Technical Specifications for Wärtsilä Gas Conversion Portfolio

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BACHELOR'S THESIS

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Abstract

This bachelor's thesis was made in response to an assignment given by Project Proposals in Energy Services which is a part of Wärtsilä Finland Oy. The core purpose of this thesis was to compile technical specification templates for Wärtsilä gas conversion portfolio. These specifications will be used by the Project Proposals team when making proposals. The specifications shall present the content of a gas conversion project in a descriptive way to the customer. Furthermore, the aim was to create technical specifications that can be linked to a new gas conversion sales tool that is under development. The goal was that the result of this thesis, the specification templates, would help the team members in their daily work, reduce non-value adding work, save time and eliminate unnecessary mistakes.

A qualitative research approach was chosen for this development project. The data collection methods used to gather information for this work were document collection and semi-structured interviews with selected experts in various areas. The documents used for this study were previously made specifications and power point presentations.

The result of this thesis is ten different technical specification templates. These cover all the engine types and gas conversion concepts included in the new gas conversion sales tool. The specification documents contain instructions for the programmer who is developing the sales tool. Furthermore, the documents contain comments regarding information that needs to be modified based on different case requirements when creating a proposal.

Language: English
Key words: gas conversion, technical specification, technical documentation, technical communication

EXAMENSARBETE

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Abstrakt

Detta examensarbete är gjort på uppdrag av Project Proposals vid Energy Services som är en del av Wärtsilä Finland Oy. Syftet med detta examensarbete var att sammanställa tekniska specifikationsmallar för Wärtsiläs gaskonverteringar. Dessa specifikationer kommer att användas av Project Proposals teamet när de gör offerter. Specifikationerna skall presentera innehållet i ett gaskonverteringsprojekt på ett beskrivande sätt till kunden. Vidare var målet att skapa tekniska specifikationer som kan linkas ihop med ett nytt försäljningsverktyg som är under utveckling. Målet var att resultatet av detta arbete, de tekniska specifikationsmallarna, skall hjälpa teammedlemmarna i deras dagliga arbete, minska icke värdeskapande jobb, spara tid och eliminera onödiga misstag.

En kvalitativ forskningsdesign valdes för detta utvecklingsarbete. Datainslamlingsmetoderna som användes för detta arbete var dokumentinsamling och semi-strukturerad intervju med utvalda experter inom olika områden. Dokumenten som användes för studien var tidigare gjorda specifikationer och power point presentationer.

Resultatet av examensarbetet är tio olika tekniska specifikationsmallar. Dessa täcker alla motortyper och gaskonverteringskoncept som är inkluderade i det nya försäljningsverktyget. Specifikationsdokumenten innehåller instruktioner till programmeraren som utvecklar det nya försäljningsverktyget. Dessutom innehåller dokumenten kommentarer gällande information som måste modifieras baserat på olika projektspecifika krav när man skapar en offert.

Språk: engelska
Nyckelord: gaskonvertering, teknisk specifikation, teknisk dokumentation, teknisk kommunikation

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Abbreviations

B2B	Business to business
DF	Dual fuel
EPC	Engineering, procurement and construction
GD	Gas diesel
GTC	General terms and conditions
HFO	Heavy fuel oil
HSE	Health, safety and environmental
LFO	Light fuel oil
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LQO	Liquid optimized
PLC	Programmable logic controller
SG	Spark ignited gas
UNIC	Unified controls
WOIS	Wärtsilä operator’s interface system

1 Introduction

This introductory chapter will describe the background, problem area and the purpose of this bachelor's thesis. Further delimitations and confidentiality of the thesis are presented.

1.1 Background

This thesis is made in response to an assignment given by Project Proposals in Energy Services which is a part of Wärtsilä Finland Oy. The assignment was to compile technical specification templates for Wärtsilä gas conversion portfolio.

Wärtsilä is a global company and a leader in smart technologies and complete lifecycle solutions for both the marine and the energy sector. The company's goal is to be a forerunner in sustainable innovation and to reduce emissions in their customer's operations. By doing this, Wärtsilä helps its customer's and societies overall to meet environmental guidelines and regulations. They provide all the essential services, technologies and solutions needed for reliable and affordable power systems. (Wärtsilä, 2021a, 2021b).

Energy services in Wärtsilä offers high-quality services and solutions to enhance business performance of power generation companies. They have considerable experience with gas engines and power plants. Wärtsilä has completed over 30 gas conversion projects globally by converting more than 100 engines and there are currently five projects under execution. Gas conversion of a power plant is a justified solution when there is pressure to discontinue HFO operations and when gas fuel is available. It is a proven solution to lower production costs with environmental benefits, including reduced emission levels. (Wärtsilä, 2020a, 2020b, 2021b).

The Project Proposals team is a part of the project sales and support function which means that they provide sales support to the front-line salespeople. This type of personnel is needed when a product or a solution is very technical, and when the negotiation process is complex. The team members are a combination of technical and financial experts and they can provide detailed technical information required by the customer. The proposal team is responsible for evaluating the need of the customer, investigating possible solutions, creating cost calculations and proposal materials required by a specific opportunity, including gas conversions of power plants. This is the type of project this thesis will address.

1.2 Problem Area

When selling a technical product or solution a technical specification is usually delivered to the customer at some point of the selling process. This document specifies the content of the project, describes the mechanical and electrical parts, the features of the product and all the services provided by Wärtsilä. Thus, the area of responsibility is allocated between Wärtsilä and the customer.

Default technical specifications for Wärtsilä's new power plants exists but there are currently no specification templates for gas conversion projects. Each member of the proposal team creates technical specifications for different gas conversion projects. The specifications are usually not provided until the contractual stage of the sales process. The reason for this is that it can be very time consuming to create a good technical specification and the team members make many budgetary offers per month. The aim is to start sending out technical specifications already in the early stages of the sales process, with the budgetary offer, to anchor the baseline of what is being delivered in a more descriptive way. This would be possible if they had specification templates.

Another problem is that variations in the specifications can occur when different people make their own versions. Mistakes can also be made, especially during time pressure, one might forget to change some values or forget to delete information that is not relevant for that specific project. With specification templates available, the personnel could use their working time more efficiently and human errors could be reduced. In some cases, Energy Services cooperates with Energy Business (sales of new power plants), it would therefore be preferable if the technical documents would have a consistent design and the request is that the technical specifications would follow the same layout as the ones for new power plants. This would give the company a more uniform image.

Furthermore, the proposal team is in the process of developing a new gas conversion sales tool. Their aim is to reduce the time it takes to prepare a proposal for a gas conversion. Therefore, all proposal documents needed will be linked to this tool, including the technical specifications. The tool will generate a cost calculation, GTC, scope of supply and a technical specification for a specific gas conversion project based on the user input. This must be considered when creating the specifications.

1.3 Purpose

The core purpose of this thesis is to compile technical specification templates for Wärtsilä gas conversion portfolio. These specifications will be used by the Project Proposals team when making proposals. The aim for the company is to present the content of a gas conversion project in a descriptive way to the customer. The content being the parts and services delivered by Wärtsilä. The technical specifications will act as a basis for understanding the requirements to be fulfilled by the customer. The specifications will also act as a basis for final contracts.

Furthermore, the aim is to create technical specifications that can be linked to the new gas conversion sales tool that is under development. The goal is that the result of this thesis, the technical specifications, will help the team members in their daily work, reduce non-value adding work, save time and eliminate unnecessary mistakes.

1.4 Delimitation

Since the assignment is to compile technical specifications for Wärtsilä's gas conversions, this thesis will deal with the subject of gas conversions. Wärtsilä offers three different gas conversion concepts, SG, DF and GD. The thesis will be limited to the first two as they make up the majority of all proposals. The market for the GD concept is very small since it is only suitable in areas where the gas is of inferior quality, therefore this solution is offered only a few times a year and will not be included in the new sales tool.

I will use existing documents as a basis for the specifications and with the help of experts in different fields modify these so that they can be applied to gas conversion projects. These experts are people that have been involved in previous projects.

The technical specifications should be applicable to gas conversions on a general level, meaning that project specific details must be modified based on different case requirements when creating the proposal. Technical specifications will be created for all the different engine types included in the gas conversion sales tool; the engine types are presented in Table 1.

Table 1. Engine types included in the gas conversion sales tool

Existing engine		Engine after conversion	
Product type	**Product type configuration**	**SG concept**	**DF concept**
Wärtsilä 46	W12V46 W16V46 W18V46	W18V50SG	W12V50DF W16V50DF W18V50DF
Wärtsilä 50	W18V50HFO	W18V50SG	W18V50DF
Wärtsilä 34	W9L34LQO W12V34LQO W16V34LQO W20V34LQO	W9L34SG W12V34SG W16V34SG W20V34SG	W9L34DF W12V34DF W16V34DF W20V34DF
Wärtsilä 32	W9L32 W12V32 W16V32 W18V32 W20V32	W9L34SG W12V34SG W16V34SG W18V34SG W20V34SG	W9L34DF W12V34DF W16V34DF W18V34DF W20V34DF
Vasa 32	Vasa 12V32 Vasa 16V32 Vasa 18V32	Vasa 12V34SG Vasa 16V34SG Vasa 18V34SG	Vasa 12V32DF Vasa 16V32DF Vasa 18V32DF

Since the specifications will be linked to the new sales tool, certain requirements are placed on the design of the documents. The user input from the tool needs to be transmitted to the technical specifications. Examples of such information is the power plant's existing engine type, number of engines and engine type to be converted to. The required format of the specifications is word-format since they must be editable, and this is also the format used for the other proposal documents.

1.5 Confidentiality

The result of this thesis, the technical specifications that are created for the Project Proposals team, contain confidential information and will only be shared within Wärtsilä. The content of the specifications is summarized and presented on a general level in Chapter 4.

2 Theory

In this chapter the theoretical framework of this thesis will be presented. Wärtsilä's gas conversion concepts will be described and different engine types will be presented. Further the benefits of a gas conversion will be highlighted, and the scope of supply is presented on a general level. The importance of good technical communication is also described; thus, this is essential for understanding the benefits of the practical part of this thesis.

2.1 Gas Conversion of Power Plant

As the gas grids expand and the limits for exhaust gas emissions become stricter, the alternative of converting a power plant to gas operation becomes more and more feasible. Wärtsilä's engines are flexible and easy to adapt for gas operation, and in the future also for synthetic renewable fuels. (Wärtsilä, 2020b).

2.1.1 Different Gas Conversion Solutions

A gas conversion means that an existing engine is converted from using liquid fuel, usually HFO, to run on either natural gas or on gas and liquid fuel instead. A conversion project can include all the engines of a power plant, just a few or even just one of the engines. Wärtsilä's two most offered gas conversion concepts are presented below.

SG Concept

Wärtsilä's SG engine is a four-stroke spark ignited gas engine designed for pure gas operation, which means that it cannot run on liquid fuels. The engine works according to the Otto cycle, were the gas and air mixture is ignited with a spark plug. The engine utilises low pressure gas directly from the pipeline or from vaporized gas (LNG or LPG). This is the best solution if there is continuous gas supply to the power plant. The SG engine has the highest efficiency and the lowest maintenance costs in Wärtsilä's engine portfolio. (Wärtsilä, 2018; Wärtsilä, 2020b).

DF Concept

Wärtsilä's DF engine is a four-stroke dual-fuel engine, which means that it can run on multiple fuels, gas, LFO and HFO. Therefore, it is the most flexible engine in fuel operation modes. The DF engine is the best solution for high efficiency while still having the possibility to use liquid fuels as backup in case of interruption in the gas supply. (Wärtsilä, 2020b). The DF engine can operate in three different modes; gas mode, diesel mode and backup mode (usually HFO).

In gas mode the engine works according to the Otto cycle and it utilises low pressure gas directly from the pipeline or from vaporized gas (LNG or LPG). The gas and air mixture is ignited by pilot fuel (diesel) injection. The engine can be transferred from gas mode to diesel and backup mode during operation. (Wärtsilä, 2019).

In diesel mode the engine works according to the diesel cycle and it utilises main fuel and pilot fuel injection in order to keep the pilot injector ready for a switch to gas mode. The engine can be transferred from diesel mode to gas mode during operation. (Wärtsilä, 2019).

In backup mode the engine also works according to the diesel cycle, but it only utilises main fuel injection. This because it acts as an emergency mode without pilot fuel and therefore it is not possible to switch to gas mode during operation. (Wärtsilä, 2019).

2.1.2 Different Engine Types

Wärtsilä’s product portfolio includes a wide range of different engine types, this thesis will however only focus on the product families included in the new gas conversion sales tool (see Table 1. in Chapter 1.4). Through my work experience at Wärtsilä I have learnt that Wärtsilä’s engines are named based on the cylinder bore size and based on the fuel type. For example, the engines included in Wärtsilä 32 product family have a cylinder bore size of 320 mm. Examples on how engines are named is presented in Table 2.

Table 2. Engine abbreviations

W	**9**	**L**	**32**
Wärtsilä engine	9 cylinders	In-Line	Cylinder bore 320 mm
W	**18**	**V**	**46**
Wärtsilä engine	18 cylinders	V-engine	Cylinder bore 460 mm

A W9L32 engine will after a gas conversion be named W9L34SG or W9L34DF depending on the conversion concept and a W18V46 will be named W18V50SG or W18V50DF. In the first case the cylinder bore size is increased from 320 mm to 340 mm and in the latter, from 460 mm to 500 mm. The cylinder bore size is increased when the engine is converted to run on gas, this is done to ensure the same output as before the conversion.

2.1.3 The Benefits of a Gas Conversion

To convert an existing engine from using HFO or LFO as a fuel, to run on natural gas instead, has several economic benefits. Operational costs are lower for a gas power plant since gas is generally a cheaper fuel, in addition, the consumption of lubricating oil is reduced when switching from HFO to gas operation. As a power plant age and the equipment age, efficiency often declines leading to increased fuel consumption and reduced output. In the case of a gas conversion, a relatively large upgrade of the power plant is made because a significant part of the engine parts and external systems are renewed. Which means that after the conversion the engine will perform like a new one in terms of performance (output and heat rate) and reliability. The operational life of the power plant is also extended since the engine’s running hours can be reset to zero, therefore a new maintenance schedule, starting from zero, can be given. Which results in a reduction of both short- and long-term maintenance costs. The best timing for a gas conversion is therefore instead of a major overhaul. (Project Proposals manager, personal communication 2021, January 7).

Another advantage of converting a power plant to gas operation is that exhaust gas emission levels are reduced, which in turn shrinks the power plant’s environmental footprint and helps counteract climate change. In some cases, there may be local recommendations or even regulations regarding emission levels that the organisation must achieve. A gas conversion can therefore be the solution to this problem. (Project Proposals manager, personal communication 2021, January 7). According to the Project Proposals manager, the reduction of Nitrogen oxide (NO_x) and Sulphur oxide (SO_x) emissions are significant. When converting from HFO to gas operation, NO_x emissions can be reduced by up to 90 % and SO_x emissions can be reduced by more than 95 %.

Furthermore, a gas conversion also includes obsolescence management of the power plant, meaning that the on-engine automation system, human machinery interface and the PLC system are upgraded to the latest standards. This will secure the long-term support of the electrical systems. (Project Proposals manager, personal communication 2021, January 7).

2.1.4 Scope of Supply

A gas conversion project involves much more than just the engine of a power plant. In addition to modification of the engine, mechanical auxiliary systems, electrical and automation systems, everything from feasibility studies and solution proposals to execution planning and implementation are also included. Two important aspects are also safety and reliability, i.e. that the power plant meets all safety requirements set on a gas operated plant and that it performs according to given performance guarantees. The conversion concept follows the same principles as a new power plant in terms of the latest type of design and engineering standards. The same engineering partner is used as when selling a new power plant. (Project Proposals manager, personal communication 2021, January 7; Wärtsilä, 2020b).

According to the Project Proposals manager, the majority of all gas conversion projects that have been done have been so-called EPC solutions, which means that Wärtsilä takes care of all phases of the project, the planning, the purchasing and the actual implementation, a key in hand project so to speak. Taxes, duties and various permits are usually handled by the customer. Wärtsilä’s EPC solution includes the following:

- Project management
- Engineering
- Parts delivery
- Installation
- Commissioning and start-up
- Training
- Performance guarantees and warranty

2.2 The Importance of Good Technical Communication

In sales and especially when it comes to selling highly technical products or solutions, good sales skills are of course essential, but one should also keep in mind that sales documents of good quality may have a great impact on the outcome of a sales situation. This chapter deals with B2B sales briefly. Furthermore, the importance of good technical communication is discussed and finally some aspects of what is considered good quality, in terms of technical documents, are presented.

2.2.1 Selling B2B

A company selling industrial products have in general a smaller number of potential buyers than companies in the consumer market. It is said that 80 percent of the company's output is sold to about 10-15 customers in the B2B market. One single customer can therefore be very important to the selling organisation. Because of this, it is often valuable to maintain long-term relationships with these large customers. (Jobber & Lancaster, 2015, p. 78).

Jobber and Lancaster (2015, p. 14) points out that a good product does in fact not sell itself. Even an excellent product might pass unnoticed unless its features and benefits are properly explained to the customer. Furthermore, a great product might not be suitable for every customer.

In B2B marketing it is quite common for the customer to have specific product requirements that the seller need to meet, meaning that the seller must tailor the product offerings for each specific sales case. This process can be costly; however, the potential large revenue of such products makes it feasible. (Jobber & Lancaster, 2015, p. 78). Steehouder, Jansen, van der Poort and Verheijen (1994, p. 4) states that a company must be able to produce coherent and quality writing in order to create great proposals and win bids. Because of the increased demand for well-written proposals, the company's ability to implement the process around creating such documents might be life-preserving.

2.2.2 Technical Communication

International communication has increased massively because of globalisation and English is the language commonly used. Even though the communication is carried out in one language, there are many possibilities for misperceptions. The English used in different countries and in different industries might vary quite a lot. Poor technical communication could have serious consequences and might even lead to accidents causing personal injuries or environmental damages. If we look back in history, we find many examples of such accidents, to name a few, there is the nuclear meltdown in Chernobyl, the space shuttle Challenger disaster and the Bhopal gas tragedy. Investigations have shown that these accidents could have been avoided through better technical communication. If the consumer misunderstands technical instructions and get injured, it could lead to a lawsuit against the manufacturing company. The best way for manufacturers to protect themselves against these kinds of incidents is to make sure that the technical documents are written in such a way that it is impossible for the consumer to misinterpret the information. (Olsen & Huckin, 1991, p. 6-7). Olsen and Huckin (1991, p.1) states that ”*Concise technical messages and clear professional communication are needed to ensure that information is effectively received and/or sent*”.

Studies shows that scientists, engineers and other technical professionals in average spend almost 25 % of their working time writing, and if the time spent on other communication activities is added to this, the total amount increases significantly. Therefore, one can understand that if these time-consuming activities can be reduced, the personnel can focus on other, more value-adding, tasks. This can be done by development of effective strategies for analysing communication activities and producing technical material such as reports, instructions and specifications. (Olsen & Huckin, 1991, p. 7-8).

Olsen and Huckin (1991, p. 11-13) states that when writing technical documents, basic language skills are not the only thing one need to master. According to studies, engineers and other experienced businesspeople consider the following things important when creating technical documents:

- Writing clearly
- Clearly stating one’s purposes to readers
- Knowing how to organise a communication
- Writing concisely

Olsen and Huckin (1991, p. 13) have also highlighted the result from another study where senior officials in science and industry listed their complaints about technical writing, the following things where the top mistakes one can do according to the respondents:

- Foggy language, inadequate vocabulary and wordiness
- Failure to connect information to point at issue
- Lack of stressing important points
- Too much “engineering gobbledygook”
- Poor overall organisation

2.2.3 Quality of Technical Documentation

Quality as a concept is multidimensional and can have several meanings, hence no unambiguous definition can be found. Steehouder et al. (1994, p. 1) quotes Pirsig, who deems that, ”*quality does not have to be defined [...] Quality is a direct experience independent of and prior to intellectual abstractions*”. According to Steehouder et al. (1994, p. 1) this does not necessarily mean that quality, in the sense of technical documentation, cannot be discussed. They consider an analytic approach feasible when addressing the concept of quality in this case.

Steehouder et al. (1994, p. 1) points out that there is a variety of dimensions on which the quality of documentation can be assessed; one approach is the interplay between quality and usability which they also call the *product-oriented* view. Where the usability of the document is determined with regards to instructions, definitions and different tools for finding information in the document. However, one may have to make compromises, since it is rarely possible to only ensure user-friendliness. Steehouder et al. (1994, p. 10) refers to an example by Waller and Lewis where they address various requirements that can be placed on a document containing instructions for a payphone. In addition to the information following and conveying the organisation's identity, it must also comply with international standards regarding symbols for emergencies, contain different credit companies' logos, etc. In addition, it must be printed on a material that is fireproof.

Compromises may also need to be made regarding quality and affordability; how much money is worth investing in a new solution? What is the possible profit? Looking at training materials, for example, using a video is probably more effective, but paper is cheaper. However, there does not always have to be a conflict between these two, in some cases, improving the design can lead to savings for the organisation. Another compromise that can be encountered is between quality and availability, where time pressure might be the issue. In this case one must decide whether something should be done perfectly or if it should be done as quickly as possible. Thus, one may have to lower the quality in order to prioritize other set requirements. This may also be true in the previously mentioned situations. (Steehouder et al., 1994, p. 11).

Cultural factors have a major impact on what is considered to be of good quality. One of the strongest factors that affects the user's perception of quality is whether the written document is created for a specific group of people who have a certain type of knowledge and opinion, and thereby use a language adapted to this category of users. (Steehouder et al., 1994, p.3-4). Lannon (2008, p. 463) points out that the purpose of technical descriptions is to provide information about a product to people who are going to use or operate it, assemble or manufacture it. One can visualize a product from different perspectives, and one should therefore choose the perspective depending on the purpose and the target audience. Steehouder et al. (1994, p. 3-4) mentions also that a manual should be adapted to the customer group it is aimed for, e.g. professionals in the field or ordinary consumers. Therefore, it is essential to consider the user's level of knowledge when creating the content.

Since the quality of a document is affected by the user's perception, it is important to determine the target group in advance and to analyze what requirements this group may have on a particular document. Reading can be described as a strategic activity where the reader usually has a predetermined purpose for his reading. An example is reading for decision-making, which means that the reader gathers information from different places in order to make an informed decision. Such a situation can, for example, be a car purchase. Situations like these are often multidimensional, which means that the reader analyzes the alternatives based on several different criteria. They are looking for a solution that meets all or as many of their requirements as possible. Another way to start the work process is to try to answer questions such as what information is to be communicated, in what way, and finally, what the reader will use the information for. (Steehouder et al., 1994, p. 10-21).

Since there are many different types of technical documents, it can be hard to find any exact instructions for how a technical document should look in order to be considered to be of good quality. Markel (2012, p.12) however deems that there are eight measures of excellence for technical documents. These are honesty, clarity, accuracy, comprehensiveness, accessibility, conciseness, professional appearance and correctness. Below follows a summary of these measures.

Honesty – technical documents should provide information, not mislead the user. As mentioned in chapter 2.2.2, dishonesty can have serious consequences; the user could e.g. get injured and the organisation could be faced with legal charges.

Clarity and accuracy – these are important because unclear and inaccurate documentation can like dishonesty be dangerous but also expensive if the user e.g. needs to call customer support in order to understand the instructions in a manual.

Comprehensiveness – the document must contain all the needed information, all details that the user needs in order to carry out a task or to make a decision.

Accessibility – technical documents often consist of small, independent sections, it's therefore important to make the different parts easily accessible to the user. This can e.g. be done with informative headings and index tables.

Conciseness – to much text, unnecessary phrases and long sentences should be avoided.

Professional appearance – a neat and professional document will give the user a positive impression. The document should follow the format standards of the organisation.

Correctness – incorrect writing can mislead and confuse the user; it can also give an unprofessional impression to the reader. (Markel, 2012, p. 12-14).

2.2.4 Feedback

Based on what was presented earlier in this report, it can be concluded that exact guidelines for creating a technical document of good quality doesn't really exist. How do one then decide if what has been written is good or not? The answer is; using feedback. Steehouder et al. (1994, p. 31) points out that there are different types of feedback that can be useful for writers and that little feedback is better than none at all. Furthermore, they believe that feedback from experts in various areas can be valuable and that this also can lead to other communication alternatives being highlighted. Markel (2012, p. 8) also believes that collaboration with several people is common when creating technical documents. He points out that no one alone can have all the information, time or skills needed to produce a large document.

The best-case scenario is if one succeeds in getting feedback from people who possess relevant knowledge regarding all of the document's communicative roles, since a document can have several different purposes to fulfill. One document can e.g. both highlight the properties of a product while also presenting various safety regulations. The document then functions partly as marketing material at the same time as the legal aspects are considered with regard to informing the customer about how the product is to be used in a safe manner. A detailed evaluation of the document can thus be essential in order to discover all problem areas. (Steehouder et al., 1994, p. 26-33).

3 Method

This chapter will give a brief introduction to how the research method for the practical part of this thesis, the work of compiling the technical specification templates, was chosen. The choice of research method and methods for data collection will then be presented and the execution of the practical work will be described.

Blomqvist and Hallin (2014, p. 57) describes research design as a model for how to make a problem researchable. Which means that one need to answer the question of; who or what needs to be studied in order to get the information needed to solve the problem that the problematisation entails. Choosing a research design therefore means that one need to investigate what type of empirical material will help one to understand a certain phenomenon.

In order to answer questions and solve a problem in a development project, thesis project or research project, information must be collected and analyzed, this will form the basis for the conclusions that are drawn. Data collection can be done in different ways and the method will depend on the purpose and focus of the study. (Carlström & Carlström Hagman, 2006, p. 123).

The assignment for this thesis was to compile technical specification templates for Wärtsilä's gas conversions. Since there are technical specifications for new power plants as well as specifications made for previously performed gas conversions, the work can be classified as a development work rather than a direct research. Documentation from these previous projects can be used when creating the specification templates. For this thesis, a qualitative research approach has thus been chosen. The data collection methods used to gather information for this work are partly document collection and partly semi-structured interviews with selected experts in various areas.

3.1 Qualitative Research Method

A qualitative research assumes that everything must be assessed based on people's experiences of reality and their different perspectives on this reality, this applies not only to the participants in the study but also to the researcher. The reality the researcher is interested in is the one that people themselves perceive or construct in interaction with others. When it comes to reliability, for example, several interpretations of the same information are entirely possible and are also expected to be so. A summary of some recommendations for achieving good reliability in qualitative studies are presented below.

- Participant control, this means that the people who have provided information in the research is given access to the descriptions and the interpretations, in order to decide whether the results seems reliable.
- Horizontal review and feedback mean that colleagues take part in and discuss the results as they emerge.
- Participatory approach, this means that those who participate in the research are also involved in its various phases, reviewing and commenting.

(Carlström & Carlström Hagman, 2006, p. 137-138).

3.2 Document Collection and Semi-structured Interview

Collecting different documents as one of several data collection methods is quite common when doing a research or development project. The documents used as empirical material varies depending on the purpose and problem area of the research. One can for example use official documents, documents from organisations, letters, e-mails, photos, media products and virtual products. (Blomqvist & Hallin, 2014, p. 69).

One of the most common methods of gathering empirical data in qualitative research is through interviews. The reason for this is that one can, with relatively simple means, learn more about how people reason regarding different issues. If the interview is of an open nature, one can also discover new dimensions of the studied subject, which can open up for other questions. The interview provides good opportunities to make unexpected discoveries, which is an important part of qualitative research. There are different types of interview methods, the type used in this thesis is the semi-structured interview. This type of interview is organised around a number of themes or question areas that have been decided in advance. The questions asked during this type of interview are not usually formulated in advance. (Blomqvist & Hallin, 2014, p. 69-71).

3.3 Gathering Information and Implementation

The work was initiated by a meeting with my supervisor from Wärtsilä. The purpose of this meeting was to discuss the assignment in more detail, what the company's expectations were and what information I needed to gather and from who I was going to get the needed input for the specifications.

As previously mentioned, technical specifications for new power plants are available and the goal is that the specifications for gas conversions would have the same design as those. Therefore, the existing specifications were used as a basis for developing the new specifications. Another reason is that the conversion concept follows the same principles as a new power plant, thus general information regarding Wärtsilä's design etc. is also applicable for gas conversion projects.

In order to create technical specifications for the different engine types, information about which engine parts, mechanical auxiliary systems, electrical and automation systems that are being replaced or modified is needed. Since gas conversion projects have been carried out before, this information has been documented. Document collection was therefore used as a data collection method. The documents used for this study are previously made specifications for different engine types and conversion concepts as well as existing power point presentations. The documents were found via Teams and Wärtsilä's internal webpages. When selling a gas conversion, a completely new power plant is not delivered, so the work that needed to be done was to delete a large share of the parts presented in the specifications for new power plants and only leave the descriptions of the parts that are actually delivered. Modifications were also made to descriptions since one start from an already delivered solution.

The technical specifications also describe all services provided by Wärtsilä in connection with a project. The task was thus also to go through these sections of text to ensure that the descriptions of the services are relevant for a gas conversion. Semi-structured interviews with selected experts in the various areas was used as a data collection method for this part of the work. Some interviews were also held regarding descriptions of technical parts and the actual design of the specifications. Most interviews were conducted through Teams because the majority of Wärtsilä's staff worked remotely due to the ongoing coronavirus pandemic.

The text sections that were to be reviewed were sent to the selected experts in advance, together with a short description of the purpose of the thesis, so that they would have the opportunity to familiarize themselves with the material before the interview. In most cases, the texts were modified during the interviews, i.e. changes were made directly in consultation with the various experts. In the other cases the interview was recorded, and the modifications were made afterwards. In these cases, the modified text was sent to the interviewed expert to verify that the final text was consistent with what was discussed. After that, small changes were made in accordance with the expert's feedback. In two cases, no interview was needed, and the experts gave their comments directly by e-mail and the changes were made based on their feedback.

When the first specification was almost done, a review was arranged with a project proposal manager. The purpose of the meeting was to review general information in the specifications as well as all parts delivered. The proposal manager has several years of experience of gas conversion projects and knows which parts are delivered for the different engine types and conversion concepts. Changes were made during the meeting in accordance with the feedback given by the proposal manager. A new review was held for each new specification. Below follows a summary of the people interviewed for the different sub-areas:

Table 3. Interviews conducted for this thesis

Field	Interviewed person(s)
Engineering & Documentation (Face to face meeting)	Representative from Citec Project proposal manager
Training (Teams meeting)	Solution development manager Director, training services Training sales support manager Project proposal manager
Project Management (Teams meeting)	Project group manager
Site management (Two separate Teams meetings)	Project proposals manager Project group manager Project manager Senior project manager (2 persons)
Engine automation (Teams meeting)	Product manager, engine control upgrades Project proposal manager
Control system (E-mail)	Chief project engineer
Plant isolation valve (E-mail)	Development manager, performance
Gas pressure to gas regulating unit (Teams meeting)	Development manager, performance
Transportation & the development of the specifications (Teams meeting)	Value modelling manager
Commissioning	Senior project manager (2 persons) Project manager
Review/feedback (Eight Teams meetings)	Project proposal manager

4 Result

This chapter summarizes the results of the thesis. The solutions that were made in order to minimize the number of technical specifications are described and a list of all the specifications is presented. The technical specifications that have been created for the project proposals team are confidential and will only be shared within Wärtsilä. In order for the reader to get an overview of the content, a summary of general information will be given and the technical concept for a gas conversion will be described. Furthermore, the services provided by Wärtsilä are presented.

4.1 Development of the Technical Specifications

The purpose of this work was to compile technical specification templates for Wärtsilä gas conversion portfolio and the engine types to which this work would be limited were listed in chapter 1.4 (see Table 1.). One goal was to minimize the number of specifications and during the work, various solutions for how this could be done have been discovered.

The specifications contain information about the number of components delivered and certain quantities are related to the number of cylinders in the engine. In order not to have to create different specifications for e.g. a W9L34SG (9 cylinders) and a W20V34SG (20 cylinders), the number of components has been marked with an “X” together with the comment “same as number of cylinders”. When the specification is generated, the X will be replaced with the correct number based on the input used in the tool. The same applies to the number of engines that will be converted, in the specification templates the number is marked with "X" and the comment "same as number of engines", the correct number will be generated from the tool.

In order not to have to differentiate between the L and V engines' specifications, the number of, for example, turbochargers is marked with an "X" together with the comment "one per bank", which means that if it is an L engine, the X will be replaced with number 1 and if it is a V engine, the number will be 2. The result was ten different specifications, these are presented in Table 4. The biggest differences between the specifications are the engine parts delivered. This depends partly on the existing engine type and partly on which concept converted to.

Table 4. The engine types for which technical specifications were compiled

Existing engine type	Engine type after conversion
Wärtsilä 46	Wärtsilä 50SG
Wärtsilä 46	Wärtsilä 50DF
Wärtsilä 50HFO	Wärtsilä 50SG
Wärtsilä 50HFO	Wärtsilä 50DF
Wärtsilä 32	Wärtsilä 34SG
Wärtsilä 32	Wärtsilä 34DF
Wärtsilä 34LQO	Wärtsilä 34SG
Wärtsilä 34LQO	Wärtsilä 34DF
Vasa 32	Vasa 34SG
Vasa 32	Vasa 32DF

The technical specifications also contain data that cannot be determined in advance, since it depends on how the existing power plant is built and what the conditions are at the site. This type of information is marked in red in the specifications together with the comment "to be checked case by case". In this way, the person making a proposal can quickly find the things that should be checked before the offer and the specification are sent to the customer.

Furthermore, the technical specifications describe the transportation, i.e. what is included in Wärtsilä's scope of supply and what is the customer's responsibility. There are five different transportation alternatives (Incoterms); CIF port, CIP port, CIP site, DAP and FCA port. The transportation option will also be selected in the new tool, so depending on which option is selected, the correct terms must be described in the technical specification. Together with the programmer, it was decided that the transportation terms would be placed in separate documents and a blank page would be left in the specifications where the terms will be inserted. This was another action made to reduce the number of final specifications.

4.2 General Information

The first part of the technical specifications consists of an executive summary, where the basics of the design and function of the engine is presented, the type of product is also specified. Further main data and conditions are presented including information about the number of engines to be converted, existing engine type and site conditions. The site conditions belong to the category of information that must be checked case by case and are thus marked with a red X. Operation media is also defined, this includes fuel parameters, limits for engine cooling water, charge air and lubricating oil. Lastly codes and standards for the mechanical and electrical systems are listed and abbreviations are described.

4.3 Technical Concept

The starting point for a gas conversion is that an engine type is converted to either an SG or DF engine. For the engine to work, be safe and for Wärtsilä to be able to provide performance guarantees, specific modifications must be made. When doing a gas conversion an engine is converted to another type that has previously been produced in a factory, i.e. the concept is tested and safe. This means that the project team knows what needs to be done in order to ensure that all requirements are met. The engine parts, mechanical auxiliary systems and electrical and automation systems delivered during a gas conversion are presented below on a general level. A more detailed description of the parts replaced is presented in the technical specifications that have been developed.

4.3.1 Engine Parts

The biggest change is that the new engine uses a different fuel, which means that, for example, the fuel system needs to be renewed. In most cases, the cylinder bore size is also increased, in order to guarantee the same output as before the conversion. Listed below are the engine parts replaced on a Wärtsilä 32 engine when converting to either Wärtsilä 34SG or Wärtsilä 34DF. The modifications made are visualized in Figure 1 (SG) and in Figure 2 (DF).

Turbochargers and charge air coolers – The turbocharger feeds air into the engine through the charge air cooler. These must be replaced in order to ensure that the right amount of air and right air temperature is supplied to the engine for gas operation. The turbocharger and charge air cooler are performance critical parts that needs to be replaced in order to be able to give performance guarantees.

Main gas piping and main gas valve – These does not exist on an HFO or LFO engine. Are needed in order to take gas fuel into the engine.

Cylinder heads and cylinder head equipment – The cylinder heads must be replaced since the design is different on a gas engine. The pilot fuel injector on a DF engine is e.g. not compatible with the cylinder head on an HFO engine.

Cylinder liners, pistons and piston rings – The cylinder bore size is increased from 32 cm to 34 cm, larger cylinder liners, pistons and piston rings are thus needed.

Shims for connecting rods – The shim is a small plate located between the upper and lower part of the connecting rod. This is replaced since an HFO and a gas engine have different compression ratios.

Camshafts – The camshafts control the intake of air to the cylinder, the injection of liquid fuel (only on DF) and the exhaust gas from the combustion chamber. The air and fuel mixture, the inlet and exhaust sequence are different on a gas engine, the profile of the camshaft is therefore different.

UNIC engine control system – The engine automation differs between an HFO and a gas engine. The control system for a gas engine is more advanced since there are much more things to be controlled, gas injection, main gas valves, safety system etc.

Pre chamber and spark plugs (SG) – Serves as the ignition source for the main fuel charge.

Pilot fuel injector (DF) – The pilot fuel is needed since the gas-air mixture is ignited by a small amount of pilot fuel.

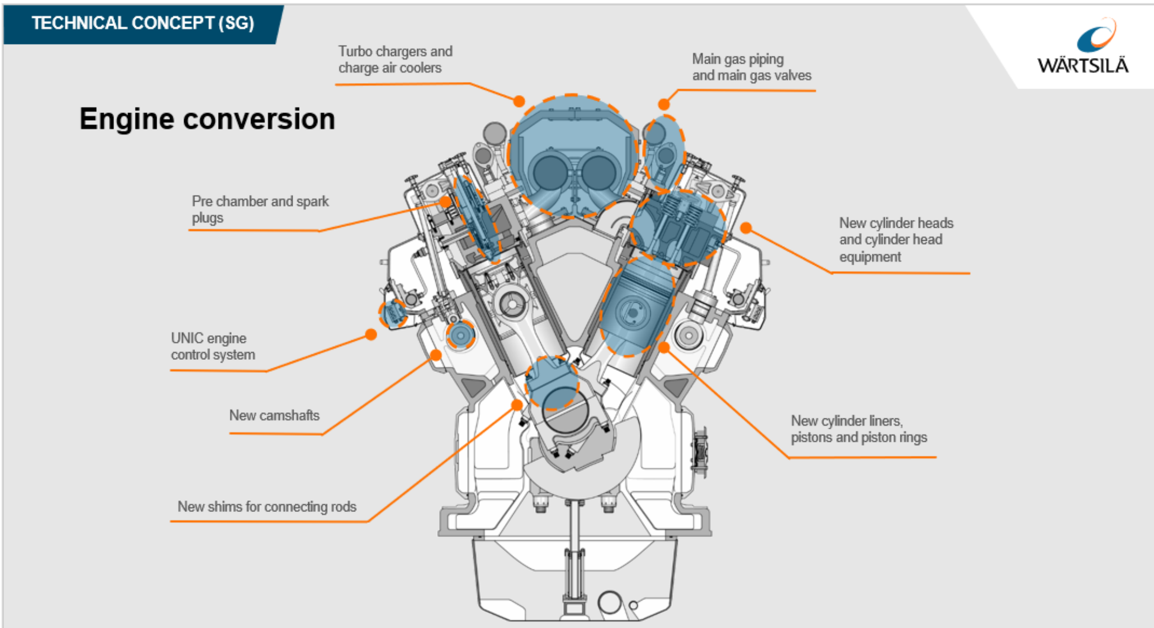

Figure 1. Engine modifications for SG concept.

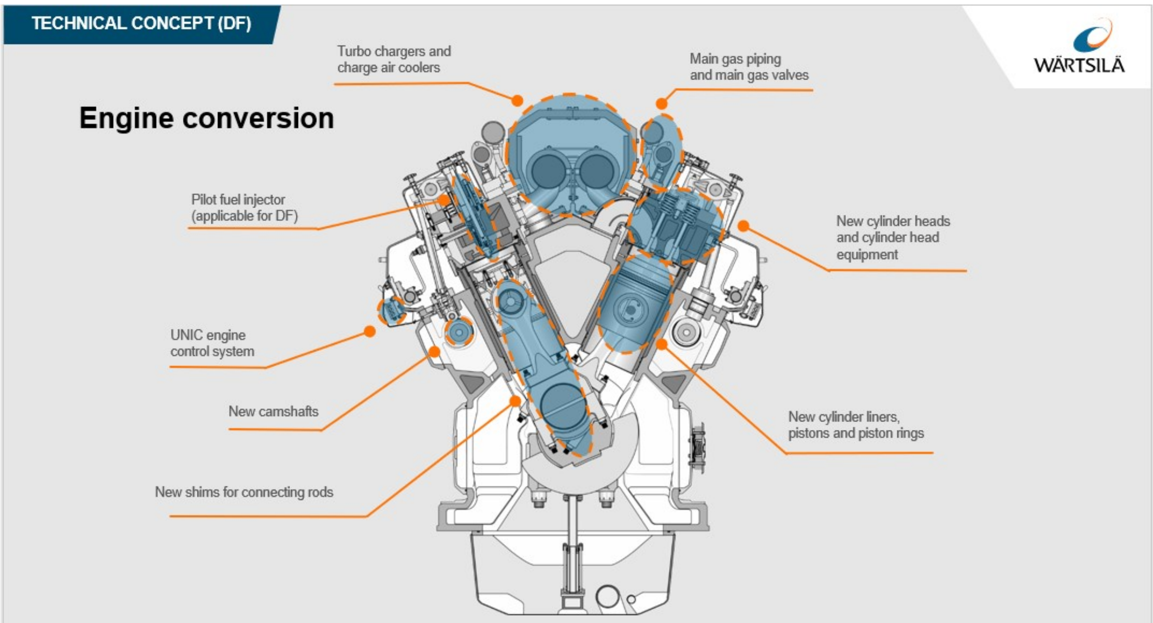

Figure 2. Engine modifications for DF concept.

4.3.2 Mechanical Auxiliary Systems

The mechanical auxiliary systems delivered in a gas conversion project are presented below and the changes are visualized in Figure 3.

Exhaust gas ventilation unit – This unit will be added during a gas conversion. Consists of a purge fan that will be activated before start-up and after stop of the engine. It blows fresh air through the exhaust system to ensure that there are no unburned gases from the combustion, this prevents a build-up of pressure and is a safety measure.

Gas regulating unit – This unit is also added during a gas conversion. It regulates the gas pressure into the engine, and it is equipped with a flow meter. This is needed to ensure that the right amount of gas is supplied into the engine.

Cooling water system modifications – This is a small valve that regulates the cooling water temperature to the engine. Must be renewed since old engines have old types of valves that does not have the same control ability and gas engines are generally more sensitive to temperatures.

Safety vents – The safety vents are placed on the exhaust duct and if there for some reason is unburned gases in the exhaust system and the pressure is too high the safety vents will open and release the pressure. This is a safety measure because high pressure can damage the system.

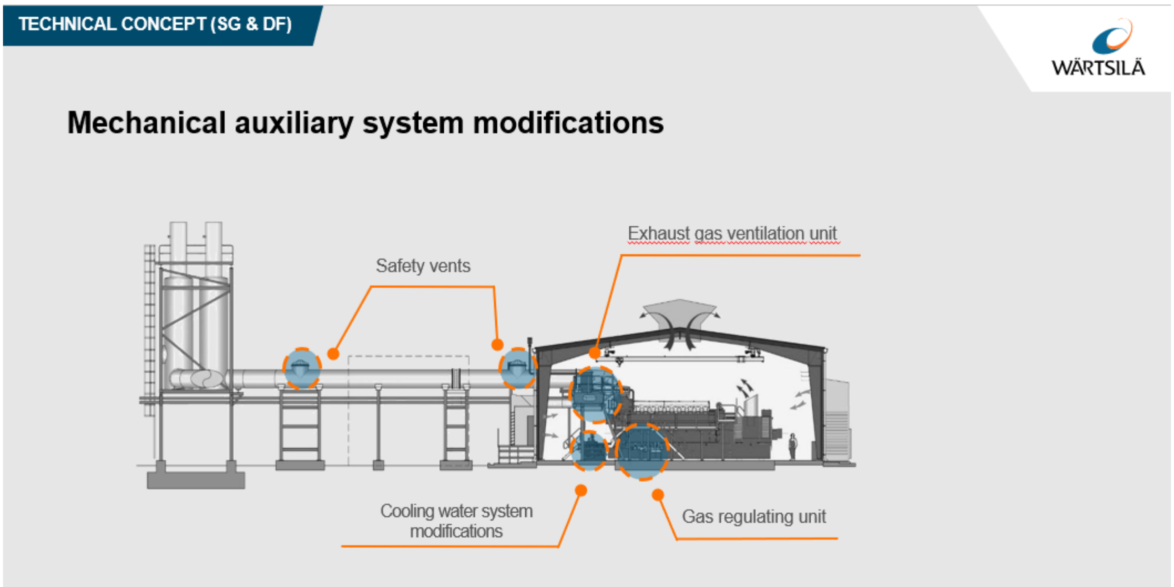

Figure 3. Mechanical auxiliary system modifications for SG & DF concept.

4.3.3 Electrical and Automation – Plant System

The electrical and automation systems that are updated in connection with a gas conversion are presented below and visualized in Figure 4.

WOIS – This is the computer from which the operators run the power plant. The system must be upgraded to the latest standards and updated for gas operation.

Common and generating set PLC – The existing systems are not compatible with gas operation and the control panels need to be upgraded to the latest PLC standards.

LV switchgear – Modifications are made to conform with the new consumers, for example the exhaust gas ventilation unit.

DC panels – Needs to be upgraded because of the new consumers, for example the engine automation system.

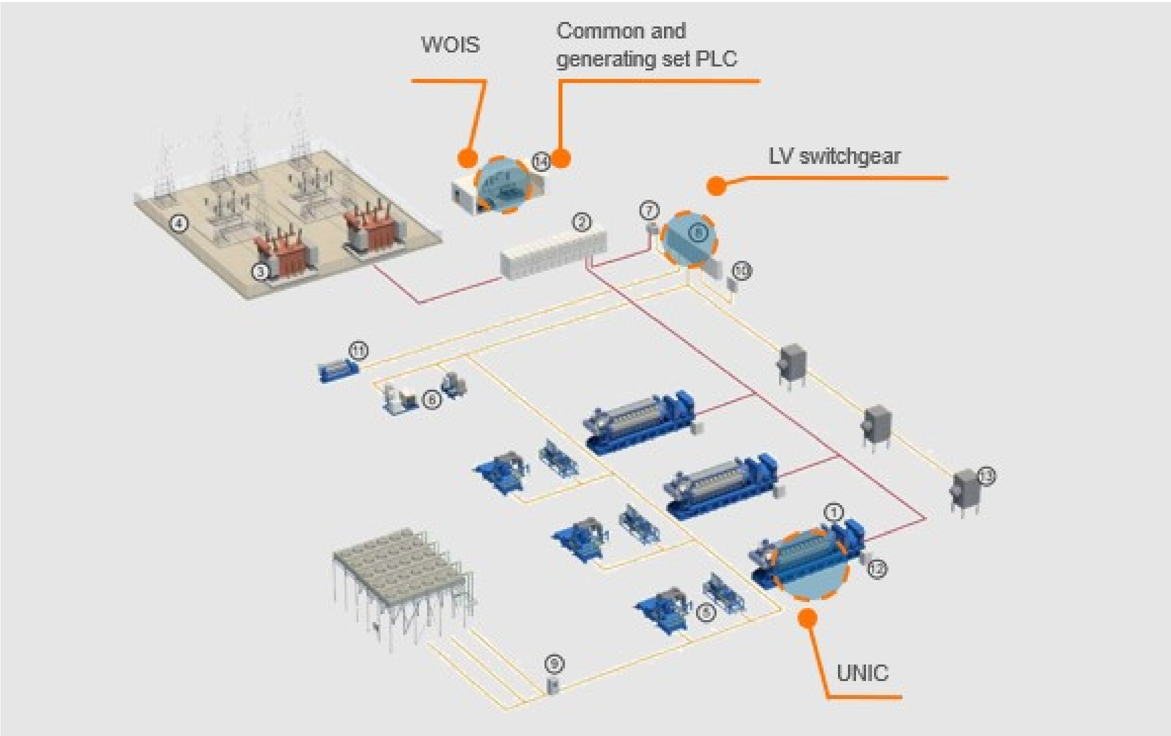

Figure 4. Electrical & automation system modifications for SG & DF concept.

4.4 Services Provided by Wärtsilä

A gas conversion project also includes services of various kinds. These services are described in the technical specifications. However, the descriptions are the same regardless of engine type or conversion concept, which means that the text sections are the same in all specifications. The services provided by Wärtsilä are briefly described below and a more detailed presentation can be found in the technical specifications.

Engineering – The engineering process at Wärtsilä is well-defined with clear responsibilities and phases. The engineering of items supplied by Wärtsilä is divided into two disciplines; mechanical and process engineering and electrical and automation engineering. The work is categorised into basic and detailed engineering. Where basic engineering means development of a well-defined design package of equipment or solutions delivered by Wärtsilä and detailed engineering is further development of the basic design. The detailed engineering enables final procurement and further the proceeding of installation and commissioning of the system. The detailed design is also input for quality assurance and manuals.

Documentation – Operation and maintenance manuals contain all the necessary information for safe operation and maintenance of the power plant. The content of the manual is presented in the specifications and limitations are also mentioned.

Project management – The deliverables are presented in the specifications, everything from planning, execution, reporting and change control to project closure. This section describes how the project is organised including the following; risk management, financial management, time management, project communication management, quality management and procurement management.

Site management – Includes the planning and managing of all activities related to the conversion site. This is needed to ensure that the activities are performed according to the contract and according to quality and safety requirements and also within the set time schedule. The following services are described in the specifications; site organising and resourcing, HSE and security management, conversion planning, subcontracting, supervising and steering the conversion works, communication at site, site materials management, time management and site quality management.

Commissioning and commissioning management – Commissioning refers to the activities done to achieve, validate and document that the installation and its systems are designed, installed, tested and performs according to contract requirements. The commissioning consists of installation quality assurance, functional test and performance test. These are described in the specifications. The commissioning management includes planning, organising and resourcing of the commissioning works. HSE management, coordination, meetings, time management and documentation are also presented in the specifications.

Training – Two different training courses are included in the gas conversion supply. Both courses are held at site. The programme for the training courses is presented in the specifications. The time and duration, course language and number of participants are also specified.

5 Conclusion

In this chapter, I analyze my thesis in its entirety. I discuss the validity of the result, i.e. if the result is relevant and if it fulfills the purpose of the assignment. Furthermore, the reliability of the results is discussed, whether the technical specifications are useful and whether the information in them can be considered correct.

The core purpose of this thesis was to compile technical specification templates for Wärtsilä gas conversion portfolio. The specifications will be used by the Project Proposals team when making proposals. The aim for the company is to present the content of a gas conversion project in a descriptive way to the customer. The content being the parts and services delivered by Wärtsilä. The technical specifications will act as a basis for understanding the requirements to be fulfilled by the customer. The specifications will also act as a basis for final contracts.

Furthermore, the aim was to create technical specifications that can be linked to the new gas conversion sales tool that is under development. The goal is that the result of this thesis, the technical specifications, will help the team members in their daily work, reduce non-value adding work, save time and eliminate unnecessary mistakes.

The result is ten different technical specifications, these cover all engine types included in the new tool. The specifications describe everything that is delivered in a gas conversion project, all parts and services. In addition to this, fuel quality parameters and other requirements are presented. The specifications contain comments and instructions with regards to linking the document to the new gas conversion sales tool. In addition, there are parts that are marked in red so that the person making the proposal easily can find the things that should be checked case by case. Thus, I believe that the purpose of the thesis has been achieved.

In Chapter 3.1, some ways were presented on how to ensure the reliability of the work. It was mentioned that the people who have provided information in the research can be given access to the descriptions and the interpretations, in order to decide whether the results seems reliable. Furthermore, the Chapter 2.2.3 highlighted that the quality of a document is affected by the user's perception. In Chapter 2.2.4 it was mentioned that feedback from experts in various areas is valuable and the best-case scenario is if one succeeds in getting feedback from people who possess relevant knowledge regarding all of the document's communicative roles.

To be able to create the technical specifications, I have studied Wärtsilä's gas conversion concepts and different engine types. I have compared previously made specifications with each other to understand which parts are delivered depending on the existing engine type and the choice of conversion concept. Furthermore, I have studied the subject of technical communication and documentation to understand how to create technical specifications of good quality. To ensure the reliability of the information, the content has been presented to an expert with long work experience in the field. Modifications have been made in consultation with the expert.

In addition to this, experts in the other areas described in the specifications have also been interviewed. It was discussed as to whether the descriptions of different areas are relevant for gas conversion projects and the content has been edited based on the feedback given. These experts consist of people who work or have worked with gas conversion projects and thus possess practical knowledge of how these projects are carried out. My conclusion is therefore that the results, the technical specifications, can be considered reliable and that they can be used by the project proposals team when submitting proposals.

Furthermore, I believe that all parts of this thesis project are relevant. The theoretical part deals with the subject gas conversion, technical communication and quality of technical documents. These serve as a basis for the practical work. The choice of data collection method has been made based on the purpose of the work and my opinion is that the methods were suitable for achieving a reliable result.

I would also like to point out that continued update of the content of the technical specifications is essential as Wärtsilä continuously develops its products. New designs and solutions are developed, and this can affect the content of the specifications. Cooperation between different departments should be maintained and new solutions communicated, in this way it can be ensured that everyone has the latest information and that the sales material is up to date.

Finally, I can state that the thesis project and this assignment has been very educative. I have gained deeper insight into what requirements are placed on a research work and different ways to carry out a study or a development project. One of the most important things I have learnt is that planning is an essential part of the process. Good planning facilitates the following steps in the work process. Another thing I have learnt is that as a researcher one has to take on a project with an open mind, in this way one can make discoveries that one otherwise would not. In addition to this, I have of course also learnt a lot about Wärtsilä's gas conversions and gained a better understanding of the differences between different engine types and conversion concepts.

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