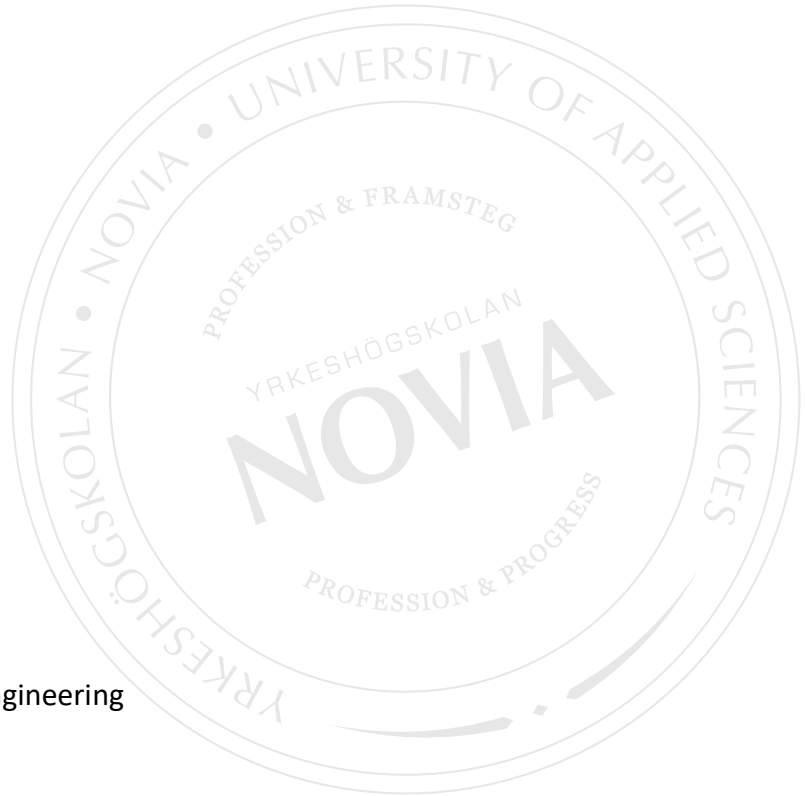
NOVIA
UNIVERSITY OF APPLIED SCIENCES

Wärtsilä Swing Set Management

Improved Way of Working

Richard Klemets



Bachelor's Thesis

Mechanical and Production Engineering

Vasa 2021

BACHELOR'S THESIS

Author:	Richard Klemets
Degree Programme and place of study:	Mechanical and Production Engineering
Specialization:	Operation and Maintenance Technology
Supervisor(s):	Christian Hällund, Wärtsilä Kaj Rintanen, Novia UAS

Title:	Wärtsilä Swing Set Management Improved Way of Working

Date: 18.9.2020 Number of pages: 43 Appendices: 1

Abstract

This bachelor's thesis was made for Wärtsilä Finland Oy, Marine Power, Performance Services, Maintenance management, Maintenance planning 4S.

The purpose was to improve the Way of Working in the management of Swing Sets, a selection of exchange parts. The current working method is cumbersome and time-consuming since the information is scattered in different places and hard to find, also complicated to document. The thesis points out which part in the management needs to be improved.

The research method used to achieve the result of the thesis is qualitative. The material has been gathered through interviews and meetings with stakeholders, workshops and from internal documents. The theory is gathered from literature.

The result of the thesis presents a timesaving and a lot smoother Way of Working that is also cost-effective.

The result of the thesis is partly confidential and will not be presented to the general public.

Language: English
Key Words: Swing Set, Exchange Parts, Management, Maintenance, Way of Working

EXAMENSARBETE

Författare:	Richard Klemets
Utbildning och ort:	Maskin- och produktionsteknik, Vasa
Inriktning:	Drifts- och underhållsteknik
Handledare:	Christian Hällund, Wärtsilä
	Kaj Rintanen, Novia UAS

Titel: Hantering av Swing Set – Förbättrat arbetssätt

Datum: 18.9.2020 Sidantal: 43 Bilagor: 1

Abstrakt

Detta examensarbete har gjorts på uppdrag av Wärtsilä Finland Oy, Marine Power, Performance Services, Maintenance Management, Maintenance Planning 4S.

Syftet med arbetet var att förbättra arbetssättet i hanteringen av Swing Sets, en typ av utbytesdelar. Det nuvarande arbetssättet är krångligt och tidskrävande eftersom informationen är spridd på olika platser och svår att hitta, dessutom komplicerad att dokumentera. Examensarbetet pekar ut vilken del i hanteringen som behöver förbättras.

Forskningsmetoden som har använts för att uppnå resultatet i examensarbetet är kvalitativ. Materialet har samlats in genom intervjuer och möten med intressenter, genom workshops och från interna dokument. Teorin har samlats från litteratur.

Resultatet presenterar ett tidsbesparande och mycket smidigare arbetssätt som också är kostnadseffektivt.

Resultatet av examensarbetet är delvis konfidentiellt och kommer inte att presenteras för allmänheten.

Språk: Engelska
Nyckelord: Swing Set, Utbytesdelar, Hantering, Underhåll, Arbetssätt

OPINNÄYTETYÖ

Tekijä:	Richard Klemets
Koulutus ja paikkakunta:	Kone- ja tuotantotekniikka, Vaasa
Suuntautumisvaihtoehto:	Käyttö- ja kunnossapitotekniikka
Ohjaaja(t):	Christian Hällund, Wärtsilä
	Kaj Rintanen, Novia UAS

Nimike: Swing Set hallinto – Parannettu työmenettely

Päivämäärä: 18.9.2020 Sivumäärä: 43 Liitteet: 1

Tiivistelmä

Tämä opinnäytetyö tehtiin Wärtsilä Finland Oy, Marine Power, Performance Services, Maintenance Management, Maintenance Planning 4S:lle.

Tavoitteena oli parantaa työskentelytapaa Swing Set vaihto-osien hallinnassa. Nykyinen työskentelytapa on työläs ja aikaa vievä koska tiedot ovat hajallaan eri paikoissa ja vaikeasti löydettävissä, myös hankala dokumentoida. Opinnäytetyö osoittaa mikä osa hallinnassa kaipaa parantamista.

Opinnäytetyön tuloksen saavuttamiseksi käytetty tutkimusmenetelmä on laadullinen. Aineisto on kerätty haastattelujen ja sidosryhmien tapaamisten, työpajojen ja sisäisten asiakirjojen avulla. Teoria on poimittu kirjallisuudesta.

Opinnäytetyön tuloksena on aikaa säästävä ja paljon sujuvampi tapa toimia, joka on myös kustannustehokas.

Opinnäytetyön tulos on osittain luottamuksellinen, eikä sitä esitetä yleisölle.

Kieli: Englanti
Avainsanat: Swing Set, Vaihto-Osia, Hallinta, Työskentelytapa, Kunnossapito

Table of Contents

Table of Figures

Table of Appendices

Abbreviations

Here follows terminology and central abbreviations used in the thesis:

Swing Set	A type of exchange parts
Maximo	IBM Maximo Asset Management System
Compass	Wärtsilä's intranet
FS Mobility App	Field Service Mobile Application
WoW	Way of Working
WAMS	Workshop Activity Management System
STH	Smart Technology Hub
TEAMS	Microsoft application
SWR	Service work report
DB2	Database 2 by IBM
SQL	Structured Query Language
WGLS	Wärtsilä Global Logistics Services
IRL	In Real Life

1 Introduction

This chapter will present the background and purpose of this thesis and give the reader an intro on the thesis. Further, background, delimitation, and disposition for the thesis will also be described.

1.1 Background

This thesis work was made for and in cooperation with Wärtsilä Finland Oy, Marine Power, Performance Services, Maintenance management, Maintenance planning 4S. The scope of the thesis was to improve WoW in the Swing Set Management, and to improve the tracking procedure of the Swing Sets. To get less downtime during engine overhauls and fewer risks, many customers are planning to invest in Swing Sets, so it is very important to get the Swing Set Management system to be faster, less time consuming and more reliable. Today one single contract can include over 5000 Swing Set spare parts and the amount is constantly increasing.

1.2 Purpose and Delimitation

The purpose of this thesis work was to improve WoW with swing sets by simplifying and to do the tracking procedure more reliable and through this reach better traceability. The scope was delimited to cylinder head swing set management for marine engines.

1.3 Wärtsilä

Wärtsilä, established in 1834 is a Finnish company and a global leader in smart technologies and complete lifecycle solutions for the marine and energy markets. The company has gained experience in a wide range of business areas and companies over the years. To constantly maximize the economical and environmental performance of vessels and power plants is the main reason for the company's success. In the year 2020, Wärtsilä had approximately 18.000 employees in more than 80 countries and 200 locations. In the same year the company had a net sale on total 4.6 billion euros. As of 2021, Wärtsilä is divided into two different areas, Marine and Energy. Wärtsilä is listed on Nasdaq Helsinki and since February 2021 Håkan Agnevall is the CEO and President of Wärtsilä Corporation. This thesis is made for Wärtsilä Marine.

Figure 1. Wärtsilä STH 2021 (Wärtsilä internal document)

1.4 Lasermark Oy

Lasermark is a Finnish company located in Vaasa, specializing in laser marking. They have been developing laser marking for almost thirty years. Their laser markings can be seen in energy, process, printing and in the pharmaceutical industry. They have also developed successful solutions for many global companies by combining laser capabilities with the customer needs, the latest application is tone coding of barcodes. (Lasermark, 2021)

1.5 Gambitgroup Oy

Gambitgroup is a Finnish company located in Vaasa, Varkaus and Pietarsaari that takes digitalization to the next level by developing websites, webshops, applications etc. They started in 2011 and have formed long-lasting partnerships with clients that shares same values as they do. Gambit has 50 employees and the 2020's turnover was 2,6 M€. Since 2011 they have had over 300 different projects.

1.6 Disposition

This thesis is built up in different chapters and the disposition is the following:

Chapter two presents the theory of the thesis.

Chapter three describes the method used for collecting the theory for the thesis and which sources that was used.

Chapter four presents the results of the thesis.

Chapter five gives a conclusion and suggestions for further work.

Chapter six, afterword.

2 Theory

This chapter will be about the theory that this empirical study was based on. It will introduce basic elements about marine diesel engines, cylinder heads and Swing Set management.

2.1 Diesel Engine

The diesel engine is named after its inventor Rudolf Diesel. It is an internal combustion engine and built with one or more cylinders. The combustion of air and diesel fuel forces the piston in each cylinder, attached to a connecting rod to do an up and down movement. The work of that action gets converted to a rotational movement of the crankshaft. These engines are designed as either two or four-stroke cycles. (Wikipedia, 2021)

2.1.1 Cylinder Head

The cylinder head in an internal combustion engine is mounted above the cylinders, on top of the engine block. The cylinder head closes the top of the cylinder and forms the combustion chamber. Between the cylinder and the cylinder head a head gasket is mounted which seals the joint. Most engines have passages, that feed air and fuel in the cylinder head, also passages for exhaust gases to escape. In many engines the valves and fuel injectors are located in the cylinder head as well. (Wikipedia, 2020)

Figure 2. Cylinder heads removed for overhaul (Wärtsilä internal SWR)

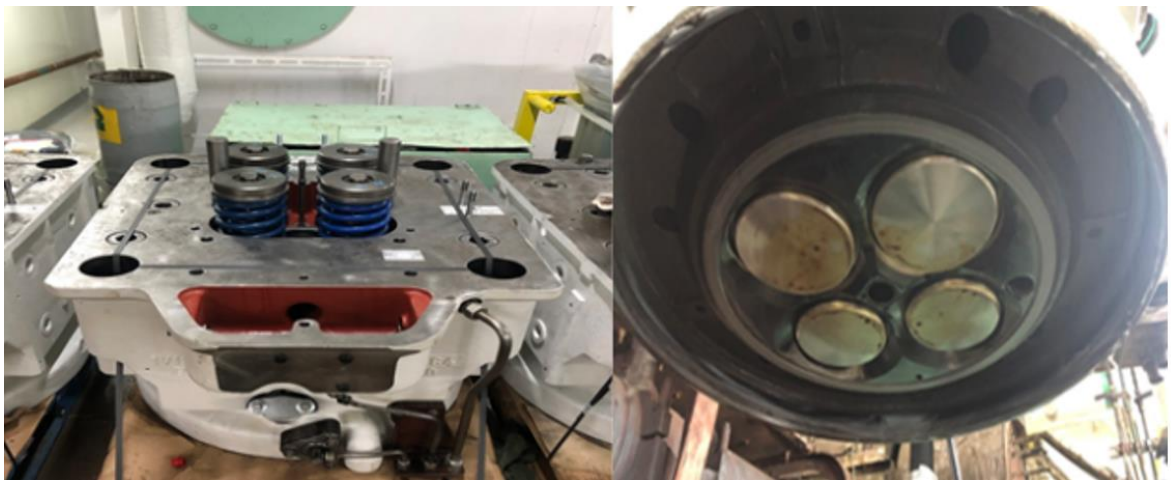


Figure 3. Overhauled cylinder heads ready for installation (Wärtsilä internal SWR)

2.2 Wärtsilä Exchange Parts

Exchange parts are reusable spare parts that are remanufactured or reconditioned, which supports the product strategy by offering high technology spare parts in an environmentally friendly way. Exchange parts enhance high engine uptime and reduces overhaul times by having ready overhauled parts available when the time for maintenance takes place. Exchange parts are stocked and managed by Wärtsilä Global Logistics Services. Parts replaced with an exchange part will be returned to WGLS for possible reconditioning or remanufacturing, depending on the condition of the part and after that available as an exchange part in the stock again. Typical exchange parts are cylinder heads, injection pumps, injection valves, cooler inserts, governors, and different kinds of pumps. (Wärtsilä internal document, 2021)

2.2.1 Swing Sets

Swing Sets is a selection of an exchange parts package including Field Service work, workshop services and full scope of required spare parts for the maintenance task, enabling fast equipment maintenance with a high level of predictability. The field service work is done either by the customer or Wärtsilä. Swing sets are owned by the customer and managed by Wärtsilä. These swing sets are tracked and traced in Maximo by Swing set managers and Swing set Maintenance planners. (Wärtsilä internal document, 2021)

2.3 Swing Set Management

Swing Set management and tracking of Swing Sets is a reoccurring challenge. Wärtsilä can provide tracking of these assets, and especially if they are moved from an installation with different classifications societies it is a must to have a tracking system.

The Swing Set Management ensures traceability of the customer's assets in an organised manner. The Swing Sets are traced in Maximo, this gives the customer a complete overview of the status of their swing Sets. This leads to fast and on-time overhauls. With traceability systems the Classification Societies accept mixing of assets from different Classification Societies. A dedicated Swing Set planner or Maintenance Planner keeps track of the assets through the Swing Set Application in Maximo and the workshop personnel update their part in the same application in Maximo, this results in fast overhauls on time, tracking of running hours of the assets, oversize etc of the components.

Benefits of Swing Sets and Swing Set Management

- Traceability and less risk of extended downtime
- Better quality of the spare parts when the reconditioning is done in a workshop and not just repaired on the vessel.
- Shorter overhaul duration, less downtime
- Swing Sets ready for overhauls on time
- Workshops also have the Swing Set application, so they have the ability to manage Swing Sets and have an overview of incoming work and deadlines
- Possibility to estimate lifetime of components
- In according with demands from Classification Societies to have traceability in case assets with different Classification Societies are mixed

Requirements

- IBM Maximo Asset Management System
- A service agreement with Wärtsilä
- Easy to add installations and assets to the tracking system
- User access
- A dedicated planner for Swing Set tracking can be needed if many Assets needs to be tracked

Below you can see the whole chain of actions in the Swing Set follow-up procedure.

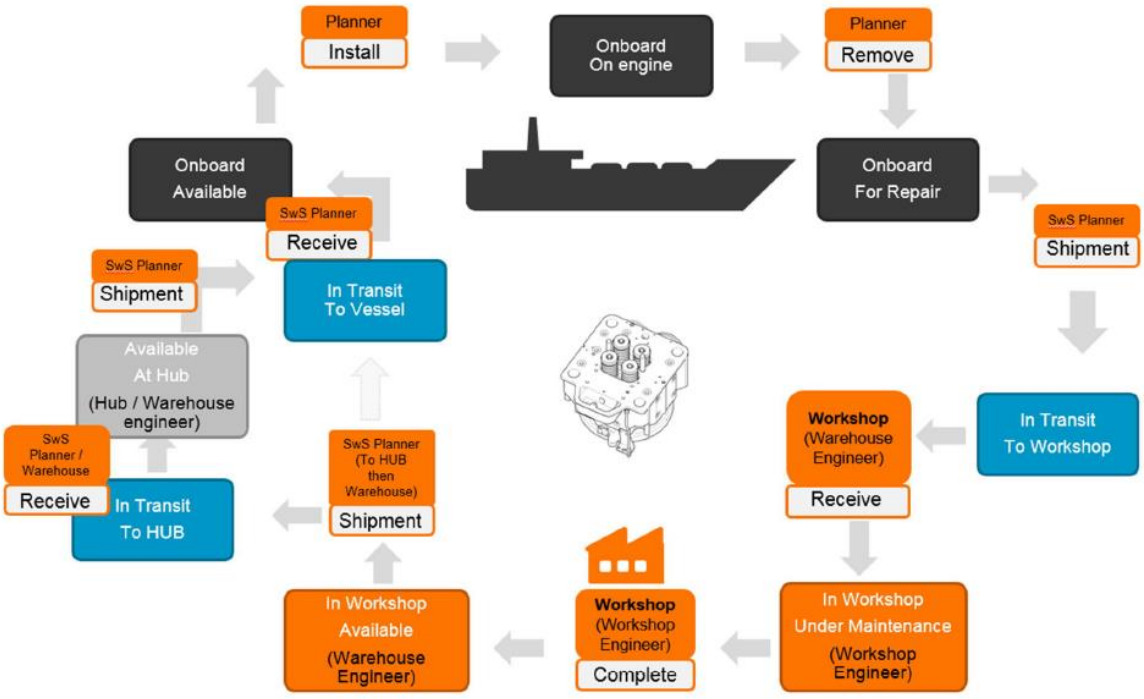


Figure 4. Scheme of Swing Set follow-up (Wärtsilä internal document)

2.3.1 Swing Set Management – Today

Today the Swing Set planner or the Maintenance Planner does every step of the tracking procedure manually in Maximo asset management system, Wärtsilä's maintenance planning application. All information about these steps comes to the planner mainly by emails from workshop engineers, field service engineers and coordinators, so there is a lot of persons that handle the information. Sometimes the information can also be found from different excel documents and from service work reports, so the process is very time consuming and quite unreliable, also a bit difficult to keep up with. All cylinder heads are hard marked with a WAMS code and a serial number, these numbers are marked in the cylinder head with a Hard stamp (hammer), Electrical pen or with an Air pen but the number can't be read optically with a scanner therefore these steps have to be done manually. These pictures below do not show all steps, only a few as an example.

The very first action in the Swingset tracking procedure is when you have logged into Maximo and the right site (ship) is chosen and where you go the application that is used for this procedure, Swingset Tracking.

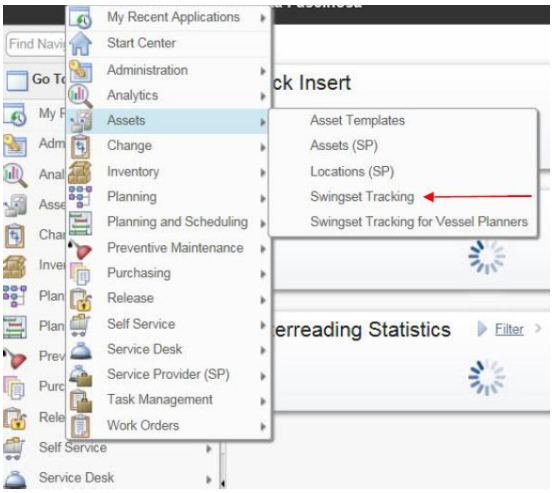


Figure 5. Go to Swingset tracking application in Maximo (Internal picture)

The second step is when you are logged in to the Swingset application and in the “Onboard On Engine” section, here you can see all parts that is installed on the engine at the moment.

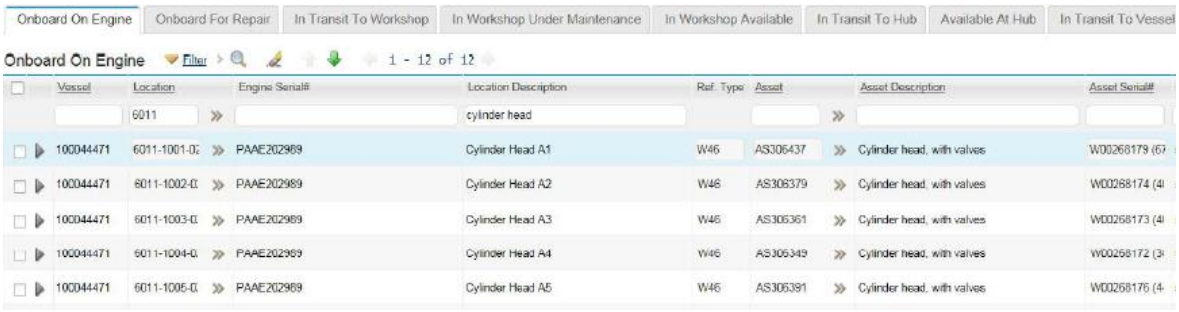


Figure 6. Cylinder heads still installed on engine (Internal picture)

Here you are still in the same section, and you choose which parts you want to uninstall from the engine, for example parts that needs to be sent to a workshop for overhaul.

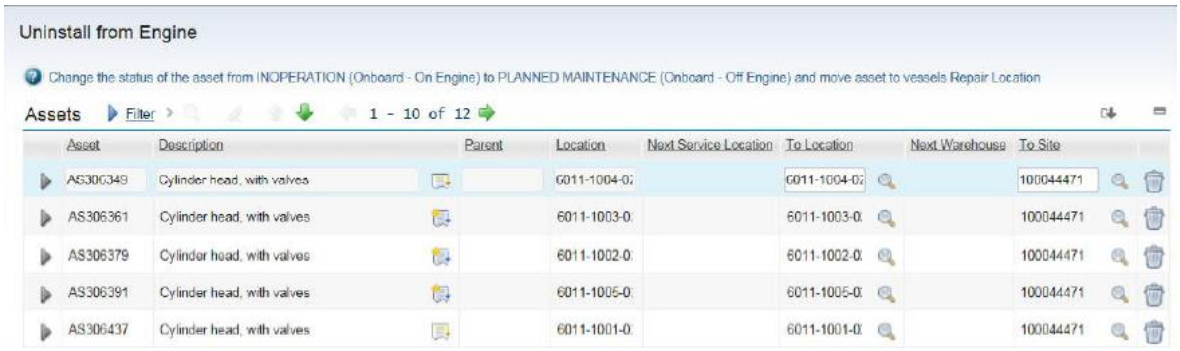


Figure 7. Cylinder heads picked for removal from the engine. (Internal picture)

In this section “Onboard for Repair” you can see all parts that are uninstalled from the engine and onboard the ship waiting to be shipped to the workshop for overhaul.

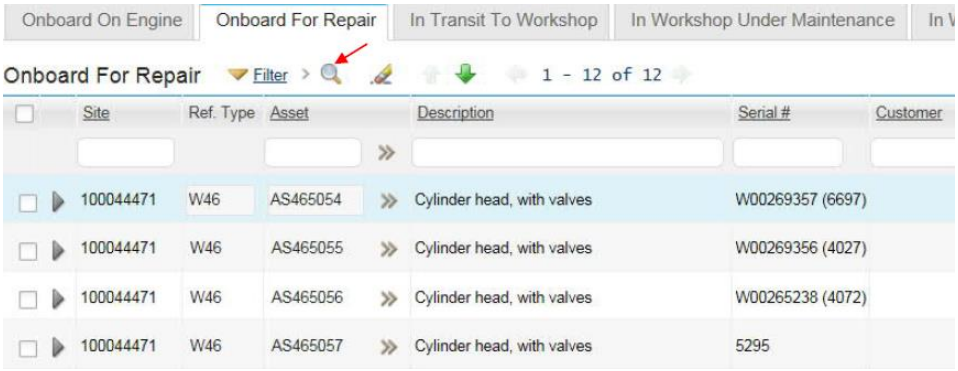


Figure 8. Cylinder heads removed from engine to onboard (Internal picture)

This section “In Transit To Workshop” shows which parts are in transit to the workshop at the moment, i.e., parts shipped for overhaul.

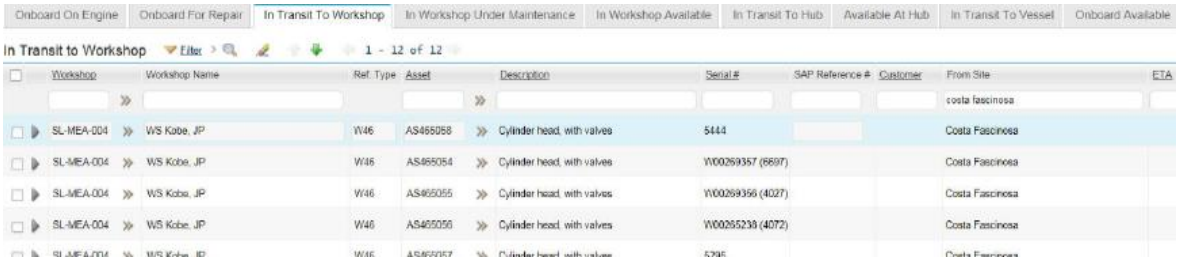


Figure 9. Cylinder heads shipped to workshop for overhaul (Internal picture)

In this section you can fill in information regarding the selected part if something is missing or has to be added.

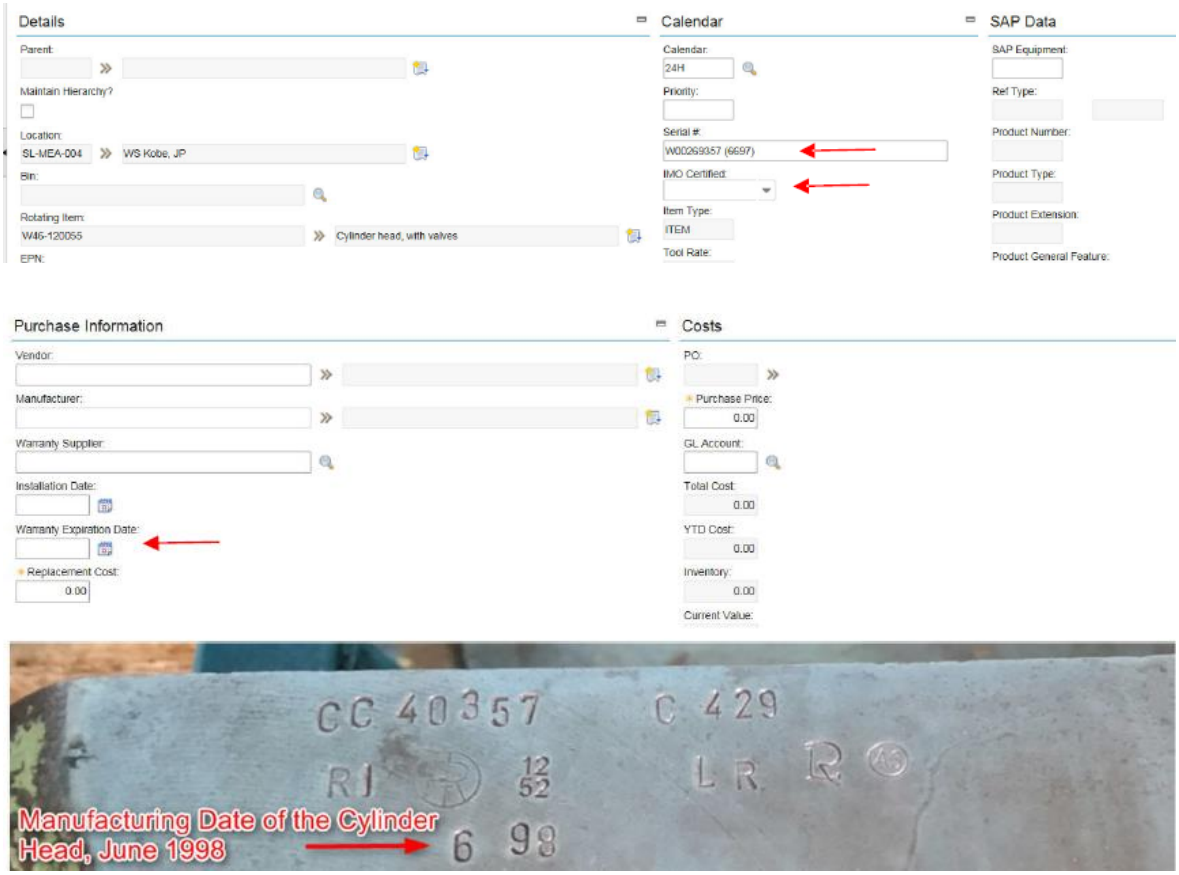


Figure 10. Adding information about the Cylinder head from for example an SWR (Internal picture)

Here it is also possible to attach some documents if needed, for example an SWR.

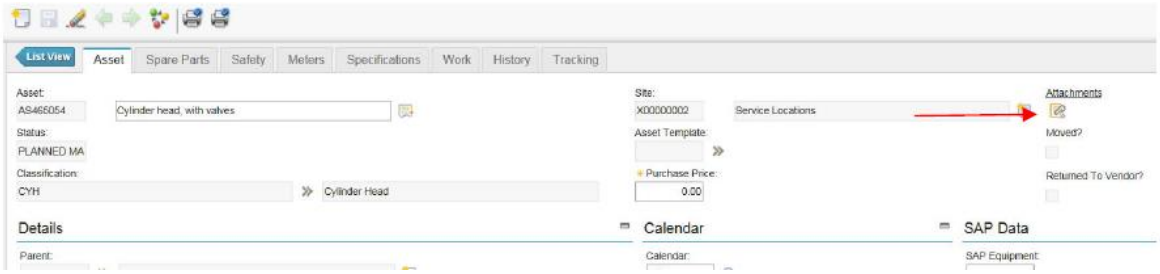


Figure 11. Attaching a SWR (Internal picture)

It is also possible to fill in relevant specifications about parts, such as oversize etc.

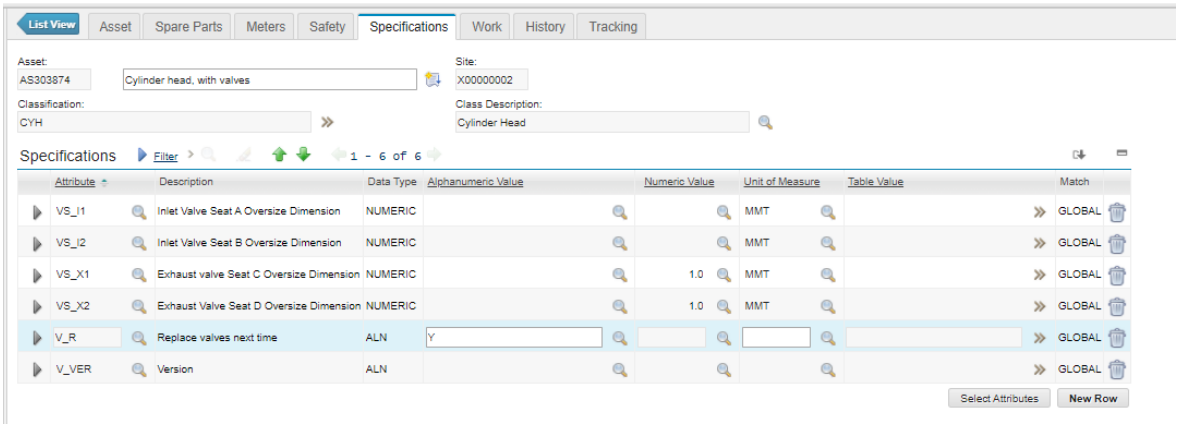


Figure 12. Adding specifications (Internal picture)

2.3.2 Swing Set Management - In the future

In the future the Swing Set Management system will be more automated. Every step of the tracking will be updated by scanning a QR code with a mobile device that has a custom-made application, so that the information will be sent directly into the Maximo asset management system. This results in a much less manual work and a much less time-consuming process. Another thing to improve in the future is to get more specifications about the cylinder head added in the system, such as the landing surfaces X-measurement and different kind of relevant information, such as last change date, numbers of times at workshops, asset running hours and so on, which is described below.

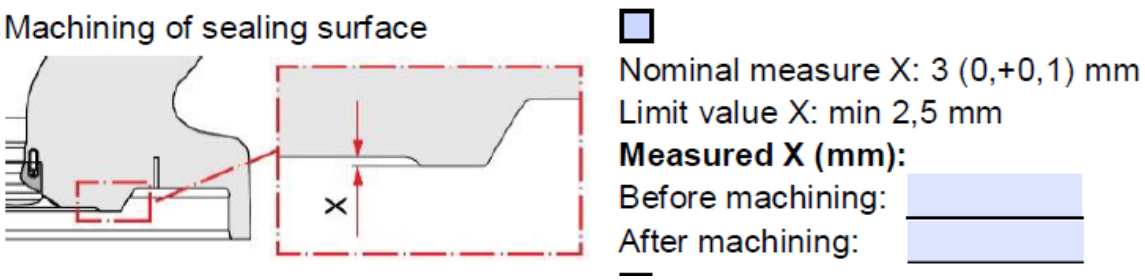


Figure 13. Describing of X-measurement (Internal picture)

Current version of an asset report.

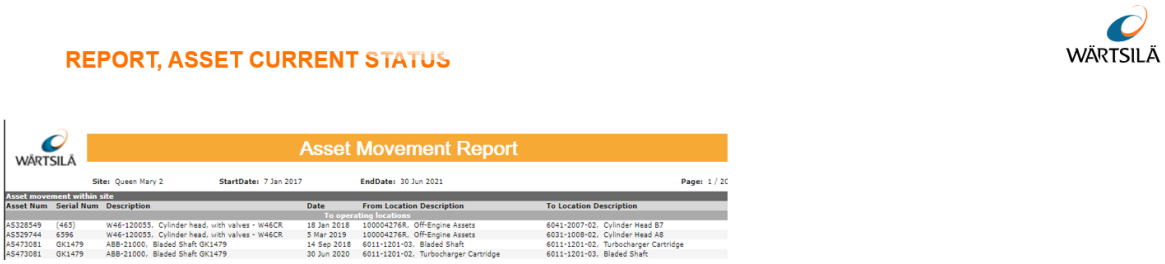


Figure 14. Report with asset information today (Internal picture)

Updated version of an asset report in the future, with more specifications.

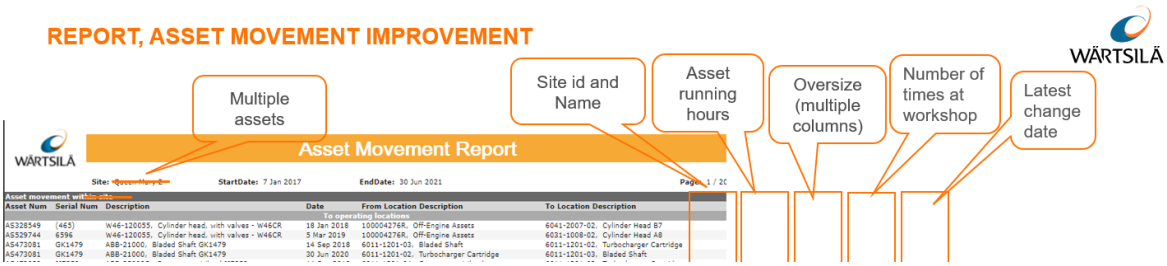


Figure 15. Improved asset report (Internal picture)

2.3.3 IBM Maximo Asset Management System

IBM Maximo Asset Management is a workflow process management system that provides insight for enterprise assets, work processes and conditions for better control and planning. In the system you can manage which users can log in and which applications, sites, and options each user can access. The system is highly customizable to suit different business requirements. Maximo uses multiple software servers and system requirements depend on database platform, site configuration and operating system. The system is a collection of different applications with different purposes but the function of these is similar. Information entered by an application is stored as data in the database and you can view the same data from different applications in different ways. Maximo Asset Management supports several kinds of database servers, including DB2, Microsoft SQL and Oracle. IBM Maximo Asset Management enables bar code and QR code scanning for assets and locations in service requests and following code types are supported: Codabar, Code-39, Code-93, Code-128, EAN, EAN-8, Interleaved 2 of 5, QR code and UPC. Scanning of these codes is supported by Apple and the latest version of Safari, Android and the latest version of Chrome, Windows, and the latest version of Edge. (IBM, 2014), (IBM, 2019)

2.4 Marking Technologies

Marking is used to add information, makers marks, serial numbers and so forth to different kinds of materials and products. There are many methods available because of different needs and the variety of materials.

2.4.1 Laser Marking

Laser marking is a method in which a laser vaporizes a material in several thin layers. The advantage of laser engraving is speed, flexibility and the small size of the engraving when needed. Laser marking is exact, high quality, lasting and an environmentally friendly way to identify a product. It is resistant to abrasion, chemicals, and various environmental effects such as weather and temperature changes. Laser marking is also an inexpensive method. (Ionix, 2021)

2.4.2 Engraving

Engraving is very similar to stamping, made with electric or compressed air tools. Engraving removes material from the surface to create deep marks. Engraving is an easy, flexible, quick and inexpensive method. The method does not require any special tools or programming. (Ctemag, 2016)

Figure 16. Engraving (Finecut)

2.4.3 Dot (-peen) marking

Dot Peen marking, is another method of permanent marking, often used on metal surfaces. It makes an intended dot that is fried into the surface by a pin, or a stylus. It utilizes 2D Matrix codes to receive the traceability on a product. (Ctemag, 2016)

Figure 17. Dot Peen Marking (Pryor)

2.5 Marking approaches

Things can be marked in many ways, either the marking is done permanently in the gods, or it can be marked with plates, labels, stickers and so forth, depending on the needs.

2.5.1 Metal Identification Plate

On a metallic identification plate, you can easily generate what kind of information you want, such as serial numbers, codes or WAMS numbers. You can easily produce your own plates and save time and money. These identification plates can be laser marked or engraved.

Figure 18. Metal identification plate (Trotec)

2.5.2 Chemical Resistant Labels

Labels can carry information needed, they can be printed with ribbon materials and can be protected by a thick layer of overcoat laminate for protection. There are many different options like different colours, barcodes, graphics (QR codes) or just text/numbers. Versions tested against many chemicals like oil, diesel, alcohol, acetone, xylene, brake fluid and so on are available. Also, heavy duty labels with ultra-aggressive adhesive for dirty surfaces. (barcode-labels.com, 2021)

Figure 19. Chemical resistant barcode label. (ChemDefend)

2.6 Code Types

A code is a kind of system of symbols, letters, words, or figures. With this system you can convert mentioned above into another form such as shortened or secret. There are many kinds of code types for different purposes.

2.6.1 Linear Bar Code (1D)

A Linear barcode is the code type that people are most familiar with, you can find many different styles of them, some contain just numbers, and some can encode any character. They can store about 20-25 characters Information in the code is organized just vertically from left to right and they can be read with any type of scanner. (Jia, Rachel, 2020)

Figure 20. Type of 1D Barcode. (Dynamsoft)

2.6.2 QR codes (2D)

QR code stands for Quick Response, it is a type of matrix barcode (or two-dimensional barcode) that is being read with an optical reader. QR code was invented and designed in 1994 by Masahiro Hara from the company Denso Wave. Behind the code you can store information or a tracker that sends you to a website or an application when the code is scanned. QR stores information in both vertical and horizontal directions so it can store much more data (up to 2000 characters) than ordinary 1D bar codes. The purpose of the QR code development was that it should be easily read by the user. You can find QR codes almost everywhere, like in manuals, price catalogues, in transport vehicles for information about the schedule, personal cards and so forth. QR codes come in different types with different features. QR codes require an image scanner to be read. (Denso, 2020)

QR code model 1 is the original QR code that can contain up to 1167 numerals, and it is the so called original QR code.

Figure 21. QR code Model 1 / 2 (Denso)

QR code model 2 is a facelift of the model 1, that can contain up to 7089 numerals. When QR codes are mentioned today, it is referred to QR code model 2. Model 2 can be identified by counting the number of modules in a column by counting: from 25 modules you can subtract 17 and divide by 4

$$\frac{25-17}{4}=2$$

Figure 22. QR code Model 1 / 2 (Denso)

There is also one type of QR code that is called Micro QR code, and it can be up to 35 numerals, and it can be scanned from only one orientation.

Figure 23. Micro QR code (Denso)

Another type of QR code is iQR code, it can be formed as a square model or in a rectangular form and store up to 4000 numerals. It can be generated and printed as a dot pattern barcode as well and is often used on pipes.

Figure 24. iQR codes (Denso)

SQRC code, also known as Security QR code, can be used for encrypting private data in that way, so that only a scanner with the correct decrypter can read it. The user interface of this code is the same as QR code model 2.

Figure 25. SQRC code (Denso)

Frame QR codes can be used for advertising or branding purposes.

Figure 26. Frame QR code (Denso)

2.7 Pros & Cons of using QR codes

Using QR codes brings many pros for a company but cons as well, so it will be needful to do some research at first and keep gathered information in mind when starting the use of QR codes.

2.7.1 Pros

Utilizing new methods like digitalization brings many modifications, possibilities, developments and sometimes threats. Faster and new methods replace the old way of working to achieve faster and better results, for that reason companies can't use old business models but must have a strategy for more flexible solutions. With only a scan done with a mobile phone on site, a QR codes provides faster connection between the company's different departments. Via the QR code it is possible to get instructions in manuals, animations and even videos. Even more information like part lists or location can be linked for maintenance and service purposes. The QR code can also provide a telephone number or an email address to a responsible person of the item. QR codes are environmentally friendly since they reduce printing costs and paper consumption by having all information scanned and stored digitally. (Jansson & Andervin, 2016)

2.7.2 Cons

QR codes can also bring a couple of drawbacks, one of them is that you need smartphones with suitable software to do the scanning of these codes. Another is that the code can get damaged or destroyed, a damaged code can be restored depending on how much it is

destroyed and on the correction level. The lowest level you can restore up to 7% and with the highest 30% This is depending on the design of the QR code if it is designed to store more data or have more capability to restore damaged code. One more drawback is that people are often unfamiliar using the QR code technology and that results in that more training is required. (Jansson & Andervin, 2016)

3 Methods

This chapter will describe the way of working in this thesis and introduce the methods used for collecting, validating, and receiving qualitative data. This chapter will also present Wärtsilä's requirements of the improved method that this thesis will result in.

3.1 Requirements of the improved method

The method that this thesis will result in has to be easy to use by all stakeholders, and that the method does not result in more workload or complicates the current work for workshops. One significant factor in this thesis is the marking method and the tracking procedure in the Swing Set management. So, the new marking method must be able to manage all kinds of stress like high temperatures, chemicals, tear, and wear and so forth. The new method must also have the ability to use a mobile device to scan and pass the tracking steps with the information directly into Maximo and it must be able to develop further in the future for upcoming needs.

3.2 Data collection

To gather knowledge that was needed in this thesis, many kinds of methods were used. The methods varied quite a bit depending on what part of the thesis was ongoing. It all started with gathering information and knowledge about Wärtsilä's Swing Set system and different kinds of marking methods and marking types. Searching for information on the Web and in Wärtsilä Compass was done a lot and much reading was done in the beginning of the thesis. So, the main sources of data have been gathered through interviews, discussions with colleagues, internal documents, and power points. Also, a lot of e-mails, Teams meetings, chatting and phone calls took place along the way.

3.2.1 Qualitative research

In this thesis the qualitative research method is used since much of the data is gathered mainly face to face and through Teams interviews. Therefore, theory of the qualitative research method is relevant and presented here.

There are two different ways of research, qualitative and quantitative research. Qualitative research is to collect data by speaking with stakeholders and participants and visiting the actual place where the study is done, therefore the researcher has the possibility to in real

life notice issues and how involved people act and what kind of experience they have and what the motivation level is. (Surbhi, 2018)

Quantitative research is a method that relies on natural sciences, which brings forth hard facts and numerical data, it can be recognized as an empirical method for it can be measured accurately and exactly. (Surbhi, 2018)

Factors that can be mentioned why the researcher has chosen the qualitative method are earlier research and missing theory, incorrect theory that cannot be used, requirements of describing an experience, or that the study cannot be done by using the quantitative method.

3.3 Data analyzation

All knowledge and data that was gathered were compared to Wärtsilä's other similar follow-up procedures, internal documents and the opinion of colleagues and people working with Swing Set Management.

3.4 Methological evaluation

Methods used and results in the thesis work are discussed with stakeholders involved in the Swing Set management and that can be considered to be a correct way to construct a thesis work. The way of gathering information, little by little and from many different aspects, can be justified by that a wide picture of the problem in front is processed step by step.

3.5 Meetings and Workshops

The initial meeting was held IRL at Wärtsilä, it included my supervisor at Wärtsilä and the line manager. In this meeting the purpose and goal were discussed, and the problem area was explained. It was obvious that the WoW with Swing Sets had to be improved. Regular meetings were held with my supervisor at Wärtsilä along the process and that helped me to keep the course and focus on the purpose of the thesis. The supervisor could also inform me about the todays WoW.

The second meeting was held at Novia University of Applied Sciences, it included my supervisor at Wärtsilä and my supervisor at Novia. In that meeting the scope of the thesis was discussed, the setup and how the process was going to proceed, also a time schedule was set up.

3.5.1 Meeting with Gambitgroup

A meeting with Gambitgroup's Business Director and Business Development Manager was held 5th of October. Key topics were to go through Wärtsilä's needs and today's WoW and what kind of system Wärtsilä wants to have. So, it was discussed different kinds of code types and how a possible application could be implemented so that the information from the chosen code could be inserted into Maximo, and eventually in the future into some other system than Maximo. It was ascertaining that Gambit has done similar projects before and that this project would be fully possible to accomplish, and that Gambit is going to make an estimation and a suggestion of an application that will suit Wärtsilä's needs and requirements.

3.5.2 The first Workshop

A Workshop in Wärtsilä's facilities in Runsor was held 12th of October. In this workshop I and a Swing Set planner exposed test versions of chemical resistant labels with laser marked QR codes ordered from Lasermark Oy for different kinds of stresses, like chemicals, heat, and mechanical stresses. We used a heat gun and a Fluke infrared thermometer to gather really high temperatures and to get reliable proofs, for the QR code scanning an iPhone 11 was used. The chemicals that we used in this test were different kinds of solvents like thinner and brake cleaner and other common substances you often find in a workshop, like normal lubrication oil, cutting oil and welding spray. We did these tests with three different labels attached to the cylinder head in different ways, one attached to a painted surface that was cleaned, one attached to painted surface that was quite greasy and dusty, and the third label was attached to a cleaned metal surface. All these labels resisted the heat and these different chemicals very well, the QR codes on these labels were readable very easily after all these chemicals, even after a quite brutal mechanical stress. The labels were made of the material that Lasermark Oy recommended for labels with laser marking, the 3M's version 7847 that is used much in different industries. In the Results chapter you can find pictures of all the tests done in the first workshop.

3.5.3 The Second Workshop

A second Workshop was held in Wärtsilä's facilities in Runsor 13th of October. In this workshop I and a Swing Set planner exposed test versions of chemical resistant labels with laser marked QR codes ordered from Lasermark Oy for hot water and industrial washing detergent in a washing machine for industrial use. We attached a test label on a room

temperature cylinder head and started a 10-minute lasting washing program in an Teijo C-1600 industrial washing machine with Kiilto TK 123 washing detergent and 80-degree Celsius water at 7 bars pressure. After the procedure the label was a bit soft, but it was still attached to the cylinder head and the QR code was fully readable with an iPhone 11. We waited a couple of minutes and started the washing machine again, this time we chose a 30-minute lasting washing program, when the program was completed, the label was still attached to the cylinder head and looked completely the same as it did before and was still fully readable. After that we let the cylinder head cool down and the label rest, then when 24 hours had passed, we went back and inspected it again, and the label was still very well attached to the surface. In the Results chapter you can find pictures of all the tests done in the second workshop.

4 Results

This chapter will present the results for this thesis work. The result is based on outcome of workshops and interviews with employees from Wärtsilä, Gambit and Lasermark.

As stated, the outcome of this thesis was to find a method that is reliable, secure, and easy to implement on existing components across the world. The method also needs to have development potential for upcoming needs in the future. Further, the new method also must be able to reduce the time-consuming workload.

The chosen method for improving the overall WoW of Swing Sets is to utilize a system that uses chemical resistant labels with laser marked QR codes from Lasermark Oy, which can be scanned with a mobile device that has an application installed that Gambit has developed. With this solution the Swing Set management will be a lot easier, smoother, and faster. The suggested code type would be QR codes of type 1 or 2 since these are standard QR codes and easiest recognizable QR codes, but it is possible to change the code type on request. I would suggest that the labels are laser marked on the same material that we used in the workshops, the 3M's version 7847. We can state that they were very durable, they managed to handle all the chemicals we exposed them to, very high temperatures and even pressured high temperature water with industrial detergent in a washing machine. We did test the labels first 10 minutes in the washing machine and directly after that another 30 minutes and according to the personnel in the overhaul workshop the normal washing time of a cylinder head is around 10 minutes, so our tests have a quite large safety margin. For extra safety it would also be good to attach two QR code labels to each cylinder head in case that one is being damaged for some reason.

The chosen marking method with chemical resistant labels is also because they are easy to produce and very cheap, they are also easy to mount on the cylinder heads. Compared to identification plates of metal the chemical resistant labels are more suitable for marking Swing Sets that are already in use across the world, since it is much less work to attach them. Metal identification plates require either glue, screws, or rivets to be attached to the cylinder head and if a mistake in the attaching procedure takes place, it is a lot worse to fix the problem. Permanent laser marking of the cylinder head would be very difficult under these kinds of circumstances, laser marking tools are very expensive and since overhauls of cylinder heads are done in many different workshops this option requires laser marking equipment at each place and is therefore not economically defensible. But I would suggest

that it is being investigated if it is possible to make permanent laser marking of cylinder heads when they are manufactured.

The marking procedure could be done in different ways, one way is that the labels could be sent to the workshop that does the overhaul of the cylinder head. Another way that I would suggest is that the labels get spare part numbers so that they can be ordered at the same time as all other spare parts needed for the overhaul of the engine, or that they are being included in the overhaul kit. Then when the mechanics from Wärtsilä is performing the complete engine overhaul, they can attach the labels to the cylinder heads.

Time saving with the chosen method is very notable, as mentioned earlier the WoW with the Swing Set management today is very time consuming and the procedure can take more than one hour per cylinder head each time it is being overhauled, the new method takes just the time it takes to scan the code and to choose the location in the application that Gambit has developed, which takes a few seconds. So, you can easily say that the time saving is roughly one hour per cylinder head. Today Wärtsilä handles over five thousand of Swing Set cylinder heads and the amount is increasing all the time, so the total time saving will be huge. This method could also be used to track other Swing Set spare parts than cylinder heads, it just has to be investigated what suites different spare parts.

The financial gain is also noticeable, for an example:

Confidential

A cost estimate for implementing this method is roughly as following:

Confidential

4.1 Test results from the first Workshop

Here the test labels are attached to the Cylinder Head and the test is ready to be started.

Figure 27. Labels attached to the cylinder head (Internal picture)

Ongoing heat test of the labels, 150 degrees Celsius at this moment.

Figure 28. Heat gun test, 150 degrees Celsius (Internal picture)

In this picture you can see that it is fully possible to read the label with an iPhone 11 at the same time as it is exposed to heat.

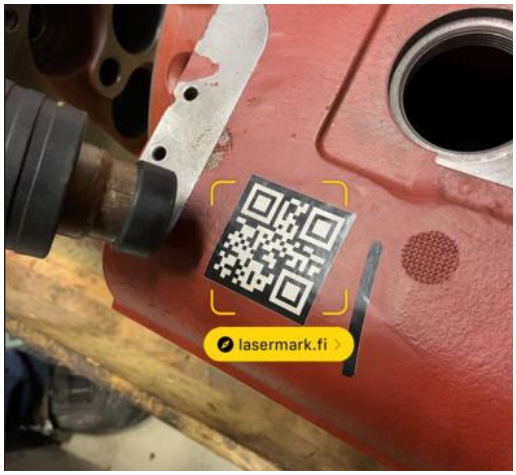


Figure 29. Heat test and QR code scanning (Internal picture)

The label is exposed to heat very close by, the heat gun is about 10mm from the surface.

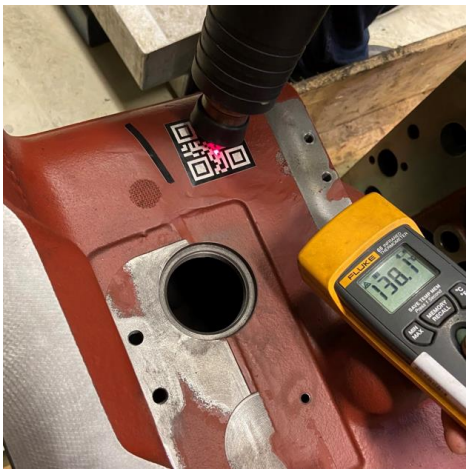


Figure 30. 138 degrees Celsius 10mm from the label (Internal picture)

Same type of test of a label on a different location but on the same Cylinder head.

Figure 31. Test of label attached to metal surface (Internal picture)

Here a test label is exposed to both heat and lubrication oil at the same time.

Figure 32. Heat and lubrication oil at the same time (Internal picture)

This picture shows that the test label is scannable and readable even when it is covered with lubrication oil.

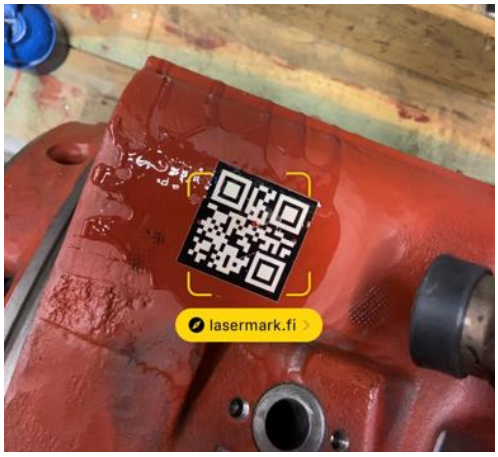


Figure 33. Fully scannable with oil all over the label (Internal picture)

This test label is fully scannable and readable even with serious damages.

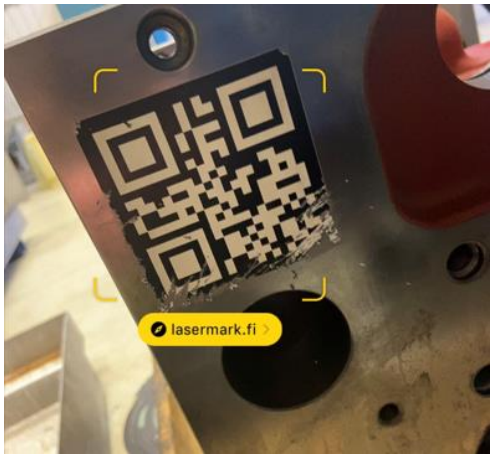


Figure 34. Fully readable even with serious damages (Internal picture)

4.2 Test results from the second Workshop

Here you can see the condition of the test label after it has been in the washing machine for 10 minutes.

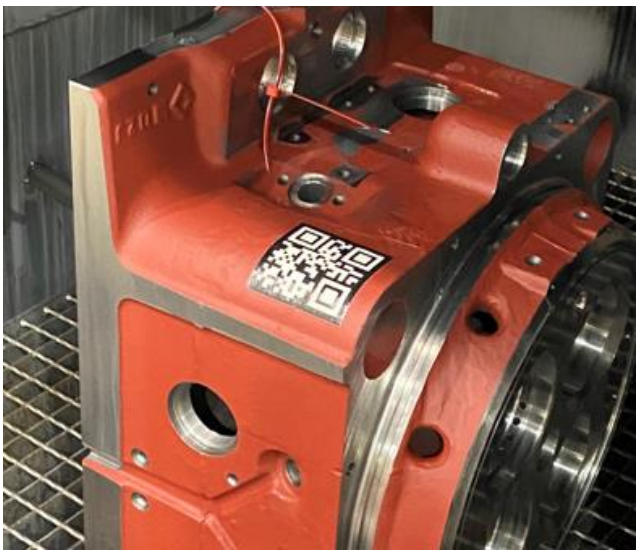


Figure 35. The test label after 10 minutes in the washing machine (Internal picture)

This picture shows the same test label after another episode in the washing machine, first 10 minutes and after that another 30 minutes.

Figure 36. The test label after 10+30 minutes in the washing machine (Internal picture)

Here the test label has been left drying and cooling down for 24 hours and this picture shows the condition after that.

Figure 37. The test label 24h after washing machine test (Internal picture)

After all tests we exposed the test label for it is still firmly attached to the Cylinder head and fully scannable and readable.

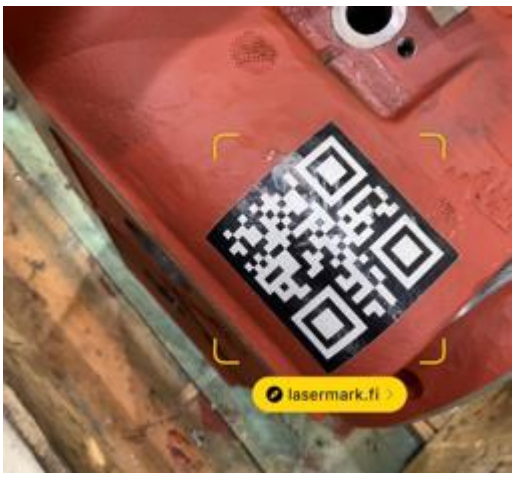


Figure 38. The test label fully readable after all the tests. (Internal picture)

5 Conclusion

The purpose of the thesis was to improve Wärtsilä's WoW in the Swing Set management system, the plan has in my opinion been followed as much as possible. The thesis work shows a describing theory part about different kinds of methods that could be used to facilitate the overall process. Literature was studied for achieving better a understanding regarding QR codes, software applications and fusing different systems. The qualitative research method was chosen for collecting information through discussions, workshops, and interviews with employees from Wärtsilä, Gambit and Lasermark.

My conclusion for this thesis would be that further investigation can be done by doing a business case of it. When that is done, a pilot project in form of a field test can be performed to gather more information about how this thesis result would work IRL. Further research can be done by investigating what kind of new solutions and opportunities using QR codes can bring to the Swing Set Management and how to fully utilize them, such as including material like manuals or instructions in PDF or video format in the QR code.

5.1 Further Work

An important thing would be following up on how an implementation of the result in this thesis works IRL if a pilot project is being performed. For example, are these labels performing as they are supposed to do, like they did in the workshops? If not, another field test with the second option: metal identifications plates could be done.

Further work would be to investigate if this application and QR codes could be implemented in some other system that Wärtsilä is using, such as the FS mobility app.

5.2 Challenges

One big challenge for me was to understand the WoW in Wärtsilä's Swing Set management's different stages, how the information was handled, and how the documentation process was setup. To understand how the process was performed at different locations in the whole system and what all the requirements was, since I did not have any previous experience of these kinds of procedures. In the beginning it was difficult to structure and to formulate the approach for the thesis, how much I was going to involve external stakeholders, Lasermark and Gambit or should I just go on my own and my colleague's opinions. To find relevant information and studies on QR codes and marking of equipment

already in use was very challenging, and that is a crucial part of improving the WoW in the Swing set Management since there is a large number of spare parts already in use across the world. If it would have been about to improve WoW in a system with new spare parts and not exchange parts, it would not have been any problem finding usable information.

6 After word

Finally, I want to thank everybody that has been involved in this thesis. I would like to thank Wärtsilä, and especially Tero Vesterlund, the Manager of Maintenance Management for giving me the opportunity to work with this interesting, challenging and rewarding thesis subject. Also, many thanks to my supervisor, Christian Hällund for all given help and uplifting feedback.

I also want to thank all my colleagues in the team, and all other people in Wärtsilä that has answered all my questions, that was a lot of people and even more questions.

I also want to thank Kaj Rintanen for all help and discussions regarding this thesis and overall, over the years at Novia University of Applied Sciences.

7 References

Denso.com. (2020, 10 07). Retrieved 09 2021, from Denso.com: https://www.denso.com/global/en/news/newsroom/2020/201007-g01/

Diesel engine. (2021, 09 07). Retrieved 2021, from en.wikipedia.org: https://en.wikipedia.org/wiki/Diesel_engine

IBM. (2014). *Introduction to Maximo Asset Management*. Retrieved 09 28, 2021, from ibm.com: https://www.ibm.com/docs/en/mam/7.6.0?topic=overview-introduction-maximo-asset-management

IBM. (2019, 04 09). *Scanning bar codes and QR codes to identify assets and locations in service requests*. Retrieved 09 23, 2021, from ibm.com: https://www.ibm.com/support/pages/scanning-bar-codes-and-qr-codes-identify-assets-and-locations-service-requests

Inc., E. I. (2021, 09 07). *Chemical Resistant Labels*. Retrieved from barcode-labels.com: https://barcode-labels.com/solutions/industrial-labels/chemical-resistant-labels/

Ionix. (2021). *Laser Marking*. Retrieved 09 07, 2021, from ionix.fi: https://www.ionix.fi/en/technologies/laser-processing/laser-marking/

Jia, R. (2020, 02 02). *The Comprehensive guide to 1D and 2D Barcodes*. Retrieved 09 07, 2021, from dynamsoft.com: https://www.dynamsoft.com/blog/insights/the-comprehensive-guide-to-1d-and-2d-barcodes/

Marie Andervin, J. J. (2016). *Att leda digital transformation.* Helsingborg: Hoi Förlag.

Pros & Cons of parts marking methods. (2016, 12 1). Retrieved 09 2021, from ctemag.com: https://www.ctemag.com/news/articles/pros-cons-parts-marking-methods

QR-Codes.com. (2021). *QR-Codes.com*. Retrieved 09 2021, from https://qr-codes.com/qr-codes-for-customer-service/

Quick Guide to the Most Popular Marking Methods. (2017, 10 26). Retrieved 09 2021, from Durable-tech.com: https://www.durable-tech.com/blog/quick-guide-to-the-most-popular-marking-methods

Surbhi.S. (2018, 11 19). *Key differences*. Retrieved 09 24, 2021, from difference between qualitative and quantitative research: https://keydifferences.com/difference-between-qualitative-and-quantitative-research.html

Wikipedia. (2020, 11). *Cylinder head*. Retrieved 09 2021, from Wwkipedia.com: https://en.wikipedia.org/wiki/Cylinder_head

Appendix 1. Datasheet of 3M 7847

3M Science. Applied to Life.™

ASK A 3M EXPERT

June, 2017

3M™ Laser Markable Label Material 7847

Product Description

3M™ Laser Markable Label Material 7847 are specialty film label materials where a laser can ablate the top layer of a dual-layer facestock to create an image. The same laser can also kiss cut the label to size, maximizing flexibility for producing variable labels for durable applications.

Product Features

- Cast modified acrylate facestock offers long-term durability and excellent abrasion, temperature, chemical and environmental resistance
- High-resolution and high-contrast images markable with standard Nd-Yag lasers for smaller barcodes, 2-D symbologies and fine point text.
- Excellent convertability ("kiss cutting") of acrylate facestock on densified kraft liner.
- Matte surface provides good printability resulting in excellent bar code readability.
- 3M™ High Performance Acrylic Adhesive 350 provides reliable, permanent adhesion to LSE plastics, oily metals, powder coatings and textured surfaces.
- Brittle facestock material provides destructibility to meet security labeling requirements.
- No corrosive emissions during the laser marking process.
- UL Recognized Component under file MH11410.
- CSA Recognized Component under file 99316.

3M™ Laser Markable Label Material 7847

Technical Information Note

The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

Typical Physical Properties

Property	Values	
Adhesive Thickness	1.2 mil	0.03 mm
Facestock Thickness	2.4 mil	0.06 mm
Liner Thickness	3 mil	0.077 mm
Adhesive Type	#350 high-holding acrylic	
Liner	Densified Kraft	

Note

Calipers are nominal values

Typical Performance Characteristics

Property	Values	
Tensile Strength	28 N/cm	3.1 oz/in
Elongation at Break	ca. 5 %	
Minimum Application Temperature	4 °C	39 °F

3M™ Laser Markable Label Material 7847

Typical Environmental Performance

Environmental Resistance

Note: The following tests are intended as a guide to product performance. Application testing is recommended using actual substrates, expected dwell times, and actual conditioning for best determination of product suitability.
Temperature Resistance: Resistant up to 392°F (200°C) (when applied to aluminum surfaces) 440°F (225°C) for 60 min
Dimensional Stability: <1% after 2 hours at 200 °C, or 24 hours at 150 °C
<1% after 24 hours -40°C:
Adhesive Performance/Bond Strength:

Substrate	Oz/in	N/in
Stainless Steel	115	32
Polypropylene	86	24
Polycarbonate	82	23
ABS	93	26

72 hour room temperature dwell, 300 mm/min, at 180° angle, film width: 25.4 mm. Adhesive performance for each case can depend on the texture of the surface. The above adhesive values are average values. They are not appropriate for specifications.
Weather Resistance: Acceleration test in the Xenon device, 2000 hours: No change.
Resistance to Environmental Conditions:
(applied to aluminum): No change.
24 hours: -40°F (-40°C)
24 hour:s 300°F (150°C)
2 hours: 390°F (200°C)
Resistance to Chemical Immersion:

Substance	Exposure	Time Results
Diesel	4 hours	No change
Dot 4	1 hour	No change

Salt Spray: 150 Hours : no change

Processing

Laser Marking:
• 3M™ Laser Markable Label Material 7847 are compatible with many kinds of dispenser systems and is suitable for a continuous process with minimal supervision.
• 3M recommends operating an exhaust system combined with a charcoal filter to reduce emissions during the laser operation.
• All Nd-Yag laser marking equipment on the market can ablate and "kiss cut" 3M™ Laser Markable Label Material 7847.
• For optimized optical results, 3M recommends individually adjusting marking parameter, such as power, pulse rate, and speed, to your individual requirements depending on the type of labels to be produced (bar codes or characters).
Printing:
• When using press printing methods, 3M recommends pre-printing tests to check for sufficient ink adhesion.

3M™ Laser Markable Label Material 7847

Handling/Application Information

Application Examples

- Durable goods marking
- Under hood labels
- Barcode labels
- Process labeling in-plant
- Asset labels
- Security labels
- Information labels with 2-D symbologies

Storage and Shelf Life

Store at room temperature conditions in cool, dry and sun-protected rooms.
If stored under proper conditions, product retains its performance and properties for 24 months from date of manufacture.

Industry Specifications

UL Recognized (File MH11410)
CSA Accepted (File 99316)

Trademarks

3M is a trademark of 3M Company.

References

Property	Values
3m.com Product Page	https://www.3m.com/3M/en_US/company-us/all-3m-products/~/3M-Laser-Markable-Label-StockX/?N=5002385+3291133795&rt=rud
Safety Data Sheet SDS	https://www.3m.com/3M/en_US/company-us/SDS-search/results/?gsaAction=msdsSRA&msdsLocale=en_US&co=ptn&q=7847

ISO Statement

This Industrial Adhesives and Tapes Division product was manufactured under a 3M quality system registered to ISO 9001 standards.

3M™ Laser Markable Label Material 7847

Information

Technical Information: The technical information, guidance, and other statements contained in this document or otherwise provided by 3M are based upon records, tests, or experience that 3M believes to be reliable, but the accuracy, completeness, and representative nature of such information is not guaranteed. Such information is intended for people with knowledge and technical skills sufficient to assess and apply their own informed judgment to the information. No license under any 3M or third party intellectual property rights is granted or implied with this information.

Product Selection and Use: Many factors beyond 3M's control and uniquely within user's knowledge and control can affect the use and performance of a 3M product in a particular application. As a result, customer is solely responsible for evaluating the product and determining whether it is appropriate and suitable for customer's application, including conducting a workplace hazard assessment and reviewing all applicable regulations and standards (e.g., OSHA, ANSI, etc.). Failure to properly evaluate, select, and use a 3M product and appropriate safety products, or to meet all applicable safety regulations, may result in injury, sickness, death, and/or harm to property.

Warranty, Limited Remedy, and Disclaimer: Unless a different warranty is specifically stated on the applicable 3M product packaging or product literature (in which case such warranty governs), 3M warrants that each 3M product meets the applicable 3M product specification at the time 3M ships the product. 3M MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR ARISING OUT OF A COURSE OF DEALING, CUSTOM, OR USAGE OF TRADE. If a 3M product does not conform to this warranty, then the sole and exclusive remedy is, at 3M's option, replacement of the 3M product or refund of the purchase price.

Limitation of Liability: Except for the limited remedy stated above, and except to the extent prohibited by law, 3M will not be liable for any loss or damage arising from or related to the 3M product, whether direct, indirect, special, incidental, or consequential (including, but not limited to, lost profits or business opportunity), regardless of the legal or equitable theory asserted, including, but not limited to, warranty, contract, negligence, or strict liability.

Disclaimer: 3M industrial and occupational products are intended, labeled, and packaged for sale to trained industrial and occupational customers for workplace use. Unless specifically stated otherwise on the applicable product packaging or literature, these products are not intended, labeled, or packaged for sale to or use by consumers (e.g., for home, personal, primary or secondary school, recreational/sporting, or other uses not described in the applicable product packaging or literature), and must be selected and used in compliance with applicable health and safety regulations and standards (e.g., U.S. OSHA, ANSI), as well as all product literature, user instructions, warnings, and limitations, and the user must take any action required under any recall, field action or other product use notice. Misuse of 3M industrial and occupational products may result in injury, sickness, or death. For help with product selection and use, consult your on-site safety professional, industrial hygienist, or other subject matter expert. For additional product information, visit www.3M.com.

3M™ Laser Markable Label Material 7847

3M United States
3M Center
St. Paul, MN 55144-1000
800-362-3550
www.3M.com

Please recycle.