Creating documentation for sub-assemblies facilitating the outsourcing of Finndent production

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Sammandrag:

Detta examensarbete är en praktisk rapport som omfattar dokumentation av under-enheter för tillverkningen av tandvårdsmaskinen FD-8000. För att företaget skall kunna lägga ut egen verksamhet (outsourcing) framgångsrikt måste dokumentationen i form av arbetsinstruktioner vara grundligt utförda. Utmaningar för denna uppgift kan vara eventuell brist på kunskap oförmåga att skriva på ett begripligt sätt. Detta har uppmärksammats genom konsultering av personal som kan processerna utantill och de kan sedan skrivas ner svart på vitt. Strukturen för dokumentationen följer monteringsprocessen och borde vara förståelig för vem som helst. Utmaningar till denna metod är att processerna är speciellt anpassade för denna maskin, till exempel storleken eller mångfalden av underenheter. Resultaten bekräftar att det fortfarande finns mycket att förbättra för att göra instruktionerna klara för användning av utomstående. Säkerheten och kvalitéten är väldigt viktiga även om de kan bli förbisedda. Processerna för outsourcing har också utforskats inför detta arbete för att utreda vad man bör tänka på i början på ett dylikt projekt. Baudin, 2020, tar upp många ändamålsenliga frågeställningar om Lean produktionen samt monteringsanvisningar som har använts i detta arbete.

Nyckelord:	Finndent, outsourcing, dental, documentation, instructions, production, sub-assembly
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Abstract:

This thesis is a practical report on making documentation for sub-assembly production for the FD-8000 dental unit. For the company to outsource its production successfully, they need thorough documentation in form of working instructions. Some of the challenges of writing working instructions are possible lack of knowledge in the assembly process and making instructions understandable. This is addressed by consulting with personnel that know the processes by heart and trying to transfer the knowledge into words and pictures. The structure of the documentation is linear to the assembly process and should be easily understandable by anyone. Challenges to this method are the individuality of the processes, for example the size or complexity of a sub-assembly. The results confirm that there is still much to improve in order to make the instructions ready for outside use. Although sometimes overlooked, the consideration of safety when working and the overall quality is of utmost importance. Outsourcing processes are also researched to determine what to consider when starting an outsourcing project. Baudin, 2020, discusses many applicable subjects in Lean assembly as well as working instructions that have been used in this thesis.

Keywords:	Finndent, outsourcing, dental, documentation, instructions, production, sub-assembly
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Abbreviations and terminology

BOM = Bill of Materials

CAD = Computer Aided Design

The company = Finndent Oy

EN = English language

FD = Finndent Oy

FI = Finnish language

HR = Human Resources

PD = Production

R&D = Research and Development

WI = Working Instructions

SLA = Service Level Agreement

Sub-assembly = “an assembled unit designed to be incorporated with other units in a finished product” (Merriam Webster)

FOREWORD

The idea for this thesis came from the CEO at Finndent Oy, Hans Ahlström. The need for documentation in production has been and still is relevant for the company's outsourcing ventures. I would like to thank Hans and all other personnel at Finndent for their support during my studies at Arcada.

I would like to express my gratitude for Arcada, my supervising teacher, Silas Gebrehiwot as well as the examiner, Mathew Vihtonen. Lastly, thank you to my friends Hannes Paulin and Mathias Lunabba for proofreading and support during my thesis work.

Helsinki, May 2021
Jonatan Lehtinen

FÖRLÄNGT ABSTRAKT

Outsourcing användes för första gången som verksamhetsstrategi kring år 1989. Företag började outsourca (lägga ut) delar av verksamheten som företagen inte själva hade experter för, som till exempel bokföring, HR eller säkerhet. Företagen gjorde detta för att spara bland annat pengar och andra resurser. Syftet med detta arbete är att skriva arbetsinstruktioner för att kunna outsourca produktionen av FD-8000 tandvårdsmaskinen för Finndent, denna maskin används av tandläkare på olika kliniker. Företaget har i över 30 år tillverkat tandvårdsmaskiner i Norden och västra Europa och de har diverse samarbetspartners i bland annat Tyskland, Nederländerna, Belgien, Frankrike, Sverige och Norge. En del av produktionen är för tillfället redan outsourcad men största delen av Finndents produkter produceras i företagets produktionsutrymmen i Helsingfors. Innan arbetsinstruktionerna skrevs, måste företaget lita på att personalen kunde processerna utantill. Målet med arbetet är att få arbetsinstruktioner för produktion av underenheter till tandvårdsmaskinen FD-8000, att erhålla relevanta anteckningar om säkerhet och kvalitet samt att skriva en guide som kan användas för att skriva samstämmig dokumentation i framtiden. Tandvårdsmaskinen FD-8000 består i grund och botten av följande komponenter: instrumentbrygga, parallellogramarm, ram, transformator, sugsystem, patientstol, lampa och övriga elektroniska och mekaniska komponenter. Alla dessa hör till helheter som bör outsourcas. För dokumentationen använder företaget Arter IMS mjukvara, detta program är designat för kvalitetshantering samt integrerad förvaltning inom företag. I och med detta är den bättre tillämpad för företagsbruk än någon annan molntjänst. IMS gör det lätt att göra versionskontroll, vilket är viktigt då man gör arbetsinstruktioner. Arbetsinstruktionerna bör vara så lätta att förstå att en nybörjare klarar av att bygga en underenhet utan andra hjälpmedel. Därför bör det finnas mycket bilder och illustrationer som kompletterar texten, monteraren borde inte behöva granska texten mera efter några monteringar. Instruktionerna skrivs på både finska och engelska. Metoden som använts för att skriva dokumentation inför outsourcing är följande: forskning, anteckningar och bilder, första utkastet, diskussion med kvalitetsingenjörer, bifogandet av kvalitets- och säkerhetsanteckningar, efter detta borde dokumentet vara klart. Instruktionerna var sist och slutligen skrivna som planerat men vissa bristfälligheter upptäcktes ändå. I FD-8000 maskinen finns vissa underenheter som helt enkelt är för stora och komplexa för att kunna dokumenteras effektivt. En bild av alla komponenter, som hör till monteringen, bör vara inkluderad men detta var inte

alltid möjligt på grund av brist på utrymme. Sådana problem kunde iakttas i forskning och utvecklingen av produkterna. En annan motgång i dokumenteringen var implementeringen av mekaniska-, elektroniska-, pneumatiska- och hydrauliska komponenter i underenheterna. Då det kan verka lätt att skriva hur en mekanisk hopsättning görs, är det mycket svårare då andra rörliga delar inkluderas. Ett exempel på ett sådant problem kan vara att bestämma längden på en slang eller kabel, det kan spela en stor roll då de kan vara flexibla och toleranserna kan vara ner till en millimeter. Det viktigaste resultatet är dock inte ännu klart förrän företaget börjar lägga ut underenheterna, dvs. ifall instruktionerna kan användas i utläggning av produktion. Det kan dock konstateras att instruktionerna har hjälpt till i produktionen och kan förbättras enligt behov. Själva arbetet kan användas som en mall för att skapa instruktioner för att lägga ut produktion.

1 INTRODUCTION

1.1 Background

The first stages of outsourcing as a business strategy were in 1989. (SCRC SME, 2006) Companies outsourced services essential for their businesses which they did not have the competency or internal resources required. In the 1990s however, companies started to outsource services in order to save costs in a lot of areas. At this time, many were outsourcing services that were necessary for the companies but not related to the core business. Some typical examples of these types of services are accounting, HR, data processing and security. (SCRC SME, 2006)

Two of the biggest influences on outsourcing are globalization and the development of information technology. The world economy has unified and competition between companies have grown worldwide. (Virtanen, 2016)

1.1.1 Company

Finndent Oy has over 30 years of experience in developing and manufacturing dental units for clinics in western Europe and Nordic countries. The company has several distribution partners in Europe including Germany, Netherlands, Belgium, France, Sweden and Norway. The headquarters, where the manufacturing and testing is made at the moment is located in Helsinki, Finland. (Finndent FD-8000, Brochure) A typical FD-8000 dental floor mounted unit is shown in Figure 1.

When starting the documentation process there were some instructions made over the course of the company's history. This documentation was not up to date and did not include most of the sub-assemblies used nowadays. Most of the assemblies for the dental unit are made at Finndent's facilities but some are already outsourced. However, documentation on these products is non-existent. A dental unit refers to a machine that dentists

use for their practices, i.e., the instruments etc. A list of these components can be found in chapter 3.2.

Since there was a lack of documentation for the dental units, the company had to rely on production personnel to know all processes i.e., assembling, testing and packing by heart. The company saw an issue in this and thus started to make changes in the entire process for the company to not have to rely on specific personnel to know how to manufacture the products.

The author of this thesis has been working in the production facilities at Finndent since early 2017 and later moved on to making working instructions for processes in production. This was a natural step for an engineering student to take in the company in order to learn skills that are relevant to the field.

Figure 1 FD-8000 Dental Unit (finndent.com)

1.2 Aim

The aim of this thesis is to research the making of documentation i.e., working instructions for outsourcing of sub-assemblies used in the FD-8000 dental unit. The company's product line is focused on dental units which are usually comprised of the following

components: a chair, instrument arm and bridge, cuspidor, suction and a dental light. Sub-assemblies are a part of these components. The purpose of outsourcing for the company is to lower costs in manufacturing sub-assemblies by reducing labor costs and freeing up space in the facilities. (Twin, 2020) Documentation will be made from scratch using Microsoft Word with the help of production personnel and other engineers at the company.

Finndent does currently have some operations outsourced. However, these operations will not be included in this thesis since the objective is to write documentation from scratch.

1.3 Problem Statement

Finndent does not have adequate documentation of the FD-8000 dental unit for its outsourcing requirements. Additionally, there are no clear guidelines in how this documentation is made.

1.4 Objectives

Main objectives of this thesis are:

- Writing working instructions for outsourcing the production process of the FD-8000 dental unit
- Making relevant quality and safety notes for the instructions
- Writing a guide for documentation of working instructions to help the company outsource successfully

2 THEORY

2.1 Outsourcing

“Outsourcing is the business practice of hiring a party outside a company to perform services and create goods that traditionally were performed in-house by the company's own employees and staff.” (Twin, 2020) The benefits of outsourcing especially in a small company such as Finndent Oy will be lowered personnel costs and freeing up production space. (NMA OUTSOURCING, 2004) Another reason for outsourcing is for companies to not have to specialize in everything but to concentrate their work on what the company produces. It is desirable that companies focus on their own field and core-businesses. There are many service providers that are specialized in various functions that can produce these services better, faster and cheaper. With technological advances in the last 30 years, communication around the world is fast and easy. This in turn makes outsourcing relationships easy to find and handle even if the service provider is far away. (Virtanen, 2016)

Figure 2 Six basic steps to outsourcing (Outsourcing Management, 2011)

Companies that understand the outsourcing process tend to be most successful at it. Therefore, there should be a basic template to help manage the process. An example on a plan on how to approach an outsourcing project can be seen in Figure 2.

Before the outsourcing contract is made, the company must objectively evaluate critical factors such as company structure, processes, management style and the employees' ability to adapt to new innovation. It is easier to get an overview of outsourcing possibilities by mapping the company this way. It is also important to sort out which processes have a priority for outsourcing. (Salonen, 2015) The commissioning company and the vendor should discuss each party's business needs, different outsourcing solutions and the design and R&D process for the companies to have a productive relationship. It is important that both parties communicate during their outsourcing relationship. There should be an agreement of governance for this type of relationship. Key elements of governance are monitoring, communication (in case of changes in R&D), quality assurance, documentation and agreement modification. Governance of the production will obviously be done by the commissioning party. The department or employee in charge of this is recommended to be well educated in the process and is able to understand the client-vendor relationship of the two companies. (Brown, 2005)

There are generally two ways of pricing in outsourcing contracts. Fixed-price billing will put the responsibility of variability in production on the vendor while limiting flexibility for the commissioning party. Variable-price billing on one hand gives the commissioning party more flexibility for changes in the products, deadlines and quality but on the other hand they have to account for extra costs. (Brown, 2005)

There are several aspects of manufacturing to discuss with the provider. These matters will be agreed upon in an SLA between the provider and client. One of these is the documentation for the different sub-assemblies. This documentation is necessary for the client in order to receive sub-assemblies as instructed so that the quality of the product will meet the expectations of the company. Therefore, the documentation must include working instructions with quality and safety notes which will be detailed enough for a worker, who is not familiar with the product, to assemble correctly. (Brown, 2005)

A worthwhile consideration for an outsourcing project in this size would be to decide if the outsourced assemblies will be provided by one company or several specialized companies. To make outsourcing contracts with a lot of different specialized vendors may be a good solution for big corporations since they have a lot of resources to use in the process. This type of approach will most likely reduce errors in manufacturing and the overall quality of the products. For smaller companies, a more profitable solution would be to make an agreement with only one or a few vendors. The reason for this is that it will reduce the amount of work for the commissioning party in management. This also depends on what type of products or services are needed. (Brown, 2005) Since Finndent is looking to outsource physical sub-assemblies, it makes sense to choose vendors in Finland in order to lower shipping costs and delivery times. (Koskelainen, 2006)

2.1.1 Risks

Despite outsourcing being a productive tool to make processes more efficient, there are some risks that must be accounted for. Since outsourcing as a practice in business management is fairly new, long term overall costs are hard to define or calculate. Companies tend to exaggerate advantages and vendors tend to produce better results in the beginning of the outsourcing relationship to make a better first impression. This can then lead to a poor outsourcing venture. (Salonen, 2015)

2.2 Working Instructions

Instructions are key for any manufacturing process to be successful in the long run. These instructions should also be kept up to date and followed exactly, this is only possible when they are precise and clear to the assembler. Especially in outsourcing, working instructions are essential for the products to be of the highest quality possible. (Baudin, 2020)

Working instructions can be written in many ways but the most important aspect is that it contains a lot of pictures, illustrations or drawings. Photos that are taken during assembly should be of good quality, show every step, and only include relevant information.

This can be achieved by cropping the photos accordingly or highlighting relevant parts of the photograph. The text should contain only relevant information for the assembler to understand the next step. When making working instructions it is good practice to think of the assembler as someone who does not have any knowledge of the product (which they probably do not have anyway). (Baudin, 2020)

Considering the instructions must be well written and well thought through, it can be hard to find someone with enough knowledge about the process and documentation proficiency to make the instructions. Production personnel might not be willing or have enough proficiency to write instructions and engineers might have trouble expressing themselves in simple enough terms for assemblers to understand. This task is therefore more suitable for someone who has worked in production and later progressed to more engineering related assignments. (Baudin, 2020)

A good instruction is one that is clear and straight forward, leaving something up to interpretation risks the quality of the entire process and the company. They should be written in simple language and with brief paragraphs as not to confuse or lose the interest of the worker. Anyone in the company should be able to follow the instructions and make a functioning product, this can be achieved by testing the documentation. Asking someone who is not familiar with the assembly process to follow the instructions and taking notes of the progress is a good method or testing. It is important not to help or give any advice, only letting the instructions do its job. If there is something missing or to revise, it will become apparent from the notes. (GLUU GUIDES, 2020)

3 METHOD

This chapter contains information on all aspects of the working instructions. Most importantly the template and how pictures and illustrations are implemented in manner that is easy to understand. However, language use, version control, tools, BOM:s, quality and safety play a big role in making a successful working instruction for outsourcing.

A brief summary of Finndent products and sub-assemblies is presented, after which the different parts of the instructions are presented in the same sequence as they appear in the documents.

3.1 Products

The FD-8000 product line includes a lot of different solutions. When purchasing a product for a dental clinic, the customer can freely choose from a multitude of solutions that fit the needs of the dentists using the unit. This way Finndent is trying to compete with bigger competitors in the industry. Different types of units and their respective solutions can be seen in the bulletins below. (Finndent Designer)

- **Floor unit (FD-8000B1/B2/B1+)**
    - Instrument bridge
    - Location of suction arm
    - Cuspidor
    - Patient Chair
    - Dental light
    - Monitor
- **Ceiling unit (FD-8000P1/P1+/P2/P2+)**
    - Instrument bridge
    - Horizontal arm length
    - Location of suction arm
    - Cuspidor
    - Patient Chair

    - Dental light
    - Monitor
- **Cart unit (FD-8000D2)**
    - Location of suction arm
    - Cuspidor
    - Patient chair
    - Dental light
    - Monitor
- **Color of unit and upholstery**

3.2 Sub-assemblies

The word subassembly is defined as "an assembled unit designed to be incorporated with other units in a finished product" (meriamwebster.com, 2021). As mentioned, all Finndent units have a set of sub-assemblies that are all equally important to the production process. The unit is divided into sub-assemblies to make assembly of the finished product easier for multiple assemblers to work on. These are the sub-assemblies that will be documented for outsourcing.

FD-8000 sub-assemblies include:

- Instrument bridge, hoses and tray
- Instrument/parallelogram arm
- Frame
- Transformer
- Cuspidor
- Suction system
- Patient chair
- Dental light
- Foot control
- Other mechanical and electronical components

3.3 Working instructions

The company files its working instructions and other documents in Arter ® IMS software. It is a cloud software designed for quality management and integrated management in companies. (Arter, 2020) This software has been found helpful in managing all kinds of documents in an intuitive manner. Compared to an ordinary cloud service or file sharing, IMS makes it easier to follow up on version control and it lets the user know everyone who has updated specific documents.

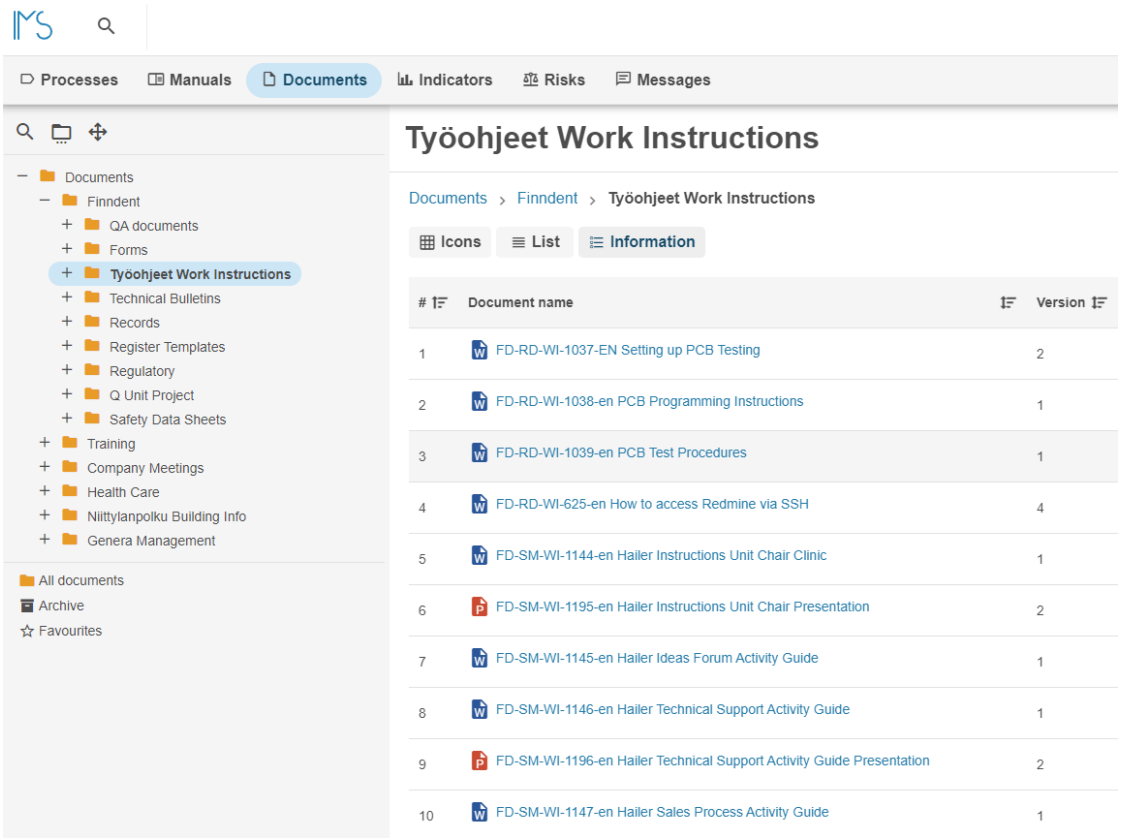


Figure 3 IMS-Software (Arter, 2020)

3.3.1 Template

As previously mentioned, for the instructions to be clear enough for a beginner to understand, there should be a lot of pictures, drawings and illustrations as opposed to a lot of text. (Baudin, 2020) Therefore, the author has implemented a template for the instructions that follow this principle. It is assumed that the instructions are made in Microsoft Word since most workers are familiar with it.

The first page or cover page (Figure 4) consists of the company logo, name and number/code for the instruction and version control (more on version control in chapter 3.1.3). The number/code (example: FD-PD-WI-1962-EN-FI), i.e., the four-digit code in the title, is generated by the IMS-software when uploading the document. See “Abbreviations and terminology” for the abbreviations in the example.

A table of contents is generated on the next page. This includes some of the bigger steps in the assembly. These are not necessarily important for an assembly that is done completely from start to finish. Instead, this can be helpful for R&D personnel to find specific steps in the assembly if there is something to be improved, especially in larger sub-assemblies. An abbreviations list is also added below contents.

The bill of materials (BOM) is inserted on the next page/pages. It is also good practice to include a picture with all materials/components used in the assembly. More on this in chapter 3.1.6. The first step in assembly is inserted next. The following pages should only be working instructions, this allows the assembler to work uninterrupted through the entire assembly process.

FINNDENT

FD-PD-WI-1962-EN-FI J-Pipe to Chair Assembly Imuvarsi Tuoliin
J-Putki Koottu 9805520

Ver.	Author	Reviewer	Approved	Date	Notes
1	Jonatan Lehtinen	Referring to IMS	Referring to IMS	9.5.2018	Created document
Referring to IMS	Jonatan Lehtinen	Referring to IMS	Referring to IMS	16.5.2018	Corrected errors made in first draft
Referring to IMS	Jonatan Lehtinen	Referring to IMS	Referring to IMS	24.8.2018	Corrected mistake regarding 6809680
IMS	Jonatan Lehtinen	IMS	IMS	3.3.2020	Updated to use of cable ties for hoses

Figure 4 Cover page (Lehtinen, 2020)

3.3.2 Pictures and Illustrations

Baudin suggests that instructions for toys can be a source of inspiration when writing working instructions. Step 19 and 20 of a 38-step assembly is covered in this example (Figure 4). This demonstrates the importance of visual aids in working instructions since it is meant for children around the age of 8. Using these types of instructions, a child can build a very complex toy without the use of text or prior training. (Baudin, 2020)

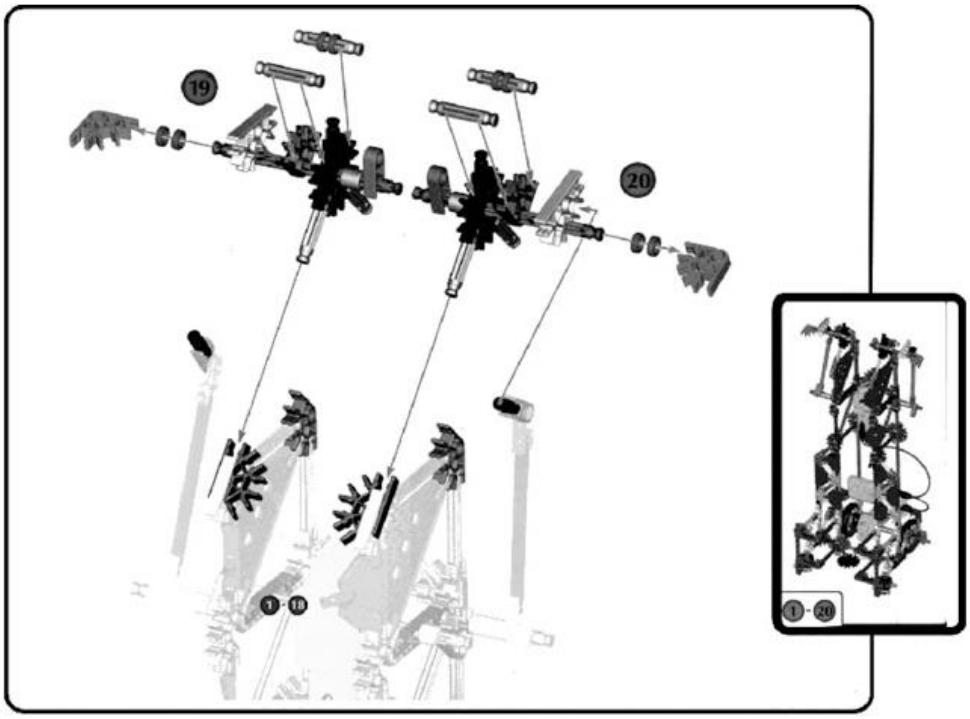


Figure 5 Toy assembly without text (Baudin, 2020)

Working instructions for Finndent sub-assemblies are thus made using the same kind of principle. Since an exploded view, as seen in Figure 5, requires a lot of knowledge in some kind of a CAD-software and a lot of work, they are therefore not used in the instructions. An example of using pictures as the main source of information can be seen in Figure 6 and Figure 7. Every step in the assembly, big or small, can also be seen documented here. Every step of the instruction is relevant and important even if it seems redundant to document.

2 Procedure

2.1 Arm

Aseta muovilaakeri 6809680 imuvarren kiinnikkeen 9805055 kierteiden ympärille. **Place plastic bearing 6809680 around the threads of the suction arm bracket 9805055.**

Figure 6 Demonstration in the use of pictures as the main source for information (Lehtinen, 2020)

Aseta kuula 6000015 loveen jossa vaseliinia. **Place ball 6000015 into the dent with vaseline.**

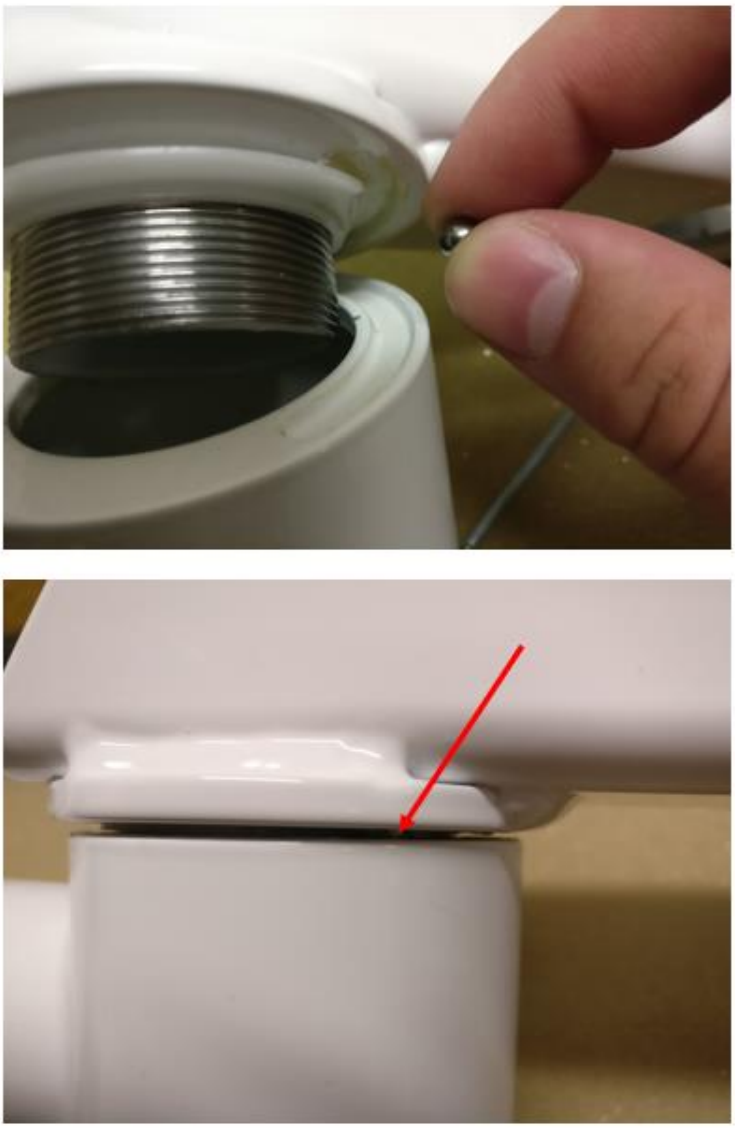


Figure 7 Demonstration in the use of pictures as the main source for information (Lehtinen, 2020)

3.3.3 Version control and labeling

Before IMS was used for version control, it was important to have a table on the first page to let others know what has been updated, who made the update and when. These changes need to be approved by quality engineers and then published. Quality engineers are in charge of all documentation in the company. They could make instructions, but they do not necessarily have the time or technical knowledge.

The following table is still used in documents that were first written before the implementation of the IMS-Software. Version numbering is important for referencing of the document in question, the numbering can be for example 1, 2, 3… or 1.1, 1.2, 1.3… as long as it is clear. The author is the name of the person who has made the instructions or updates. The author cannot be the same person as the reviewer, but the reviewer is usually the one who approves the document. Changes made or the creation of document is written in the "notes" column. It is important to write down changes for the reviewer to find the changes and approve the document efficiently. A similar table is also good to use in the footer, it gives the reader useful information without having to search through the document. An example of a footer in Table 2. It is also useful to insert a header including the company logo and name of document. An example of this in Table 3.

Table 1 Version control

Ver.	Author	Reviewer	Approved	Date	Notes

Table 2 Footer

Status: draft/published	Page 21 of 35	IMS Doc #: DOC-1948-en-fi
Publish date:		Version: Use IMS for most current version
Author:		Replaces:
Finndent Oy Niittylänpolku 16, 00620 Helsinki		

Table 3 Header

FINNDENT	FD-PD-WI-1830-EN-FI Changeable Instruments Instructions

3.3.4 Language use

All documentation at Finndent must be available in English since it is a company with international partners and personnel. It is also desirable that all working instructions are available in Finnish as well. The instructions are written in the simplest way possible to make it easy to understand even if it is not the reader's native language. If instructions are needed in another language than the provided English and Finnish, it should not be difficult to translate.

Since it is preferred, that instructions are written in both English and Finnish, it is important to separate the two languages. This is done by first writing normally in Finnish and then translating it to English right after using a bold font.

Example: Kiinnitä imutelineen pelti stoppariin 6420150 kahdella M3X6 ruuvilla 5000408. **Fasten the plate to a stopper 6420150 with two M3X6 screws 5000408.**

It is important to note that all of this is done by engineers and not linguists and naturally some things are difficult to translate. This is an important reason to always use the 7-digit code given to each product and material.

3.3.5 Introducing responsibilities and scope

Usually, the scope and responsibilities are stated in the introduction. This part does not have to be very long since the document type is very straight forward. But as mentioned in chapter 3.1.3, quality engineers are responsible for the instructions even if they do not write them. There must be a section that clarifies who is responsible for possible errors in documentation.

3.3.6 Bill of Materials

When making the bill of materials, it is good practice to review and assemble the whole sub-assembly and writing down technical data for every product used. This has been found through trial and error while documenting. The BOM must include at least: name of the product, dimensions (if applicable), product specification (if applicable) quantity and company specific code.

Ideally, as seen in Figure 8, an engineering drawing can be attached with the BOM. This drawing is made using PTC Creo, as this is the company's standard modelling software. A picture of the products with balloons can also be used if an engineering drawing is not accessible as seen in Figure 9. The structure of the BOM is depicted in Table 4.

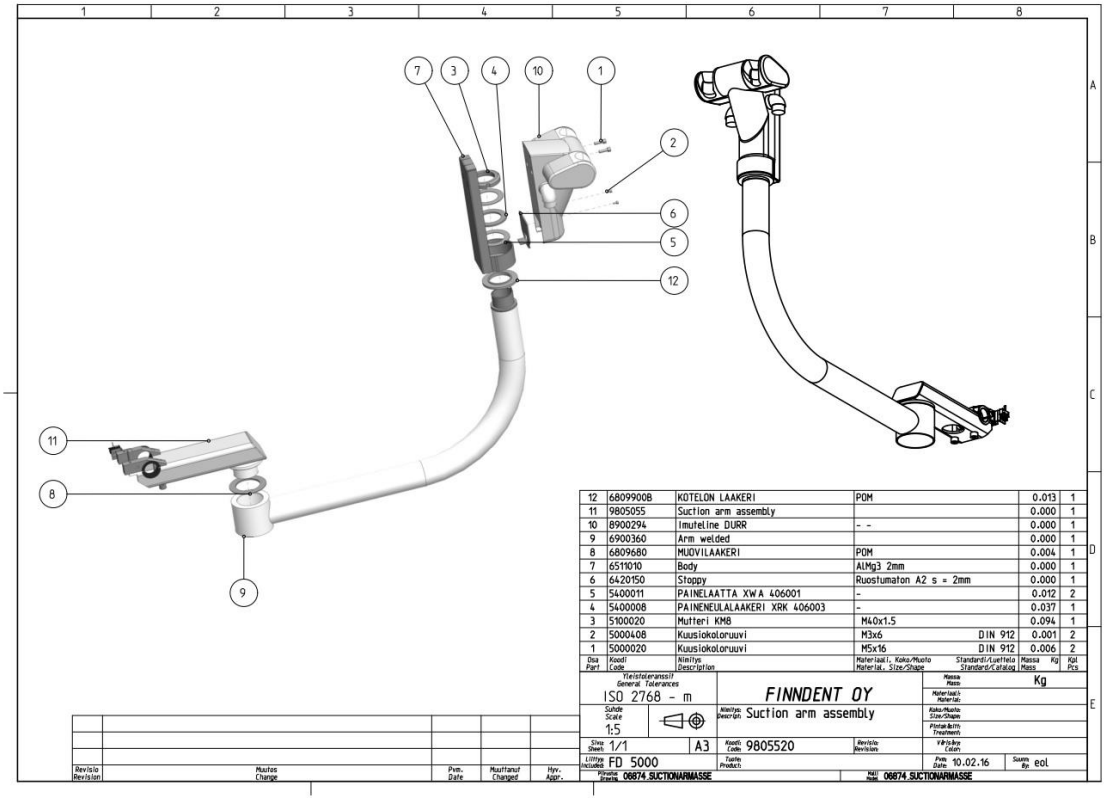


Figure 8 Engineering drawing with balloons and captions (Lehtinen, 2020)

Table 4 BOM Structure

No.	CODE	ITEM	Qty
1	6511075	PIIRILEVYTELINE	1
2	6511080	IMUPESUKOTELO. KAAPPIIN	1
3	6511085	IMUPESUKOTELO. KANSI	1
4	6806860	HUUHTELUNIPPA ISO	1
5	6806865	HUUHTELUNIPPA PIENI	1
6	8900397	PERISTALIC PUMP SR 10/30. GARDNER DENVER-THOMAS	1
7	8900285	HUUHTELUYKSIKKÖ DÜRR 7100-250-50	1
8	6802015	IMUKORKKI ANIOS PULLOLLE	1
9	5000014	KUUSIOKOLORUUVI 912/8.8ZN M4*10	2
10	5100004	KUUSIOKOLOMUTTERI M4 SIN 934	4
11	3800397	KOROTUSHOLKKI	1
12	5500216	TIIVISTERENGAS	2
13	6310620	LETKUNIPPA 3 mm LETKULLE	3
14	6309055	YHDYSNIPPA 3 mm LETKULLE	2
15	4802930	Q930	1
16	3800375	KAAPELIKENKÄ	1
17	5200014	TÄHTIALUSLEVY M8	1
18	5001071	KUUSIOKOLORUUVI M8*10	1
19	5100014	KUUSIOKOLOMUTTERI M12*1,5 DIN 439	2
20	4801366	JOHTOSARJA	1
21	4200053	KORTINPIDIN	3

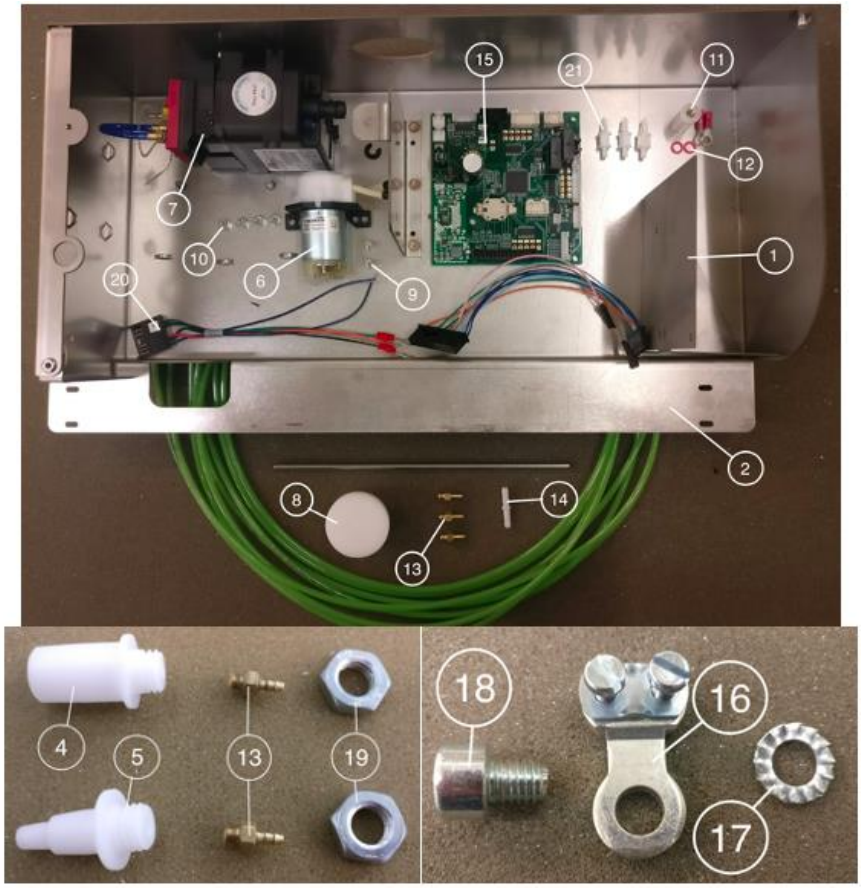


Figure 9 Flushing unit products with balloons (Lehtinen, 2018)

3.3.7 Tools

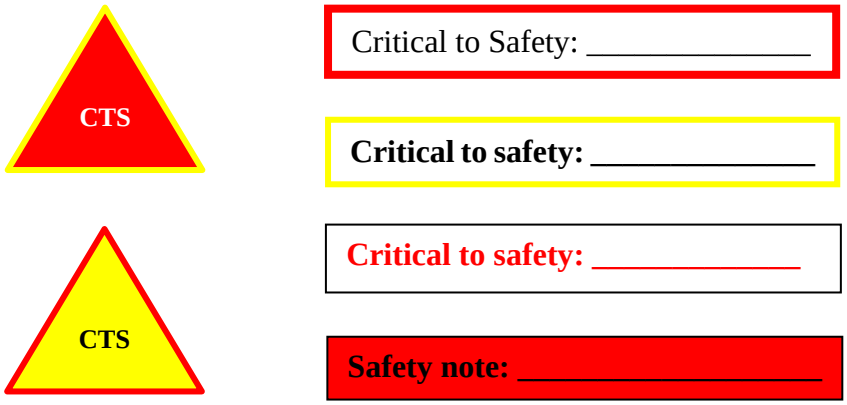
Tools used in the assembly is also relevant and should be laid out in the same manner as the bill of materials. Similarly, to the materials, relevant tools should be listed as accurately as possible. Most commonly used tools in Finndent production are for example: screwdrivers, electric handheld tools, wrenches and pliers. The proper tool and how to use it should always be mentioned when describing any action, the assembler should take. For example, what kind of pliers to use when crimping a connector to a wire. Figure 10 is an illustration on how to set up the tools for a picture attached in the instructions, the tools are not relevant to Finndent.

Figure 10 Example of tool placement for picture (copperpipe, 2021)

3.4 Safety Notes

Gluu Guides state that 9 out of 10 workplace accidents happen because of human error. This is why it is important to have safety notes in the instructions. These safety notes are important for the customer i.e., the dentist as well as for the assembler to avoid workplace accidents. Ideally, working instructions reduce the risk of workplace accidents

significantly. That is if they are done clearly, in a simple manner, and personnel follows them religiously. (GLUU GUIDES, 2020) Whoever is making safety notes in the document should be experienced enough with the assembly to know and understand the safety risks in order to document them. Sometimes the risks might be something only someone with a high level of experience in quality and risk management can detect, therefore it is good practice to have more than one person reviewing the documents. The notes should be eye-catching and brief, the reader has to understand the importance of a quality or safety note. Additionally, there cannot be too many notes on quality or safety. Safety notes can be added as a text box, some examples can be seen below.



3.5 Quality Notes

As with safety notes, the same principles apply to quality notes. These are notes that can be added by the author or a quality engineer, they should also be clear, noticeable to the reader and leave no room for interpretation. The easiest way to write quality notes is to consider the customer and think of the sub-assembly as a whole. When thinking about the customer, the easiest way is to consider a consumer product, like a new car, and think about what kind of faults would be acceptable to oneself. Since the author knows the sub-assembly and the product, it should be easy to determine what to take to account when writing quality notes. For example, checking if a micro switch engages properly, checking the paint job, making sure wires and hoses are secure and not rubbing against anything or making sure all moving mechanical parts move as they are supposed to. The text boxes can be similar to the safety notes, but a different color should be used.

4 RESULTS AND DISCUSSION

For the most part, the instructions were written as described in chapter 3. A system with sub-assemblies facilitating mechanical, electrical, and wet systems has a lot of difficulties regarding the instructions. Some applications in the assembly process require a certain level of skill to execute in accordance with quality standards. It is of course easy to instruct anyone to drill a hole or to insert a specific screw in its place. However, a problem in instructing assembly-line workers arises when something cannot be accurately specified. Some examples are installation of hoses or wiring, when the length of these components depend on the specific space of the individual assembly. An example of this type of issue is depicted in Appendix 1 (appendix is not the original document, it is modified and condensed). In this type of sub-assembly, it becomes apparent that the assembly of changeable instruments require some prior knowledge of the procedure. In this example, if the wires and hoses are pulled too tight or left too loose, the silicone insulation will deform. There is also very little room for error when making the connector since the crimps break very easily and there is not a lot of space for the wiring.

The photo description of the BOM and tools in the assembly was not always feasible to implicate due to the size of some sub-assemblies, limited space in the production facilities and time limitations. This might affect the productivity if the assembler is not familiar with the materials or tools.

The issues mentioned could potentially be resolved by making changes in the product through R&D, organizing the production facilities differently or by modifying the sub-assemblies to smaller entities. Every assembly is different and requires individual specifications depending on the circumstances. Regarding the outsourcing, it is still unknown if the working instructions are feasible for outsourcing on their own. It is believed that these instructions are at least a good starting point to making sufficient instructions. The main steps of the documentation process are shown in Figure 11. This is the process used for this thesis, the effectiveness of this type of model depends greatly on the knowledge and motivation of the staff responsible for the documentation. Some of the company staff know the assembly processes by heart and from past experiences, it can be very hard to study the processes if none of these are willing to or have the motivation to help.

This thesis can serve as a sufficient template in writing working instructions for the FD-8000 dental unit. It can help engineers in the future to maintain a consistent template for instructions and other documentation.

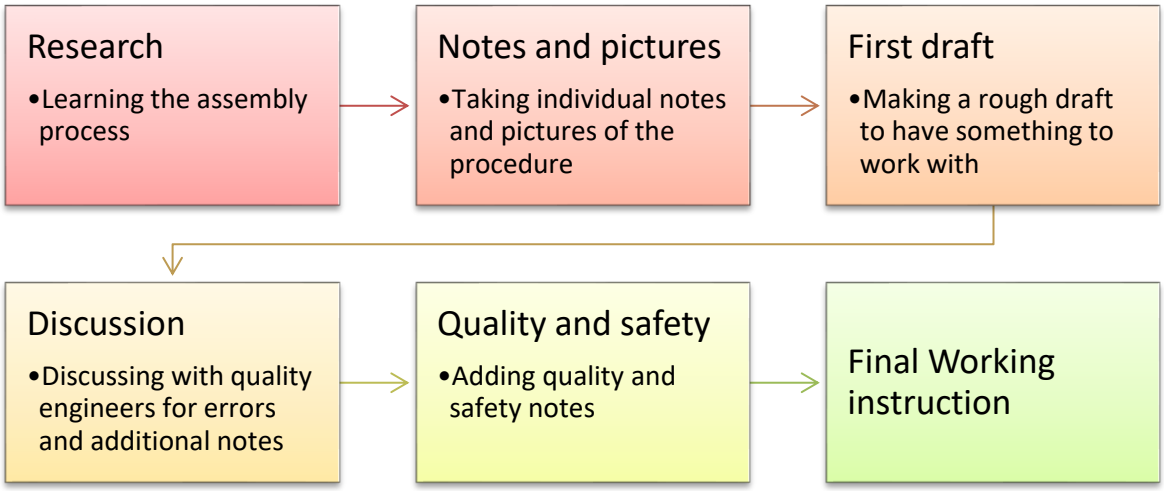


Figure 11 Graph of the steps to writing working instructions.

The documentation is done in close accordance with the literature researched for this thesis. A significant reference to this work is *Lean Assembly – The Nuts and Bolts of Making Assembly Operations Flow* by Michael Baudin. He discusses about lean assembly and combining the working instructions to the assembly line in an efficient manner. Many ideas for the working instructions were taken from this literature, although not the lean assembly aspect of it. This can also be a good resource for R&D and production planning, but it is not directly the topic of this thesis.

5 CONCLUSION

Documentation of Finndent dental unit production process for outsourcing was studied in this thesis. The company will benefit from the outsourcing of as much of the production process as possible since it will save costs in labor, facilities, and materials. Some of Finndent's sub-assemblies are outsourced but the documentation needs to be updated. Particularly the focus of this research, the working instructions for assembly. The objective was to effectively write working instructions for the outsourcing of sub-assemblies in the FD-8000 dental unit. Despite some guidelines in writing documentation for outsourcing is set, the outcome depends on the specific project and the results are not known before the implementation of outsourcing. Documentation was done in accordance with the literature used for this report, although not perfect, an acceptable start in the right direction.

When comparing to other documentation about writing working instructions, few have assemblies that are as complex as the FD-8000 which also include mechanical-, electrical- and wet systems. This thesis is specifically designed to suit instructions for dental units and therefore, the company can have use for it in future outsourcing endeavors. With the help of this report, it is easier for documentation engineers to have a uniform template for working instructions. All Finndent requirements for documentation are included in this thesis.

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FIGURES

Figure 1 Six basic steps to outsourcing.
Outsourcing management, 2011, Q/P Management group, INC. Available from: http://64.130.210.157/outsourcing_management.html [28.12.2020]

Figure 2 FD-8000 Dental Unit
Finndent website, available from: https://finndent.com/dental-solutions/ [28.12.2020]

Figure 3 IMS-Software
Arter, IMS-Software, available from: https://www.arter.fi/en/software/ims-software/ [8.1.2021]

Figure 4 Cover page
Lehtinen, J, 2018, FD-PD-WI-1962-EN-FI J-Pipe to chair Assembly Imuvarsi Tuoliin J-Putki Koottu 9805520. Finndent Oy [12.4.2021]

Figure 5 Toy assembly without text
Baudin, M, 2020, *Lean Assembly – The Nuts and Bolts of Making Assembly Operations Flow*, Taylor and Francis. Available from: Perlego eReader. [21.2.2021]

Figure 6 Demonstration in the use of pictures as the main source for information
Lehtinen, J, 2020, FD-PD-WI-1962-EN-FI J-Pipe to chair Assembly Imuvarsi Tuoliin J-Putki Koottu 9805520. Finndent Oy [12.4.2021]

Figure 7 Demonstration in the use of pictures as the main source for information
Lehtinen, J, 2020, FD-PD-WI-1962-EN-FI J-Pipe to chair Assembly Imuvarsi Tuoliin J-Putki Koottu 9805520. Finndent Oy [12.4.2021]

Figure 8 Engineering drawing with balloons and captions
Lehtinen, J, 2020, FD-PD-WI-1962-EN-FI J-Pipe to chair Assembly Imuvarsi Tuoliin J-Putki Koottu 9805520. Finndent Oy [12.4.2021]

Figure 9 Flushing unit products with balloons

Lehtinen, J, 2018, *Imupesujärjestelmä 9805525 FD-PD-WI-1676-FI-EN*. Finndent Oy [26.2.2021]

Figure 10 Example of tool placement for picture

Copperpipe, 2021, Tools Laid out, Motion Array. Available from: https://motionarray.com/stock-photos/tools-laid-out-745585 [28.2.2021]

Figure 11 Graph of the steps to writing working instructions.