

SCR Insulation Investigation

Wärtsilä Finland Oy

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BACHELOR'S THESIS

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Abstract

This thesis was made in cooperation with Wärtsilä Finland. The thesis covers, in detail, insulation work done on an exhaust gas system for a power plant. Issues have in the past surfaced, and an improvement in quality in the insulation work and proper documentation of the process were needed to update installation instructions. New insulation materials were also compared, and measurements were taken to potentially find a better insulation material than the one currently used.

In order to get a proper documentation of the insulation process, I have followed along in the factory as the insulation workers have worked on the selective catalytic reduction unit and other pipes that belong to the exhaust gas system. Photos were taken of the steps and discussions held with the workers to gain an understanding of the process in its entirety.

The result covers the different insulation wools tested and also compares the heat measurements both before and after a new kind of insulation paint that has never been used before by Wärtsilä was applied. The results chapter is presented with the help of images taken with a thermal camera.

Language: English

Keywords: insulation, selective catalytic reduction, SCR, wool, heat

EXAMENSARBETE

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Abstrakt

Det här examensarbetet har gjorts i samarbete med Wärtsilä Finland. Arbetet täcker, i detalj, isoleringsarbete som gjorts på ett avgassystem för kraftverk. Problem har tidigare dykt upp och förbättring av kvalitét av isoleringsarbete och en ordentlig dokumentation av processen behövdes för att kunna uppdatera installationsanvisningarna. Nya isoleringsmaterial har även blivit jämförda och mätningar har utförts för att potentiellt hitta ett bättre isolerings material än det som för nuvarande använts.

För att få en bra dokumentation över isolerings processen har jag följt med i fabriken då isoleringsarbetarna har arbetat på katalysatorn och andra rör som hör till avgassystemet. Foton har blivit tagna av de olika stegen och diskussioner hållna med arbetarna för att bilda en uppfattning om processen i sin helhet.

Resultatet går över de olika isolerings ullen som testats och här jämförs även värmemätningar som tagits både före och efter att en ny sorts isolerings färg som inte tidigare använts av Wärtsilä tillämpades. Resultats kapitlet presenteras med hjälp av bilder tagna med en värmekamera.

Språk: Engelska

Nyckelord: isolering, selektiv katalytisk reduktion, scr, ull, värme

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Abbreviations

Throughout this thesis, some abbreviations will be used; all of the abbreviations used will be compiled in a list here to make it easier to follow the text.

SCR Selective Catalytic Reduction

LFO Light Fuel Oil

HFO Heavy Fuel Oil

WT-% Weight percent

1 Introduction

The thesis has been done in cooperation with Wärtsilä. The thesis will cover the process of insulation work and compare different types of insulation material to each other. In the introductory chapter, I will discuss why this topic is relevant and explain the purpose of this study.

1.1 Background

In today's business world, cost reduction has become an important factor for organizations. By effectively managing and reducing costs, companies can optimize their resources, increase efficiency, and thereby achieve improved performance (Couto, Leinwand & Subramanian, 2023). By improving and streamlining workflows, as well as reducing product and production costs, the company achieves cost reduction.

By optimizing the manufacturing processes and constantly finding new ways to do things better and faster, the company remains competitive. In order to continuously improve the process, the company needs to identify and get rid of waste, both in terms of time and money (ATS, n.d). Kolosky (2024) writes that a company should constantly think of how it can improve production so that it does not run the risk of losing sales and stumble upon unnecessary production costs. By carefully analysing these things, the company can avoid stalling in the development and losing its competitiveness.

As the world becomes increasingly aware and interested in environmental impact, it is of high importance for companies to reduce their carbon footprint. By reducing the carbon footprint of the company, the reputation can increase, and the same goes for customer loyalty. Large companies have a significant impact on the environment, and their actions to reduce their carbon footprint are of high importance when it comes to climate change (Plan Be Eco, 2022).

Alberius (2024) writes that if you use appropriate insulation for the intended purpose, you can reduce energy consumption and therefore reduce carbon dioxide emissions. Even by making small improvements in the insulation process, companies can gain an advantage over their market competitors (Kaimann, 2017). The choice of insulation, therefore, has an impact on both the environment and the economy.

1.2 Aim

The main purpose of this thesis is to document the process of insulation work done on a selective catalytic reduction (SCR) unit and its connecting pipes in a way that has not been done before. This can then be used as a base of knowledge on how the insulation process should be done. The purpose is also to compare different kinds of insulation material to see which one works the best and should be prioritized for use.

The idea is that this would gather information in one place to turn to in order to do a good job when insulating the SCR module or connecting pipes that belong to the exhaust gas system. There have, in certain cases, been problems with insulation work before, and because of poor insulation work, the process has had to be remade, and this, of course, leads to an added cost when the faults are noticed, and work has had to be done twice.

1.3 Limitations

In this chapter, some limitations that have affected either the results of the study or the work itself will be presented.

1.3.1 Weather and measurement limitations

The most significant limitation of this study is the inconsistency of the weather conditions of the two days of measurement, which leads to it being very difficult to compare how well the heat-insulating paint has worked on the parts that were insulated. The first measurements that were taken before the paint was applied, we had an engine load of 100% running, and the ambient temperature was around 10 degrees Celsius. On the second measurement day, when the paint had been applied, we ran on only 10% engine load, and the ambient temperatures were just a couple of degrees Celsius. This was unavoidable as I had to wait for the workers that were assigned to paint the system to come and paint which led to the second measurement day being pushed later on into the year where colder ambient temperatures came along and also had to adjust the days when the engine was running and the fact that it was ran on different engine loads is not something I could affect. As a result of this limitation, the findings should be interpreted with caution, and further testing would be needed under consistent weather conditions in order to get a more accurate result.

1.3.2 Time constraint limitations

Another limitation of this study is related to the documentation of the insulation work done at JTK – Power in Vöyri. Due to time constraints, it was not possible for me to be present during every moment of the insulation process to follow along and document every detail. As a result of this, some steps might be less detailed.

1.3.3 Limitation due to delays

The final limitation of this study is that the system that was insulated at JTK Power was supposed to be installed at Wärtsiläs facilities much earlier than it actually was. This was due to the fact that the construction on which the system was to be installed had not yet been built because the concrete foundation could not be poured in the winter due to cold weather. This delayed the measurements by quite some time, and as a result of this other commitments got in the way of collecting measurements at times.

2 Company

The company Wärtsilä was established in the year 1834 and was in the beginning a company in the sawmill sector. Only later did Wärtsilä transition into a company focused on marine and energy solutions, and today the company is one of the global leaders in its market. Wärtsilä offers its customers a broad range of solutions when it comes to power plants with flexible choices of engines, which can also run on sustainable fuels. The marine sector of the company is also able to offer its customers a huge variety of solutions when it comes to engines and technologies. On top of providing services for the energy and marine sector, Wärtsilä can also offer services for the entire lifecycle of its power plants and marine solutions (Wärtsilä, 2025a).

Sustainability plays an essential role in Wärtsilä, both on the marine and energy side of the company. As a leading company in both sectors, renewable energy and decarbonisation are of utmost importance when it comes to the solutions provided by the company, and Wärtsilä is constantly working on finding energy-efficient green solutions and innovations. Focus lies heavily on finding new innovative technologies with the purpose of lowering emissions for its customers. Recently, Wärtsilä has started working on new types of engines that run on methanol and ammonia to reduce the amount of greenhouse gas emissions. Replacing fossil fuels with these types of solutions will ultimately lead to decarbonisation (Wärtsilä, 2024b).

Wärtsilä operates in over 230 locations and 77 countries worldwide. At the end of 2024, Wärtsilä employed more than 18 300 people across the globe. In the year 2024, the company had a net sale of 6,4 billion euros, with 33% of this coming from Europe, 28 % from the Americas, 26 % from Asia, and 13 % from other parts of the world (Wärtsilä, 2025a).

3 Theoretical framework

In this chapter, some basic theory about the insulated system will be presented, as well as the theory on the material used in the insulation process.

3.1 Selective catalytic reduction

A selective catalytic reduction module is a system that reduces emissions from the exhaust gases that the engines produce. The unit uses a reducing agent in order to get rid of nitrogen oxides from the exhaust gas. The reducing agent usually consists of a urea water solution, but can also, in some cases, consist of an ammonia water solution. The reducing agent is added with the help of a dosing unit into the mixing duct before the SCR module itself, and the exhaust gases then react with the reducing agent inside the SCR module on the catalyst elements that can be found stacked inside. The result of this chemical process is that nitrogen oxides are turned into water and molecular nitrogen. The unit itself needs to be installed close to the engine before any systems that recover heat are installed. This is because the SCR needs to maintain the heat in order for the chemical reduction process to be successful (Wärtsilä, 2021a). An overview of the SCR system can be seen in Figure 1.

In order to determine how much reducing agent needs to be used to lower the emissions, a control system is used. A measurement point that measures the nitrogen oxide levels is located downstream of the SCR unit, and this measurement point then sends a signal to the control system about the levels, and the reducing agent is automatically adjusted when needed (Raudaskoski, 2021).

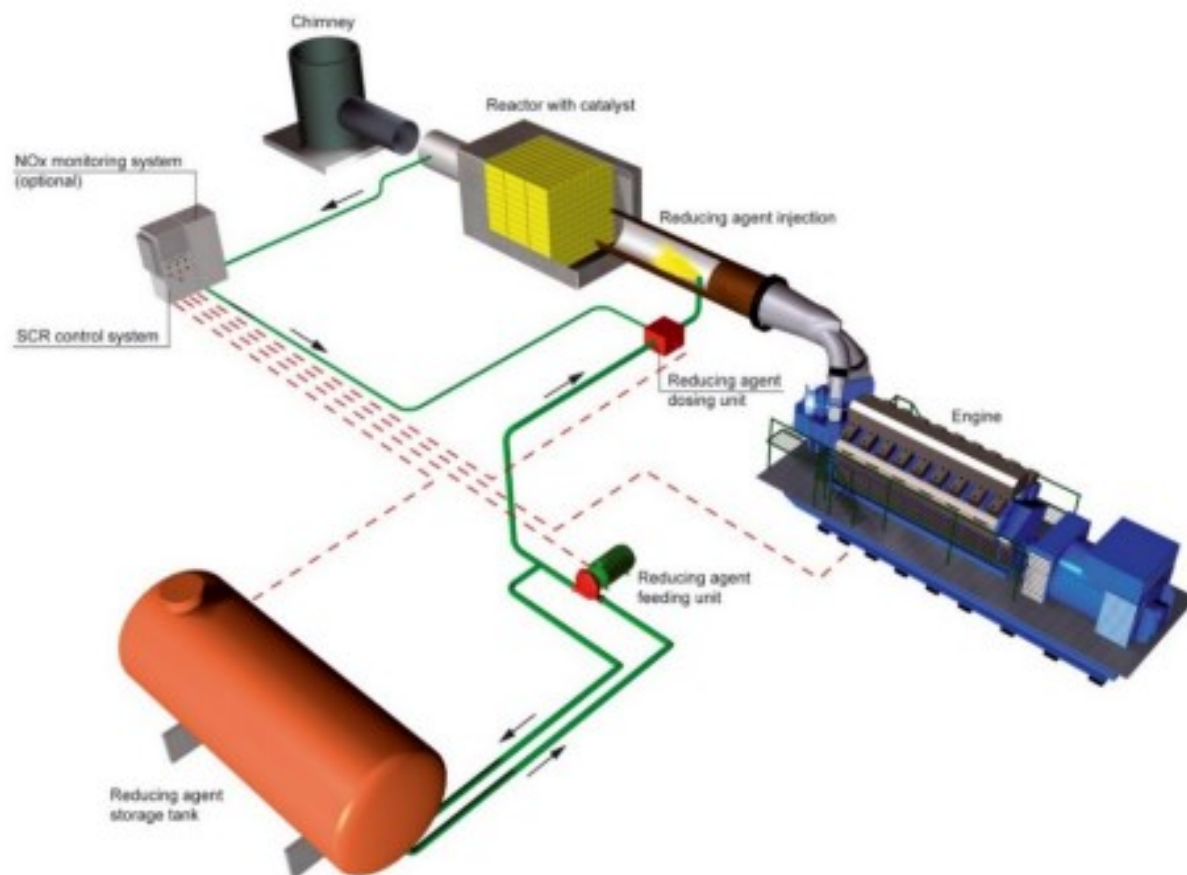


Figure 1. Overview of the SCR system (Raudaskoski, 2021).

The catalyst elements inside the reactor housing are normally installed in at least 2 layers and can, in some cases, be installed in even more layers. The normal way to install the catalyst elements is from the side through doors in the reactor housing. A side-loaded SCR can be seen in Figure 2, but it is also possible to install the elements from the top of the reactor, depending on the model of the SCR. It is very important that the catalyst elements are not installed before the engine's first smoke, this is because otherwise, dirt will clog up the catalyst elements if the system is not allowed to be burned clean beforehand (Raudaskoski, 2021).



Figure 2. An image of a side-loaded reactor. Photo by author, 2023.

The temperature inside the pipes for the SCR process to be successful depends on the fuel type used.

3.2 Materials used in insulation work

Insulation of the exhaust gas system was done at JTK Power by workers from Vaasan Lämpöeristys, and it was later installed at the rooftop of Wärtsiläs test site in Vaskiluoto, Vaasa, in test cell 8. In this chapter, the different insulation materials that were used in the insulation process will be described.

3.2.1 Wool

Stone wool is a good insulation material because it is durable, energy efficient, reusable, safe, moisture-proof, fire-safe, and sound-reducing. The material is known to be easy to install and maintains its good attributes in different weather conditions. Stone wool is an excellent material to use in power plants due to its fire-safe qualities, such as being a non-combustible material that protects from fire in up to 1000 °C (Paroc, n.d).

The wool that was used in the insulation of the SCR module in this case was PAROC Pro Wired Mat 680 AL1, which is a stone wool mat with an aluminium foil and a wired net. This wool has a density of 100kg/m³ (Paroc, 2023). An example of the stone wool used for the SCR module can be seen in Figure 3.

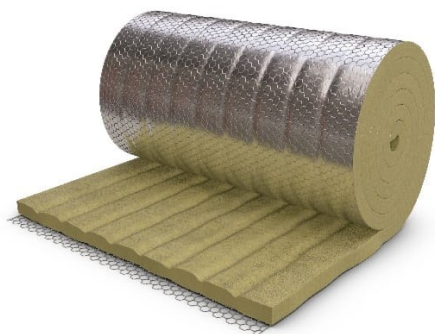


Figure 3. The stone wool used in the insulation of the SCR module (Paroc, 2023).

As one of the main objectives of this thesis is to compare different kinds of insulation wools, a few other wools were also used, but in the exhaust gas duct for easier comparison. The duct that is connected downstream from the SCR module was then divided into 4 different sections of insulation material. The first part of the duct was insulated with the same wool as the SCR, Paroc Pro Wired Mat 680 AL1, with a thickness of 100 mm and a density of 100 kg/m³. The second part of the duct was insulated with a much less dense glass fiber wool with a thickness of 50 + 50 mm. The third part of the duct was insulated with the same insulation material as the first part, but with a thickness of 50 + 50 mm. The fourth part of the duct was insulated with the most commonly used wool for insulation of exhaust gas piping, Paroc Pro Wired Mat 660 with a thickness of 100 mm and a density of 80 kg/m³.

3.2.2 Support structures

In order to more easily install the cladding on the SCR module, support structures are needed all over the SCR frame; these can be seen in Figure 4. These supports are welded to the frame of the module and are there to better keep the insulation in place and to have something to attach the cladding to.



Figure 4. Two vertical support structures are seen welded in place. Photo by author, 2023.

3.2.3 Fiberglass tape

To avoid heat discoloration on the cladding, fiberglass tape needs to be used on the area of the support structures that come in contact with the cladding; an example of such a case can be seen in Figure 5. The fiberglass tape acts as a thermal break between the cladding and support structures, which also leads to lower surface temperature on the cladding itself (Wärtsilä, 2021b).



Figure 5. Fiberglass tape attached to the support structure. Photo by author, 2023.

3.2.4 Cladding

The cladding's main function is to cover the insulation from rain and dirt; it also gives the insulated parts a cleaner look. The cladding is usually made out of aluminium, but can in some cases also be made from galvanized steel or stainless steel. When insulating exhaust gas pipes and units that belong to the exhaust gas system, such as the SCR, the thickness of these sheets needs to be at least 1mm; the sheets are, in most cases, 1m wide (Wärtsilä, 2021b).

An important thing to remember when installing the cladding is to have the sheets of metal overlap each other and to remember to bend the edges on the sheet lying on top towards the one on the bottom. This is an extremely vital part of the cladding installation, as this stops the wind from penetrating between the metal sheets and ripping them apart. Also, vibrations and heat expansion when the engine is running can cause the same effect. Failing to follow this method of installation will most likely mean that some of the cladding will start coming loose in strong winds or due to expansions/vibrations, and the cladding needs to be reinstalled. Sharp sheets of metal flying away in the wind can also pose a threat to human injury.

When installing the cladding on top of a flat surface, such as the SCR, it is also very important to be aware of the final position where the SCR will be installed. If the SCR is to be installed outdoors without any sort of cover from the rain, the cladding itself needs to be installed at an angle so that rainwater can run off it smoothly. If this is not followed, it will most likely lead to rainwater finding its way in between the sheets of metal and ruining the wool underneath. If this happens, the effects of the insulation are ruined, and the system will not work as intended, nor will it be as safe as it should be, so the insulation has to be redone.

3.2.5 Wool pins

To better keep the insulation wool in place, wool pins are used. These pins are thin metal pins welded to the frame of the reactor and can be seen sticking up from the wool in Figure 6. The idea is that these pins would be easy to bend so the wool can be pierced right through, and the pins can then be bent down to keep the wool in place. The pins are to be welded all over the reactor frame at suitable gaps.



Figure 6. Wool pins sticking up through the wool, at this stage, the points of the pins will be bent down back into the wool. Photo by author, 2023.

3.2.6 Rivets/Screws

In order to keep the cladding in place, blind rivets are commonly used. The size of the blind rivets used for the exhaust gas system should be 4,8 x 12 mm. Smaller sizes of rivets have been used in some cases previously, but this was found to be damaging to the insulation work as the smaller rivets did not hold the cladding in place well enough and the metal sheets started coming loose. It is also important to note that the rivets need to be connected with the support structures behind the cladding itself to properly stay in place. If the rivets only go through the cladding sheets, the rivets may come loose. Screws can also be used in places where the cladding might have to be removed temporarily.

3.2.7 Heat-insulating paint

As a last bit of experiment, a heat-insulating paint was used. This is new for this kind of solution for Wärtsilä and could be something considered for other projects in the future. The paint that was used is called Geve Therm Safe, made by a Finnish company called GVK. The paint was applied by spraying in multiple layers until a paint thickness of 1mm was reached. The thicker the layer of paint is, the lower the surface temperature becomes. There comes a point, however, where there is no longer worth making the layer thicker; this should be calculated if to be used in future projects.

Geve Therm Safe is a waterborne dispersion-based paint meant to insulate a surface so that contact does not burn the skin. The paint is meant for industrial use both outside and inside, for insulating pipes and indoor engines, for example (GVK, n.d).

According to EN ISO 13732-1 standard, the temperature for a hot and smooth surface made of uncoated metal should be according to Figure 7 below. The allowed temperature depends on how long contact is made with the surface, and as can be seen, the maximum temperature allowed is 59 degrees Celsius for 10 seconds of contact in order to avoid burns. The idea is that the heat-insulating paint would be able to lower the surface temperature for parts of the system that are just above the safe surface temperature to lower it to a safe level (EN ISO 13732-1).

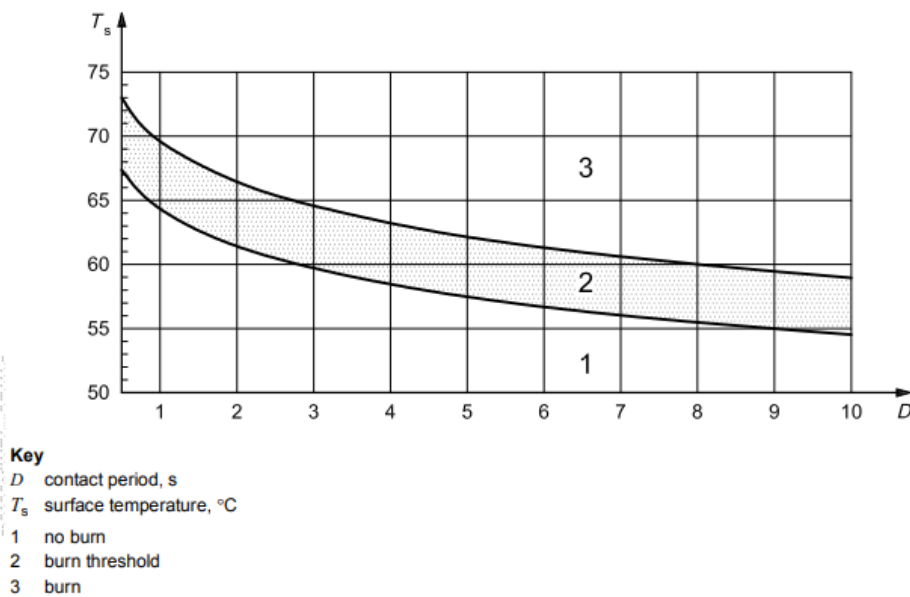


Figure 7. Graph taken from EN ISO 13732-1 standard that explains the burn threshold for skin contact with a hot uncoated metal surface.

On top of helping with lowering the temperature of the surface, this paint also gives a clean look for pipes sprayed, as can be seen in Figure 8. It also helps with a previously mentioned problem; it acts as a glue of sorts and stops winds from blowing in between where the cladding sheets overlap. Movements in the cladding due to heat expansion can affect this if the paint starts to crack up where the sheets of metal overlap, which would lead to winds once again making their way in between the cladding.



Figure 8. The exhaust gas duct here is seen spray-painted with Geve Therm Safe heat-insulating paint. Photo by author, 2024.

4 Methodology

In order to create a base for the installation instruction, some key details need to be looked at. Different types of insulation materials will be compared, and heat temperatures will also be compared on the different materials to figure out which one works the best. Containing the heat within the SCR is of very high importance both in order to prevent human injuries and to prevent fire hazards; the SCR itself also needs to maintain the heat within itself in order to function as intended. Other details of the insulation that need to be looked at are cladding material, support structures, and smaller parts such as pop rivets and wool pins to keep the insulation and cladding in place.

To gain insight into this project, I first of all went to JTK Power in Vöyri to watch the insulation workers from Vaasan Lämpöeristys insulate the SCR and other pipes that belong to the exhaust gas system. Down below, I will give a short introduction to JTK Power and Vaasan Lämpöeristys and explain the process of gathering the information.

4.1 JTK Power

JTK Power is an engineering company with its manufacturing facilities in Vöyri and Isokyrö in Finland; these municipalities are close to Vaasa. JTK Power is a part of JTK Power Group, which has production facilities in Finland, Estonia, and China with over 200 employees. The company focuses on producing steel solutions for the leading companies in the world in the building trade, power plant sector, marine and mining industries, and logistics.

They manufacture silencers, valve seat inserts, shelter equipment, welded structural solutions, and provide mechanical and acoustic consulting services. Wärtsilä is mentioned on its website as one of the major customers (JTK Power, n.d).

4.2 Vaasan Lämpöeristys

The company Vaasan Lämpöeristys Oy specializes in industrial insulation and air conditioning installations in Ostrobothnia, Finland. In addition, they manufacture heat-resistant insulation pillows and sheet metal products. Their clients include the public sector, as well as the industrial and construction sectors (Vaasan Lämpöeristys Oy, n.d).

4.3 Timeline and process of gathering information

The insulation work was done in December 2023. I visited the factory multiple times to follow along with the work that was done and document each step of the process, and take pictures of the steps taken. This is explained above in the theory chapter.

Once the insulation work was completed, a longer break was needed in the project because the platform on which the SCR module would later be installed had not yet been built. The system was eventually installed in June 2024, but with the vacation period having just started, the test run had to be delayed. There were also some finishing touches to the insulation that needed to be done after installing the pipes and modules in their correct place. Insulation and cladding of areas connecting 2 different parts of the system, for example, had to be done after the different parts had been bolted together. This work took place in early September 2024.

After all the insulation work had finally been finished up it was time for the test running of the engine, which also meant that heat measurements could be taken to see how well the different insulation wools compared to each other. For this, a thermal camera was used to identify hot spots on the metal sheets; more about this in the following chapter and in the results chapter further down.

As a final bit of experimenting with this, it was decided that a couple of layers of heat-insulating paint would be sprayed on the exhaust gas duct to compare temperatures and see if this is something that could be used in projects in the future to further lower surface temperatures of pipes where human access is a possibility. This work was done in the last few days of October 2024, where painters were hired to wash the cladding before applying a layer of paint primer and two layers of Geve Therm Safe heat-insulating paint to the exhaust gas duct.

Following this, new heat measurements were taken to showcase the differences with and without the layer of paint. Again, the same thermal camera was used, and the results of this experiment will be showcased further down in the results chapter.

4.4 Thermal camera

In this project, a ThermaCAM from Flir Systems has been used to get heat measurements from the SCR and surrounding pipes. A thermal camera is simply a sensor that, by identifying infrared radiation, senses the temperatures of an object and converts it to a picture, which then shows the differences in heat over the object. A thermal camera can sense very small differences in temperature, and is, because of this, a good tool when a precise result is wanted. The thermal camera can see things that regular cameras and our eyes can not even see. This makes the areas where such cameras can be applied enormous. Thermal cameras are used today in a wide range of industries and research (Teledyne FLIR, 2020).

As previously mentioned, the thermal camera creates images where temperature differences of an object are displayed, and these are made visible by different colours with their respective values. This makes it easy for us to read the temperature differences. A picture of the temperature differences and the order in which they occur can be seen in Figure 9. Darker colours such as blue and purple usually indicate that the area is on the cooler side. Bright colours, for example red and orange, show warmer temperature areas. Between the Darker and Brighter colours, we can also see green and yellow, which indicate the middle temperatures (Accurate Sensing Technologies, 2023).



Figure 9. Description of the thermal cameras' colour scheme (Accurate Sensing Technologies, 2023).

5 Results

In this chapter, pictures from the thermal camera will be displayed with an explanation of each one regarding which stage the picture was taken in and which kind of insulation wool belongs to that picture. The result that will be presented here is to be taken with a grain of salt, as the conditions between the two measurement days are not very similar at all. The first pictures taken before the insulating paint was applied were during 100% engine load, while the second pictures taken after the insulating paint was applied were during 10% engine load. Furthermore, the pictures taken before painting of the exhaust gas duct were taken earlier in the year with ambient temperatures above 10 degrees Celsius, while the pictures after painting of the exhaust gas duct were taken with significantly lower ambient temperatures of just a few degrees Celsius. This was an unfortunate effect of timing, but one that could not be helped.

To actually see how well the insulating paint that was used works, a picture of an uninsulated lifting hook has also been photographed before and after painting it. The pictures taken of this hook were taken on the same day, the day of painting, so the conditions for this were the exact same and can therefore be seen as accurate. The second picture, taken after painting, however, is taken after only one layer of paint had been applied, so the temperature drop off would be even greater after a second layer of paint had been applied.

As a quick explanation on how to read the pictures presented below, there are two things to keep in mind. The temperature measured in a precise spot is shown in the top left corner of the pictures. This might not be the highest temperature found in each part, as the small red triangle in the middle of each picture jumps around while taking the picture to try and find the warmest part. As can be seen on the right side of the picture, there is a colour scale which also shows the highest and lowest temperatures found in the picture. It is therefore in certain pictures more accurate to look at the right side to see what the warmest temperature actually is.

5.1 Heat measurement taken before heat-insulating paint

In this chapter, heat measurements taken before the heat-insulating paint was applied will be presented on the different insulation materials and on a lifting hook that was not insulated at all with any kind of wool.

5.1.1 First layer – 100mm stone wool with aluminium foil

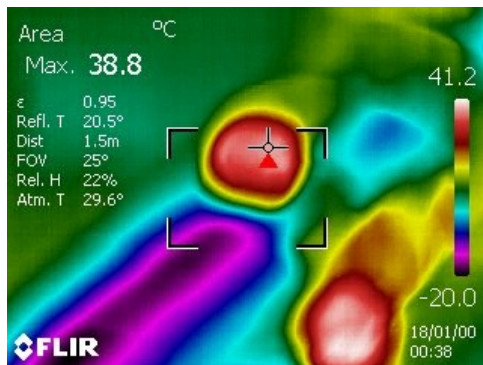


Figure 10. Photo by author, 2024.

The above Figure 10 is taken of the exhaust gas duct and specifically in the part that had been insulated with Paroc Pro Wired Mat 680 AL1, with a thickness of 100 mm; the density of this wool is 100 kg/m³. The warmest identified temperature that can be found is around 41 degrees Celsius; this looks to be an excellent insulating wool, as the temperature is not close to levels that can be dangerous to human contact.

5.1.2 Second layer – 50+50mm glass fiber wool

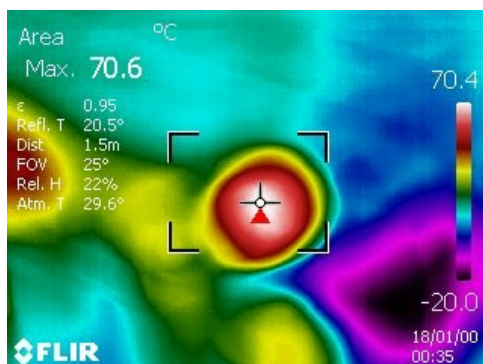


Figure 11. Photo by author, 2024.

The next wool that was compared is the glass fiber wool, with a much lower density than the stone wool used in other parts of the exhaust gas duct. As can be seen in Figure 11, this wool lets through more heat, with the warmest temperature found in this part of the pipe being around 70 degrees Celsius. This temperature is posing a risk for human injury if one were to come in contact with the cladding.

5.1.3 Third layer – 50+50mm stone wool with aluminium foil

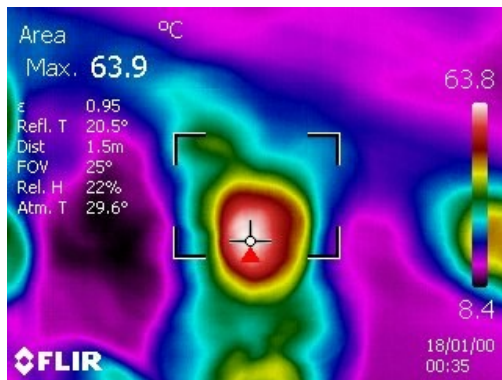


Figure 12. Photo by author, 2024.

The third part of the pipe, as previously mentioned, was insulated with the exact same wool as the first part, the Paroc Pro Wired Mat 680 AL1, but this time in two layers, with each layer being 50mm thick. The warmest temperature identified in Figure 12 on this part of the pipe is just below 64 degrees Celsius, which is also a bit too warm if human access is a possibility.

5.1.4 Fourth layer – 100mm stone wool

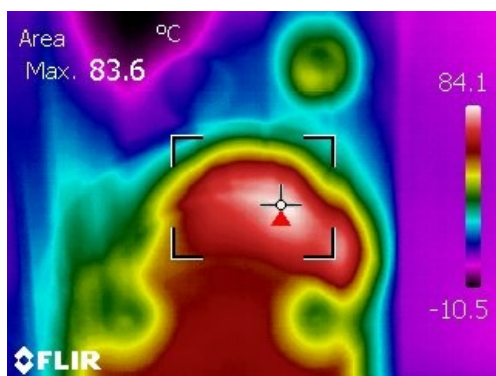


Figure 13. Photo by author, 2024.

The final part of the exhaust gas duct was insulated with Paroc Pro Wired Mat 660; this wool has a density of 80 kg/m³. This wool is also the one that is most commonly used when insulating these types of pipes. As Figure 13 shows us, there looks to be a spot where the temperature rises to just above 84 degrees Celsius in this part of the pipe. This sounds high, but it is important to remember that these temperatures do not necessarily need to be 100 % accurate; a tiny hole or the wool having been pushed aside in a certain part of the insulation could result in higher temperatures in certain spots. The measured temperature is, however, too high to be deemed safe where access is needed.

5.1.5 Uninsulated lifting hook

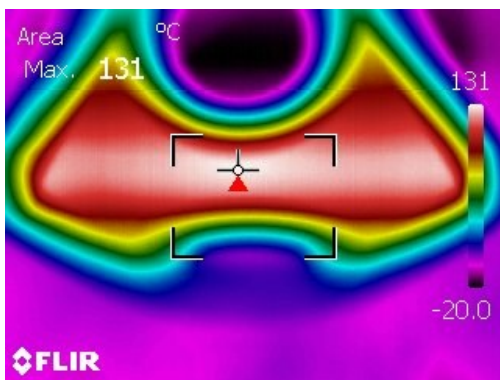


Figure 14. Photo by author, 2024.

Figure 14 above is of an uninsulated lifting hook meant to be accessible when lifting and mounting the exhaust gas duct in place with a crane. This is therefore a measurement of the steel without any type of wool or cladding to protect it. The warmest temperature measured was 131 degrees Celsius, which was measured when the engine was running on only 10 % load, so even hotter temperatures would be measured with higher engine loads.

5.2 Heat measurement taken after heat-insulating paint

Below will be presented new heat measurements that were taken after the heat-insulating paint was applied on the exhaust gas duct, where the four different wools were located. A heat measurement of the uninsulated lifting hook will also be presented after one layer of Geve Therm Safe heat-insulating paint.

5.2.1 First layer – 100mm stone wool with aluminium foil

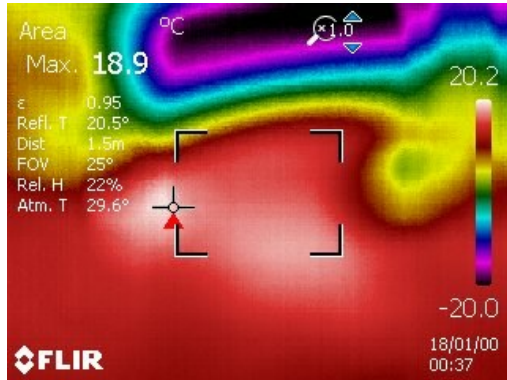


Figure 15. Photo by author, 2024.

After one round of painting, the highest temperature found in the first part of the exhaust gas duct was much lower. Before painting, the temperature measured was around 41 degrees Celsius, and after painting, the highest temperature we can see in Figure 15 is around 20 degrees Celsius. As previously mentioned, though the conditions between the two days of measuring were not similar.

5.2.2 Second layer – 50+50mm glass fiber wool

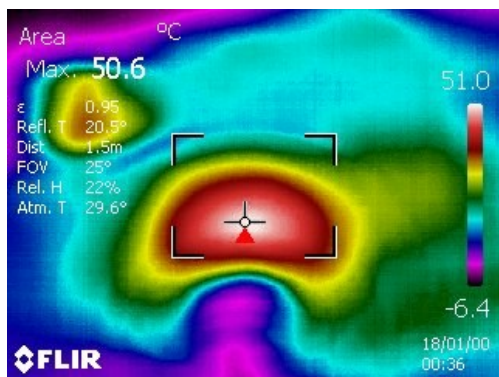


Figure 16. Photo by author, 2024.

The part of the pipe insulated with the glass fiber wool also sees lower temperatures after the first round of paint is applied to the cladding. The first measurement before the paint was around 70 degrees Celsius, while the second measurement taken after painting shows a temperature of just under 51 degrees Celsius in Figure 16.

5.2.3 Third layer – 50+50mm stone wool with aluminium foil

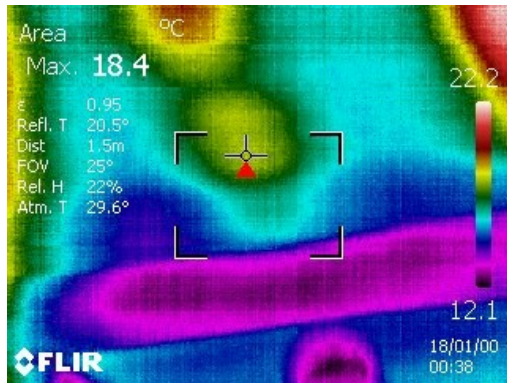


Figure 17. Photo by author, 2024.

This part of the pipe, where the same wool was used as the first part, sees a significant decrease in temperature from just under 64 degrees Celsius before painting to around 22 degrees Celsius after painting, visible in Figure 17. Once again, this big drop-off is most likely due to the conditions being different on the two days the measurements were taken.

5.2.4 Fourth layer – 100mm stone wool

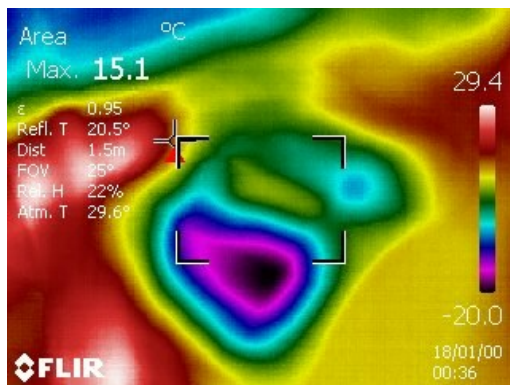


Figure 18. Photo by author, 2024.

The fourth part of the pipe also sees a significant drop in temperature from the previously measured 84 degrees Celsius before painting to just above 29 degrees Celsius after painting seen in Figure 18. As previously mentioned, the part to look at in the picture is the measurement value on the right instead of the one on the left of the picture, as this is a good example of where the small red triangle has not managed to find the warmest spot of the area.

5.2.5 Lifting hook with one layer of heat-insulating paint

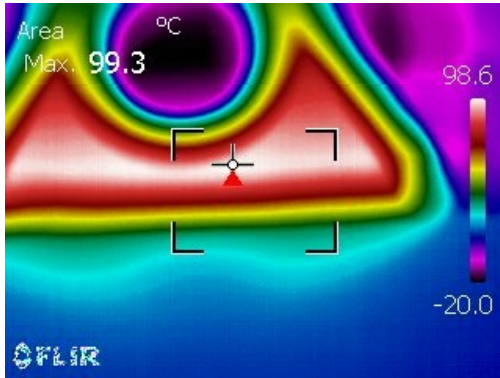


Figure 19. Photo by author, 2024.

Of all the measurements taken, this is by far the most important one to look at for an accurate result; both the above Figure 19 and 14 further up were taken on the same day with the same engine load and ambient conditions. After only one layer of heat-insulating paint, the measured temperature has dropped from 131 degrees Celsius to around 99 degrees Celsius. This is, of course, still too high a temperature if human access is possible in this area; however, a second layer of paint would drop the temperature even more and possibly even to safe levels. This example, if nothing else, shows that the paint has an effect on the heat values of not only the uninsulated lifting hook but also most likely on the cladded areas themselves.

6 Conclusion

Heat-insulation of exhaust gas systems are as we have learned of high importance, both because of safety reasons to avoid injuries or risk of fire, and because of making sure the heat remains inside the system, ensuring that modules that need to be at a specific temperature work as intended. This is why constantly improving ways of working and properly documenting and updating instructions are vital for the company to stay on top of things and remain competitive. Hopefully, this thesis has managed to gather some information about the insulating process that could be used to update existing installation instructions with the aim of improving their quality.

It is unfortunate that the results of the heat measurements can not really be trusted due to previously explained reasons, with different conditions during the two days of measuring. We can, however, see the differences between the different insulation wools during the same days of measurements to get an idea of which ones are the best insulating ones. Looking at the results of the heat measurements taken before the heat-insulating paint was applied, it looks like the 100mm thick stone wool with a density of 100 kg/m^3 and with a layer of aluminium foil has worked the best. This wool, along with the other two stone wools used, was also, according to the workers who insulated the entire system, the easiest one to handle, while the experimental glass fiber wool was, according to them, a lot harder to install because it was so loose and airy.

On the upside, the heat measurements of the lifting hook that were taken on the same day before and after painting of the system are quite accurate, and it also shows us that it has worked very well. Perhaps this heat-insulating paint could be used in the future by Wärtsilä in certain instances where problems with heat containment have been an issue or in areas where pipes are too hot to be deemed safe.

6.1 Future research suggestions

As there seem to have been a lot of issues with insulation in previous projects, and the way of working with this insulation of different systems at the moment seems to be that everything is insulated when the pipes are already mounted at the site, I would suggest doing what we did in this project and have all the equipment insulated in a workshop before delivery. Doing the insulation in a workshop before delivery, I would assume, is both faster

and cleaner with no influence from weather conditions. Things that need to be considered with this are what the difference in pricing would be and logistical differences, and how to get the equipment that has been insulated delivered without damaging the insulation, for example.

If a change in wool is to be considered, I would also suggest that further research and heat measurements are to be made, as the results in this thesis might not be very accurate. In order to get the best results, I would suggest taking the measurements on a smoother area with less structural steel scattered around under the insulation wool, as this most likely has affected the results for some of the wools in my measurements.

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