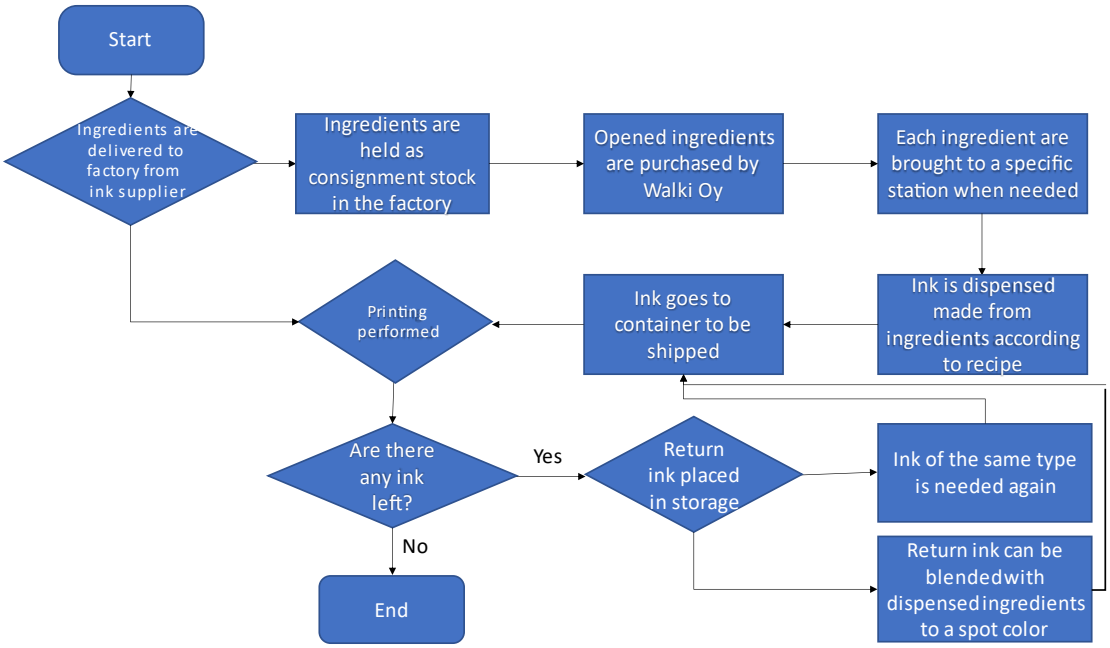

Figure 13. The current process

The points of interest summarized in the Value-stream map can be found in Figure 14.

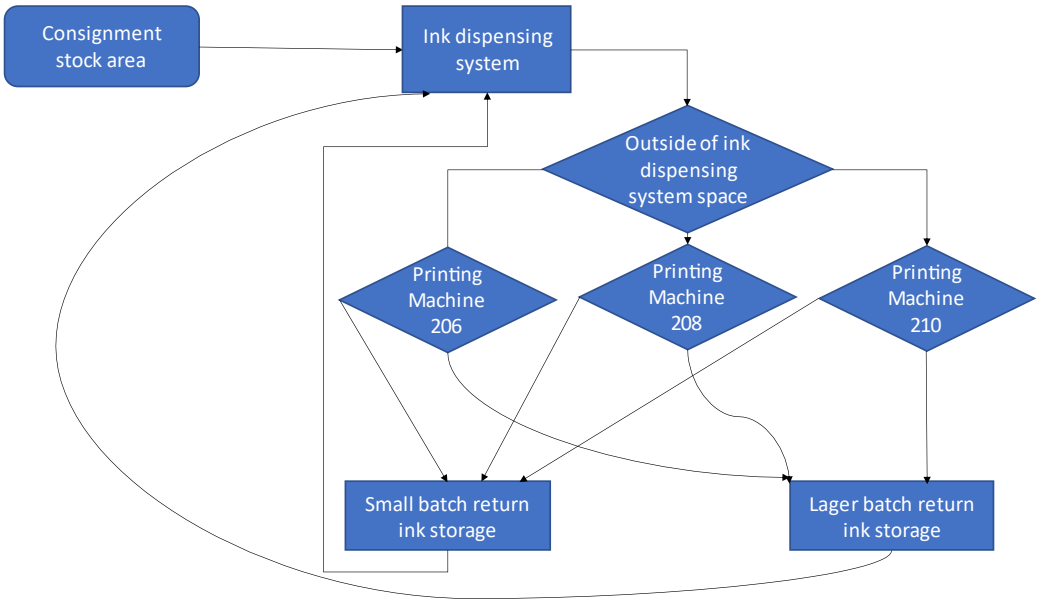

Figure 14. The current Value-stream map

4.3 Planning proposals

This part first highlights the strong points of the current system's way of handling things and then goes into what areas can be remedied to improve work safety and work more accordingly to the LEAN principles.

4.3.1 Current strengths of the system

The operator has been very pleased with the washing system of the Inkmaker unit. After the dispensing is done a few deciliters of water are flushed through the valves removing close to all substances. The current Inkmaker unit has rarely had any problems with ingredients dried solid.

Pumping the ingredients into solid containers has some advantages. The pump system empties the IBCs efficiently and they are left with almost no trace of residues. The metal solid containers with the largest capacity can store their ingredients for longer periods and need to be refilled infrequently.

The printing machines have established a cleaning schedule and have their cleaning utensils and maintenance tools arranged in a 5S manner.

The whole department has a clear "pull system" established. The demanded inks are dispensed and placed on the same pallet with a clear marking of the order they belong to. The printing machine operators can identify the demanded inks easily and bring the pallet back to the same place to be transferred into either return ink storage.

While the storage is not arranged most optimally, the return inks are handled well with a clear circularity in mind. Close to none of them are expired and will find usage in other printing orders. The small-batch return ink storage has clear markings of where the buckets should be placed on the shelves corresponding to their batch code following the 5S method.

The ventilation in the space where dispensing is performed is generally good and the water-based colors do not present a hazard of VOCs.

4.3.2 Improvements to promote work safety

Through direct observations when visiting the concerned area and when going through the most recently made risk analysis the following problems were in immediate need of action before the new system was implemented:

- High noise levels
- Moving trucks
- Stair usage
- Bacterial contamination
- Danger of slipping
- Problem with the old sewerage system
- No clear marking of the ingredients used or the direction of the flow in the ink dispensing system

The Table for the most recent risk assessment and management in Finnish is in appendix 2.

High noise is ubiquitous in the factory and the concerned area, but especially high when the automatic circulation function of ingredients is put on. This has been managed by using ear protection and the operator usually puts on the function to operate during the hours when he is out of work.

Sound propagation can be prevented, for example, by building around the sound source, shielding with a wall, or damping. (Andersson, 1998)

The current system relies heavily on the usage of trucks. The movement of the trucks by themselves, as well as the lifting, can be dangerous. This has been managed by urging everyone to pay more attention and defective pallets are thrown away.

Since the operator's break room and the larger stations are located on the second floor the stairs are used frequently. This makes it a risk of falling and has been managed by increased awareness of the importance to hold the stair railing and not carrying other objects while climbing the stairs.

Pumping to the second floor has faced problems in the past with potential bacterial and mold formation in the stations that have not been regularly and thoroughly cleaned. The inks are used on substrates that go to the food industry and must not be contaminated.

Water spilled from the washing station and accidental leakage from the drums make a risk of slipping. The room has an old sewerage system that makes the floor uneven and the drainage is rather ineffective. Slipping is prevented by proper cleaning.

Tube systems where chemicals are used must be safe and work reliably with the company responsible to provide this. (Tukes, u.d.)

4.3.3 Improvements toward LEAN

Rather few traces of direct LEAN applications can be found in the current system. The large-batch return ink storage lacks any 5S-styled storage and the drums are only placed where free space is available.

A large amount of unnecessary movement is performed ranging from the need to lift objects from the shelves by truck and the long transportation distances, especially to printing machine 206. No fresh ingredients are stored directly inside the ink dispensing system room and have to be delivered from the consignment stock storage area every time a container at a station is empty.

While the system allows 32 stations in total to be used only 20 of them have ingredients in them, resulting in a waste of available space.

Aside from being overall outdated, the current software does not at all provide corrections to dispensing errors. For example, if a larger amount of an ingredient is dispensed by mistake the calculations have to be performed manually to get the right proportions of the other ingredients included in the recipe, resulting in extra work and waste of time.

5 Benchmarking of the suppliers' ink dispensing systems

Starting, this Chapter describes what Walki desires in the upcoming system. Then the two selected suppliers' systems are presented and compared against each other.

5.1 Main aspirations of the upcoming system

Benchmarking generally applies to the comparison of the own organization's certain business activities with competitors in the same field to take inspiration for improvement and set new standards. (Oakland, 1993)

In this context, the suppliers will be compared with determined "benchmarks", that is criteria for what Walki wants of the upcoming system.

The far most important benchmarks in choosing what supplier Walki will purchase its new ink dispensing system from are the price and the functionality.

Aside from the price of the ink dispensing system itself with all components and software, other costs will add up when construction work is done for its implementation, service costs, optional add-ons, and alternations to it in the future.

Functionality means that both the supplier's software must be easy to use for operational purposes and that the system's design must fit in comfortably with the surrounding environment and the workers interacting with it. The software should keep track of available stock, management of recipes, formulation of new recipes or alterations, provide effective management of the supply of return inks, correct dispensing errors, and perform mathematical dispensing.

5.2 GSE Colorsat® Compact High

Based in Brummen, the Netherlands, GSE, short for Gerritse Systems Engineering, was founded in 1975 and pioneered the ink dispensing business by introducing the world's first automatic gravimetric dispenser in 1981 for usage in the textile printing industry. Eight years later GSE started making dispensing machines for the packaging industry and in 1991 their "Colorsat"-line of dispensers was launched. (GSE Dispensing, u.d.)

Built with a very compact design in mind, the GSE Colorsat® Compact High is pictured in Figure 15, with a height of 1.80 m and a width of 1.70 m, which can connect to a total of 34 components of which 32 are for ink ingredients and 2 for water. The ink ingredients are connected to modular pump frames (with a height of 1.25 m) and dosed with dispensing valves in stainless steel with the ability to recirculate. The water is dosed with on/off valves. Pumping is handled with pneumatical diaphragm pumps with smooth flow pulsation dampers. The scale located under the dispensing head registers up to 300 kg and has 1 gram readability. The accuracy for dispensing is 1 gram and the dispensing speed is stated to be faster than ten minutes for a recipe of 175 kg with 4 components. The system runs on GSE Ink Manager software and the operator controls the dispensing with a computer. (GSE Dispensing)

Figure 15. Picture sent by the supplier of the GSE Colorsat Compact High with all conveyors placed out

5.3 Inkmaker P32

Established in Turin, Italy in 1987, Inkmaker is part of IM Group and specializes in ink and paint dispensers. (IM Group, 2021)

Operating through Inkmaker's software, Inkmaker P32 (pictured in Figure 16) is flexible when it comes to dispensing into different types of containers with a high output. The P32 can have up to 32 valves for ink ingredients available in either DN18 or DN28 and water is added with on/off valves. The dispensing can be done at three different speeds and the ingredients are pumped by pneumatic pumps with pulsation dampers. The dispensing accuracy is 1 gram (and 0.1 gram on request) and the dispensing speed is stated to take between 12 to 15 minutes with DN28 valves to dispense 200 kg. The scale has the same capacity as the other supplier. (Inkmaker, 2018)

By investigating the layout drawings and sales quotation made by Inkmaker, it is stated that the system utilizes a larger pump size for the IBCs than the drums. and the pump frames going from the stations to the dispensing valves are 2.40 m high and the P32 dispensing unit itself is held by a four-legged pedestal metal frame requiring an area of 2.14 m x 2.10 m.

Figure 16. Picture sent by the supplier of the Inkmaker P32 system with a conveyor system

5.4 Similarities of the systems

From going through the specifications listed on the respective suppliers' websites and the quotations the systems have the following direct similarities:

- The number of maximum valves to be connected to ingredients is 32 with extra on/off valves for water.

- The scale for measuring the dispensed amounts is placed in a floor pit and has the same capacity to read 300 kg gross capacity (with 1 gram readability).

- The systems can use return inks for dispensing. Darker and lighter shades of a color's return inks can be blended to be defined as a base ingredient. The return ink base ingredient will have a special station with a cartridge filter that prevent dirt and other unwanted bodies from entering the produced fresh ink.

- The warranty lasts 12 months.

- Both suppliers offer comprehensive software more than enough to ensure that the ink dispensing process runs smoothly at Walki.

- Both suppliers offer a variety of add-ons. Both offer a weigh-in station for return inks, mixers for the containers connected to the system, mixing devices for the produced fresh inks, and combi-tubes for switching the supplying IBC. Both systems are scalable with the possibility to add stations in the future if more ingredients are needed.

(GSE Dispensing), (Inkmaker, 2018)

Aside from the listed similarities, both suppliers have fully-functional dispensing systems on offer that overall meets the needs of Walki.

5.5 Key differences

When studying the information stated on their websites and listed in respective quotations these differences were observed:

- GSE states a much faster delivery time of 10-12 weeks. Inkmaker states a delivery time of 16-18 weeks.

- GSE guarantees fast installation to deliver a working system in four days. Inkmaker will have an engineer in place for up to 10 days but does not state exactly how long the installation will take.

- GSE's base package is cheaper than Inkmaker.

- Inkmaker's dispensing unit is much larger than GSE's resulting in more space usage.

- GSE's pump frames are wider and take up more space than Inkmaker's, although GSE's pump frames are shorter than Inkmaker's.

- The washing systems differ vastly from each other. The GSE unit uses a valve cleaning system with a wiper that combines wet and dry cleaning. Inkmaker uses a wet cleaning system styled as the current system.

- GSE's warranty includes parts and labor. Inkmaker's warranty does not include labor but will replace/repair standard components of the system.

- GSE offers one service visit and a discount on all spare parts and services for a fixed price per year.

- The GSE unit can dispense at a faster rate than the competitor.

- GSE includes an extra license for their software.

- Both suppliers offer different add-ons. Inkmaker offers an automatic conveyor system for six buckets and the possibility to refill an IBC when still connected to its station. GSE offers a manual conveyor system for eight buckets (four on the supply conveyor and four on the exit conveyor), and washing machines for drums and buckets.

- Inkmaker will take care of the old Inkmaker M48 unit.

(GSE Dispensing), (Inkmaker, 2018)

While some other aspects may differ between the suppliers, the listed differences are the ones that are desirable for the system renewal.

6 Results

This Chapter contains the results. First, the changes to the process and layout of the updated system are described and the reasoning for the selection of the chosen supplier is explained. The Chapter ends with an analysis of the achieved results and suggestions for further development.

6.1 Changes to process and layout

The updated layout, seen in Figure 17, and function of the new ink dispensing system will allow the following things the previous one lacked:

- The ability for people to pass through and to transport ingredients through all doors
- Storage of fresh ingredients directly in the same room and all IBCs and drums connected to the ink dispensing system will be placed on movable carts/platforms. This allows empty containers to be replaced faster than previously and opens up space from the outside.
- An ink dispensing system that is located in the bottom part of the room. This is nearer to the main material flow.
- All stations will be placed on the same floor with no pumping to higher levels involved. This will minimize stair usage.
- Software that corrects dispensing errors.
- Possibility to use return inks in the dispensing process.
- The small-batch return ink storage will be rearranged to 4 movable bookshelves. The return inks can be lifted down and placed back by hand. No involvement of trucks will be needed.
- Updated sewerage system to achieve an even floor and sufficient drainage. The ink dispensing system would be placed on a flat surface and in case of accidental leakage the contents would go down the drain easier than before.
- Floors in the two rooms will be coated with epoxy paint to prevent slipping.
- The tubes will have clear markings of what they contain and their flow direction.

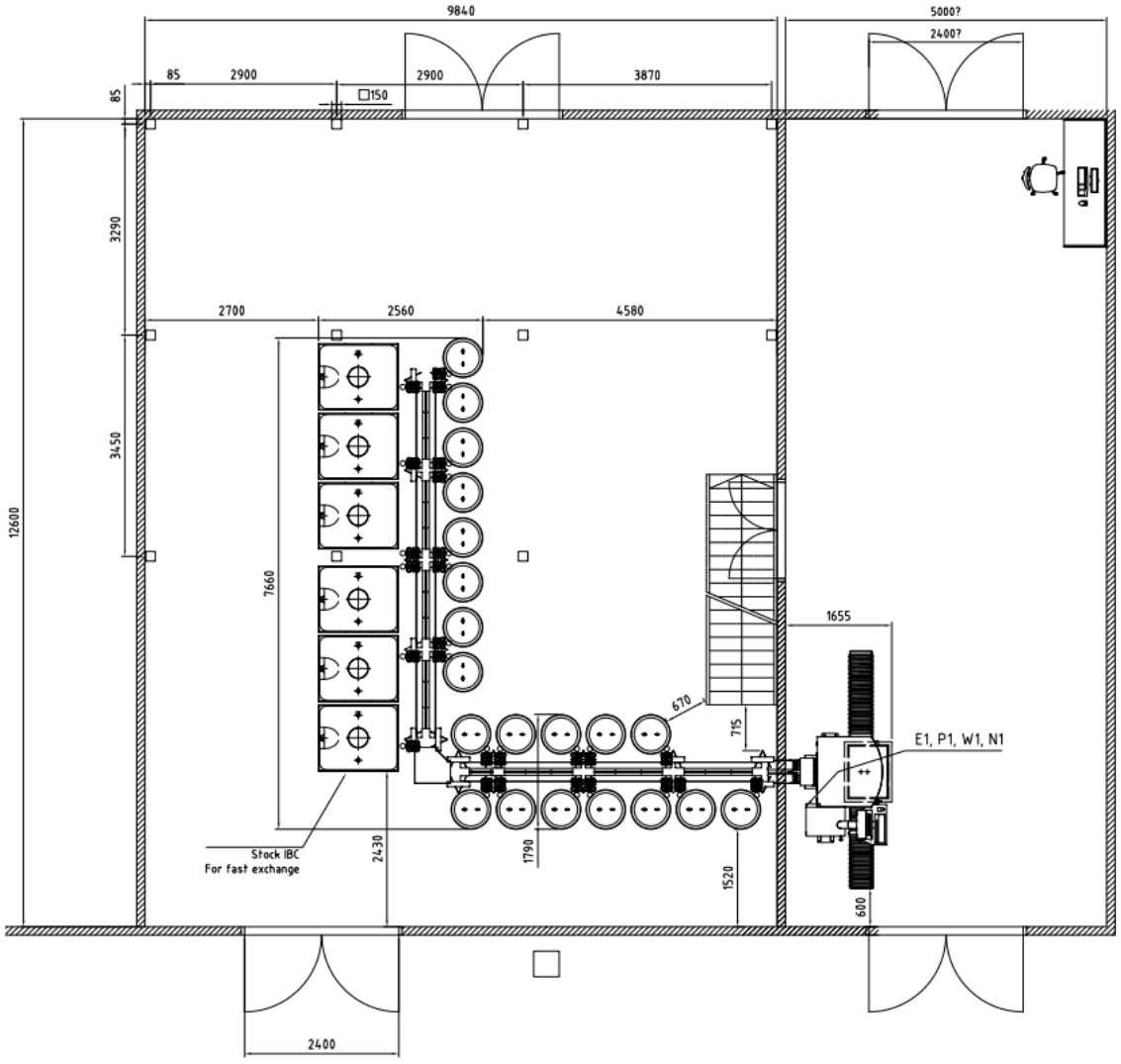

Figure 17. The layout presented by GSE

The complete layout drawing presented by GSE can be seen in appendix 3, with the technical details included.

The number of stations in the new ink dispensing system was decided to be reduced from 32 to 26. The ratio will be 20 drums of whom 4 can be used for return inks and 6 IBCs of whom 2 are connected with a combi-tube (those will thereby contain the same ingredient). The necessary ingredients for future ink production are intended to all be stored inside and thereby removing the need for usage of the consignment stock area.

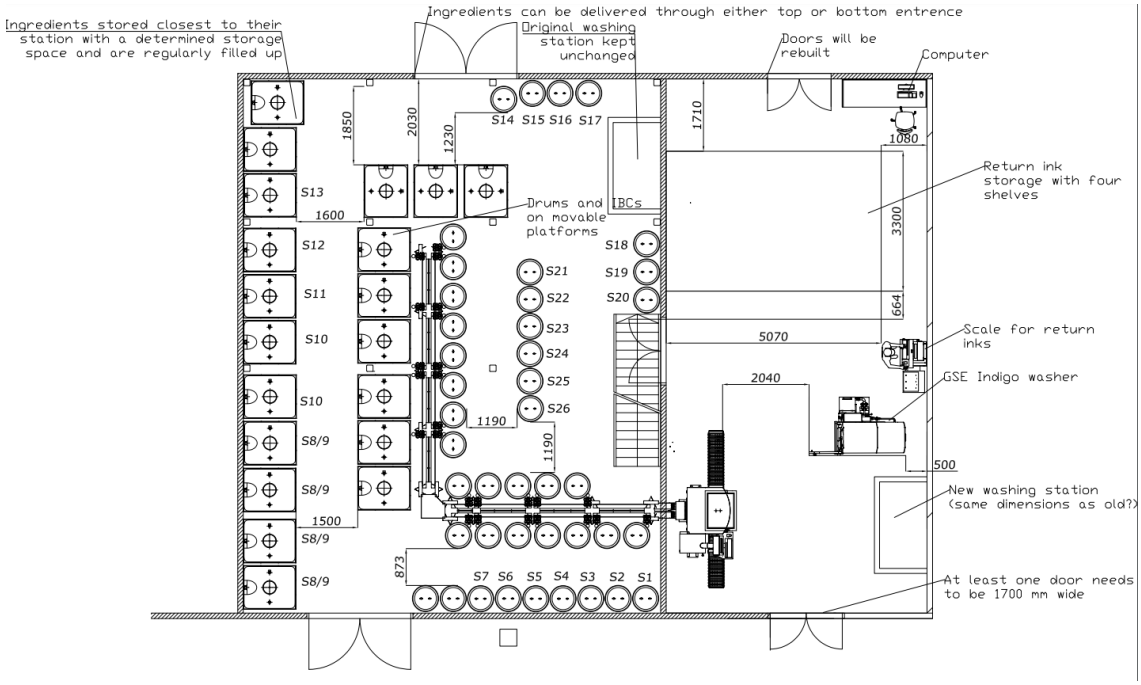

Figure 18. The complete renewed system with comments. “GSE Indigo” is a washer for buckets

In Figure 18 above the complete renewed system is displayed. Storage for containers is filled to the maximum. The numbering of the stations goes clockwise starting from the bottom right. “S” means storage for the respective station. The most used varnish has four storage spaces (S8/9) since they go to the same pump and the second most used has two (S10). Extra IBCs and drums are placed to show the storage potential in the room.

The renewed process can be seen in Figure 19.

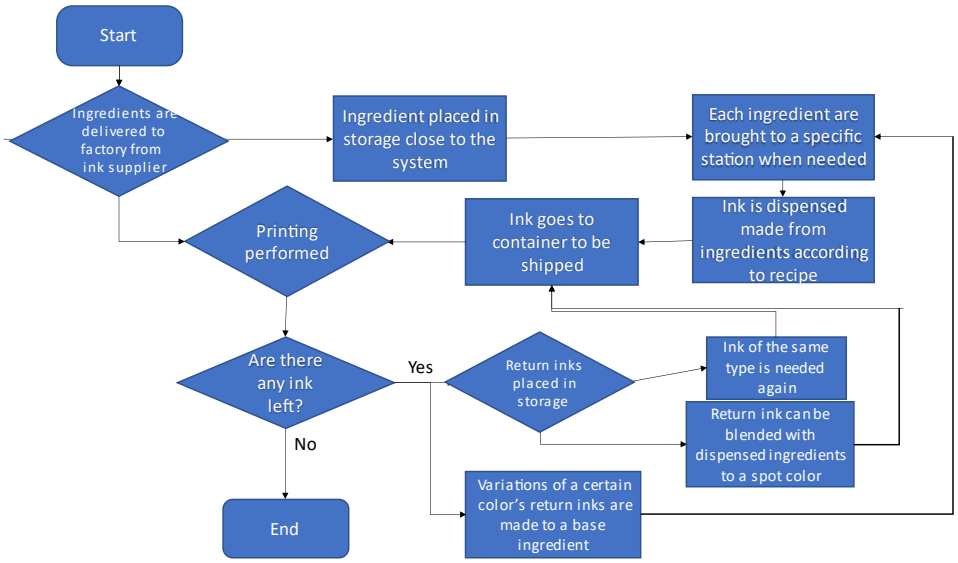

Figure 19. The renewed process without the consignment stock and more effective handling of return inks

The containers connected to the system will have movable carts under them, and the unconnected stored inside have the possibility also. While the IBCs stored on the left-hand side have rather limited space it would be possible to move them through when needed for change as they are on movable carts or a pallet jack with short forks could lift them if they are stored directly on the floor. Storage of the spare movable carts would be directly outside the room.

Because of the long paths to the storage areas for larger-batch return ink, ready-made colors, and other ingredients, new storage areas will be located directly at every printing machine. Prioritizing the larger return inks to be delivered directly to the new storage areas would reduce unnecessary movement and time consumption. Printing machine 206 has already received a shelf storage system and objects used in printing machines 208 and 210 can be placed on the floor. Transportation of the containers will be handled with a reach truck. The planned storage spaces on the floor for printing machines 208 and 210 will be used more frequently in the future and the established shelf storage system located near printing machine 206 will continue its operations. If more ready-made colors or other ingredients will be needed as a result of changes in the aforementioned printing machine work schedule the shelf system may be changed or expanded. When there is no space left at the printing machines' own storage area, the drums will be delivered to the old larger-batch return ink area.

The updated layout will vastly reduce the distance to replace ingredients compared to the previous method of transporting the ingredients from the consignments stock area. The dispensing system itself will be closer to the main material flow of receiving and delivering inks. While the small-batch return ink storage is moved several meters away from the main material flow, access to it is easier and safer than before with the bookshelf system. The renewed value-stream map can be seen in Figure 20.

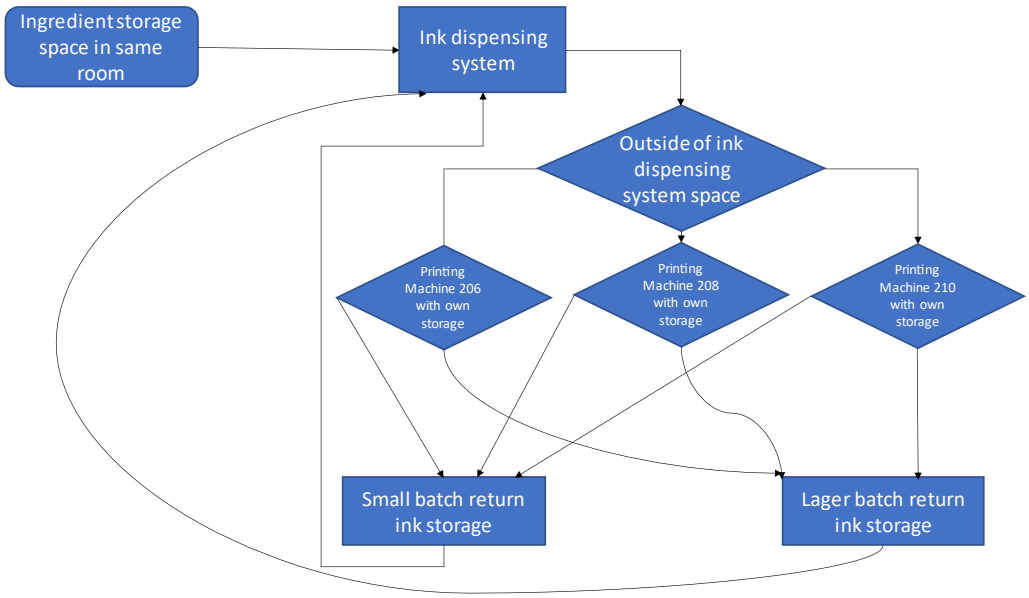

Figure 20. The renewed Value-stram map

6.2 Supplier of the Future system

GSE was considered the better supplier of the new ink dispensing system. The main reasons for the decision were the following:

- the base package including shipping was slightly cheaper than the competitor (1,3%).
- the smaller size of the dispensing unit and lower pump frames.
- much faster delivery time than the competitor.
- installation of the system was guaranteed to be faster than the competitor.
- the dispensing speed was slightly faster than the competitor.
- the extra license of GSE software.
- the well-defined service options.

Implementation of the GSE system also requires slightly less construction work. The system requires a smaller door width to be delivered and a smaller hole through the wall connecting the unit to the stations.

6.3 Plan for implementation

The tasks for the implementation process were made into the table seen in Table 2.

Table 2. The timetable of tasks for the implementation process

Task	General note(s)	Duration	Other note(s)
Relocation and disposal of old flexo plates		2 days	
Cleanup of room that held flexoplates		2 days	
Framework is set for new washing station		2 days	
Sewerage reconstruction in old flexo plate room	New washing station, water supply for new ink dispensing system and Indigo bucket washer	1 week	
Floor in old flexo room rebuilt	Space for scale need to be made/hole made in floor	2 days	
Pneumatic connections in old flexo plate room	For new ink dispensing system and Indigo bucket washer	1 week	
Electrical power and network connections in old flexo plate room	Electrical power needed for new ink dispensing system, Indigo bucket washer and operator's computer. Network connection needed for new ink dispensing system and operator's computer	1 week	
Floor in old flexo plate room gets coated with epoxy paint		3 days	
Construction work done for new doors that are fitted to old flexo plate room	Needs to be at least 1700 mm wide	2 days	
New return ink storage in bookshelf style placed in old flexo room		1 day	
Return inks moved from old place to new		2 days	
Shelves are removed from old ink storage room		2 days	
Connecting hole drilled through wall		1 day	
Ingredients from old stations are emptied to containers		2 days	
Old ink dispensing unit and stations on first floor (drums) are disposed		2 days	Time without ink dispensing system!
Floor and sewage system in ink storage room remade to recieve an even surface	Old washing station kept, but old pipes redone and a drain will be built in case of leakage from stations	1 week	Time without ink dispensing system!
Floor in ink storage room coated with epoxy paint		3 days	Time without ink dispensing system!
New ink dispensing system implemented		1 week	Time without ink dispensing system!
Fresh ingredients placed in their determined storage space		2 days	Can be done parallell to implementation?
The solid containers on the second floor are removed by lifter		2 days	Can be done after
The contents of the tubes in the ink dispensing system are marked with labels that indicate what they contain and point out the direction of the flow	This is something the current Inkmaker system lacks	2 days	Can be done after/during the installation

The duration of the tasks to be done before the new system arrives is less than 10 weeks.

While the large majority of the old flexo plates will be thrown away those that are decided to be kept will be taken to a smaller storage space just south of the consignment stock area.

The old washing station would be kept in its original form to mainly serve as the water supply for cleaning in case of leakage from stations. A new washing station would need to be built in the same room as the dispensing station to be used for the cleaning of containers at a near distance to the ink production. Since the cleaning of buckets would mainly be handled by the GSE Indigo machine, the new washing station could be smaller in size than the existing one.

The doors to the old flexo plate room are only 1500 mm wide so at least one of the needs to be replaced with a wider type of door to make it possible for the system components to pass through. A width of at least 1700 mm was stated by the supplier.

The shelves making up the small-batch return ink storage would be removed completely from the room and all inks placed in the new storage system right after it has been finished.

Before being disassembled the current system's ingredients would be emptied into various containers to prevent anything from being wasted.

While the stations on the first floor, the pumps leading to the second floor, and the dispensing unit itself must be removed for the upcoming system's implementation, the solid metal containers on the second floor can be kept unchanged. The removal is possible to be handled by disassembling the containers and placing them on a lifting device afterward. This would require that the IBCs in storage aligned to the left wall would have to be placed after the solid containers have been removed.

6.4 Discussion of the results

As the system has not been renewed in practice the results can not be evaluated in practice. The same thing applies to the risks, whether they can be managed as well as intended through the changes.

Early in the project's planning stage, the second floor was deemed unnecessary since the intention was that the new system should not need to pump ink to higher levels. The second floor would not be abolished completely since it could be used in the future as a storage area and the operator's break room would continue its normal usage.

The main question was whether the ink dispensing system and storage of return inks would need to be placed over two rooms or just one room. The first floor itself is quite big and could fit the desired components, however, the high noise level would still be a concern for the workers and already has been a problem to some extent with the initial layout. To effectively reduce the noise a wall surrounding the stations could be built along with the usage of acoustic boards or mufflers for the pumps.

Statistics regarding the concerned area influenced the choice of the number of stations for the future system to some extent, but the decision of the exact number and ratio of containers was determined through discussions and agreements between the production manager, the printing supervisor, the printing supervisor assistant, and several other employees at Walki because of the changing situation differing from the previous needs of dispensing. As the current system uses 20 ingredients the new 26 stations would allow the current 20 to still be used along with 4 return inks. Since the most used varnish takes up two stations this would allow one extra ingredient to be used. In the future, several of the ingredients used in the system will be changed from IBCs to drums and certain dispensed products will be bought as ready-made resulting in a change of ingredients being used.

The two competing suppliers were, to say the least, close to equal when it came to being able to supply a fully-functioning system to Walki regarding price, software, and ability to produce the needed ink. Both are leaders in their field with years of experience and satisfied customers worldwide.

Regarding the desired placement over two rooms GSE was considered the better supplier since the unit would take up less space. Inkmaker could place the stations over a smaller area in the ink storage room, but the unit leaves less space in the room where it is located which makes it harder to pass by and limits the possibility of placing other features, such as a washing station, with ease. While the ink storage room would have the possibility and space to add more stations in the future taking up slightly less area with the Inkmaker system, it is determined for now that the system will have 26. The final layout with the Inkmaker system with an example arrangement of storage spaces can be seen in Figure 21. The final drawing made by Inkmaker can be seen in appendix 4.

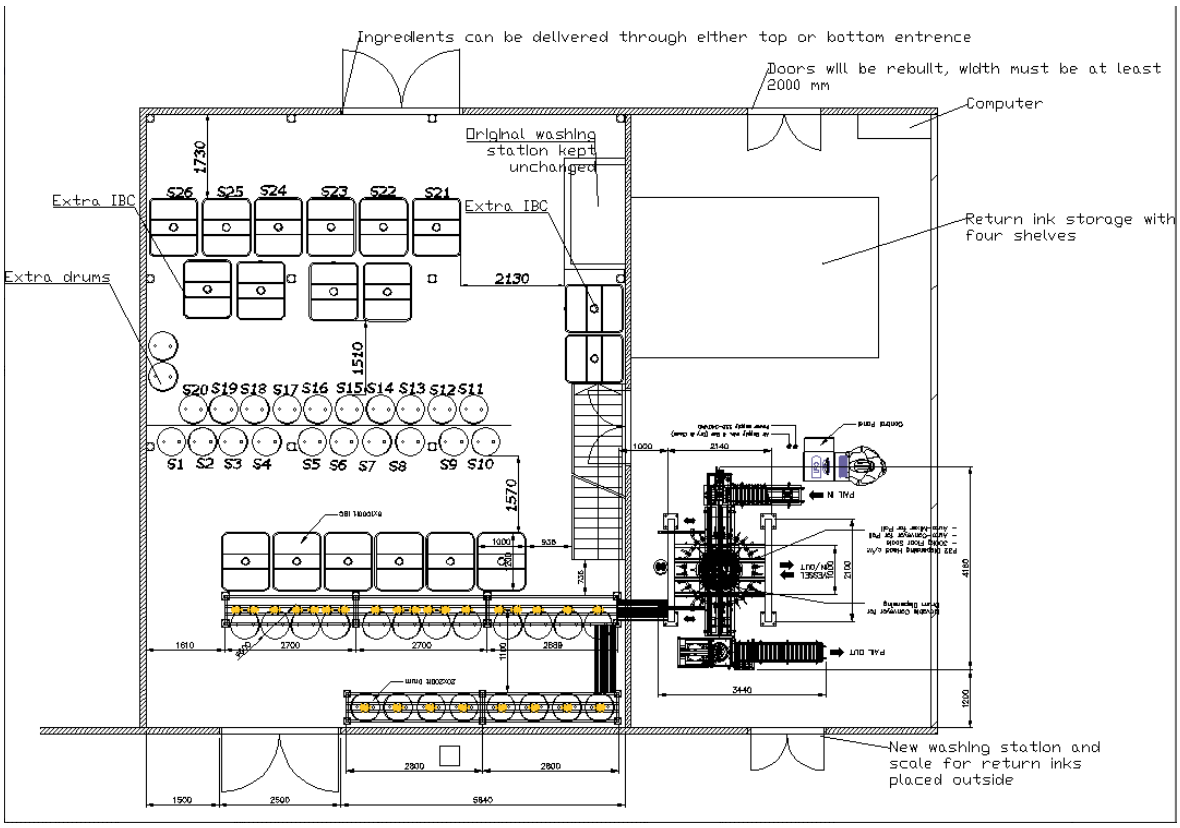

Figure 21. Inkmaker's final layout with comments

The larger of the two rooms was considered to be better suited to hold the stations because of its larger size, making transportation of ingredients to the room and changing of ingredients in the system easier. Placing the dispensing unit in the larger room's bottom part for the sake of being nearer the main material flow makes the stairs close to inaccessible and results in a tight space for the stations and storage containers located in the old flexo plate room. The larger room could also be left with a lot of unused space.

While the GSE Colorsat® Compact High has a washing system that differs from that offered by Inkmaker and a manual conveyor for buckets, both are considered functional for the upcoming system. Other advantages Inkmaker had as a supplier such as being able to take care of the old system were considered minor aspects, as the old system could be recycled in one way or another.

The timetable was made with as exact timestamps as possible from knowing the process and consulting with the people involved. In the current form, Walki Pietarsaari will not have automatic ink production available for three weeks. This means the ink dispensing system operator has to make a supply of inks for at least three weeks.

As the operator only works daytime, second-in-command printing machine operators and possibly others skilled with the system will help build up the supply during the other hours of the day to ease the workload. Since the production schedules of the printing machines can vary from day to day due to customer demand, other inks than known before may be needed which will result in having to perform the mixing manually to some degree. This was the case when the Inkmaker M48 was implemented in 2007.

6.5 Further development

While it is intended that all containers for ingredients are placed in the ink dispensing system room, storage directly on the outside is still possible if the number of containers exceeds the room's capacity. The storage system with high shelves on the outside could be rearranged, possibly by having the ingredients on the floor or lower shelves to reduce the risks of lifting.

The larger-batch return inks come in uneven quantities and the arrangement of a 5S-styled storage for those in the old space is hard to achieve. The storage spaces at every printing machine also lack a well-defined system of placement for the same reason. These could be proved further upon.

As collected return inks of certain colors, yet to be defined, can be used in the renewed system the number of return inks stored in containers needing a storage space will decrease resulting in more effective usage of return inks. The whole concept and space of storing the return inks could in the future be updated.

7 Discussion

The time horizon for this bachelor's thesis was stretched out far longer than initially expected. This was a work that included many factors that would be affected by the change and needed to be analyzed further leading to frequent side-tracking. Continuous communication was required with both suppliers regarding the best date for their respective visits and planning of the future layout of what was possible to make in practice. Top management of Walki has of March 2022 not yet approved the required financing of the new system along with the required construction work and changes necessary. The ink supplier contract is still continuing largely the same with Flint Group as the main supplier.

While the actual implementation of the system was not put into reality to give definitive results to evaluate, the improvement suggestions, the planned layout, and the timetable of tasks needed for the implementation process were well received by the company and can be used to set the guidelines in the future.

The ink dispensing system concept is rather nisché and information available was scarce. The sources used mainly stems from the different suppliers' websites and old instruction manuals for the two systems used by Walki before. The field trip to Ab RaniPlast Oy also provided a good amount of information and furthermore inspiration for the new ink dispensing systems layout.

LEAN, its principles, and subcategories had great applicability in this project. The risk assessment and management principle also could be applied when planning for the new system, but as stated earlier, could not be done in an updated version for the new system itself. The OH&S policy was kept in mind, but remained as largely a theoretical concept.

Working on this thesis has proven how many new great ideas can appear by analyzing an organization's operations, using all possible potential, while taking into consideration how small changes can have a big impact and listening to and evaluating the opinions of everyone involved regardless of job title. It is always possible to always strive for the betterment of all concerned aspects and always try to continuously improve them while maintaining the health and safety of everyone which are essential for an organization to work properly in the long run.

This thesis could not have been compiled without the support, time, answering questions, and providing valuable input and ideas from both of this thesis' supervisors Tobias Ekfors (at Novia University of Applied Sciences), Petteri Pihajoki (Production Manager at Walki Oy), as well as printing supervisor Niklas Käldman, printing supervisor assistant Kari Tilus, ink dispensing system operator Arto Rajala, Supply Chain Manager Sami Saari, Environment Manager Pernilla Stubb, Safety Officer and Maintenance Development Manager Pasi Peltokangas, Mechanical Maintenance Supervisor Tommy Snellman, Sales Manager at IM Group Martin Black, and Sales Engineer at GSE Patrick Apeldoorn. All deserve credit and a big thanks.

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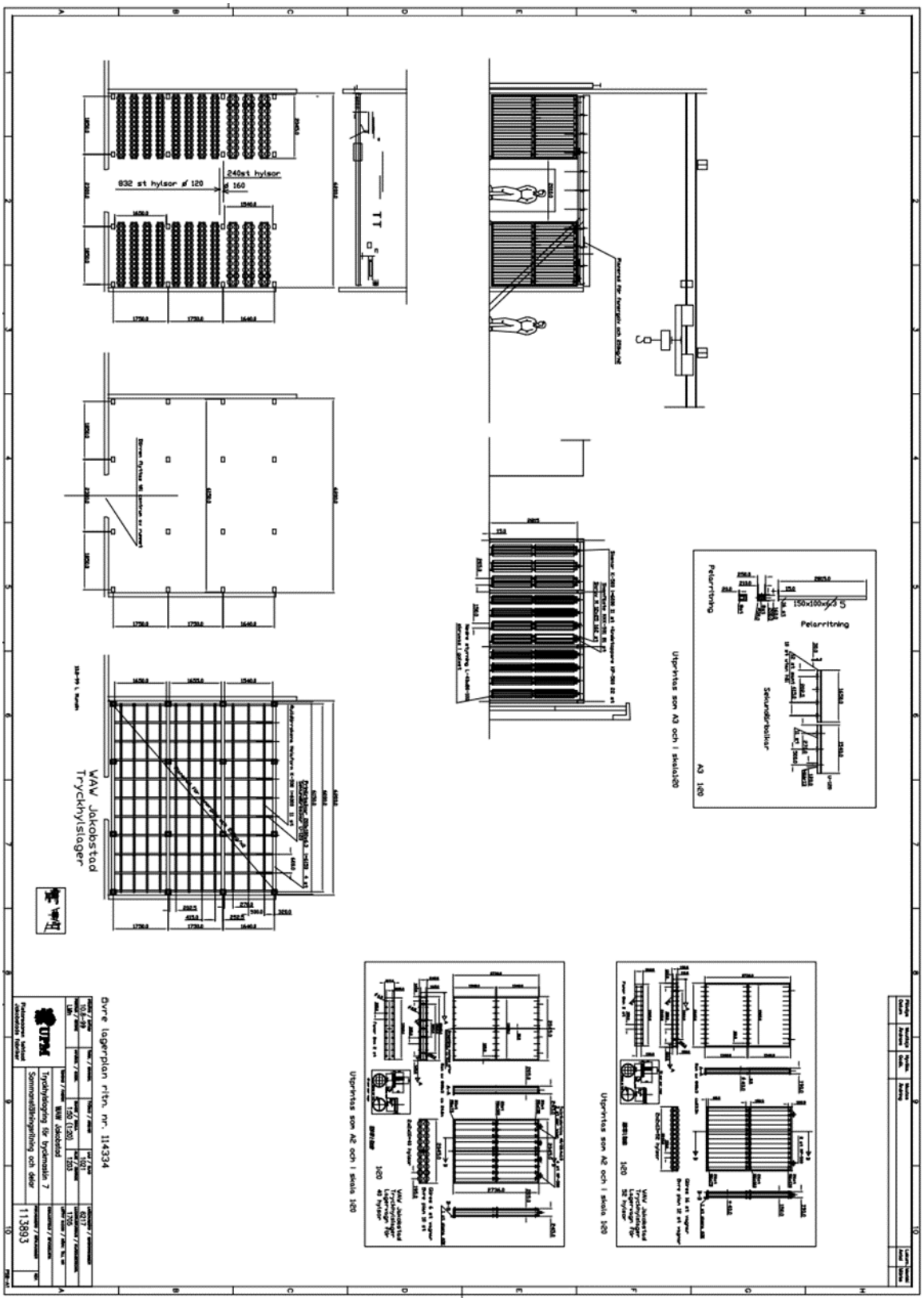
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ø 160
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Tryckhylslager
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Utprintas som A2 och i skala 1:20
Tryckhylslagring för bryterivalin 7
Sammanställningsritning och delar
113893

Kohde:	Väriasema	IV-riskien päivitys	
Päivämäärä:	18-10-2018	09-06-2020	24-02-2021
Tekijät:	Tommy Snellman	18-10-2018	Rajala Arto
	Jarno Pikkumäki	Pikkumäki Jarno	Käldman Niklas
	Kenneth Granö	Peltokangas Pasi	Peltokangas Pasi
VAAROJEN TUNNISTAMINEN JA HALLINTA		Kaptens Sune	Pikkumäi Jarno

Vaaraluokka			
A	Tapaturmavaarat	F	Ympäristövaarat
B	Vartalon kuormituksesta aiheutuvat	G	Elintarviketurvallisuusvaarat
C	Fysikaaliset vaarat	H	Psyykkiset, sosiaaliset ja organisatoorist vaarat
D	Kemialliset ja biologiset vaarat	I	Informaatio ja IT vaarat
E	Tulipalo- ja räjähdysvaarat		

Prosessin ja vaaran tunnistaminen		
Numero	Prosessin vaihe	Vaara
1	PREREHDYTYS	Uuden henkilön taloon tulo: turvallisuusasiat , opastus ja perehdyttäminen
2	LIIKKUMINEN	Melu kun liikutaan tuontannossa
3	LIIKKUMINEN	Iskumelu kun liikutaan tuontannossa
4	LIIKKUMINEN	Liikkuminen tehtaalla ja puhelimessa keskustelu samanaikaisesti
5	LIIKKUMINEN	Liikkuminen tehtaalla korvakuulukkeella korvissa joka estää mahdollisuuden havaita muu toimintaa ympäristössä tehtaan halleisa
6	LIIKKUMINEN	Kompastuminen portaissa
7	LIIKKUMINEN	Kaatuminen ulkona, liukasta
8	TYÖN SUORITUS	Kompastuminen ja putoaminen portailta
9	TYÖN SUORITUS	Tynniriprässin käytössä vaara että puristettu paali tulee ulosottaessa päälle tai vannenauha katkeaa.
10	TYÖN SUORITUS	Henkilökunta altistuu homeeseen (väreissä)
11	TYÖN SUORITUS	Tulipalo
12	TYÖN SUORITUS	Altistuminen uuteen kemikaaliin
13	TYÖN SUORITUS	Viiltovaara puukon terästä tai vanteista.
14	TYÖN SUORITUS	Kuulovamma kovasta taustamelusta.
15	TYÖN SUORITUS	Kuulovamma kovasta iskumelusta.
16	TYÖN SUORITUS	Trukin alle jäämisen vaara risteyksessä (osa varasto on toisella puolella)
17	TYÖN SUORITUS	Iskuvaara lavan rikkoutuessa, kun tynnyreitä liikutellaan nostolaitteella.
18	TYÖN SUORITUS	Purkkien kaatumis- tai putoamisvaara nostinta käytettäessä ajettaessa.
19	TYÖN SUORITUS	Rasitusvamma purkkien nostamisesta. Ja tynnyreiden siirrossa
20	TYÖN SUORITUS	Melu. Pumput ovat äänekkäitä ja ilmastointi humisee.
21	TYÖN SUORITUS	Liukastumisvaara lattialla olevasta nesteestä.
22	TYÖN SUORITUS	Kompastumisvaara epäjärjestyksen vuoksi.
23	TYÖN SUORITUS	Roiskevaara silmille ja liukastumisvaara tynnyreiden pesussa.

	Riskien arviointi					
Numero	Vaaraluokka	Todennäköisy	Vakavuus	Riskiluokka	Esiintyminen	Valvontatiheys
1	I	2	2	III	Uuden henkilön tullessa taloon	
2	F	1	2	II	Jatkuva	
3	F	1	2	II	Jatkuva	
4	A	1	3	III	Jatkuva	
5	A	1	3	III	Jatkuva	
6	A	2	2	III	Portaissa	
7		2	2	III	Ulkona	
8	A	1	3	III	Jatkuva	
9	A	2	2	III	Jatkuva	
10	D	2	2	III	Jatkuva	
11	A	2	1	II	Jatkuva	
12	A	1	2	II	Värin käsittelyssä	
13	A	2	2	III	Veitsen käsittely	
14	C	2	2	III	Jatkuva	
15	C	2	2	III	jatkuva	
16	A	1	3	III	Jatkuva	
17	A	1	2	II	Tynnyreitä siirrettäessä	
18	A	1	2	II	Purkkeja kuljetettaessa	
19	A	2	2	III	Siirroissa	
20	A	3	1	III	Jatkuva	
21	A	3	1	III	Jatkuva	
22	A	2	1	II	Jatkuva	
23	A	2	1	II	Pesun yhteydessä	

	Riskien hallinta		
Numero	Korjaavat toimenpiteet	Vastuuhenkilö	Valvontatehtävä
1	Asiallinen koulutussuunnitelma ja sen noudattaminen	Esimies	*HR*
2	Käytetään hyväksyttyjä kuulosuojaimia	Työntekijä	Esimies
3	Käytetään hyväksyttyjä kuulosuojaimia	Työntekijä	Esimies
4	Puhelimessa ei saa puhua kun liikutaan	Työntekijä	Esimies
5	Musiikin kuuntelu korvakuullokkeella tehtaalla kielletään, käytettävä asianmukaista kuulunsuojausta	Työntekijä	Esimies
6	Pidetään kaiteesta kiinni kun se on mahdollista, kävellään rauhallisesti ja ei käytetä puhelinta liikuttaessa	Työntekijä	Esimies
7	Talvikenkien käyttö	Työntekijä	Esimies
8	Käsissä ei ole tavaraa kun liikutaan ylös ja alas. Pidä	Työntekijä	Esimies
9	Henkilökunta on koulutettu käyttämään laitetta	Työntekijä	Esimies
10	Homehtunut väri poistetaan hallitusti käytöstä ekokemin kautta	Työntekijä	Esimies
11	Suoritetaan alkusammutus	Työntekijä	Esimies
12	Tutustutaan KTT:en ennen käyttöä	Työntekijä	Esimies
13	Käytetään viiltosuojahanskoja	Työntekijä	Esimies
14	Käytetään kuulosuojaimia	Työntekijä	Esimies
15	Käytetään kuulosuojaimia	Työntekijä	Esimies
16	Pysähdys risteyksessä, peilien käyttö, ei käytetä puhelinta liikuttaessa	Työntekijä	Esimies
17	Huonot lavat hävitetään	Työntekijä	Esimies
18	Varovaisuutta nostinta käytettäessä	Työntekijä	Esimies
19	Nostetaan purkkeja ja siirretään purkkeja työergonomia huomioon ottaen ja apuvälineitä käyttäen	Työntekijä	Esimies
20	Käytettävä kuulosuojaimia	Työntekijä	Esimies
21	Pidetään työnympäristö puhtaana	Työntekijä	Esimies
22	Pidetään työympäristö järjestyksessä	Työntekijä	Esimies
23	Suojalaseja käytetään	Työntekijä	Esimies

	Korjaavat toimenpiteet			
Numero	Korjaavat toimenpiteet	Vastuuhenkilö	Määräaika	OK/NOK
1	Perehdytyksessä huoitava asia	Esimies	Jatkuva	OK
2	Perehdytyksessä huomioitava asia	*Esimies*	Jatkuva	Ok
3	Perehdytyksessä huomioitava asia	*Esimies*	Jatkuva	Ok
4	Perehdytyksessä huomioitava asia	*Esimies*	Jatkuva	OK
5	Perehdytyksessä huomioitava asia	*Esimies*	Jatkuva	OK
6	Perehdytyksessä huomioitava asia	*Esimies*	Jatkuva	Ok
7	Perehdytyksessä huomioitava asia	*Esimies*	Jatkuva	Ok
8	Perehdytyksessä huomioitava asia	*Esimies*	Jatkuva	Ok
9	Perehdytyksessä huomioitava asia	*Esimies*	Jatkuva	Ok
10	Perehdytyksessä huomioitava asia	Esimies	Jatkuva	OK
11	Säännöllinen alkusammutus koulutus	Pasi Peltoniemi	30-10-2021	NOK
12	Kemikaalien hankinta ja käsittely prosessi on selvitettävä	Pernilla Stubb	30-10-2021	NOK
13	Perehdytyksessä huomioitava asia	*Esimies*	jatkuva	Ok
14	Perehdytyksessä huomioitava asia	*Esimies*	jatkuva	Ok
15	Perehdytyksessä huomioitava asia	*Esimies*	jatkuva	Ok
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18	Perehdytyksessä huomioitava asia	Esimies	jatkuva	Ok
19	Perehdytyksessä huomioitava asia	Esimies	jatkuva	Ok
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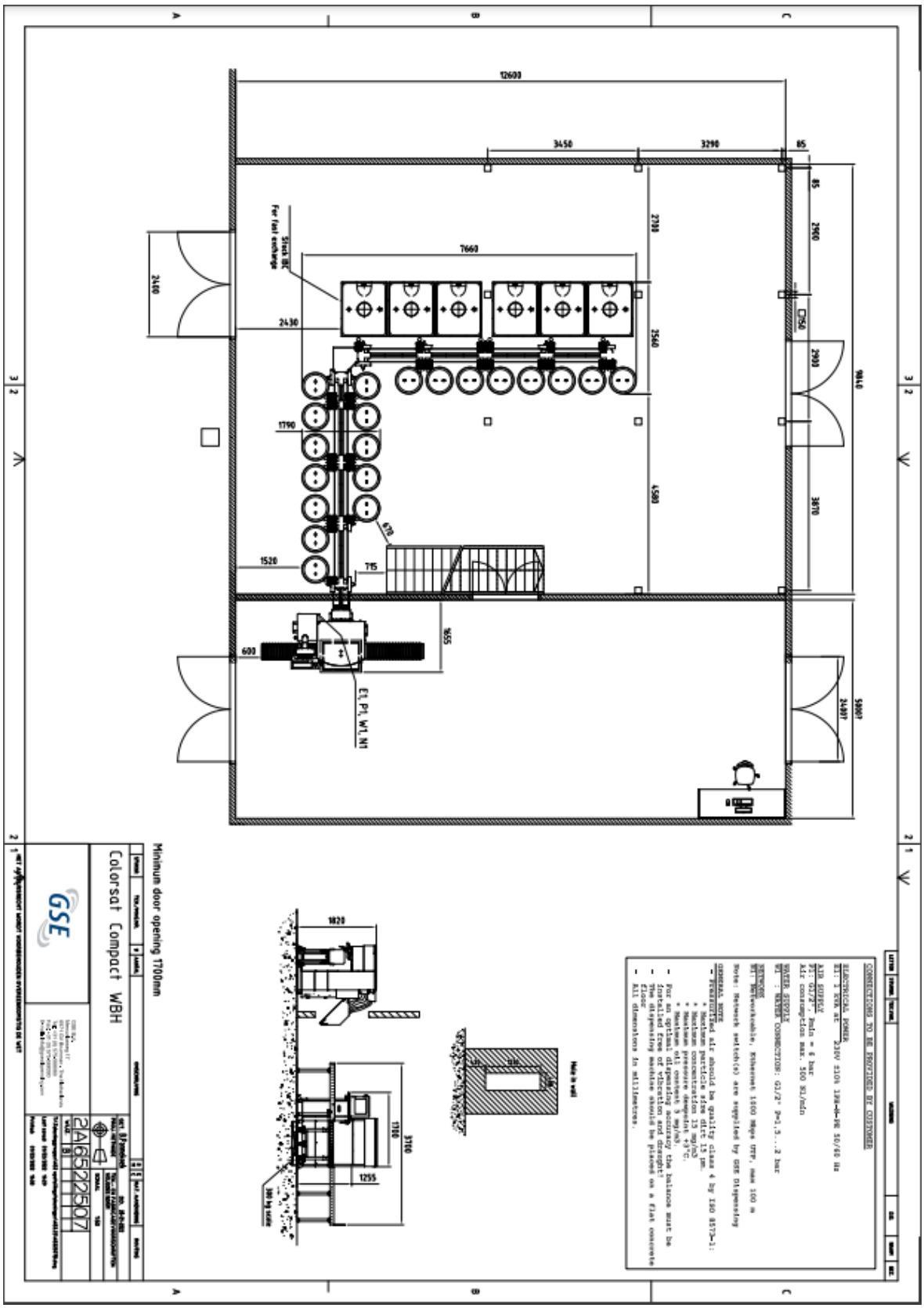
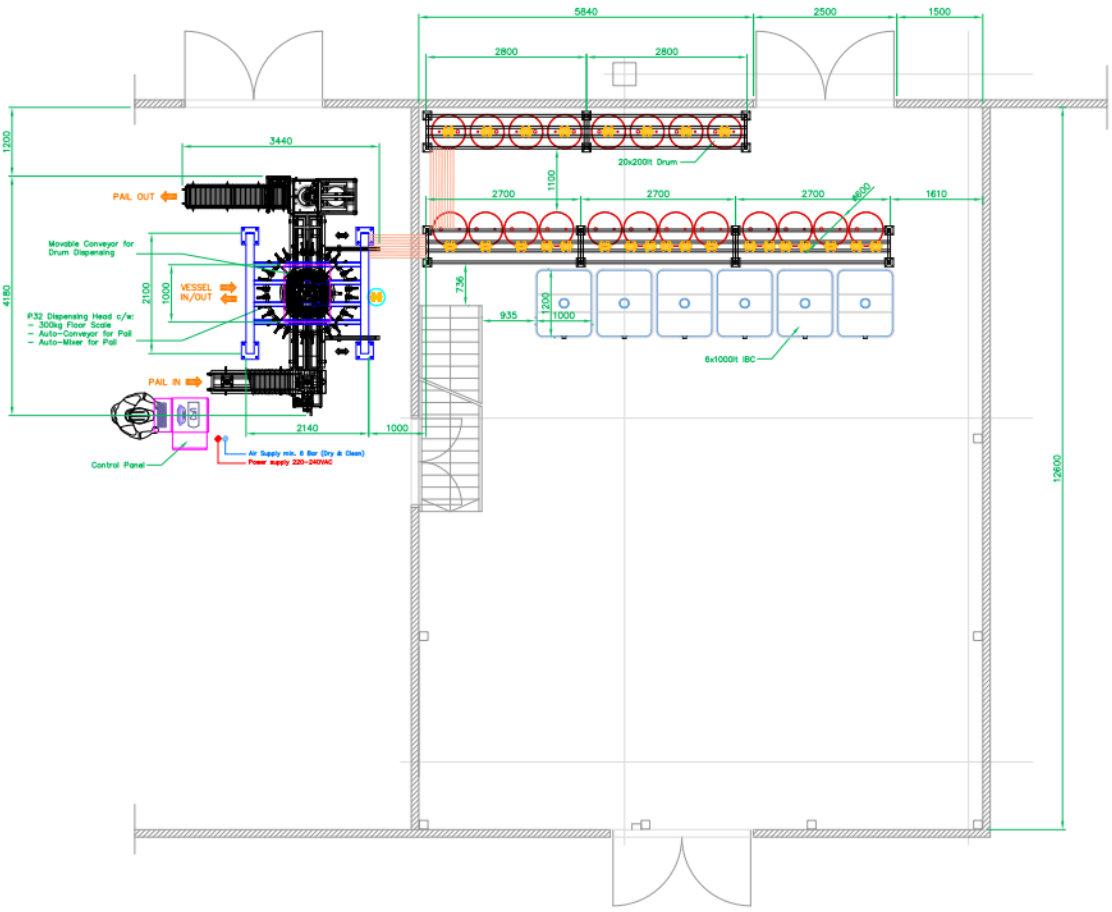
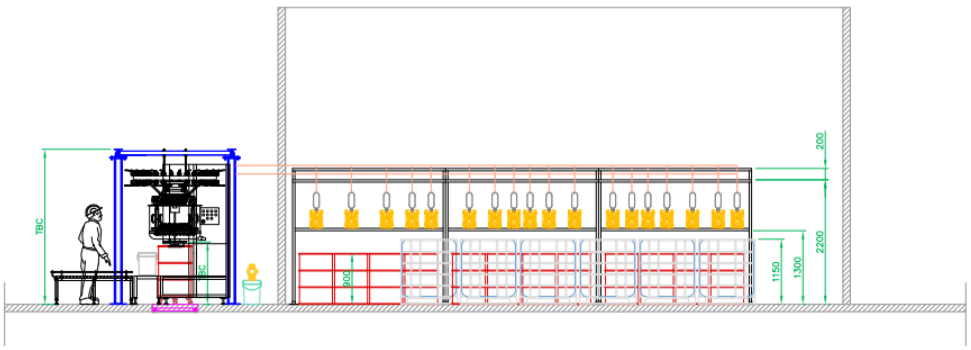
22	Perehdytyksessä huomioitava asia	Esimies	jatkuva	Ok
23	Perehdytyksessä huomioitava asia	Esimies	jatkuva	Ok

	Jäännösriskien arviointi				
Numero	Todennäköisyys	Vakavuus	Riskiluokka	Päivämäärä	OK/NOK
1	1	2	II		OK
2	1	1	I		OK
3	1	1	I		OK
4	1	2	II		OK
5	1	3	III		OK
6	1	2	II		OK
7	1	2	II		Ok
8	1	3	III		OK
9	1	2	II		OK
10	1	1	I		OK
11	2	1	II	31-12-2021	NOK
12	1	2	II	31-12-2021	NOK
13	1	2	II		Ok
14	1	2	II		Ok
15	1	2	II		Ok
16	1	3	III		Ok
17	1	2	II		Ok
18	1	2	II		Ok
19	1	2	I		Ok
20	2	1	II		Ok
21	2	1	II		Ok
22	1	1	I		Ok
23	1	1	I		Ok

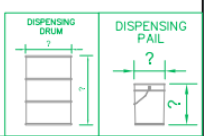

12600
3450
3290
85
2960
2700
7660
2560
2430
2450
1790
6500
3870
2993
9940
1520
715
600
9655
24897
50997
Ø56
Ø50
Ø76
E1, P1, W1, N1
Minimum door opening 1700mm
1820
3780
1380
1255
Hole in wall
Colorsat Compact WBH
GSE
2A65222507



SYSTEM LAYOUT PLAN VIEW



SYSTEM LAYOUT ELEVATION VIEW



INKMAKER DISPENSING SYSTEM – Perfection in Precision	
DATA 26.01.2022	CLIENTE Walki Finland
SCALA NTS / FORMATO A3	IMPIANTO P32 WB
DIS. nsari / VISTO	TITOLO LAYOUT PRELIMINARY
CONT. / APPR.	COMMESSA OFF / DISEGNO N. / FOGLIO 1 / DI 1
NOME FILE Layout_01.DWG	