



# Inspection procedure for engine block after hot run

Kim Mattans

Bachelor's thesis  
Industrial Management  
Vaasa 2010





## BACHELOR'S THESIS

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Degree Programme: Industrial Management  
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Title: *Inspection procedure for engine block after hot run*

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### Summary

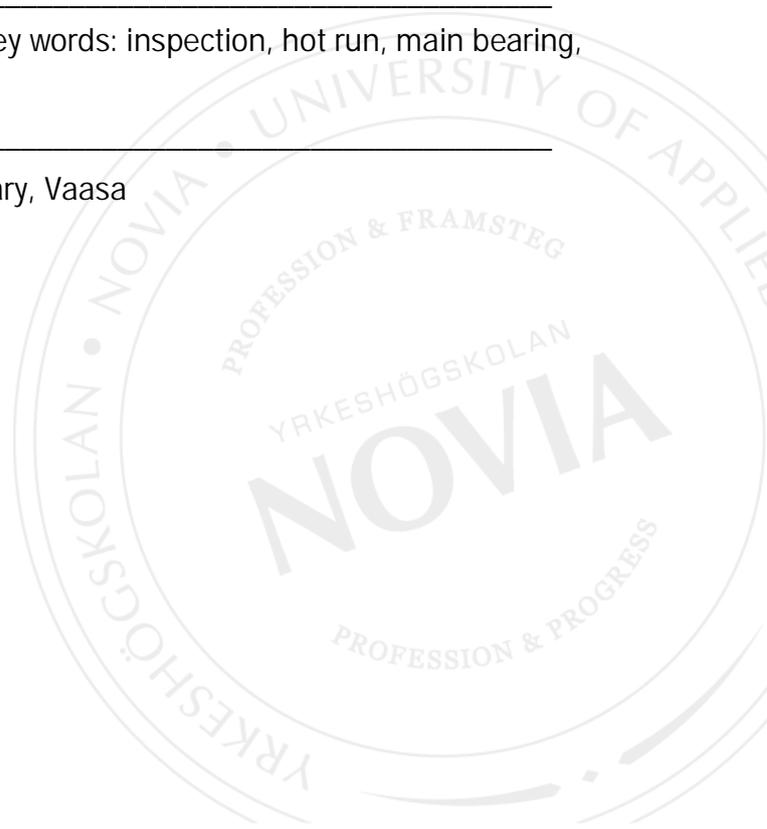
This Bachelor's thesis was made at Technical Service W20 in Runsor, Vaasa. The task was to compile instructions for measurements and inspections of the engine block in case of a hot run. Instructions are needed because at this moment there are no instructions for what is to be done in case of a hot run. The main goal of the thesis was to compile a service letter that includes all the information and measurement records that are needed when an inspection of the engine block is carried out. Methods that was used to do this thesis was to interview people and study how a inspection of a engine block are done. The result was an internal service letter that is to be used when a hot run occurs.

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Language: English                      Key words: inspection, hot run, main bearing, camshaft

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## EXAMENSARBETE

Författare: Kim Mattans  
Utbildningsprogram och ort: Produktionsekonomi, Vasa  
Handledare: Roger Nylund

Titel: *Inspektionsprocess för motorblock efter varmgång.*

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### Sammanfattning

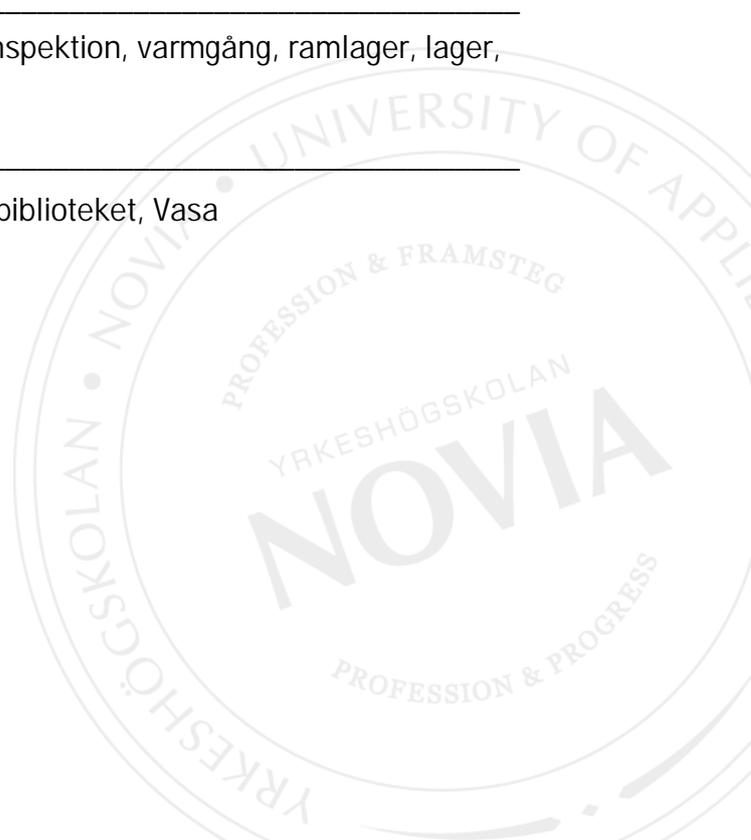
Detta examensarbete gjordes vid Technical Service W20 i Runsor, Vasa. Det gick ut på att sammanställa instruktioner för mätningar och inspektioner av maskinblocken vid en varmgång. Instruktionerna behövs eftersom det inte i dagens läge finns några liknande instruktioner till hands ifall en varmgång sker. Målet med examensarbetet var att sammanställa ett servicebrev som innehåller all information samt mätprotokoll som behövs när en inspektion av ett motorblock behövs. Metoderna som användes för att göra detta examensarbete var intervjuvning av folk samt litteraturstudier angående om hur inspektioner av motorblock går till. Resultatet blev ett internt servicebrev som skall användas ifall en varmgång uppstår.

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Språk: Engelska    Nyckelord: inspektion, varmgång, ramlager, lager, kamaxel.

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## **1 INTRODUCTION**

I did my Bachelor's thesis at Wärtsilä Services, Technical Service W20. Mr. Niklas Donner has supervised my work at Wärtsilä and Mr. Roger Nylund has been my supervisor at Novia. To work with this Bachelor's thesis about inspection procedures and reconditioning in case of a hot run in the engine block has been very interesting. The main goal of the thesis was to compile a service letter that includes all the information and measurements that are needed when an inspection of the engine block is to be performed. The service letter includes all the Vasa 22 engines. The service letter is an internal document so therefore it will not be added as an appendix but a screenshot of the first page can be found in appendix 1.

## **2 PURPOSE OF THE BACHELOR'S THESIS**

The purpose of this Bachelor's thesis was to compile instructions for measuring and reconditioning actions regarding the main bearing caps/bores and the camshaft bores in case of a hot run. The assignment also included to make new measurement records because the old ones did not include all the different tolerances for each engine. There are two different kinds of tools that are used when the diameter and the straightness of the main bearing caps and the camshaft bearings are being measured, the laser measurement tools and the optical measurement tools. To find cracks and defects on the main bearing caps there are two different methods that might be used, either magnetic particle inspection or liquid penetrant inspection. These two ways to find cracks and defects are called non-destructive testing.

## **3 COMPANY**

Wärtsilä was founded in 1834 in the municipality of Tohmajärvi in eastern Finland. In 1936 Wärtsilä was established in Vaasa. In 1954 the first manufacturing of diesel engines started. Wärtsilä has more than 18.000 employees and they have operations in 160 locations in 70 countries all around the world. There are more than 3000 employees in Finland and they are stationed in Vaasa, Turku, Raisio, Helsinki, Espoo and Kiuruvesi. /7/

Wärtsilä in Finland is both a ship power supplier for all types of marine and offshore applications and a provider of power plants in the decentralized energy market. The global service network provides service, maintenance and reconditioning solutions both for machinery and power plants throughout the lifetime of the installations. Wärtsilä's main export areas are Europe, Asia and America. Five different engines are manufactured in Vaasa: W20, W32, W34DF, W34SG and Wärtsilä Auxpac. /7/

### 3.1 Services

Wärtsilä supports its customers throughout the lifecycle of their installations. Wärtsilä provides service, maintenance and reconditioning solutions both for ship machinery and power plants. /7/

### 3.2 Ship Power

Wärtsilä is the leading supplier of ship power solutions including engines, generating sets, reduction gears, propulsion equipment, automation and power distribution systems as well as sealing solutions for the marine industry. /7/

### 3.3 Power Plants

Wärtsilä is a leading supplier of flexible power plants for decentralised power generating. They offer solutions for generation of baseload, grid stability & peaking, industrial self-generation as well as for the oil and gas industry. /7/

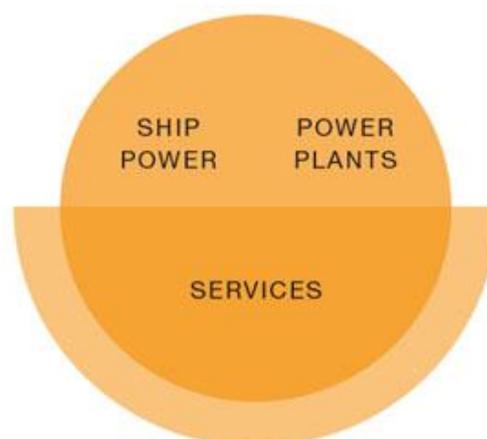


Figure 1. The three segments in Wärtsilä./7/

#### **4 REASONS WHY INSTRUCTIONS ARE NEEDED**

Instructions are needed because at this moment there are no existing instructions for what is to be inspected on any engine type. Instructions for measurements and reconditioning of the main bearing caps/bores and the camshaft bores are needed when a hot run has occurred on an engine block. The purpose of the instructions is that one should be able to find the instruction and the needed measurement records easily on the internal bulletin board. In the instructions, the tolerances for the main bearing bore and the camshaft bearing bore for each Vasa 22 type are listed. In the instructions the drawing numbers for the new measurement records are listed to make it easy to obtain the different measurement records that might be needed. This will simplify and speed up the work. In the old measurement records there were not all the tolerances and dimensions that are needed when a measurement is to be made. The workers that took the measurements had to start by searching for all the tolerances and dimensions in different drawings and thereafter proceed with the work.

#### **5 REASONS WHY A HOT RUN MIGHT APPEAR**

The most common reason why a hot run occurs is that the lubrication oil in the engine system is bad. There are several reasons why a hot run might appear and the most common ones have been listed below.

- Bad lubrication oil in the system
- A lot of particles in the oil
- Metal to metal wear
- The bearings have been wrongly installed
- The service on the engines has not been done as it should.

## 6 MEASUREMENT TOOLS

There are different kinds of measurement tools on the market such as laser tools, optical tools, dial gauges and non-destructive testing apparatus. These are the ones that have been dealt with in this bulletin and thesis. The laser tool brands that are used in Wärtsilä are Easy Laser and Rotalign. The Easy Laser is used at the product factory after the main bearings have been mounted onto the engine block. The Rotalign is a recently bought laser tool that is to be used at Service in case they will have to travel to a ship to investigate the hot run on an engine block. The dial gauges are used to measure the diameters of the main bearing bores and the camshaft bearing bores.

The optical measurement tool brand is Rank Taylor Hobson. Today the laser tools are much more commonly used in Wärtsilä at least at the product factory. But when for example the service department sends out some of the fitters to check the engine block it is good if the fitters are familiar with both the laser and the optical tools.

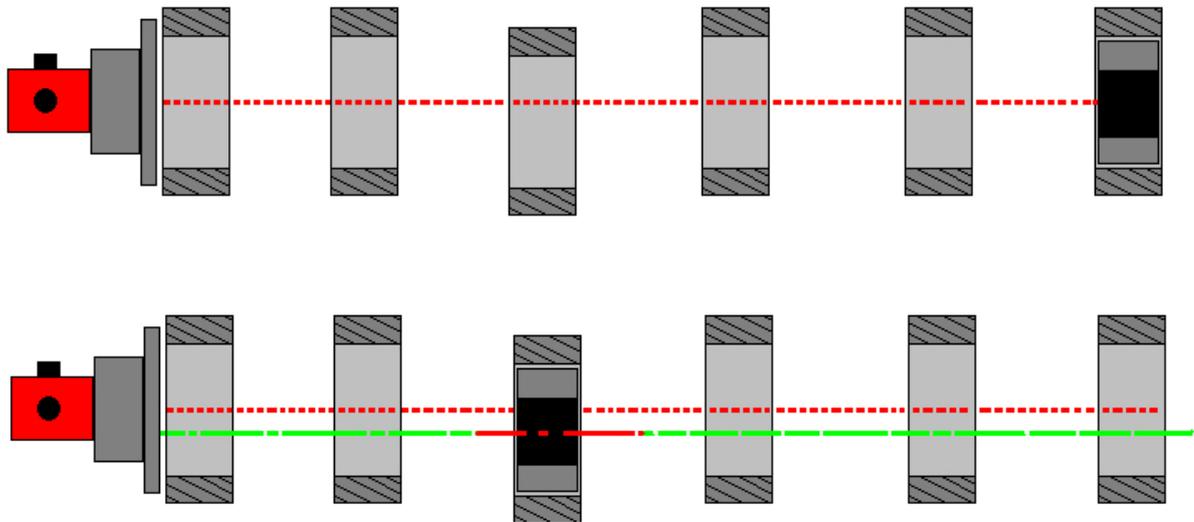
Non-destructive testing apparatus is used to inspect if the main bearing caps and camshaft bearings have cracks or defects that are not visible to the naked eye.

### 6.1 Geometric measurement – Easy Laser

Easy Laser is a measurement tool that is used for measurements of the straightness of the bores and bearing journals in diesel engines. See Figure 2, page 6, for an example of the camshaft and crankshaft bearings. It measures both full and half bearing positions. The resolution is 0.001 mm [0.05 mils]. This measurement tool can be used both in a product factory and out in the fields. /1/

Bores from 100 mm to 500 mm [3.9"-19.7"] can be measured with the standard system. The distance that can be measured is up to 40 m [132 feet.]. The system automatically calculates the bores' positions in relation to each other both horizontally and vertically. Measurement points can be added, removed or re-measured at any time during the measurement process. /1/

The Easy Laser is used in the product factory to measure the straightness of the camshaft bores and crankshaft bores (See figure 2). In the product factory in Runsor, Vaasa W20, they have developed different flanges for the detector depending on what they are measuring. There are different flanges for the camshaft bore and the main bearing bore. Also for the laser transmitter there has been developed a flange that can be assembled on both the camshaft and the main bearing journal.



*Figure 2. Straightness measurements*

The following parts must be available when the measuring with Easy-Laser starts

- Laser transmitter
- Detector
- Display unit
- Cable with push/pull connectors.

The following parts are optional

- User manual
- Computer/printer.

## 6.2 Rotalign

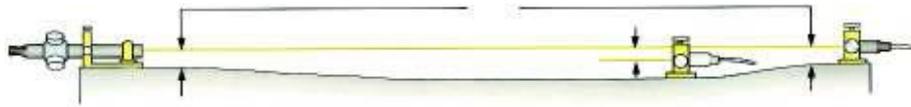
The Rotalign is like the Easy Laser a laser measurement tool that is used to measure the straightness of bores. CENTRALIGN Ultra (See picture 1) is a precision laser alignment system designed to replace older and more time-consuming technologies. It is much faster, very precise, and provides a clear measurement record. The Rotalign can measure diameters from 45 mm to 4000 mm. It is possible to measure both magnetic and non-magnetic bores. It is easy to set the CENTRALIGN apparatus to different diameters on the main bearing bores. /5/the intention is that the Rotalign Ultra is to be used when Field Service sends out their fitters to do an inspection of some engine.



*Picture 1. The Rotalign display unit.*

## 6.3 Rank Taylor Hobson

The alignment telescope is used to set and check alignment, squareness, straightness, flatness, parallelism, vertically and level. The telescope generates a straight line. This forms the basic reference from which all measurements are taken. (See figure 3, page 8).



*Figure 3. Alignment*

The Rank Taylor Hobson has been used in the product factory for measurements but has been replaced by the easier-to-use and more reliable laser tools. The optical tools are often used by the field service fitters and it is useful to have knowledge of both the optical and the laser measurement tools. In case something should go wrong with the laser tool it is easy to switch over to the optical tool. /4/

These parts should be available when the measurements with the Rank Taylor Hobson tool are started

- Binocular/telescope
- Binocular/telescope fitting

## **7 INSPECTION PROCEDURES**

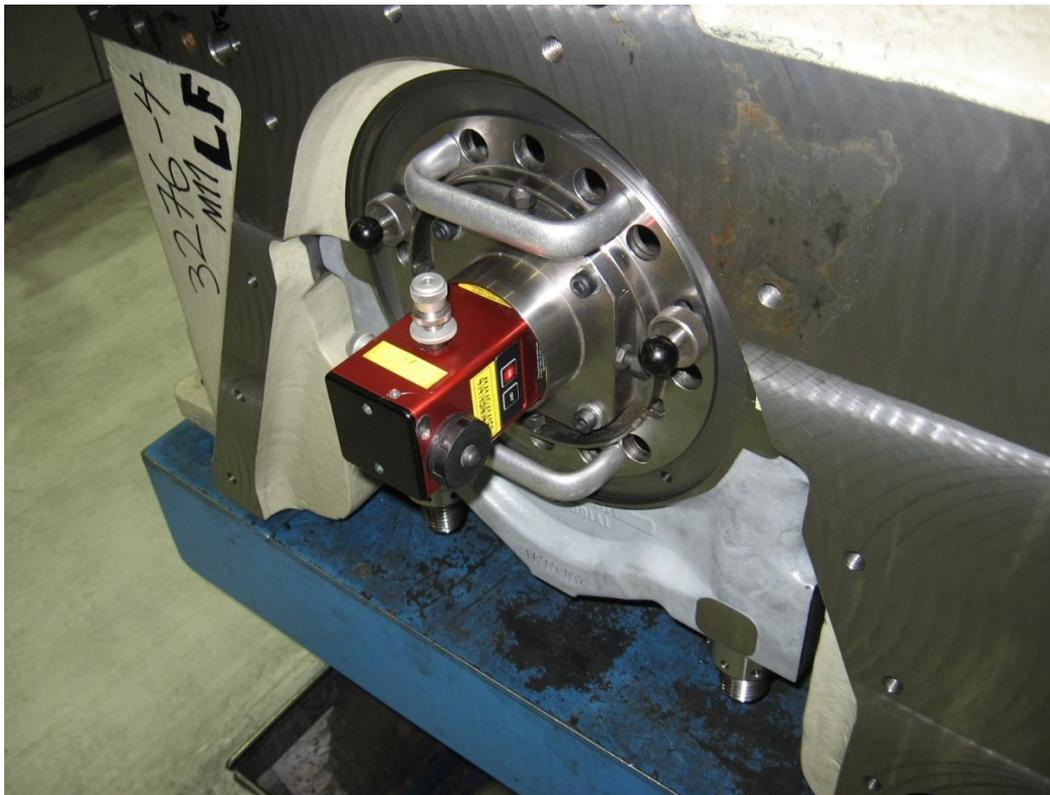
The inspection procedure of the engine block is started by dismantling the engine and removing the camshaft and the crankshaft in order to get access to the main bearing and camshaft bores. There are three different kinds of measurements that are performed on either the main bearing bore or the camshaft bearing bore: The straightness, the diameter and the non-destructive testing of the bearing caps.

## 7.1 Straightness of the main bearing centre line

The straightness of the main bearing centre line is either measured by means of a laser measurement tool or an optical measurement tool.

### 1. Transmitter

Step 1 is to attach the laser transmitter to the first main bearing bore at the flywheel end (picture 2 below) and to check that the transmitter is in the right position and level.



*Picture 2. The first step in the inspection procedure*

### 2. Detector

Step 2 is to connect the detector to the display unit (See pictures 3 and 4, pages 10 and 11). Step 3 is to calibrate the measurement tool, step 4 is to put the detector in the first

main bearing cap at the free end (See picture 3 below) and from there you start to measure every main bearing cap by moving the detector from the first bearing cap to every individual main bearing cap on the engine block.



*Picture 3. Detector at the first main bearing cap at the free end*

### *3. Display unit*

The display unit is used to easily see the established measurements and in case they look wrong it is easy to delete them and take a new measurement of the needed bearings. The display unit is also used when the tools are calibrated and optimised for the current journals. When you are done with the measuring you can choose how you wish to save the recently made measurements. You can save them on the internal storage memory, you can also transfer the gathered data to a PC and from there export them into measurement records, and there is also the possibility to connect the display unit directly to a printer if for example you do not want to connect to a computer.



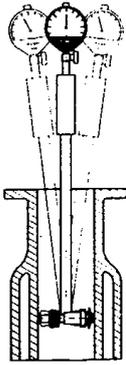
*Picture 4. The display unit*

## 7.2 Diameter of the main bearing bores

The diameters for the main bearing bores are measured with dial gauges (See picture 5 below). The first thing to be done before any measurements with dial gauges are performed is to calibrate the dial gauge towards a calibrating tool. The dial gauge is moved back and forth (Figure 4, page 12) when measuring and from that you can see if the measurements are within the tolerances for the specific part.



*Picture 5. Dial gauge*



*Figure 4. How the dial gauge is used/6/*

### 7.3 Straightness of the camshaft bearing bore

The inspection procedure for measuring the straightness of the camshaft bearing centre line is the same as for the main bearing bore. The only difference is that the flanges are exchanged for different kinds that are manufactured to fit into the camshaft bore. The flange that is used on the laser transmitter can be used for both the camshaft and the main bearing bore.

### 7.4 Diameter of the camshaft bore

The inspection procedure for measuring the diameter of camshaft bearing bores is the same as the inspection procedure for the main bearing bores.

## 8 NON-DESTRUCTIVE TESTING

Non-destructive testing (NDT) means to check the material or component without causing any damage. The most common NDT methods are ultrasonic, magnetic particle, liquid particle and radiographic. The magnetic particle and liquid particle tests are used in Wärtsilä to detect cracks in the material that are not visible to the naked eye.

### 8.1 Magnetic Particle Inspection (MPI)

Magnetic particle inspection is a method for locating cracks and surface defects in magnetic materials. The magnetic particle inspection can be applied only to ferromagnetic materials like construction steels, cast irons and spring steels. It cannot be applied to for example inlet/exhaust valves and Cu-pipes. /3/

### 8.2 Magnetic Particle Inspection procedure

The magnetic particle inspection always starts with the following procedure.

1. Start by cleaning the part that is to be inspected from rust, oil, grease or other things that are not meant to be there.
2. The second thing is to establish a magnetic field in the part.
3. When the part has been magnetized the part should be sprayed with the test medium (for approximately 5 sec.)
4. After the parts have been sprayed, the magnetic field should be turned off.
5. The part is then de-magnetized.
6. The surface is then visually evaluated for defect indications.
7. The indications are documented.
8. The part is either accepted or rejected./3/

### 8.3 Liquid penetrant test

Liquid penetrant test (LPI), also called dye penetrant test (DPI), is a widely applied and low-cost inspection method used to locate surface-breaking defects in all non-porous materials (metals, plastics...). LPI is used to detect casting and forging defects, cracks and leaks in new products, and fatigue cracks on in-service components. /2/

### 8.4 Inspection steps

#### 1. Pre-cleaning

The test surface is first cleaned to remove dirt, paint, oil, grease or any loose scale that could either keep the penetrant out of a defect, or cause irrelevant or false indication. Cleaning methods may include solvents, alkaline cleaning steps, vapor degreasing or media blasting. The end goal of this step is a clean surface where any defects present are open to the surface, dry and free of contamination. /2/

#### 2. Application of penetrant

The penetrant is then added to the surface of the item that is being tested. The penetrant is then left to soak into any possible flaws. It generally takes about 5-30 minutes for the penetrant to soak into the material. The soak time depends mainly on the material that is being tested and the size of the flaws. Smaller flaws require a longer penetration time. /2/

#### 3. Excess Penetrant Removal

The overflow of penetrant is then removed from the part's surface. The removal method depends on what type of penetrant that has been used. Water-washable, solvent-removable, lipophilic post-emulsifiable or hydrophilic post-emulsifiable are the most common choices. If you are using a solvent remover and a lint-free cloth it is

very important that you do not spray the solvent directly on the surface because this might remove the penetrant from the flaws. /2/

#### 4. Application of developer

After that the overflow of penetrant has been removed from the surface of the material a white developer is applied to the sample. The developer draws penetrant from defects out onto the surface to form a visible indication. Any colored stains indicate the positions and types of defects on the surface under inspection. /2/

#### 5. Inspection

The inspector will use visible light with adequate intensity for visible dye penetrant. Ultraviolet (UV-A) radiation of adequate intensity (1W per centimetre squared is common), along with low ambient light levels for fluorescent penetrant examinations. Inspection of the test surface should take place after a 10 minute development time. This time delay allows the blotting action to occur. The inspector may observe the sample for indication formation when using visible dye, but this should not be done when using a fluorescent penetrant. Also of concern, if one waits too long after development, the indications may "bleed out" so that interpretation is hindered. /2/

#### 6. Recording of the measurements

After that the inspection has been performed the information from the test shall be gathered in some form of record. /2/

#### 7. Post cleaning

After an inspection the surface is often cleaned. As a final post-cleaning process, the developer coating can be removed with water, an air-liquid mixture, or in a liquid solvent immersion tank. Special care should be taken with materials that must be protected from corrosion /2/

## 9 MEASUREMENT RECORDS

All measurements that are gathered during a measurement of the main bearings and the camshaft bearings should be documented in a measurement record. A measurement record is a really important certificate and a document that is to give information about the measured object's dimensions and tolerances.

In addition to the result of the measurement the following information should also be found in the measurement record:

- Engine type
- Engine No.
- Installation (When measurement records are done on a ship)
- Dates and locality
- The name of the person who performed the measurements
- Temperature
- Component drawing number
- Engine running hour/ component running hour

In the measurement records for the alignment of the main bearing caps and for the camshaft bearing caps there is a table where the information gathered from the measurement is shown and from there you can see how the x-line and y-line are presented. From this it is very easy to see if the straightness of the bearings is within the tolerances. But just because the measurement is within the tolerances it is not certain that it is approved because if every single bearing is jumping from for example 10 to -10 (if the approved tolerances are for example  $\pm 10$ ) it is not really good because in that case the main bearing bore is quite crooked.

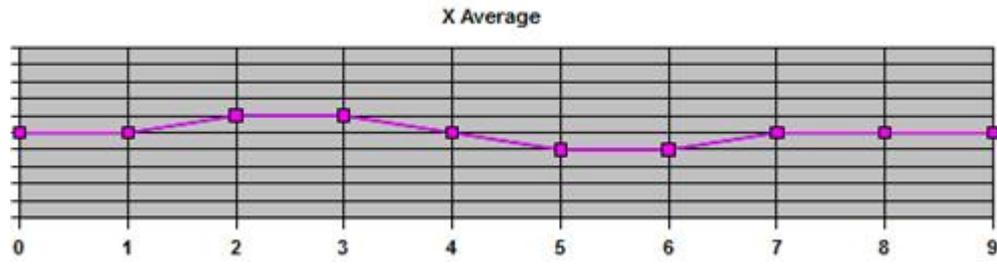


Figure 5. Good measurement

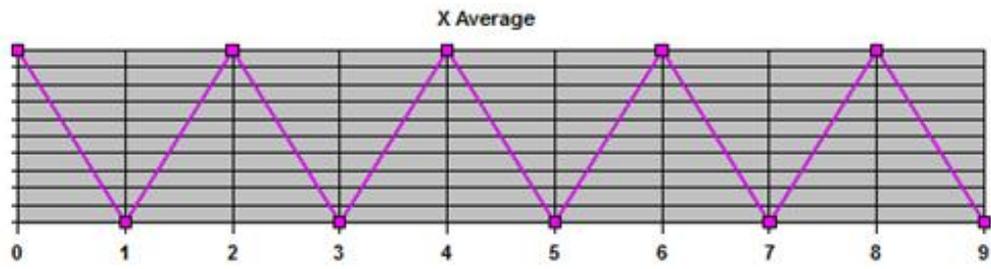


Figure 6. Bad measurement

## 10 SUMMARY

This work was really interesting and instructive. I have learned a lot about how to act when a hot run occurs on an engine, I have learned how the measurements are made and the difference between the various measurement tools. I have also acquired a lot of knowledge of the main bearing system. I have studied and gathered information from drawings and I have drawn a repair drawing in UGS NX 6.0.

I spent some time in the product factory to see how the measurements are made in real life, and I went for a 2-day course at Wärtsilä in how to use the new measurement tools that Field Service has acquired.

When I started with this Bachelor's thesis my knowledge about this subject was limited so I had to start by familiarizing myself with the work by studying some similar instructions and by studying the different measurement methods and the main bearings. During this work I have learned a lot about the things I have mentioned in this text but also a lot about other aspects of the engine.

Finally I would like to thank Wärtsilä for giving me the opportunity to do my Bachelor's thesis. I also wish to thank Mr. Niklas Donner, Mr. Curt-Erik Lindqvist at Technical Service and all the other people involved, including my supervisor Roger Nylund at Novia, for their help to make this work possible.

## LIST OF REFERENCES

- /1/ Easy Laser's Homepage  
[www.damalini.fi](http://www.damalini.fi)  
(Read 01.12.2009 – 15.04.2010)
- /2/ Liquid penetrant test  
Liquid penetrant test PowerPoint  
Wärtsilä Intranet pages  
(Read 24.03.2010)
- /3/ Magnetic particle test  
Magnetic particle test PowerPoint  
Wärtsilä Intranet pages  
(Read 24.03.2010)
- /4/ Rank Taylor Hobson's homepage  
[www.taylor-hobson.com](http://www.taylor-hobson.com)  
(Read 07.01.2010 – 15.02.2010)
- /5/ Rotalign's homepage  
[www.pruftechnik.com/](http://www.pruftechnik.com/)  
(Read 07.01.2010 – 15.02.2010)
- /6/ Sved Holger  
Mätteknikkompendum  
Novia University of applied sciences Intranet pages  
(Read 08.02.2010)
- /7/ Wärtsilä's homepage  
[www.wartsila.fi](http://www.wartsila.fi)  
(Read 15.12.2009)

## **APPENDICES**

Appendix 1 - Picture of the Service Letter

Appendix 2 - 3D picture of an engine block



**Draft X.X.2009**

## OPERATING INSTRUCTION

Services, Wärtsilä Finland Oy

Engine section	Engine type	Ref.	Date	Issue	Document No.	Page
00 Engine section	00000	WFI-5	00.00.0000	Draft	00.00.0000	1(4)

### Inspections procedures of engine block for WÄRTSILÄ® Vasa 22 engines

<b>Engine type</b>	This bulletin concerns all WÄRTSILÄ® Vasa 22 (22ABC, 22HF/MD) and Vasa 22/26 engines
<b>General</b>	The purpose of this bulletin is to give instructions for measuring and reconditioning actions of the main bearing caps/bores and the camshaft bores in case of a hot run.
<b>Inspection procedures</b>	<p>Different measurements are to be made to determine the condition of the engine block and related components.</p> <p>Following measurements should take place in case of a main bearing hot run</p> <ul style="list-style-type: none"> <li>• Straightness of the main bearing centre line</li> <li>• Diameter of the main bearing bores</li> <li>• Measuring of main bearing caps and engine block             <ul style="list-style-type: none"> <li>◦ Main bearing cap width.</li> <li>◦ Corresponding width of mating surfaces on the engine block.</li> </ul> </li> </ul> <p>Following measurements should take place in case of a camshaft bearing hot run</p> <ul style="list-style-type: none"> <li>• Straightness of the camshaft bearing centre line</li> <li>• Diameter of the camshaft bearing bores</li> </ul> <p>The inspection shall always start with that the test surface is prepared, with that means that it will be cleaned from grease, oil, rust and other particles that could interfere the inspection.</p>
<b>Crack detection</b>	It is recommended to perform the crack detection on all affected surfaces by using liquid penetrant testing method or magnetic particle testing method.
<b>Tools</b>	Typically used tools for measuring the main and camshaft bearing line bores are optical or laser tools. For bore and bearing cap measurements micrometers or cylinder dial gages are used.

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