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Student Thesis

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CE marking of a lifting beam

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Abstract

Rotork is a company stationed in Falun municipality, Sweden and manufactures electric valve actuators. This thesis will investigate one of their lifting beams used in daily production. Although already being used for more than 10 years, it is still not yet CE market which is necessary for it to be used legally. The purpose of this thesis is to investigate how the lifting beam complies with the existing directives, laws, and standards and provide a basis for CE marking. A six-step method for CE marking was decided as useful to fulfil the aims of this thesis. This method includes everything from identifying applicable directives and standards, relevant tests, documentation and a procedure to CE mark the product.

The results show that the lifting beam shall indeed be regarded as a machine by the definition provided in the Machine directive 2006/42/EG and should therefore follow its requirements as well as the Swedish version of the Machine directive, AFS 2008:3. To verify which paragraphs of AFS 2008:3 the lifting beam complies with, does not comply with or are not relevant a risk analysis was performed. In order to interpret the meaning of the paragraphs in AFS 2008:3 and its appliance, a relevant standard for lifting beam was chosen which in this case was SS-EN 13155+A2:2009. The results of the risk analysis show that the lifting beam lacks in two areas, the technical documentation which needs to be completed and further tests of the mechanical constriction are needed for the lifting beam to finally be CE marked.

Key words:

Lifting beam, CE marking, Rotork, Rejlers

Preface

I would firstly like to give thanks to God. I would also like to thank all my family and friends for being there for me and believing in me. I also want to thank all the teachers at Dalarna University especially Mats Andersson for his excellent work as a supervisor, Sarah Ramsay and finally to the examiner Dr. Roger Johansson. Special thanks goes to Machine Safety Specialist Erkki Pallin and everyone else at Rejlers and Rotork for their tremendous field experience which was a big support in this thesis. Lastly, I would like to thank the Student union for my time there as a member of the board.

Table of Contents

Contents

Abbreviations and Concepts

Abbreviations	Description
AFS	Arbetsmiljöverkets författningssamling
CE	Conformité Européene
DOC	Declaration of conformity
EEA	European Economic Area
EFTA	European Free Trade Association
EU	European Union
FEM	Finite Element Method
FMEA	Failure Modes and Effects Analysis
MWL	Maximum Work Load
RTL	Rotork Test Load
SIS	The Swedish Institute for standards

1 Introduction

European companies produce many new products every day. The task of producing a product is far from focused solely on customer satisfaction or needs, another important factor is how the product itself is produced and what kind of risks it may bring for the user. Although this can be regulated by national law, international trade and an ever more globalized economy pose problems since national laws can differ from country to country. With the creation of the European Union (EU) free trade became a key concept, thus the solution to this problem became a common Conformitè Europëenne (CE) marking for products inside the EU including countries within the European Economic Area (EEA). This means that products both used and sold must comply with several requirements specific to that product. These requirements are mentioned in directives and over 20 different directives are existing. The first use of CE marking was in June 1989 and has continued to be used for most products circulating the EU since then (Lin, Chen & Chen, 2005).

This section will describe a brief background of the problem, the goals of this thesis work, limitations of the thesis work and a general structure of the report.

1.1 Background

Rotork AB is a British international market-leading company that manufactures flow control products such as actuators, gearboxes, instrumentation and control, and valve accessories. The history of Rotork began in 1945 as a small engineering company and has steadily expanded since then (Rotork, 2021). One of their factories is situated in Falun municipality, Sweden, and this thesis focuses on a lifting beam that was manufactured and has been already in use for 10 years to lift valves in their daily production line. Rotork has outsourced the CE marking of the lifting beam to a technical consulting services company known as Rejlers. The author has carried out this thesis work for Rejlers.

The lifting beam poses a risk for the user since it is not yet CE marked and should not be used legally. The lifting beam must therefore obtain the CE marking as soon as possible. Since there exist over 20 different directives, it is important to figure out which directive is relevant for this specific lifting beam and further investigate what is needed to be done for it to be CE marked.

Each directive covers a wide variety of products, and some products might also have to follow the requirements in several directives at the same time. For example, the machine directive covers a range of products that are defined as machines ranging from simple drills to advanced computer numerical control routers. Other directives like the Electromagnetic Compatibility (EMC) Directive ensures that electronic products do not admit or is damaged by electromagnetic waves. Products fulfilling these requirements are physically marked with a CE label which functions as visible proof. This label must be clearly visible for both the users and the potential buyers of the machine so that they are well informed about the condition of the product. There are many types of lifting attachments and the lifting attachment investigated in this thesis is referred to as a lifting beam by Rotork. Other lifting attachments are lifting clamps which secures the load using clamps, the C-hook lifting attachment which instead secures the load by hanging it on the hook.

1.2 Problem description

Since the lifting beam is not yet CE marked but still used in the daily production this may seriously risk the safety for the user and Rotork might also run the risk of receiving fines (European Commission, 2019). It is therefore crucial that this matter will be investigated. The research questions are thus:

- What requirements are there for Rotork's lifting beam to be CE marked?
- What needs to be done for the lifting beam to be CE marked?

1.3 Aims and objectives

The thesis aims at investigating what needs to be done for the lifting beam to be CE marked and provide a plan and a base for it.

1.4 Limitations

There are both technical and physical limitations involved in this thesis work. The limitations are as follows:

- This thesis will cover regulations specifically relevant for the lifting beam made by Rotork and can be generally used for similar.
- The focus of this thesis is to provide a basis for CE marking of the lifting beam meaning this thesis alone is not enough for the lifting beam to be CE marked.
- Certain directives can only be investigated by the manufacturer. This will not be analysed in this thesis work and should instead be done by Rotork.
- Requirements that the lifting beam already fulfils or is not applicable will not be discussed in detail as the focus is on the requirements that the lifting beam does not fulfil and what ought to be completed.
- Some work towards CE marking such as an incomplete instructions manual has already been carried out by Rotork and will not be reviewed by the author.
- Some steps for CE marking cannot be fully completed that requires access to lifting beam because of Rotork's COVID-19 policy which restricts visitors to enter.

1.5 Report structure

This section describes the overall structure of the report and explains the details of each chapter.

Chapter 2 - Rotork's lifting beam

This chapter presents Rotork's lifting beam that will be investigated in this thesis. It gives details of its nomenclature, dimensions and description of the lifting beam. It also presents some of the relevant loads the lifting beam is subjected to.

Chapter 3 – Theoretical Framework

This chapter presents multiple sections of theoretical backgrounds involved in this thesis work. It presents general standards and directives relevant for the lifting beam. It also describes different studies used currently for CE marking which will be partly referred to in this thesis work.

Chapter 4 – The six-step method

This chapter presents a detailed methodology that will be used to fulfils the aim of this work. It also evaluates its credibility of the expected results.

Chapter 5 – Results of the six-step method

This chapter presents the individual results of each step of the six-step method. It will provide relevant standards and directives and a basis for the CE marking of the lifting beam.

Chapter 6 – Analysis of results

This chapter provides an analysis of the results in connection with the theoretical framework and evaluates the aims of the thesis work as to how far they have been achieved.

Chapter 7 – Conclusions and Discussion

This chapter provides a brief description of the goals and the obtained results of the work. It discusses the results and the theoretical framework and concludes what has been done for CE marking the lifting beam.

Chapter 8 – Future work

This chapter provides information about how this thesis could be used for completing the CE marking. It will also describe the path forward Rotork shall take to complete the CE marking.

2 Rotork's Lifting Beam

The lifting beam used to lift valves is V-shaped and has a loop where a hook is mounted manually and on the extreme ends there are screws that can be attached to the valve. The valve is then lifted and moved with a traverse where the total time of the lifting cycle is about 10 seconds. Tests have already been carried out by Rotork where the lifting beam has been subjected to a load of 195 kg during a load cycle of 25 times, with no visible plastic deformation seen. However, no risk analysis has been done which means the risks of using the lifting beam have not been investigated in detail and the instructions manual was not completed.

Rotork has already begun the process of CE marking the lifting beam. Already existing is for example an incomplete instructions manual presented in Appendix 1. In this instructions manual, the lifting beams dimensions and parts are also explained, see Figure 2.1. The lifting beams arms and the hook on the top are connected with welds but there is no more detailed information other than that. The outer shell is made of protective lacquer Epoxy base and painted orange with Polyurethane Tecnodur ral 1006.

1. Lifting hook
2. Lifting arms
3. Riplock washer
4. M10 Screws
5. Attachment for lifting head
6. Screwhead
7. Solid holders for screws

Figure 2.1: Lifting beam

The existing instructions manual contains the following.

- Description of the usage of the lifting beams
- Forbidden usage: how it must not be used
- The maximum load the lifting beam is tested for: 1.5 times its maximum load without plastic deformation observed
- Manufacturer's name - Rotork
- Safety labels to be visible on the lifting beam
- Necessary training the user needs before using the lifting beam
- How to repair the lifting beam and do daily/monthly check-ups for different parts, one being the screws
- How it should be disassembled if necessary

The dimensions for the lifting beam provided by Rotork are shown in Table 2.1.

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Table 2.1: Lifting beam dimensions

Name	**Type**	**Factor**
Lifting hook	M10 DIN 580	Max load 335 kg (The maximum load of the lifting hook part alone) Safety factor 4
Attachment head for lifting hook	ss2142	Dy 21.3 mm thickness 2.5 mm acc.
Lift arms steel pipes	SS-EN-10255-S195	
Screw head-on connection screws	ss4212 8086 T6 threaded grip	17 mm safety factor 10: 1
Connecting screws	M10 A4-70 or FZB 8.8, at 6 full turns, socket	factor 9: 1
Polyacetal riplock washer	Dy 21, Di 10.2 t = 8	
O-rings for screws	9.25x1.78 mm	

2.1 Loads

The following figure explains relevant loads for lifting beam as from Appendix 1, instructions manual.

Name and definition	Comment
Maximum Work load (MWL)	The maximum load the lifting beam is allowed to lift. MWL = 130 kg
Rotork test load (RTL)	1.5 times MWL which Rotork has tested the lifting beam for. The test was repeated 25 times. RTL = 195 kg
Lifting hook maximum load	The maximum load of the detachable lifting hook part alone is allowed to lift. 335 kg

3 Theoretical Framework

This chapter describes multiple sections of the background study. It involves a detailed background study of the CE marking, a description of relevant directives, a brief overview of standards for lifting beams, and similar previous work carried out.

3.1 CE marking and directives

When a product is labelled with CE (Conformité Européene) it indicates that the product meets the requirements stated in EU and directives meaning it will not endanger the user's health or safety (European Commission, 2016).

There are today around 20 different EU directives translated into each national language of the EU members which covers a wide range of products like machines, electromagnetic devices, toys, and more. The CE label enables the product to be sold and used freely within the EU borders and the EEA, but at the same time also rejects products that do not bear the CE label by warning EU members about it, so that, they may proceed to fine the responsible company. Such a fine could cause devastating economic consequences for the company.

The EU's laws and recommendations are divided into Regulations (REG), Directives (DIR), Resolutions (RES), Commissions (COM), and Suggestions (SUG), depending on the legal authority it has. Furthermore, each of the general Directives covers a certain type of product. The Machine Directive is for example applicable for products that are by its definition considered as a machine (Lin, Chen & Chen, 2005). One common definition of what a machine is that it is a put-together unit with at least one movable part and is being powered by one or more energy source. (Arbetsmiljöverket, 2020b). Important to note is that CE marking does not guarantee that the product is entirely safe for use.

3.2 Machine directive 2006/42/EG

The directive for machines is named Machine Directive 2006/42/EG passed in 2006 by the EU. The directive mentions several requirements for machines meant to be sold and used inside the EEA and the European Free Trade Association (EFTA). This directive after passed in the European Parliament gets translated into every official language of each nation in the EU. Each nation has thereafter a maximum of two years to pass the directive as law in each respective parliament. The Swedish version is called AFS 2008:3. It is the responsibility of the manufacturer that their machine complies with the current directives. If the user uses the machine in production, the user also has the responsibility to make sure that the machine is CE marked and hence does not endanger the user's health or safety.

3.3 AFS 2008:3 Machines

Arbetsmiljöverkets författningssamling (AFS) are directives written by the Swedish government Agency Arbetsmiljöverket, based on EU directives. AFS 2008:3 is the Swedish equivalent of the Machine Directive 2006/42/EG containing specific requirements that have to be followed for the machine to be CE marked. These could be for example requirements regarding the machines function, appearance, maintenance and more. There are also a wide variety of machines covered by this directive ranging from products used by companies in the production line such as lifting beams to end products used by customers such as coffee machine. Since lifting beams are mentioned in this directive it is therefore applicable (Arbetsmiljöverket, 2016).

3.4 AFS 2006:6 Usage of lifting arrangements and lifting attachments

Similarly to AFS 2008:3, this directive is also based on EU directives. AFS 2006:6 is particularly based on the EU directives 95/63/EG and 2001/45/EG. The difference is that this directive specifically focuses on requirements for the usage of lifting attachments. There is a wide variety of lifting attachments that are covered in this directive. The directive is detailed and suggests a wide range of requirements regarding the use of the lifting attachment such as, mechanical constraints, safety recommendations and requirements regarding who may use it. Some of the examples are how to avoid collisions while manoeuvring the lifting attachment, under which conditions it may be used such as different weather conditions, how it may be used, how to properly secure the load. This directive should be used by Rotork the manufacturer and user of the lifting attachment to perform a risk analysis. It should moreover always be specifically the user of the lifting beam that performs this risk analysis (Arbetsmiljöverket, 2010).

3.5 Standards

Only having directives as guidance are often not enough. The directives can be relatively open for interpretation and due to this, different solutions for the same problem may not be compatible with each other. For some products, like for example a credit card its similarity is preferable so that the dimension is the same as other credit cards made by other companies. This makes it easier for other companies such as wallet designers to design a product that fits every credit card. Therefore, to make it easier for companies to interpret directives, the global market has made agreements. These are called standards and there is over 10 000 yearly made whereas Svenska Institutet för Standarder (SIS) is working towards Swedish companies being able to influence the standards both nationally and internationally. This is done by expert group meetings that discuss the matter, and after a common solution is agreed upon it will proceed to be published as a standard (Svenska institutet för standarder, n.d.).

Standards are further divided into three levels; A, B, and C depending on how general they are. ‘A’ standards are the most general covering many types of products. ‘B’ standards cover safety for different products. ‘B’ standards are further divided into ‘B1’ special safety aspects and ‘B2’ safety-related setups for products and safety equipment. ‘C’ standards are the most specific and directed towards specific products like for example a lifting beam. Requirements found in ‘C’ standards are much more detailed than ‘B’ or ‘A’ standards (Svenska institutet för standarder, n.d.).

3.5.1 SS-EN 13155+A2:2009 Cranes – Safety – Non-fixed load lifting attachments

The standard SS-EN 13155+A2:2009 was made by the European Committee for Standardization, first implemented in 2009 and is valid for lifting beams. This standard was recommended to be used by Rejlers to the Author, since it is a C standard specifically made for different kinds of lifting attachments such as lifting beams, clamps, electric lifting magnets etc, and it is therefore adequate for guidance in this thesis. Other standards that were found during the research were mostly covering big lifting cranes, which is not relevant for this thesis. This standard is also available in both Swedish and English.

SS-EN 13155+A2:2009 begins with defining different kinds of lifting attachments and technical terms, one of them being lifting beam defined as “equipment consisting of one or more members equipped with attachment points to facilitate the handling of loads which require support at several points” (Swedish Standards Institute, 2009). The standard then proceeds to explain different safety requirements for lifting beams, for example, that the operator must make sure that the load attached to the lifting beam must be properly secured before use. The last part of this standard is the verification of the safety requirements in which the standard gives suggestions on how to theoretically verify that the lifting attachment does follow the requirements mentioned. Multiple appendixes are showing which verification method is appropriate for each of the lifting attachments. Important to note is that this standard does not include any verification of the fatigue limit of the lifting beam. Lifting attachments meant to lift food or dangerous materials mentioned are also not covered. If the Rotork’s lifting beam follows this standard, it guarantees that it will also follow AFS 2008:3 and the Machine directive.

3.6 Risk analysis

There exist several different methods for risk analysis, but what they all have in common is their aim to measure, reduce and avoid harmful risks for the user. Some commonly used methods for risk analysis are What if-analysis, FMEA, and checklists. Depending on the situation some methods may be more suitable than others. In a case study thesis published in 2005 by Claes Johansson he compares many different methods for risk analysis such as FMEA, What if and Checklists etc. The comparison was done by rating each method in a table with criteria. Each criterion was weighted depending on its importance from one to five where five means the criterion is of most importance and one means it is of least importance.

For example, the criterion that the risk analysis method accurately finds risks during the usage of the machine was weighted as five meaning it is very important. How good each risk analysis method fulfils the criteria is rated from one to four. The result of the comparison was that the checklist method came on top as the best overall method for risk analysis whereas FMEA came last. The results should be taken with precautions as the results may vary depending on how each criterion is weighed. In other words, the results may change if the company doing the risk analysis weighs the criteria differently. (Johansson, 2005)

3.6.1 Failure Modes and Effects Analysis (FMEA)

FMEA is a commonly used method to evaluate risk. Using the FMEA method on a component means it is investigated in search of potential failure modes which is defined as “manner in which the process could potentially fail to meet the process requirements and/or design intent” (Lipul and Haq, 2011, pp.75). These failure modes might cause a risk for the user. Causes, effects and detection level for the hazard is then analyzed by the investigator and rated from 1-10 depending on the severity, occurrence and how easily detectable the danger is. The level of severity, occurrence and detection are then multiplied giving a value called RPN, and the risk depends on how high this value is. The higher value, the more severe is the risk. Recommended actions for the risk are thereafter suggested by the investigator and a new value is calculated to see if the actions had any effect on the risk. Preferably the risk should be completely removed, if that is not possible then protected to minimize the risk and if that is not possible then the user must be warned. The results are presented in a sheet in which there are a few important considerations. Potential failure modes of the component that might result in danger should be described using physical or technical terms, for example, bent, deformed, shattered etc. Lastly, a measure is suggested and a new RPM value is calculated to see if the suggested measures were beneficial or not. (Lipul and Haq, 2011)

Some of the benefits associated with the FMEA are that it contributes to improved designs for products and processes. Some of the benefits are better quality, enlarged safety, decreases development time and re-design costs, decreases warranty costs. But there are also some disadvantages, one of them being methodical issues with calculating the RPM value. This linear formula suggests that all individual factors such as severity, occurrence and detection are equally valuated and rated from one to ten. This may create methodological issues since for example the ranking two might not be twice as severe as ranking one, and ranking ten might not be twice as severe as ranking five. Since potential failure modes and risks are often found through brainstorming it is preferable to do so in a diverse group of people from different departments within the company. FMEA also requires the sometimes-difficult ability to foresee risks and failure modes. (Lipul and Haq, 2011)

3.6.2 The checklist method

The checklist method for risk analysis comes in many different variants but in general, the method consists of a template with already decided safety requirements that the machine should follow. For example that the machine should follow the requirements mentioned in AFS:2008:3, if so then the checklist risk analysis contains all the requirements mentioned in AFS 2008:3. This also means that the checklist method does not analyse the machine for requirements not mentioned in the checklist. (Johansson, 2005)

3.6.3 Rejlers risk analysis

Rejlers risk analysis is a checklist method based on the recommendations for risk analysis given in standard ISO 12100:2010 and tests if the machine fulfils the requirements mentioned in AFS 2008:3. (Svenska Institutet för standarder, 2010.). Boman explains in his book the general methodology of a checklist risk analysis and the Rejlers template is built on the same methodology. (Boman, 1999)

This risk analysis uses a template shown in Appendix 2 and begins with reading each paragraph of the directive and then analysing its applicability for the product or not. Each paragraph in the directive mentions a requirement that could either be applicable and not yet fulfilled, not applicable or applicable but already fulfilled. As explained in Appendix 2 if the machine does not fulfil an applicable paragraph in AFS 2008:3 the investigator conducting the risk analysis proceeds to look at four factors for the risk, consequence (K), frequency (S), exposure/frequency within the risk area (F) and the possibility to avoid the risk (P). These are then ranked from one to five.

Three of these factors are later summed up creating a value called f = (S+F+P). The f-value is then matched in a priority matrix which gives an M-value indicating what measures are needed to be taken. The measures suggested ranges from a total re-construction for very high M-values to just warning about the risks for very low M-values. Necessary measures to avoid risk are thereafter suggested and ranked based on the priority of when these measures must be implemented (Hariri and Skalleberg, 2014), (Boman, 1999).

3.7 Important considerations of the risk analysis

Although performing a risk analysis is a common method used while CE marking a product to make sure it follows relevant directives, some studies suggest this approach has methodological issues. This is due to valuing the risk could be highly subjective and could thus vary from person to person conducting the risk analysis. For example, how dangerous one perceives the risk to be could vary depending on how much information is available, or due to subjective opinions. One case study on emergency management organizations in the USA and Canada suggests that there is a systematic underestimation of risk as a result of a too subjective method while evaluating the rare high consequence risks. The study concludes that mathematical definitions, meaning that the risk could be unequivocally measured, are preferable. For example, if the frequency of a risk happening is ranging from not frequent to very frequent, the subjective opinion could greatly affect the result of the risk analysis. If the frequency is instead unequivocally mentioned as from one time per year to one time per day and preferably linked to relevant paragraphs in directives, the subjective opinion will instead have a limited effect on the result of the risk analysis (Mamuji & Etkin, 2019). This will be taken into consideration if a risk analysis will be conducted and during the analysis of the results.

3.8 The construction method of lifting accessories

Lundqvist (2018) presents a general guide regarding CE marking of lifting accessories starting from the concept phase. This guide suggests that along with the risk analysis a life-cycle assessment should also be done. This means that at different stages of the life cycle of the lifting accessories, the user should answer certain questions, for example how it is stored when not in use, where the user is positioned during the lift and which parts of the lifting need to be replaced. Furthermore, this guide recommends using Finite Element Method (FEM) to calculate if the lifting accessory can withstand the requirements from the directive and standards. Since this thesis covers a lifting beam already constructed, testing it instead in a real load test gives a more accurate result. A FEM analysis can however be a useful way to give hints of the mechanical strength during the concept stage, but the results should be interpreted with caution. A six-step method for CE marking is also presented and recommended here.

One key difference is that Lundqvist (2018) states a guide for lifting accessory yet to be constructed whereas this thesis focuses on a lifting beam already constructed. It is important to analyse other approaches to CE marking to be able to conclude if the method chosen in this thesis was effective or not and if the results are comparative.

4 The Six-Step Method

The method chosen in this thesis consists of six steps towards CE marking and is general for any product. The six-step method should not be regarded as a unique method for CE-marking but is simply stating the requirements for CE-marking in six steps. There exist similar methods but could instead contain for example nine steps. This does not mean that these methods are different but rather that some steps from the six-step method are further divided into additional steps rather than containing three more unique steps.

Since there are several companies involved with this thesis the following flow chart will help provide an understanding of who did what and what has already been completed.

Figure 4.1 represents all squared corners are the work done by the author and the rounded corners are done by companies.

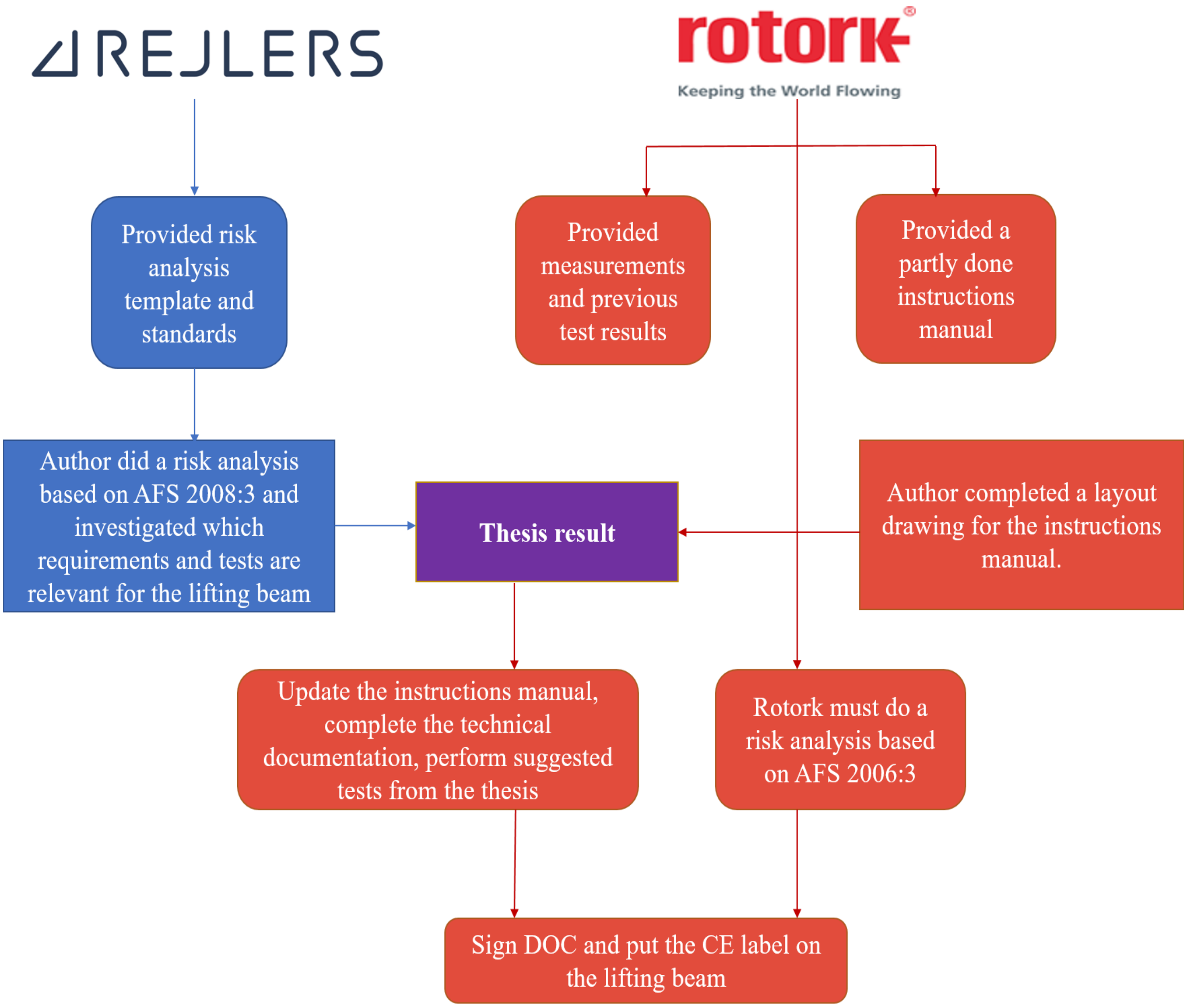

Figure 4.1: Flowchart of the work

Although there are many ways to obtain CE marking, the method chosen contains six steps and is further explained as presented below (Maskin och processäkerhetsanalys, 2018). Following these steps, the lifting beam will be CE marked.

4.1 Identify the directives and standards relevant to the product

A lifting beam is not easily viewed as a typical machine, hence it was important to confirm that the machine directive indeed was applicable. Furthermore, an applicable standard that covers Rotork's lifting beam was found. The Swedish Institute for standards has a search engine on their website which is used to search and find the correct standards. The search engine result showed over 150 standards regarding lifting attachments and after analysing and narrowing down the search results there were only a few remaining. Calls were thereafter made to SIS to confirm which standard to use (Svenska institutet för standarder, n.d.).

4.2 Make sure that the product fulfils the requirements in the directives

One way to make sure that the product fulfils the requirements in the directive was by using standards that have already been proven to meet the requirements in the directives and by carrying out a risk analysis. As explained earlier there are different methods of risk analysis but more suitable in this thesis is a checklist method implemented in Rejlers template. The advantages the checklist method has over FMEA and other risk analysis methods are mainly that it is more objective whereas FMEA may be more subjective. For the FMEA method, the investigator must imagine all the possible risks which may lead to the investigator imagining unnecessary risks not mentioned to be avoided in any directives or forget risks that are mentioned in directives. Whereas the Rejlers checklist method checks if the machine fulfils only the requirements mentioned in AFS 2008:3.

As stated earlier it is shown in Johansson's study that the checklist method was top rated. The checklist method makes sure that the machine follows the directive very well where it scored four over a level of one to four whereas FMEA scored the lowest, one. The checklist method has also proven to be the least time consuming and does not require much knowledge to carry out the risk analysis compared to FMEA. However, both FMEA and checklist method scored similarly for finding risks involved during the usage of the machine with the checklist method being slightly ahead. Based on this Rejlers risk analysis using the checklist method was decided as the best method for this thesis. (Johansson, 2005)

So, after finalizing on which directive and standard to use and which risk analysis method to choose, the next step was to sort out which paragraphs in AFS 2008:3 considered to be an applicable risk for the user.

There were three outcomes,

1) The paragraph was relevant for the lifting beam and it did not fulfil it. Hence, a risk exists and will be evaluated as the method presented in Appendix 2.

2) The paragraph was not relevant for the lifting beam, this was mentioned as N/A, not applicable in the risk analysis.

3) The paragraph was relevant but there was no risk or the risk was already eliminated, this was mentioned as OK in the risk analysis.

If the paragraph fell under 1), the method presented in Appendix 2 is used to evaluate the risk. To evaluate the risks several factors were considered, and these were then presented in a table. The total risk was then evaluated based on a summary of each factor.

4.3 Check if an independent investigation if the product meets the requirements has to be done by an announced authority

Some products must be checked by an announced authority, hence not everyone can alone CE mark a product. These products are mentioned in the directives and to complete this step one must therefore check if the applicable directive demands it.

4.4 Test the product to see if it meets the requirements

This means that the producer has a responsibility to make sure that the product de facto meets the requirements in the directive. What kind of tests and how they should be carried out depends on the result in the previous steps. For a lifting beam. Since Rotork has already conducted a load test of the lifting beam, the result of that was also examined in this step to see if that test is sufficient to prove that the lifting beam follows the requirements.

4.5 Create technical documentation and make it available

The producer must also create the technical documentation needed for it to be CE marked. What kind of documentation is needed is mentioned in the related directive and standard obtained in previous steps.

4.6 Put the CE label on the product and sign the declaration of conformity

How the CE label should look like is regulated and must be easy to find on the product. The declaration of conformity has to be signed which acts as a guarantee by the company that the product can legally be sold. This is the final step of CE marking and will be done by Rotork with support of the thesis result.

5 Results of the Six-Step Method

Below is the result of what should be considered by Rotork for the lifting beam. An effort has also been done on CE marking the lifting beam, although Rotork must do their risk analysis according to AFS 2006:6 before the lifting beam can be CE marked. All the results described in section 5 for each step are described below.

5.1 Identify the directives and standards relevant to the product

This section describes the result for 4.1 as described in the method. The literature was worked with various sources, one being Arbetsmiljöverket which has a page with facts about lifting beams (Arbetsmiljöverket, 2020a). The confirmation of the correctness of information was done by Rejlers, Arbetsmiljöverket and SIS. There are as of May 2020 over 155 standards on the SIS webpage regarding lifting attachments (Svenska institutet för standarder, n.d.). The right standard to be chosen based on different kinds of lifting accessories and the standard SS-EN 13155+A2:2009 was found suitable along with the directive AFS 2008:3 which was confirmed with recommendations from Rejlers and SIS.

5.1.1 AFS 2008:3 Machines

The definition of a lifting attachment is quoted as followed by the directive AFS 2008:3 (Arbetsmiljöverket, 2016). *"lyftredskap: komponent eller utrustning, som inte är monterad på en lyftande maskin, vilken möjliggör hållande av lasten och är placerad antingen mellan maskinen och lasten eller på själva lasten eller är avsedd att utgöra en integrerad del av lasten, och som släpps ut på marknaden separat; sling och komponenter till sådana betraktas också som lyftredskap."*. Translated by the Author as *"lifting attachment: component or equipment, not mounted on a lifting machine, which enables holding the load and is placed either between the machine and the load or on the load itself or is intended to form an integral part of the load, and placed on the market separately; sling and components for these are also considered as lifting attachments."*. Since the lifting beam is covered by this definition, AFS 2008:3 is therefore applicable.

Before Rotork could legally use the lifting beam, Rotork must make sure that the lifting beam is following the criteria in Appendix 1 and Appendix 4 presented in AFS 2008:3. The technical documentation mentioned in Appendix 7 in AFS 2008:3 must also be completed. There also needs to be an instructions manual that fulfils the requirements mentioned. The lifting beam must also be marked with the maximum load it can withstand. This label must be clearly visible. Furthermore, a declaration of conformity must be signed (Arbetsmiljöverket, 2016).

5.1.2 SS-EN 13155+A2:2009

This standard defines different kinds of lifting attachments, one being lifting beams which are defined as *"equipment consisting of one or more members equipped with attachment points to facilitate the handling of loads which require support at several points"*. By this definition, the lifting attachment made by Rotork shall indeed be regarded as a lifting beam (Swedish Standards Institute, 2009).

5.1.3 Verification of SS-EN 13155+A2:2009

For the lifting beam to follow the standard it must also be verified according to the standard, as seen in Appendix 3. Appendix 3 verifies that the lifting beams can theoretically withstand the load it is subjected to. The formulas are explained in Appendix 3. Appendix 4 further verifies the load the lifting beam can withstand, but this one is specifically aimed for lifting beams while Appendix 3 is general for all types of lifting attachments such as C-hooks and vacuum lifts etc.

5.2 Check the product-specific requirements

This was done carrying out a detailed risk analysis of the lifting beam to define the necessary measures. With the defined necessary measures, a detailed suggestion for each measure is obtained and presented below.

5.2.1 Risk analysis: AFS 2008:3

By following SS-EN 13155+A2:2009 the lifting beam will also fulfil the requirements in AFS 2008:3. A risk analysis based on AFS 2008:3 has been done as shown in the figure below. Listed below are the paragraphs that are relevant and that the lifting beam does not fulfil and thus is considered a risk. The full risk analysis is presented in Appendix 5.

Risk analysis AFS 2008:3

Table 5.1:Risk analysis

Title of the referred paragraph	Part of the Machine	Risk sources	Cause	Incident	K	S+F+P	M	Solution proposal	Reference to laws/standards
1.3.2 Risk of breakage during operation	Lifting beam	The load test already done by Rotork is not sufficient	Breakage	User injury	3	4	4	Make sure the lifting beam follows SS-EN 13155+A2:2009 regarding breakage.	SS-EN 13155+A2:2009
1.7.3 Marking of the machines	Lifting beam	There is no CE marking	Lifting beam not CE marked	User injury	2	9	5	CE marking must be done	AFS 2008:3
1.7.4.2 Content of instructional manual	Lifting beam	Instructions manual	There is no DOC and drawings	User injury	2	9	5	DOC and drawings must be completed	AFS2008:3
4.1.2.3 Mechanical strength	Lifting beam	The load test already done by Rotork is not sufficient	Breakage	User injury	3	4	4	Make sure the lifting beam follows SS-EN 13155+A2:2009 regarding breakage.	SS-EN 13155+A2:2009

		according to the standard.							
4.3.1 Chains, clamps, lines and webbing	Lifting Beam	There is no CE marking	Lifting beam not CE marked	User injury	2	9	5	CE marking must be done	AFS 2008:3
4.3.2 Lifting equipment	Lifting Beam	There is no CE marking	Lifting beam not CE marked	User injury	2	9	5	CE marking must be done	AFS 2008:3

Necessary Measures

Priorities

1) Immediately
2) Take measures as soon as possible
3) No measure needed or update the instructions

Examples of "Subject" could be;

- Document
- Electric construction
- Mechanical constriction
- Marking
- Other

5.2.2 Measures list

The results of the risk analysis present several potential risks for the user. The result from the risk analysis shows that there are two measures needed, complete the technical documentation and the investigation of the mechanical construction as shown in Table 5.2.

Moreover, to get a clear understanding of how the measures mentioned should be implemented for this lifting beam, in particular, the C-standard SS-EN 13155+A2:2009 will be used.

Table 5.2: Measures list

Part of the machine	Prioritization	Subject	Measure	Will be done	Controlled	Responsible person	Signature
Lifting Beam	2	Complete the technical documentation.	Complete full technical documentation, marking the lifting beam, DOC, etc	As soon as possible	*	*	*

Lifting Beam	2	Investigation of the mechanical constriction	Investigate if the lifting beam fulfils the requirements in the standard.	As soon as possible	*	*	*

5.2.3 General suggestions from the standard SS-EN 13155+A2:2009 for lifting attachments

The standard mentions a list of significant hazards and associated requirements. Shown below is a table from the standard, the relevant suggestions applicable are explained below.

Table 5.3: General suggestions from standard

	Hazard	Relevant clause(s) in this standard
1	**Mechanical hazards** Generated by machine parts or workpieces caused, for example, by:	
1 e) 1 c)	Inadequacy of mechanical strength Stability	5.1.1.1, 5.1.1.2, 5.2.6.3.1 Fatigue is not dealt with 5.1.5, 7.1.1
1.1	Crushing hazard	5.1.3, 7.1.1, 7.1.2
1.2	Shearing hazard	5.1.3, 7.1.1, 7.1.2
1.3	Entanglement hazards	5.2.6.3.4, 7.1.1, 7.1.2
8	**Hazards generated by neglecting ergonomic principles**	
8.1	Unhealthy postures	5.1.3
8.2	Inadequate consideration of hand-arm anatomy	5.1.2
8.7	Inadequate design of manual controls	5.1.2
10	**Unexpected start-up, unexpected overrun/Overspeed**	5.2.6.3.3
17	Falling objects	5.2.6.2, 5.2.6.3.2
18	Loss of stability/overturning of machinery	5.1.5
27 27,1	**Mechanical hazards and hazardous events** From load falls, collisions, machine tipping caused by:	 5.1.1.2, 5.2.6.1.3, 5.2.6.3.3
27.1.1	Lack of stability	5.1.1.1, 7.1.1

27.1.2	Uncontrolled loading - overloading - overturning moments exceeded	7.1, 7.2
27.1.4	Unexpected/unintended movement of loads	5.2.6, 7.2.3
27.1.5	Inadequate holding devices/accessories	5.1.4, 7.1.1, 7.1.2
27.4	From insufficient mechanical strength of parts	5.1.1.1 Fatigue is not dealt with
27.6	From inadequate selection/integration into the machine of chains, ropes, lifting accessories	5.1.4
27.8	From abnormal conditions of assembly/testing/use maintenance	5.2.5, 5.2.6, 7.1, 7.2

From the above table of the general list of hazards suggested in the standard, the relevant hazards for the measures list of section 5.2.2 for Rotork's lifting beam are discussed below.

5.2.4 Specific suggestions from the standard SS-EN 13155+A2:2009 regarding the mechanical construction of the lifting beam

- **5.1.1.1** from Table 5.3 suggests that Rotork must as stated in the standard also conduct two additional tests where the lifting beam is subjected to a static load of MWL * 3 = 390 kg without the load releasing even in case of plastic deformation, and a second test where the lifting beam is subjected to a static load of MWL * 2 = 260 kg without any plastic deformation. Rotork has already conducted a test which proved that the lifting beam could withstand a load of 1.5 times the maximum workload. But to complete 5.1.1.1 Rotork must therefore conduct additional tests from the standard which is stated further in section 5.4.

- **5.2.6.2.1** States that lifting beams with load attachment points, in this case, screws which also move along with the beam shall have the means to prevent breaking.

- **5.2.6.2.2** States that the attachment points on the lifting beam should be securely locked during load. Rotork's lifting beam locks the load using M10 screws. It is furthermore also already mentioned in the instructions manual that the user must make sure that the lifting beam is securely locked before the lifting action starts.

5.2.5 Specific suggestions from the standard SS-EN 13155+A2:2009 regarding the technical documentation relevant for the lifting beam

Referring to the section 7.2.1 Minimum Marking in the standard, the following are discussed below.

7.2.1 -Minimum Marking on the lifting beam

The following must clearly be visible on the lifting beam:

CE marking label requirement	In Rotork's case
CE sign and date	As per the machine directive
Full name and address of the manufacturer	Rotork Sweden AB Kontrollvägen 15 , Falun, Sweden
Name of the lifting beam	Yet to be decided by Rotork
Year of manufacture of the lifting beam (the year the lifting beam was manufactured)	Yet to be discovered by Rotork
Serial number	Yet to be decided by Rotork
Weight of the lifting beam if it is over 5 per cent of the MWL which is 6.5 kg, or if the lifting beam weighs more than 50 kg.	Yet to be measured by Rotork

5.3 Check if an independent investigation of the product has to be done by an announced authority

A lifting beam as for this case does not have to be checked by an announced authority, it is not mentioned in AFS 2008:3. Hence this step is not applicable (Arbetsmiljöverket, 2016).

5.4 Test the product to see if it meets the requirements

As explained in section 5.2 there are several requirements for the lifting beam that has to be tested. Below are the suggested tests for each paragraph. Paragraph 5.2.6.2.2 does not need to be further tested since it is already dealt with in the instructions manual:

- Paragraph 5.1.1.1 suggests that Rotork must as stated in the standard also conduct two additional tests where the lifting beam is subjected to a static load of 390 kg (three times the working load) without the load releasing even in case of plastic deformation, and a second test where the lifting beam is subjected to a static load of 260 kg (two times the working load) without any plastic deformation.
- Paragraph 5.2.6.2.1 suggest that Rotork must stress test the attachment points, the screws, to make sure that they will not break under load. As mentioned in the instructions manual, the lifting beam was already subjected to a loud failure test, which covered this paragraph since no breakage in the attachment points was observed. Thus the screws can withstand RTL without breaking. Furthermore, the calculation shown below suggests that the M10 screws are over-dimensioned. The calculation presented was done using Newton's third law which states that for every action there will be an equal reaction (Onlineverdan, 2019) along with the definition of normal stress, force divided by the area on which it acts upon. The normal stress that the M10 screws were exposed to was later compared to tests results of what load standard M10 screws should be able to withstand.

According to a test that was previously conducted by Rotork concludes that the lifting beam can withstand the RTL during its cycle. As shown in Appendix 1 the test was repeated 25 times. The following calculation is a simplified model showing the force the screws are subjected to in the test that was already done. Measurements mention below were conducted and presented to the Author by Rotork.

Table 5.4: Parameters of lifting beam

Phi (φ)	The angle of the lifting beam arms and the horizontal plane	35°
A	Surface area of the hollow cylinder arms	1,48 * 10^{-4} m^2
P	RTL	195 kg or 1914,9 N
T	Tension force	
$\mathbf{F_y F_x}$	Resolved components of T	

The free-body diagram for the lifting beam is shown in Figure 5.1. It is seen the vertical force F_y is the force applied on the screws. Hence the screws must be able to withstand this force.

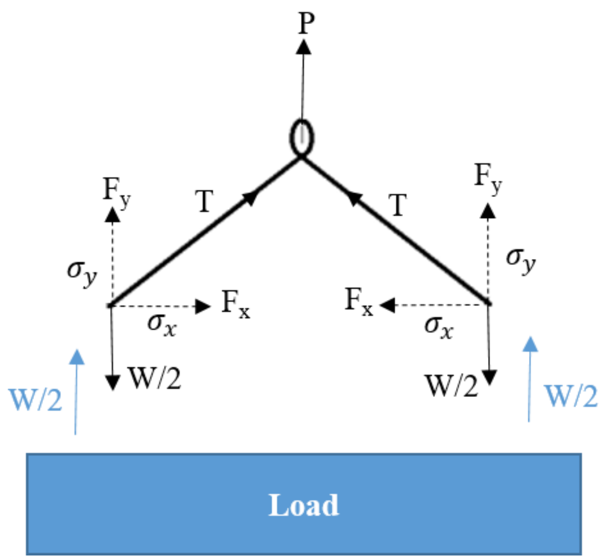

Figure 5.1: Free body diagram of the lifting beam

Calculations of all the forces and stresses in the lifting beam are shown in Table 5.5.

Table 5.5: Calculation of forces in lifting beam

$P - W = 0$	$\frac{W}{2} = \frac{P}{2}$	Sum of all forces in Y direction = 0 w/2 = 1914,9/2 = 957,45 N
$F_x - F_x = 0$		Sum of all forces in X direction = 0

The calculation above shows that the vertical force applied to each M10 screw is equal to 957,45 N. Standard M10 screws of strength class 8.8 which is used in this lifting beam has an ultimate stress level of around 46400 N. This suggests that the M10 screws are more than qualified for the maximum applied force and for the tests suggested in the standard (Nordic Fastening Group AB, n.d.).

For the lifting beam to be approved of CE marking, the lifting beam must also be tested in real conditions as suggested in paragraph 5.1.1.1 of the standard. This means that the producer has a responsibility to make sure that the product meets the requirements in the directive.

5.5 Create technical documentation and make it available

To complete this step Rotork must consider both the technical documentation that has to be stored mentioned in AFS 2008:3 as well as the minimum marking requirements mentioned in the standard in paragraph 7.2.1 which is explained in section 5.2.5.

Necessary technical documentation to be stored

The following technical documentation is needed to be kept for at least 10 years according to AFS 2008:3.

Task	**Task completion**
General description and the instructions manual of the lifting beam	Done by Rotork
Layout drawing of the lifting beam	Done by Author
Test results as suggested in the standard	To be done by Rotork as suggested in this thesis
A completed risk analysis both for AFS 2008:3	Done by Author
A completed risk analysis both for AFS 2006:6	To be done by Rotork
Declaration of conformity	To be done by Rotork as suggested in this thesis

The layout drawing for the lifting beam was completed by the Author based on measurements given by Rotork. This has to be added to the instructions manual and is shown in Appendix 6.

5.6 Put the CE label on the product and sign the declaration of conformity

This section describes the DOC and the CE label to be used on the lifting beam.

5.6.1 Declaration of conformity

The declaration of conformity must be signed by the CEO of Rotork or the highest regional manager. The DOC must also contain the following information:

What the DOC shall contain	In Rotork’s case
Manufacturers full name and address	Rotork Sweden AB Kontrollvägen 15 , Falun, Sweden
Name and address of the person that concludes and updated the technical documentation as suggested in this thesis	To be done by Rotork using this thesis as guidance
Description and identification of the lifting beam	To be done by Rotork using this thesis and the instructional manual as guidance
A sentence where the manufacturer promises that the lifting beam follows the machine directive 2006/46/EG and the standard	To be done by Rotork using this thesis as guidance
Municipality and date of the signing	To be done by Rotork
Signature from the regional manager	To be done by Rotork

5.6.2 CE label

The lifting beam must also have a visible CE label that contains the information presented below. The CE sign must strictly follow the standard design, shown in Figure 5.2.

Figure 5.2: CE label (European Commission, 2016)

CE marking label requirement	In Rotork’s case
CE sign	As per the machine directive
Full name and address of the manufacturer	Rotork Sweden AB Kontrollvägen 15 , Falun, Sweden
Name of the lifting beam	Yet to be decided by Rotork
Year of manufacture of the lifting beam	Yet to discover by Rotork

6 Analysis of Results

The aims of the thesis was to investigate what needs to be done for the lifting beam to be CE marked to provide a plan and for it. The six-step method was chosen as applicable, which in step one recommended doing this by identifying relevant directives and standards. AFS 2008:3 proved to be suitable along with the standard SS-EN 13155+A2:2009 used to guarantee the right interpretation for lifting beams of the directive. To further understand what was needed to be done for the lifting beam to be CE marked a checklist risk analysis based on AFS 2008:3 was performed. This gave a clear result of which paragraphs were not yet fulfilled and the standard helped with providing solutions.

The Rejlers checklist risk analysis was found to be useful and relevant to the lifting beam. The method was found to be user friendly, less time consuming and efficient in finding risks involved with lifting beams which were also supported by Johansson's study which was mentioned in the theory (Johansson,2005). The results of Rejlers risk analysis leads to two necessary measures that are required for the lifting beam to be CE-marked. As discussed in Johansson's study it was also found that it would be difficult to find these necessary measures if FMEA was used since it would require pre-knowledge on the exact requirements for a lifting beam which FMEA does not provide. For example, since Rejlers risk analysis checklist is based on AFS 2008:3 it provides the exact requirements on which technical documents needs to exist and how much weight the lifting beam should be able to carry.

One of the drawbacks of Rejlers risk analysis template is that it does not take into account how the risks would be reduced if the lifting beam was to be reconstructed, which could have been an advantage if the FMEA risk analysis method was used. But since the lifting beam was already constructed, this was not relevant. Another drawback is that the calculations for the risk analysis were done manually which may pose some uncertainties on the results due to human error. But since there were not many calculations this should not have impacted the result.

The lifting beam was already completed and is used in production so it is, therefore, easier to perform real-life strength tests instead and will eliminate any miscalculations from FEM which was otherwise a suggested method in the thesis *Metod för konstruktion av lyftredskap* mentioned in section 3.8 for verifying the strength of the lifting beam.

The risk analysis must not give subjective results. This was avoided since the necessary measures obtained from the risk analysis was taken from either the directive or the standard. For example, the risk analysis showed that additional tests for the lifting beam's mechanical strength were needed. The exact value of the loads for the tests was decided using the standard. This makes the measures less subjective. As mentioned in section 3.7 it seemed to be that the subjective results were avoided since the checklist method contained measurable factors for example frequency factor ranging from less than one time per year to one time per day.

One of the factors that affected the results was whether the lifting beam had to undergo an independent investigation by an announced authority or not. Since the results show it does not fall under that category for example military products, Rotork could alone CE mark the lifting beam. Otherwise, this would also be carried out.

The manual calculation suggests that the M10 screws are over-dimensioned but this factor has an insignificant effect on the results. Another important factor is that the standard being used in this thesis does not take fatigue into account for the M10 screws which is something that has to be further analysed by Rotork since this lifting beam was already used in production for an unknown amount of time.

7 Conclusions and Discussion

The purpose of this thesis was to investigate how the lifting beam complies with the existing directives, and standards and provide a basis for CE marking. The method chosen was based on six steps, out of which step 1,2 and 3 were fully completed and a basis was created for step 4,5 and 6. By following the results in this thesis Rotork could CE mark the lifting beam, and use this thesis as a guide for CE marking other lifting beams that are not CE marked yet.

This thesis could also be used as a guide for CE marking lifting beams that will be made in the future providing that the standards and directives are still relevant. This thesis also concludes that the lifting beam should be regarded as a machine and must therefore follow the requirements suggested in the Machine directive 2006/42/EG and the Swedish version of the machine directive AFS 2008:3. Moreover, the standard SS-EN 13155+A2:2009 is recommended to be followed to guarantee the solutions and interpretations of the requirements in AFS 2008:3 is sufficient.

In conclusions, this is needed to be further worked upon for the lifting beam to be CE marked.

- Complete the technical documentation: Rotork must label the lifting beam according to the minimum marking requirements suggested in the standard. These include the CE sign and date, full name and address of the manufacturer, name of the lifting beam, year of manufacture of the lifting beam (the year the lifting beam was manufactured), serial number, the weight of the lifting beam if it is over 5 per cent of the MWL which is 6,5 kg, or if the lifting beam weighs more than 50 kg.
- Rotork must also update the technical documentation that has to be stored for 10 years, add the layout drawing shown in Appendix 6 to the instructions manual, update the instructions manual with the new test results, complete a risk analysis based on AFS 2006:6 and finally sign the declaration of conformity.
- Investigation of the mechanical construction: The standard suggests that Rotork should also conduct a test to prove that the lifting beam has the mechanical strength to be able to withstand a static load of 390 kg (three times the working load MWL) without releasing the load in case of plastic deformation and must also be able to withstand a static load of 260 kg (two times the working load MWL) without plastic deformation.
- The manual calculation and the fact that M10 screws are being used to lock the load suggests that the lifting beam will by far pass the requirements regarding its mechanical strength.

In conclusion, this thesis has achieved the aims, although some steps are still pending that are required by Rotork to finish before a completed CE marking. Moreover, tests mentioned to be performed could not be done by the Author during the period of thesis work due to visitor restrictions implemented by Rotork as a result of the Covid-19 pandemic.

8 Future Work

There is no information about how many loading cycles this lifting beam will be subjected to or has already been subjected to. This is something that could be further investigated, even though this is not covered by the standard used in this thesis.

Future work for Rotork would be to conduct another risk analysis based on AFS 2006:6 and to follow through using this thesis as a guide to CE-mark the lifting beam and to conduct two more load tests and finish the technical documentation as suggested in this thesis. For example, adding the layout drawing to the instructions manual. Future work would also be to do the risk analysis using other risk analysis methods to get a more clear view if any of the other methods are more efficient in any way. The calculations during the risk analysis were done manually but if this was done using computer software instead uncertainties from human error will be avoided. Future work could also include combining several risk analysis methods to see if this may impact the results.

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Appendices

Appendix 1 – Instructions manual

rotork®

Keeping the World Flowing

Bruksanvisning i original

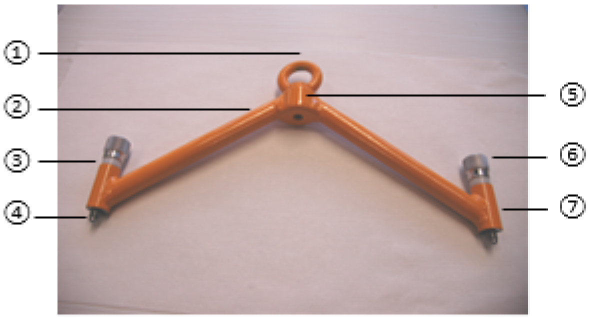
Lyftutrustning
MONT 001

År 2020

Innehållsförteckning

1 Allmänt

Lyftredskap till RC 280 DA – 88 SR är en komplett enhet utan lösa detaljer.
Registreringsnummer/Maskinnummer MONT 001.



1. Lyftögla
2. Lyftarmar
3. Glidbrickor
4. Anslutningsskruv
5. Fästhuvud för lyftögla
6. Skruvhuvud
7. Fästhållare för anslutningsskruvar

1.1 Beskrivning av lyftredskapets användning

Lyftredskapet är utrustat med två anslutningsskruvar som gängas i befintliga gänghål uppe på cylindern/manöverdonet.
Lyftverktyget skall användas, transporteras och lagras så att skador inte uppstår.

1.2 Användningsområde

Lyftredskapet är avsett för att lyfta och sänka cylindrar och kompletta manöverdon av modellerna RC 280DA-88SR med en maxlast på 130 kg.
Lyftredskapet får användas med och utan vatten inom temperaturområde -15 till +40°C.

1.3 Förbjuden användning

- Lyftredskapet får inte användas på annat sätt än vad det är avsett för.
- Lyftredskapet får inte utsättas för slag, stötar eller ryckbelastning vilket kan medföra att lyftredskapet skadas.
- Lyftredskapet får aldrig lyfta last med endast en anslutningsskruv iskruvad.
- Om skador uppstår på lyftredskapet får inte lyftredskapet användas förrän detta åtgärdats.
- Lyftredskapets maxlast får aldrig överskridas.

1.4 Värde på testfaktor

Provbelastning har utförts med 195kg (1,5 gånger max lasten) och 25 cykler utan några påvisade deformationer eller skador. Provare: Mikael Johansson, verktygsavdelningen på Rotork Sweden AB.

1.5 Tillverkare

Rotork Sweden AB
Kontrollvägen 15
791 45 Falun

1.6 Försäkran om överensstämmelse

Klistra in kopia på försäkran som gäller för anläggningen. Behöver inte vara det påskrivna exemplaret.

2 Säkerhetsanvisningar

Bruksanvisningen ska läsas innan användning.

2.1 Uppmaningar

⚠ **VARNING**
Varning anger en risk för personskada.

⚠ **AKTA**
Akta anger en risk för skada på utrustning.

2.2 Instruktioner om utbildning för operatörer

Innan användning av lyftredskapet ska operatören ha genomgått kranförarutbildningen.

3 Användning

3.1 Montera lyftredskapet på lyftanordningen

För att använda lyftredskapet behöver det monteras på en lyftanordning.

1. Montera lyftöglan på lyftkroken.
2. Kontrollera att kroklåset är i låst läge.

3.2 Lyfta och sänka cylinder eller komplett manöverdon

Lyftredskap avsett för att lyfta och sänka cylindrar och kompletta manöverdon av modellerna RC 280 DA-88 SR med en maxlast på 130kg.

⚠ **VARNING**
Vid lyft med last skall lasten hållas ifrån kroppen för att undvika olyckor om lasten skulle släppa.

⚠ **VARNING**
När last hanteras på trånga ställen skall händerna var placerade på lyftarmarna på lyftredskapet för att undvika klämrisk.

1. Gänga anslutningsskruvarna i cylindern eller manöverdonets befintliga gänghål uppe på cylindern.
2. Skruva anslutningsskruvarna i botten, ca 6 gängvarv. Detta för att säkerställa att rätt draghållfasthet uppnås.
3. Manövrera med lyftanordning som lyftredskapet är fäst i.

4 Underhåll

Utrustningen omfattas av regler kring fortlöpande tillsyn och systematisk egenkontroll och skall utföras och dokumenteras på samtliga kontroll- och underhållspunkter.

4.1 Anvisning för daglig kontroll och operatörsunderhåll

ÅTGÄRD	Dagligen	3 Mån	12 mån	Tid
Daglig tillsyn	**X**			**5 min**
Förslitningskontroll		**X**		**10 min**
Kontrollera anslutningsskruvarna			**X**	**20 min**

4.1.1 Daglig tillsyn

1. Okulärbesikta och prova för att upptäcka eventuella skador.

4.1.2 Förslitningskontroll (kontrollrutin)

1. Kontrollera att lyftredskapets fasta delar inte uppvisar några mekaniska skador.
   Fasta delar att kontrollera:
   - Lyftögla
   - Fästhuvud
   - Lyftarmar
   - Fästhållare för anslutningsskruvarna
2. Kontrollera att anslutningsskruvarnas gängor inte är slitna. Gängtopparna ska vara spetsiga och ytterdiametern får inte understiga 0.3-0.3 mm från ursprungligt mått. Byt vid behov.
3. Kontrollera att skruvhuvudet/lyftöglan på anslutningsskruvarna är fastdraget. Håll i anslutningsskruvens gängor för hand och vrid skruvhuvudet cirkulärt. Delarna ska följas åt utan glapp.

4.1.3 Kontrollera anslutningsskruvarna

Eftersom lyftredskapet utsätts för fukt (vatten), skall anslutningsskruvarna avsynas minst 1 gång per år för att säkerhetsställa att dessa inte utsatts för korrosion (vid användning av FZB 8.8).

1. Avlägsna O-ringen.
2. Ta ur anslutningsskruven.
3. Kontrollera anslutningsskruvarna visuellt efter defekter eller korrosion.
4. Om defekter eller korrosion påvisats skall anslutningsskruven bytas ut.
5. Återmontera och sätts på en ny o-ring.

4.2 Övrigt Underhåll

Övrigt underhåll får endast utföras av utbildad personal.

ÅTGÄRD	Dagligen	3 Mån	12 mån	Tid
Kontrollera sprickbildning med ultraljud			X	1h?

4.2.1 Kontrollera sprickbildning med ultraljud

Verktyg

- Ultraljudsverktyg??

1. Ssss AFS 2003:6 (AFS 2006:6 30-33§)
2.
3. Eeee

5 Anvisningar om urdrifttagning, nedmontering och återvinning

När Lyftutrustningen anses vara uttjänt ska den demonteras och delar överlämnas för återvinning eller destruktion enligt för tiden gällande regler.
Lyftredskapet kan i sin helhet sorteras som stål/blandskrot för återvinning.

Appendix 2 – Rejlers Risk Analysis Template

- **Risks source:** For example, movable parts in the process, sharp edges, the machine itself, etc
- **Cause:** For example, vibrations, leaking, not enough light, etc
- **Incident:** For example, electric shock, drowning, blunt trauma

- **Consequence (K):** What is the consequence if the worst incident happens? The severity of the consequence is rated from 1 to 5;
    1. Catastrophic — Death
    2. Critical — Serious, permanent damage
    3. Marginal — Minor damage, the user must be on sick leave
    4. Negligible — The user can continue the work

- **Frequency (S):** How often does the incident happen? This is rated from 1 to 5;
    1. Negligible — <1 one time per year
    2. Unlikely — 1 time per year
    3. Likely — 1 time per month
    4. Probable — 1 time per week
    5. Frequent — 1 time per day

- **Exposure/Frequency within the risk area (F):** Should access be limited? For how long is the exposure? How often is the risk area visited?
    1. Negligible — <1 time per year
    2. Unlikely — 1 time per year
    3. Likely — 1 time per month
    4. Probable — 1 time per week
    5. Frequent — 1 time per day

- **Possibility to avoid the incident (P):** Is the personnel trained? If an accident happens, does it happen fast or slow? Is there an opportunity for the personnel to protect themselves?
    1. Obvious
    2. Likely
    3. Possible
    4. Unlikely
    5. Impossible

- **Priority Matrix (M):** Sum up the frequency points f = (S+F+P) and consider the M value in the matrix

	f 15-13	f 12-10	f 9-7	f 6-5	f 4-3
K1	8	7	6	5	4
K2	7	6	5	4	3
K3	6	5	4	3	2
K4	5	4	3	2	1

M value:

6-8 Total re-construction
4-6 Measures with some kind of protection against the risk
1-4 Measures by informing and warning about the risk

The result is then summarized in a matrix where the risk is further explained under the following titles.

Title of the referred paragraph	Part of the Machine	Risk sources	Cause	Incident	K	S+F+P	M	Solution proposal	Reference to laws/standards

Necessary Measures

After the risks are presented, necessary measures should avoid these risks must be implemented. These are also evaluated as shown below.

- **Priority**
    1. Immediately
    2. Take measures as soon as possible
    3. No measure needed or update the instructions
- Example of "Subject"
    - Document
    - Electric construction
    - Mechanical constriction
    - Marking
    - Other

Position	Priority	Subject	Measures	Deadline	Controlled	Responsible person	Signature

Appendix 3 – General Verification Methods

Annex A
(normative)

General verification methods

A.1 Verification of mechanical strength without static tests

This method is applicable to non alloy structural steel in accordance with EN 10025.

A.1.1 Load case

The following load case shall be considered:

$$X = S_{DL} + 2 .\ S_{WLL}$$

With
S_{DL} = loads due to dead weight of the attachment
S_{WLL} = loads due to the working load limit

The factor 2 takes into account the dynamic effect due to lifting, and the static test. This factor does not take into account wind loads.

A.1.2 Verification to the elastic limit

For this load case the σi normal stresses and τ shear stresses in the structural members shall be lower or equal to the admissible stress given in table A1.

In case of combined stresses the equation (A.1) shall be also verified.

$$\left(\frac{\sigma_x}{f_y}\right)^2 + \left(\frac{\sigma_y}{f_y}\right)^2 - \frac{\sigma_x \times \sigma_y}{f_y^2} + 3\left(\frac{\tau}{f_y}\right)^2 \leq 1 \qquad \text{(A.1)}$$

Table A.1 — Admissible stress

Steel	Thickness in mm	Admissible stress in tension/compression f_y in MPa	Admissible stress in shear $f_y/\sqrt{3}$ in MPa
S 235	$t \leq 16$ $16 < t \leq 40$	235 225	135 130
S 275	$t \leq 16$ $16 < t \leq 40$	275 265	160 153
S 355	$t \leq 16$ $16 < t \leq 40$	355 345	205 200

For this load case the σ_{wi} normal weld stresses shall be lower or equal to the admissible stress $\alpha\, f_y/\gamma$ and the τ_w weld shear stresses shall be lower or equal to the admissible stress $\alpha_s\, f_y/\gamma$ with γ = 1.1.

In case of combined stresses the equation (A.2) shall be also verified.

$$\left(\frac{\gamma \cdot \sigma_{wx}}{\alpha \cdot f_y}\right)^2 + \left(\frac{\gamma \cdot \sigma_{wy}}{\alpha \cdot f_y}\right)^2 - \frac{\gamma \cdot \sigma_{wx} \times \gamma \cdot \sigma_{wy}}{(\alpha \cdot f_y)^2} + \left(\frac{\gamma \cdot \tau_w}{\alpha_s \cdot f_y}\right)^2 \leq 1 \qquad \text{(A.2)}$$

Table A.2 — Admissible stress in the weld

Type of weld ENV 13001-3-1 clause 4.4	Kind of stressing	Quality level EN 25817	α tension	α compression	α_s
Weld with full penetration or backwelded • Butt welded • Double semi V-weld, semi V-weld for T joint	Stress across the weld direction	B,C	1	1	1/√2
		D	0,9	1	1/√2
Weld with full penetration or backwelded • Weld with small web • Double semi Y-weld, semi Y-weld for T joint	Stress across the weld direction	B,C	0,9	1	1/√2
		D	0,8	0,9	1/√2
Weld without full penetration • Double semi Y-weld, semi Y-weld for T joint • Double fillet weld • Fillet weld	Stress across the weld direction	B,C,D	0,7	0,8	1/√2
All types of welds	Stress in the weld direction	B,C,D	1	1	1/√3

Appendix 4 – Verification Methods for Lifting Beams

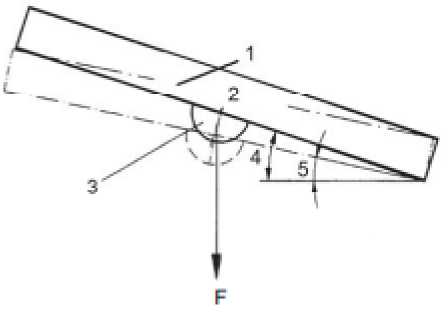
Annex E
(normative)

Verification methods for lifting beams

E.1 Verification of locking or holding devices by testing

E.1.1 Conditions

The test shall be conducted either by lifting a live test load or by means of a static force applied by a test rig.



1 & 2 Lifting beam at different working angles

3 Moving part

4 Maximum working angle of the lifting beam plus 6°

5 Maximum working angle of the lifting beam

F Test force

Figure E.1 — Angles associated with verification of lifting beams

E.1.2 Procedure

The moving part shall be locked in position by means of its locking device and subjected to a force F without shock for a minimum period of 1 minute and equal to 2 x the static force that it is required to sustain in service at an angle of 6° in excess of that specified by the manufacturer, see figure E.1. The test shall be repeated in both directions about each horizontal axis and both horizontal axes in combination for each available locking position. If the moving part does not have predetermined positions but locks by friction the test shall be carried out at the two extremes of travel and at one intermediate point.

After the force has been removed the moving part and its locking device shall be examined for deformation, cracks and other defects.

E.1.3 Acceptance criteria

The moving part and its locking device sustains the test force F without slippage, deformation or failure and, after release of the load, there are no visible defects and the moving part and its looking device operate freely.

E.2 Verification of the locking or holding by calculation

The mechanical parts shall be calculated in accordance with annex A.1 for the maximum intended tilting angle plus 6° except for lifting beams designed for a vertical position.

If the moving parts of the structure are held in position by devices operating on a friction basis (e.g. resulting from brake torque) the calculation shall demonstrate that the friction force is at least twice the force due to the self weight of the parts and the working load limit for the maximum intended tilting angle plus 6° except for lifting beams designed for a vertical position.

Appendix 5 – Results of Risk Analysis

Risk analysis AFS 2008:3

Table 0.1:Risk analysis

Title of the referred paragraph	Part of the Machine	Risk sources	Cause	Incident	K	S + F + P	M	Solution proposal	Reference to laws/standards
1.1. Generally									OK
1.1.1 .Definitions									OK
1.1.2 Principles for integrating security									OK
1.1.3 Materials and products									OK
1.4 Lighting									N/A
1.1.5 Design of machines for the purpose of making handling easier.									N/A
1.1.6 Ergonomics									OK
1.1.7 Workstations									N/A
1.1.8 Seats									N/A
1.2 Control system									N/A
1.2.1 Safety and reliability of control systems									N/A
1.2.2 Actuators									N/A
1.2.3 Start									N/A
1.2.4 Stop									N/A
1.2.4 1 Normal stop									N/A
1.2.4 2 Stop during operation									N/A
1.2.4 3 Emergency stop									N/A
1.2.4 2 Assembly of machines									N/A
1.2.5 Choice of control and mode of operation									N/A

1.2.6 Faults in the power supply									N/A
1.3.1 Risk of loss of stability									OK
1.3.2 Risk of breakage during operation	Lifting beam	The load test already done by Rotork is not sufficient	Breaka ge	User injury	3	4	4	Make sure the lifting beam follows SS-EN 13155+A2:20 09 in regard to breakage.	SS-EN 13155+ A2:200 9
1.3.3 Risks caused by falling or thrown objects									OK
1.3.4 Risks associated with surfaces, edges or angles									OK
1.3.5 Risks with combined machines									N/A
1.3.6 Risks associated with variations in mode of operation									N/A
1.3.7 Risks associated with moving parts									N/A
1.3.8 Choice of protection against									N/A
1.3.8.1 Moving transmission components									N/A
1.3.8.2 Moving parts that are directly included in the actual use.									N/A
1.3.9 Risk of uncontrolled movements									N/A
1.4 Requirements for protection and protection structures.									N/A
1.4.1 General requirements									N/A
1.4.2 Special requirements for protection structures.									N/A
1.4.2.1 Fixed protection									N/A
1.4.2.2 Interlocked openable protection									N/A

1.4.2.3 Adjustable protection that restrict accessibility									N/A
1.4.3. Special requirements for protective devices									N/A
1.5 Risks due to other sources of risk									N/A
1.5.1 Electrical supply									N/A
1.5.2 Static electricity									N/A
1.5.3 Power supply other than electricity									N/A
1.5.4 Mounting error									OK
1.5.5 Extreme temperatures									N/A
1.5.6 Fire									N/A
1.5.7 Explosion									N/A
1.5.8 Noise									N/A
1.5.9 Vibrations									N/A
1.5.10 Radiation									N/A
1.5.11 External radiation									N/A
1.5.12 Laser equipment									N/A
1.5.13 Emissions of hazardous materials and substances									N/A
1.5.14 Risk of being trapped in a machine									N/A
1.5.15 Risk of slipping, tripping or falling									N/A
1.5.16 Lightning strikes									N/A
1.6 Maintenance									OK
1.6.1 Maintenance of machines									OK
1.6.2 Access to workstations and service points used for maintenance									N/A
1.6.3 Disconnection of power sources									N/A
1.6.4 Operator Interventions									N/A
1.6.5 Cleaning of internal parts									N/A

1.7 Information									N/A
1.7.1 Information and warnings on the machine									N/A
1.7.1.1 Information and information instructions									N/A
1.7.1.2 Warningarrengment									N/A
1.7.2 Warning for permanent risks									N/A
1.7.3 Marking of the machines	Lifting beam	There is no CE marking	Lifting beam not CE marked	User injury	2	9	5	CE marking must be done	AFS 2008:3
1.7.4 Instructions manual									OK
1.7.4.1 General principals for the design of the instructions manual									OK
1.7.4.2 Content of instructional manual	Lifting beam	Instructi ons manual	There is no DOC and drawin gs	User injury	2	9	5	DOC and drawings must be completed	AFS20 08:3
1.7.4.3 Sale support material.									N/A
4. Additional basic health and safety requirements to prevent sources of risk associated with lifting									N/A
4.1.1 Definitions									N/A
4.1.2 Protection against mechanical sources of risk									N/A
4.1.2.1 Risks due to deficient stability.									OK.
4.1.2.2 Machines moving along guides or rails									N/A
4.1.2.3 Mechanical strength	Lifting beam	The load test already done by Rotork is not sufficient accourdi	Breaka ge	User injury	3	4	4	Make sure the lifting beam follows SS-EN 13155+A2:20 09 in regard to breakage.	SS-EN 13155+ A2:200 9

		ng to the standard.							
4.1.2.4 Break plates, drums, wheels, ropes and chains									N/A
4.1.2.5 Lifting gear and its components									OK
4.1.2.6 Control of movements									N/A
4.1.2.7 Movements of loads during handling									N/A
4.1.2.8 Machines serving fixed ground planes									N/A
4.1.2.8.1 Movements of the load carrier									N/A
4.1.2.8.2 Access to the load carrier									N/A
4.1.2.8.3 Risks due to contact with moving load carriers									N/A
4.1.2.8.4 Risk of load falling from the load carrier									N/A
4.1.2.8.5 Elevator floor									N/A
4.1.3 Functionality	.								OK
4.2 Requirements for machines with a power source other than manual power									N/A
4.2.1 Control of movements									N/A
4.2.2 Load control									N/A
4.2.3 Line-controlled installation									N/A
4.3 Information and marking									OK
4.3.1 Chains, clamps, lines and webbing	Lifting Beam	There is no CE marking	Lifting beam not CE marked	User injury	2	9	5	CE marking must be done	AFS 2008:3
4.3.2 Lifting equipment	Lifting Beam	There is no CE marking	Lifting beam not CE marked	User injury	2	9	5	CE marking must be done	AFS 2008:3
4.3.3 Lifting machines									N/A
4.4 Instructions manual									OK

4.4.1 Lifting attachments									OK
4.4.2 Lifting machines									OK

Necessary Measures

Priorities

1) Immediately
2) Take measures as soon as possible
3) No measure needed or update the instructions

Examples of "Subject" could be;

- Document
- Electric construction
- Mechanical constriction
- Marking
- Other

Measures list

Part of the machine	Prioritization	Subject	Measure	Will be done	Controlled	Responsible person	Signature
Lifting Beam	2	Complete the technical documentation.	Complete a full technical documentation, marking the lifting beam, DOC, etc	As soon as possible	*	*	*
Lifting Beam	2	Investigation of the mechanical constriction	Investigate if the lifting beam fulfils the requirements in the standard.	As soon as possible	*	*	*

Appendix 6 – Layout Drawing