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STANDARDIZATION AND OPTIMIZATION OF THE FUEL UNLOADING STATION

Kone- ja tuotantotekniikka

2010

OPENING WORDS

This thesis has been done in cooperation with Wärtsilä Finland Oy, Power Plants engineering management office. I have been working for Wärtsilä for a couple of years. I started as a summer trainee in R&D engine laboratory in 2007. Since then I have gained experience in mechanical installation working as an hour-based trainee in engine installation factory. In 2009 I worked five months in a project for Power Plants in Argentina as a mechanical supervisor. I have seen my work experience as a great advantage when writing the thesis as I already have knowledge of the way of working in Wärtsilä and Power Plant technology. I also have practical experience in Power Plant operations and ability to understand how different modules work in Power Plants.

I want to thank my teacher and the people in Wärtsilä who have helped me with my thesis.

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ABSTRACT

Author	Juha Mäkelä
Title	Standardization and optimization of the fuel unloading station
Year	2010
Language	English
Pages	47 + 5 appendixes
Name of Supervisor	Matti Makkonen

The objective of thesis was to research fuel unloading stations of the power plants from the view point of optimization and standardization. Purpose was to make a document which could be used in designing fuel unloading stations of the power plants.

The fuel unloading stations of the power plants were observed for noticing differences and similarities between fuel unloading stations of the power plants. 45 present fuel unloading stations were studied. The input parameters and guidelines were gathered for more convenient way to process the details of the fuel unloading stations. Input parameters and guidelines were collected from designing engineers and other experts in field of fuel unloading stations. To find out standardized and optimized modules, gathered input parameters and modules of the fuel unloading station were studied and compared.

As a result principle drawings were manufactured of the standard modules. A configuration tool of the fuel unloading stations was created to have easy introduction of the optimized and standardized modules. The configuration tool will also give guidelines in designing of the fuel unloading station. It can decrease amount of designing work of the fuel unloading stations.

Keywords Wärtsilä, Unloading station, Standardization, Optimization, configuration

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Kone- ja tuotantotekniikka

TIIVISTELMÄ

Tekijä	Juha Tapani Mäkelä
Opinnäytetyön nimi	Voimalaitoksen polttoaineaseman standardisointi ja optimointi
Vuosi	2010
Kieli	Englanti
Sivumäärä	47 + 5 liitettä
Ohjaaja	Matti Makkonen

Päättötyön aiheena oli tutkia voimalaitoksien polttoaineasemia standardoinnin ja optimoinnin näkökulmasta. Tarkoituksena tuottaa dokumentti jota voidaan käyttää hyväksi voimalaitoksien polttoaineasemien suunnittelussa.

Päättötyössä tutkittiin 45 polttoaineasemaa huomatakseen yhteneväisyydet ja eroavaisuudet polttoaineasemissa. Työssä kerättiin yhteen kaikki polttoaineaseman suunnitteluun vaikuttavat parametrit ja ohjeistukset. Parametrit kerättiin Wärtsilän eri osaamisalueiden insinööreiltä ja muilta asiantuntijoilta. Kerättyjä parametreja vertailtiin suunniteltuihin polttoaineasemiin saadakseen selville mitä osa-alueita tulisi standardoida ja optimoida.

Tulokseksi standardoitavista moduuleista valmistettiin periaatepiirrokset ja konfigurointityökalu, jolla standardoidut moduulit saadaan helposti otettua käyttöön. Suunnittelija saa konfigurointityökalusta tarvittavat piirrokset ja ohjeistuksen polttoaineaseman suunnitteluun. Konfigurointityökalu vähentää huomattavasti polttoaineaseman suunnittelun käytettyä aikaa.

Asiasanat Wärtsilä, Polttoaineasema, Standardisointi, Optimointi, Konfigurointi

USED TERMS AND SHORTENINGS

EPC	Engineer, procure and construct
EEQ	Engineered equipment delivery
EMO	Engineering management office
FWE	Fuel-water emulsion
LBF	Liquid bio fuel
LFO	Light fuel oil
HFO	Heavy fuel oil
MFD	Modular function deployment
IDM	Integrated document management

TABLE OF CONTENT

1 INTRODUCTION

In the last few decades Wärtsilä has made a remarkable effort in power plant technology. Wärtsilä designs and produces power plants with various power outputs. Two main power plant project types are EPC (Engineer, Procure and Construct) and EEQ (Engineered Equipment Delivery).

Nowadays Wärtsilä has outsourced everyday designing and diagram drawing. Citec Oy is responsible for these in cooperation with Wärtsilä. There are a lot of matters which should be taken into consideration when designing a power plant. The power output, fuel used and location of the power plants are a few examples that cause differences in designing. The basic function principle is basically the same in power plant designing.

The designing work is time consuming and a strict process. Usually designer uses methods which he has found out to be useful. It is possible that designer uses copies from an earlier project to get satisfactory and faster results. The problem in this method is the same as in any copy-paste action. Some incorrectly located components can be included in design by mistake and no one even notices those mistakes. This is obviously an undesired result. Since some modules in designing of the power plant are similar to other projects it is loss of time to design everything from the start each time.

To prevent useless designing and develop designing of the power plant Wärtsilä has established work group which controls designing. Engineering Management Office (EMO) controls designing work and focuses to look into designs to find out which designs could be standardized and modulated. This operation can prevent false designing and also make useful standards which the designer and sales department can utilize.

1.1 Objective

The objective of this thesis is to make designing work itself easier and also to develop the quality through standardization and optimization. EMO work group had defined their next target which was a fuel unloading station of the power plants. The fuel unloading station is an important part of the power plant and it is present in every power plant design in one way or another. Wärtsilä produces design of the fuel unloading stations approximately in 75% of designed power plants. The structure of the unloading station is simple and basic function principle is usually the same. Only size and capacity of the fuel unloading stations changes depending on fuel consumption of the power plants.

EMO had noticed how similar and almost identical unloading stations actually are. The designs of the fuel unloading stations are simple and usually have been copied from earlier projects. If designing of the fuel unloading station starts from the beginning, approximately 350–400 hours is used in design of the power plant. Hours used in design of the fuel unloading station can be reduced by making a standard fuel unloading stations.

The purpose of the thesis is to gather up the variables and invariables in the fuel unloading station and find out which part can be standardized or modular designed. The final standardization drawings are left out from the scope of the thesis. The principle drawings are created from layouts and designed drawings.

Based on a research it is possible to build a configuration tool which can be used in unloading station design and sales process.

1.2 Research plan

Research starts by defining the input parameters needed for designing work of the fuel unloading station. The input parameters are collected from Wärtsilä's engineers and specialists from different area of knowledge.

The plan is to know now day's solutions in designs of the fuel unloading station and compare input parameters to now day's solutions of the fuel unloading stations. To manufacture principle drawings of layouts and new modules of the fuel unloading station.

Designing and making of a configuration tool which gathers all inputs and guidelines in together and gives realistic result of the fuel unloading stations design requirements.

2 INTRODUCTION OF THE COMPANY

2.1 Wärtsilä

Wärtsilä enhances the business of its customers by providing them with complete lifecycle power solutions. When creating better and environmentally compatible technologies, Wärtsilä focuses on the marine and energy markets with products, solutions and services. Wärtsilä’s strategic aim is to strengthen its leading position in its markets and to ensure continued growth by offering customers the best lifecycle efficiency and reliability available. This is made possible by an integrated equipment and service portfolio that matches customers’ needs worldwide. /12/

In 2009, Wärtsilä's net sales totaled EUR 5.3 billion with 18,500 employees. The company has operations in 160 locations in 70 countries around the world. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland. /13/

2.2 Power Plants

Wärtsilä is the leading power plant supplier for flexible power plant solutions in selected niches. Wärtsilä supplies solutions for the developing world, islands and remote areas with base load power generation needs. Wärtsilä also supplies grid stability and provide peaking needs for industries such as oil and gas, mining, textile, cement, as well as municipalities with self-generating needs. /11/

Wärtsilä manages and executes projects for power plant customers. The company can offer a variety of project management service packages using alternative contract types. The two main power plant project types are EPC (Engineer, Procure and Construct) and EEQ (Engineered Equipment Delivery). EPC is a solution where the customer has only one point of contact and which minimizes the customer's cost, time, quality, technical and local legislation risks. /11/

2.3 Engineering management office

The objective of EMO is to lead and manage the customer solution engineering process including partnerships with engineering companies. The initial focus for EMO is to maintain, administrate and develop value added engineering activities and related information in order to reduce project engineering time while safeguarding quality. The vision is to release project engineering resources for product care activities, i.e. life cycle management, in order to improve re-use of pre-engineered and functionally optimized products. EMO will be the collaboration channel and introduce better practices that benefit both project management and full service engineering providers. /14/

3 THEORETICAL BACKGROUND

3.1 Standardization

Aim of the standardization is to reduce technically and commercially insignificant differences of the products as far as possible and to achieve the same terminology relations to concepts and definitions and to find all the requirements met by appropriate procedures in different sectors. Standardization is not a way to limit the possibilities, but to increase them. Standardization determines the adaptability of parts and defines a complex adaptation to the conditions and thus increases the number of alternative solutions.

According to the SFS 3539 standard, "The standard is publicly available technical specification or other document, drawn up in cooperation with all interested parties in the general approval. The standard is based on the established science, technology and experience to help with the results achieved, and is designed to take the most advantage of society. Standard is adopted nationally, regionally or by internationally recognized body. "

Standards can be divided as follows:

- **Basic Standards**, which deals with such components as measurement units, concepts, symbols and signs
- **Method Standards**, for example which deal with measuring, testing and analysis, delivery terms and methods of work
- **Product standards**, which deals with the dimensioning of products, the range and type of properties such as quality, composition, structure and safety

Productivity and motivation can be significantly improved by internal standards. Standardization can reduce the amount of repeated operations of routine activities, thus leaving more time for planning and implementation of the unfinished tasks.

Established internal standards release superiors for repeated queries, when everyone has the same written instructions. Also internal standards reduce the number of misunderstandings. Internal standards must not be too detailed, so that activities can be developed. Attention should be paid to internal coordination and information flows in order to control changes in designing and in implementation. For example, knowledge of customers' wishes can be provided by sales organization. Information of manufacturing techniques and the potential difficulties can be received from production department. The standardization is a development activity, which includes almost every development worker to be responsible. The standards designed incorporate the company acquired experience and knowledge of the company for future use. This way standardization can serve all activities. The standardization will change frequently recurring problems routinely and released in time for productive and creative activity. The aim of the standardization is to promote the company operations in areas of provision of means of communication and promotion skills.

Standardization and standards can be exploited for the following:

- to systematically develop the company's operations and product
- to improve the profitability of a company
- to get more systematic management and improve motivation
- to limit the range of component
- distribute the production
- to speeds up the process of production
- to improves customer service
- to receive marketing information
- to make the company renowned

The standards will provide a cost-saving, but they cause costs in the preparation phase. The standards will provide a cost-saving, but they cause costs in the preparation phase. The achievement of the standards in the corporate level will take time, but those involved in drawing up standards have completed their work, they will be a good resource to drive standards for the use of the company and contribute to helping the firm's management of its objectives. /05/

3.2 Modularization

Modularization is one way to implement product standardization. Modularization is based on different functional parts of a product. The aim of the modularization is to create product with similar physical structure and function abilities. Thus, product is divided into functional parts and these parts are defined to be interchangeable with different variations. By small number of modules relatively large number of the end products can be combined. Product variations can be more easily managed by using modularization and it also increases the use of standard components. Difference between modularization and standardization is that modularization does not decrease the amount of the end product assortment. When modularizing end product assortment the aim is to identify the needs of different customer segments and limit the strategic features of the product variations. /09/

3.2.1 Modular function deployment

Many modularization methods can be used. For the purposes of the current thesis is one of the modularization methods needed to be presented.

Modular Function Deployment ™ (MFD) is a structured, company-supportive method with the objective of finding the optimal modular product design, taking into consideration the company's specific needs. MFD supports the entire concept phase of the product development process, from product idea to computer-aided design (CAD) drawing. The method is applicable to an entire product range and is most successful when implemented by a cross functional project team. MFD consists of five major steps, as shown in Figure 1.

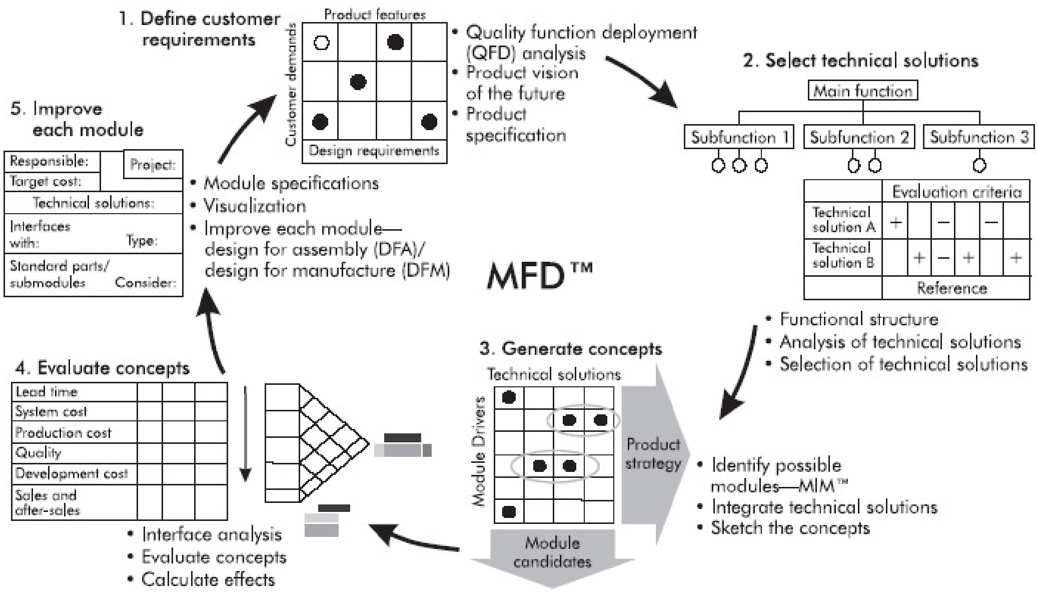

Figure 1. The five steps of Modular Function Deployment. The circle illustrates that design work is an iterative process.

The first step makes sure that the right design requirements are derived from the customer demands. The properties the product must have to satisfy present and future market demands are defined by analysis of competition and customer requirements.

In the second step, functions that fulfill the demands and their corresponding technical solutions are identified. There might be several technical solutions to fulfill a specific function, but only the most appropriate technical solutions with regard to customer needs and other company-relevant criteria are chosen.

In the third step, the core in the MFD method, the technical solutions are analyzed regarding their reasons for being modules. The results of the first two steps of the MFD method are essential in supporting the decisions made when using the module drivers to evaluate the technical solutions. Module concepts are then generated and the interface relations of the modules derived are evaluated in step four. In addition, economic forecasts are made and the expected effects of the modularization are calculated.

In the final step, a specification is established for each module. The specification contains technical information about the module as well as cost targets, planned development, description of variants, etc. From here on, the modular concept can be improved by focusing separately on each module. Depending on the module's characteristic, tools such as design for manufacture (DFM) and design for assembly (DFA) may be successfully applied.

The presentation of the MFD method follows an ideal working manner from step one to five. However, design work very seldom starts from the first specified step in a method, continues through every single step, in the right order, and ends with the final step. Starting points vary and several iterations might be needed before a satisfying result is reached. /03/

3.3 Configuration

To respond quickly as possible to clients' rapidly changing demands is the aim of the configuration. Customer defined products are the result of the configuration. The customer can select the needed components into the installation. From customers' need, it is possible to determine input parameters. From the input parameters company can manufacture a customer defined product. /08/

In this thesis, designer means the same as a customer.

Companies can make configurable products either from mass product articles or project product. When designing configurable products it is possible to get benefits from both of the production ways. A product can be considered as mass-product article if it is produced in series and is always the same regardless of customers' demands. To manufacture more customer defined products, it is reasonable to change mass-produced articles to configurable products. Project specific products are designed exclusively by customer demands. When changing from project specific product to configurable products the company must make a selection list of the product variants. From product variants the customer can choose the needed modules for end product instead of manufacturing exclusively a customer specific product.

The mass-product articles are relatively cheap to manufacture, but customers' demands are hardly considered. The project specific products are designed exclusively by customers' demands, but the product is expensive to manufacture. /08/

Configurable products can be defined as follows:

- Specific customer demands are noticed in every product
- Demands from different group of customers' are designed in to the product
- Products are defined from pre-designed components and there is no need to design new components during the order-delivery process.
- Product structure is planned for the product family
- No need for additional design, the product can be defined in order-delivery process by routine manners.

Definition of the configurable products separates mass-product articles from configurable products, since mass-products have not been designed with customers' demands. Products are not designed to satisfy every clients need, but to cover a large number of the customer needs and also taking corporate resources into consideration.

Products are not designed to satisfy every clients need, but to cover a large number of the customer needs and also taking corporate resources into consideration.

Configurable products are not designed from the beginning every time for different customers and that is how they differ from project specific products. With view of maintain the customer satisfied with the end product, the product structure is defined during product development of the configurable product. /08/

4 UNLOADING STATION

4.1 The function of the fuel unloading station of the power plants

The fuel unloading station is a link between the power plant fuel system and road tankers. The fuel unloading station has to be able to unload several tank trucks simultaneously. There are a number of different fuels like HFO, LFO, Bio fuels, and other emulsions to unload in use in to the power plant.

The measurement of the fuel amount from tank trucks is also executed in unloading stations. There are two different methods to measure the fuel amount by scales or pump-specific flow meters.

The fuel unloading stations have fuel pumps which deliver fuel from tank trucks to the storage tanks. The pump capacity of the fuel unloading station is calculated to response to fuel consumption of the power plant. Common rule in pump capacity is to be able to deliver approximately four times more what fuel consumption of the power plant is. In ideal case fuel unloading station should be able to unload one day consumption in six hours.

The fuel unloading station is usually located near the storage tank area. This is an ideal location for the fuel unloading station, but location depends on ground differences and overall layout of the power plant.

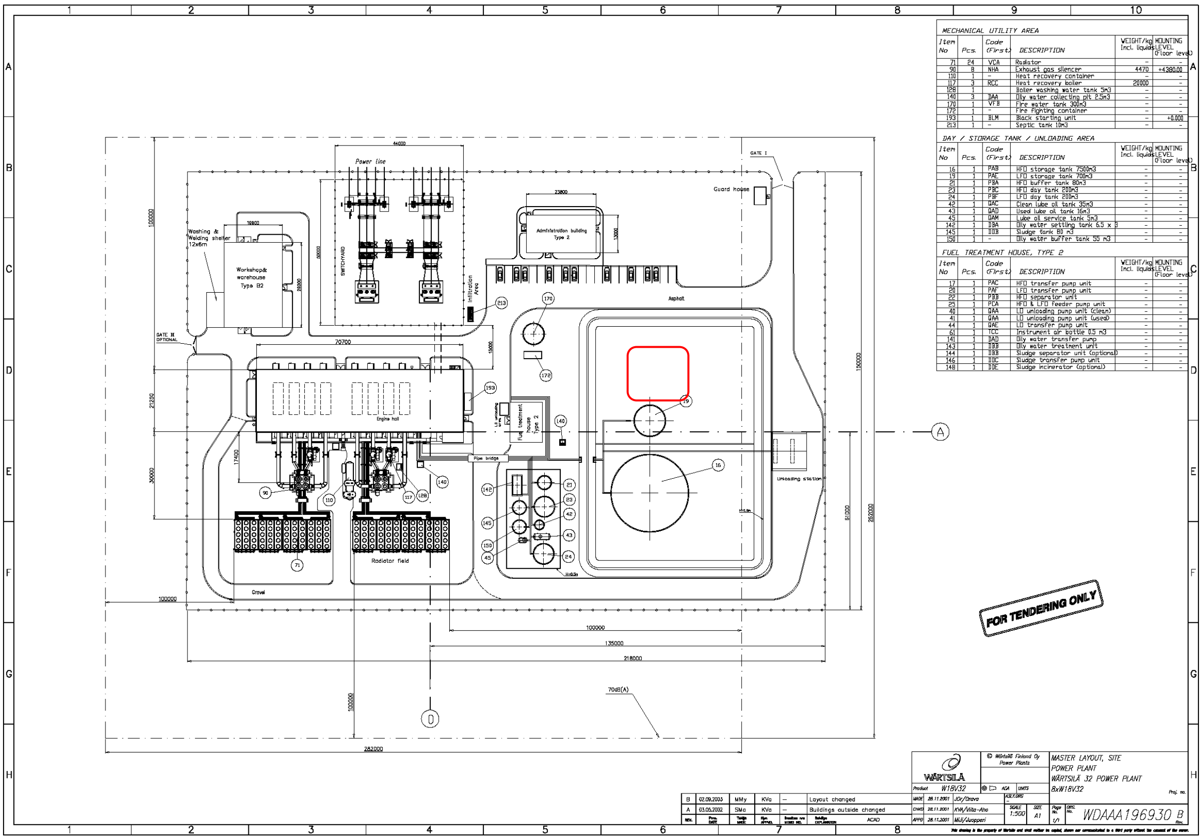

Figure 2. Picture of the basic oil power plant. In highlighted red rectangle is the fuel unloading station.

4.2 Fuels

Wärtsilä has diesel engines designed for continuous operation on:

- Light Fuel Oil (LFO)
- Heavy Fuel Oil (HFO)
- Crude Oil (CRO)
- Liquid Bio fuel (LBF)
- Fuel Water Emulsions (FWE)

The dual fuel or tri-fuel engines 32DF and 50DF use LFO (or HFO) as back-up fuel. The GD engines run on both gas & liquid fuel. The fuel sharing system allows the GD engine to run on gas and liquid fuel in different proportions.

The external fuel system has to be designed to provide fuel to the engines with regard to four essential parameters:

- viscosity [cSt] (depends on temperature [ºC])
- filtration grade [Fm]
- flow over engine [m³/h]
- pressure [bar]

Power plants with HFO, CRO or LBF as main source of energy also need LFO for emergency use and for maintenance situations./02/

This thesis focuses only on LFO and HFO since these two fuels are the most used oil fuels in Wärtsilä power plants.

4.2.1 HFO

Heavy fuel oils are blended products based on the residues from various refinery distillation and cracking processes. They are viscous liquids with a characteristic odor and require heating for storage and combustion. Heavy fuel oils are used in medium to large industrial plants, marine applications and power stations in combustion equipment such as boilers, furnaces and diesel engines./01/

Heavy fuel oil is a general term. Other names commonly used to describe this range of products include: residual fuel oil, bunker fuel, bunker C, fuel oil No 6, industrial fuel oil, marine fuel oil and black oil. In addition, terms such as heavy fuel oil, medium fuel oil and light fuel oil are used to describe products for industrial applications to give a general indication of the viscosity and density of the product./01/

4.2.2 Heavy fuel oil specification for Wärtsilä engines

The fuel specification “HFO 2” is based on the ISO 8217:2005 (E) standard and covers the fuel categories IDO-F-RMA 30-RMK 700. Additionally, the engine manufacturer has specified the fuel specification “HFO 1”. This stricter specification is an alternative and by using a fuel fulfilling this specification, longer overhaul intervals of specific engine components are guaranteed. /02/

4.2.3 LFO

Light fuel oil is used in power plant for emergency situations and in case of service therefore the need of the LFO is much lesser than HFO’s.

4.2.4 Light fuel oil specification for Wärtsilä engines

The fuel specification is based on the ISO 8217:2005 (E) standard and covers the fuel categories ISO-F-DMX, DMA, DMB AND DMC.

The distillate grades mentioned above can be described as follows:

- DMX: A fuel is suitable for use at ambient temperature down to -15 °C without heating fuel. In merchant marine application, its use is restricted to lifeboat engines and certain emergency equipment due to reduced flash point

- DMA: A high quality distillate, generally designated MGO (Marine Gas Oil) in the marine field.

- DMB: A general purpose which may contain trace amount of residual fuel and is intended for engines not specifically designed to burn fuels. It is generally designated MDO (Marine Diesel Oil) in the marine field.

- DMC: A fuel may contain a significant proportion of residual fuel. Consequently, it is unsuitable for installations where engine or fuel treatment plant are not designed for the use of residual fuels /02/

5 TECHNOLOGY RELATED TO THE FUEL UNLOADING STATION

5.1 Unloading pump unit

The pump unit is the main part in unloading station. The pump unit is calculated to respond to power plants fuel consumption. The unloading pump unit basically consists of the following components:

- Steel frame
- Suction filter
- (two) electrically driven pump(s)
- Valves
- Control panel
- Drip pan

To avoid operation interruption, at least two pumps (working/stand-by) should be available since designing procedures concerning the amount of LFO, LBF, FWE and HFO unloading units have differences. /10/

5.1.1 Pump

Screw pumps are rotary, positive displacement pumps that can have one or more screws to transfer high or low viscosity fluids along an axis.

Although progressive cavity pumps can be referred to as a single screw pumps, typically screw pumps have two or more intermeshing screws rotating axially clockwise or counterclockwise. Each screw thread is matched to carry a specific volume of fluid. Like gear pumps, screw pumps may include a stationary screw with a rotating screw or screws. Fluid is transferred through successive contact between the housing and the screw flights from one thread to the next. Geometries can vary. Screw pumps provide a specific volume with each cycle and can be dependable in metering applications.

The geometries of the single or multiple screws and the drive speed will affect the pumping action required. The capacity of screw pumps can be calculated based on the dimensions of the pump, the dimensions of the surface of the screws, and the rotational speed of the rotor since a specific volume is transferred with each revolution. In applications where multiple rotors are used, the load is divided between the numbers of rotating screws. The casing acts as the stator when two or more rotors are used. Based upon the needs of the application, timed or untimed rotors may be chosen. Untimed rotors are simpler in design.

The combination of factors relating to the drive speed, flow, and the characteristics of the fluid transferred may affect the flow rate and volume fed through each cavity. In water and wastewater treatment applications, a less viscous solution will require a lower power drive compared to untreated sewage, excess sludge, or concentrated slurries, which may require a higher power motor. The viscosity of the fluid transferred and the lift required may affect the speed and power required. Indicators of pump malfunction include decrease in flow rate or increased in noise. The efficiency of screw pumps requires that each rotor turns at a rate that allows each cavity to fill completely in order to work at full capacity. /06/

There are a couple types of pumps to be used in the fuel unloading stations. The screw type pump is most common in the fuel unloading station. To handle viscosity differences between HFO and LFO screw pumps can be equipped with frequency converter to change rpm for the fuel viscosity.

5.1.2 Flow meter (additional)

The measuring principle is based on the controlled generation of Coriolis forces. These forces are always present when both translational and rotational movements are superimposed.

The amplitude of the Coriolis force depends on the moving mass, its velocity in the system, and thus on the mass flow. Instead of a constant angular velocity, the

Promass sensor uses oscillation. In the Promass F and M sensors, two parallel measuring tubes containing flowing fluid oscillate in antiphase, acting like a tuning fork. The Coriolis forces produced at the measuring tubes cause a phase shift in the tube oscillations (see illustration):

• At zero flow, in other words when the fluid is at a standstill, the two tubes oscillate in phase (1).

• Mass flow causes deceleration of the oscillation at the inlet of the tubes (2) and acceleration at the outlet (3).

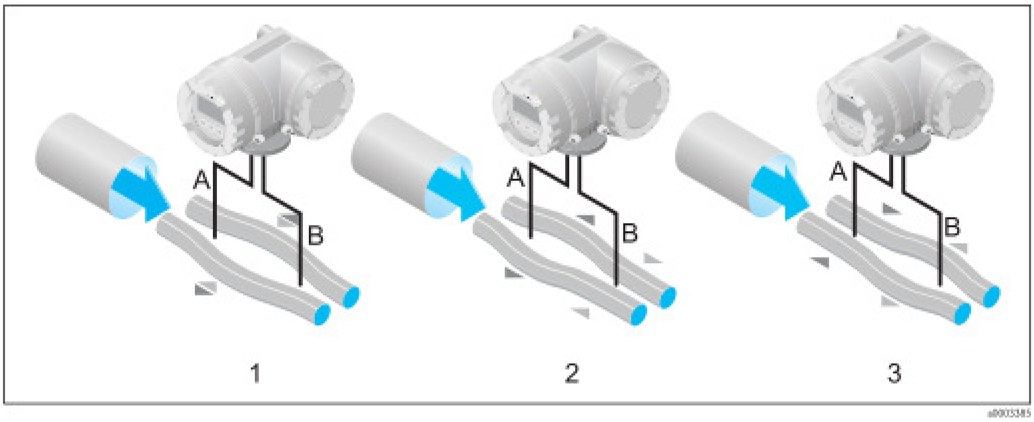

Figure 3. Flow meter functions in the tube oscillation.

The phase difference (A-B) increases with increasing mass flow. Electrodynamic sensors register the tube oscillations at the inlet and outlet. System balance is ensured by the antiphase oscillation of the two measuring tubes. The measuring principle operates independently of temperature, pressure, viscosity, conductivity and flow profile. /07/

5.2 Pipes

Pipes are selected in the fuel unloading station by project team personnel. Pipe selection depends on capacity of the unloading pump. The diameter of fuel pipe can be from 100mm up to 300mm. Pipes are usually located above of the metal structures of the unloading stations.

5.2.1 Heat trace

The viscosity of heavy fuel oil in power plants is usually controlled by steam heating. Using electric heaters is only reasonable in plants where no steam is produced. It's also possible to use hot water, at least for part of the heating demand. Standard heating media is 8bar. /05/

In an HFO-system the following components must always be heated

- Storage tanks
- Fuel Oil day tank
- Fuel Oil buffer tank
- Sludge tank
- All pipes for HFO
- Transfer pump unit
- Booster unit
- Lube oil separator unit

All the HFO piping must be trace heated. All trace piping must be equipped with a closing valve. Trace heating of the piping system is sized according to following criteria:

Insulation thickness of the piping 50 mm /07/

- Ø 100 pipe @ 58W/m
- Ø 150 pipe @ 77W/m
- Ø 200 pipe @ 97W/m

5.3 Shelter

The shelter is the main building of the fuel unloading station. It consists of foundations, self carrying steel beam structure and outer surface roofing sheet and wall surface sheets. Inside of the shelter are located unloading pumps, connecting pipes and main fuel unloading pipes. The shelter is drive-through type and it is closed only from side walls. The dimensions of the shelter are sufficient enough to handle most common tank truck widths.

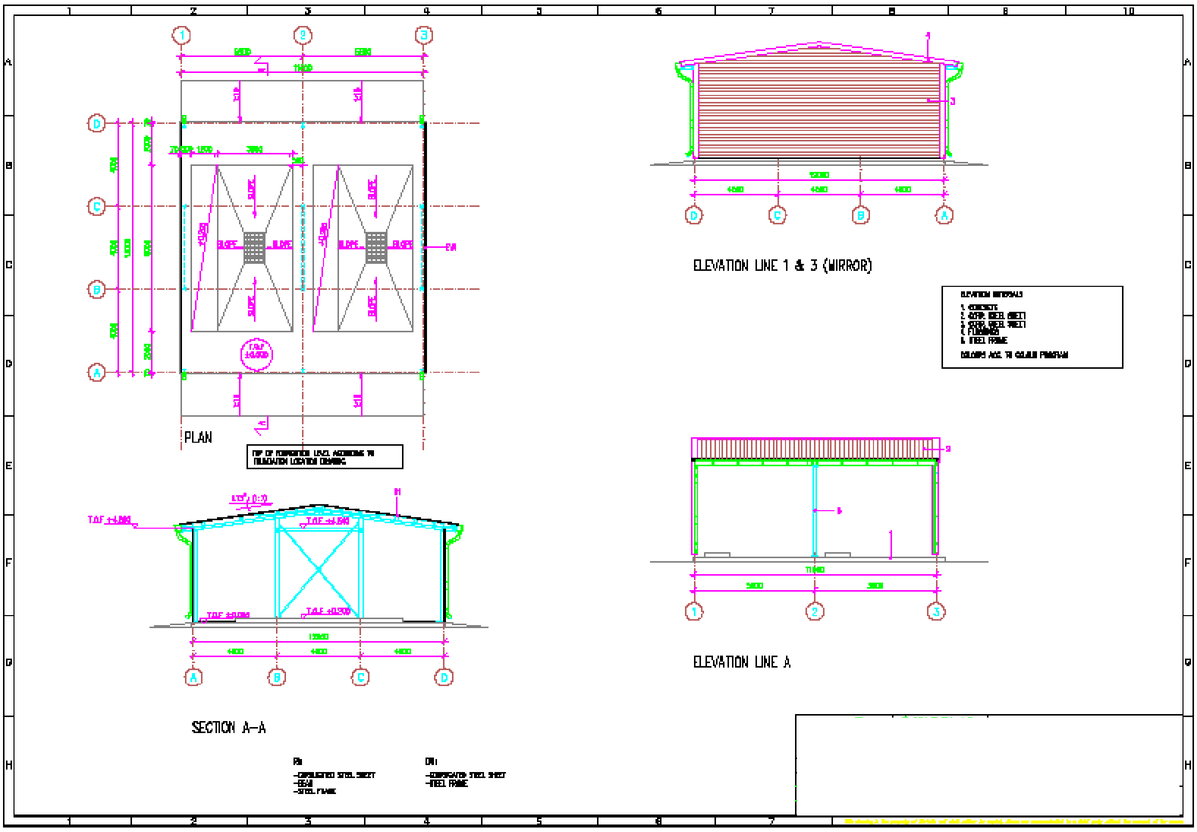

Figure 4. Typical fuel unloading shelter drawing

Mechanical design of the shelter is taking notice of basic structure loads as wind load and earthquake load. Closer research of structure loads has been left out the scope of thesis, but information is collected from Wärtsilä engineers.

5.3.1 Oil pit

There is always a possibility for an error in the fuel unloading station. If the unloading event is unsuccessful it could be possible that fuel is spilled on the ground. Therefore there has to be a system that will collect the dirty fuel oil. An oil pit is placed beneath the tank truck unloading point. Slopes around the pit make sure that the spilled fuel is collected into oil pit. Oil pit is usually 1 meter deep, 1 meter wide and 1.5 meters long.

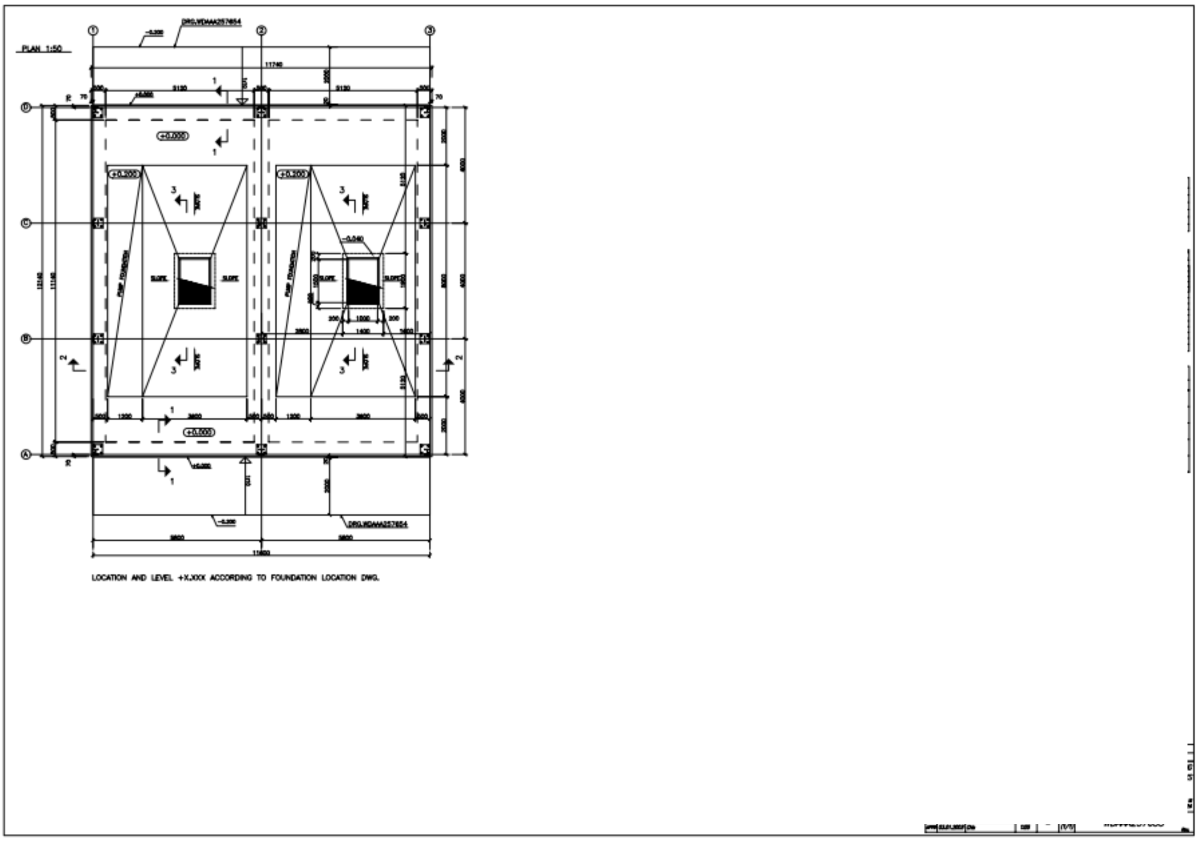

Figure 5. The dimensional drawing of the oil pit

All the fluids from oil pit are gathered in the sludge tank. From sludge tank fluids are collected to be disposed by burning or handle by other methods.

6 RESEARCH WORK

6.1 Input parameters

The research work was started by collecting input parameters from Wärtsilä engineers and other experts in field of the fuel unloading stations. Input parameters were collected by interviews and studying Wärtsiläs guidelines regarding the fuel unloading station.

The mechanical inputs were collected from Wärtsiläs engineers who have specialized in the functions of the fuel unloading unit. Relevant information was obtained from them, regarding on the fuel unloading pumps specification. Wärtsilä uses three types of screw pumps in the HFO unloading units ACG060, ACG070 and ACF090. The basic principle is same in every pump selection, the capacity is different on the pumps and from the pump it is possible to get two outputs by changing the frequency from 50 Hz to 60 Hz. The same pumps are used in the LFO unloading but viscosity is different on LFO and pumps unloading capacity changes. The only pump which is not used in LFO unloading is ACF090, since pumps capacity is too great and LFO need is not that high.

Pump capacities on HFO:

Pump type	50 Hz	60 Hz
ACG060	16.2 m^3/h	19.7 m^3/h
ACG070	25.9 m^3/h	31.5 m^3/h
ACF090	28.6 m^3/h	34.4 m^3/h

Pump capacities on LFO:

Pump type	50 Hz	60 Hz
ACG060	14.2 m^3/h	17.7 m^3/h
ACG070	23.2 m^3/h	28.8 m^3/h

Other input parameters for the fuel unloading unit were collected from Wärtsiläs internal fuel unloading unit document.

The parameters of the civil input were collected from Wärtsiläs civil engineers. Parameters of the civil engineering input were actual rules which were determined by UBC 1997 standards. The UBS 1997 rules are explained in more detailed in section 6.6.

The parameters of the electrical input were collected from Wärtsiläs engineers who have experience from the field of electricity.

During the research work it was possible to predetermine work again and re-define the objects and wanted result. At this point EMO decided to determine the work scope of layout design in the fuel unloading station, unloading pump unit determination and research for interdependences in the design of the fuel unloading station.

6.2 Comparing of the fuel unloading stations

Comparing was started with collecting as many design drawings of the fuel unloading stations as possible. Drawings were found in Wärtsiläs integrated document management (IDM) system by using IDM search machines or studying old and present projects of the power plants.

By studying the fuel unloading station solutions and comparing input parameters to solutions it was possible to found the interdependences of the fuel unloading stations. At this point of the research it was noticed, that only mechanical input parameters affected the interdependences on design of the fuel unloading station and the other input parameters would come as overall rules in the design of the fuel unloading station.

In researching the layouts many design variations of the fuel unloading stations were discovered. In the layout tank truck can be unloaded at one fuel unloading unit or the fuel unloading unit can be shared between two tank trucks. The designed capacity of the layout is from 32.4 m^3/h up to 170 m^3/h of the fuel unloading. The smallest layouts have one or no platforms and biggest can have eight platforms or even more. To find appropriate layout for standardization 45 layouts were studied and compared.

6.3 Fuel unloading unit

The basic principle in the unit is that there are two separate inlets into the pumps and from the pumps pipe lines are connected into main fuel line. A large number of the fuel unloading units were found. The basic solution is usually the same and the fuel unloading unit consists at the same modules.

Differences of the fuel unloading units are in the output connection pipes. Different connection pipes give variations in the unloading process. Model types of the fuel unloading unit are uniting connection pipe model, separated connection pipe model and various models with closing valves to change the unloading output lines in same main line or separate line depending on the unloading process. Also a flow meter can be installed in the fuel unloading unit.

6.4 Interdependences of the fuel unloading station

The interdependences were found during studying the design process of the fuel unloading station. The interdependence list was created to help standardization defining and manufacturing of the configuration tool.

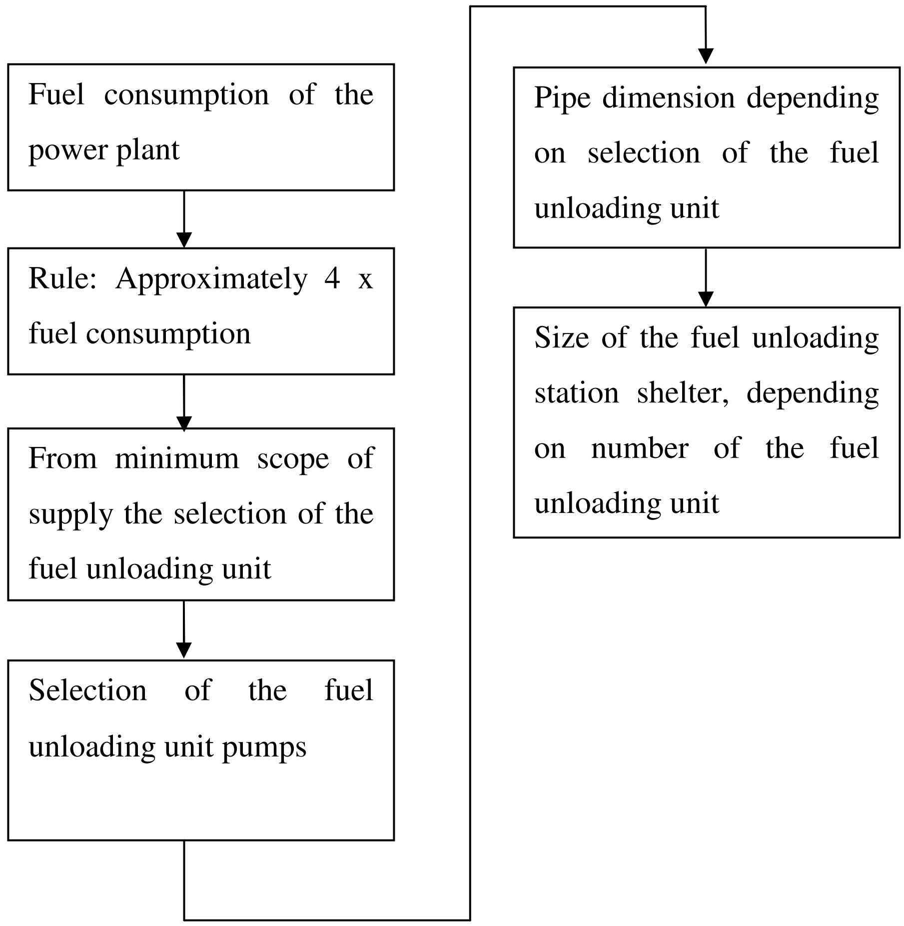

Table 1. Interdependences on the design of the fuel unloading station.

6.5 Variables

Variables are differences in the unloading station which can be selected or leave out from design.

The flow meter is optional in design, but the selection is not relevant from the view point of this thesis. The flow meter selection is up to project team work group. Project team can decide more accurately flow meter actual type.

The connection pipes from unloading unit to the main pipe line vary depending on the selection of the fuel unloading unit. To decrease the number of variations of the fuel unloading unit, connection pipes should separated out of the fuel unloading units to connection pipe modules. The connection pipe modules are discussed in more detail in section 7.3.

6.6 Invariables

Invariables are defined in Wärtsiläs guidelines as items which have always the same value no matter where and what size unloading station is going to be. These invariables are constrains, rules and other mandatory items.

Invariables in civil construction are wind loads, earthquake loads and other Wärtsilä guidelines. Wind loads and earth quake data are from uniform building code (UBC 1997).

Wind load (UBC 1997):

- 110 mph fastest mile
- Exposure C

Earthquake input (UBC 1997)

- Zone 4
- Near fault distance min 10 km
- Earthquake type 3
- Occupational category 3
- Importance factor 1
- Soil profile: Sd

Wärtsiläs requirements and ICE standards are important issues and should be considered in doing of the electric designs.

Other invariables rule in electrical work are cable tray mounting. Cable trays are mounted with pipe lines and use the same support structures what pipe lines are using. Lightning is selected by customers' demands or guide lines related to Wärtsilä requirements.

7 SOLUTION OF THE STANDARDIZATION AND OPTIMIZATION

7.1 Layout of the fuel unloading station

When studying fuel unloading station layouts, one layout appeared to be most feasible and ideal for standardization of the fuel unloading station. Layout of the fuel unloading station was different from other fuel unloading station layouts. In the selected layout, trucks would drive through the station and unloading pump would be on side of the truck. The main difference to other layouts is that in the selected layout has one pump unit for two truck lanes whereas the other layouts had one truck lane for one pump unit. To reduce material cost of the fuel unloading stations it was reasonable to reduce the number of pump units as low as possible.

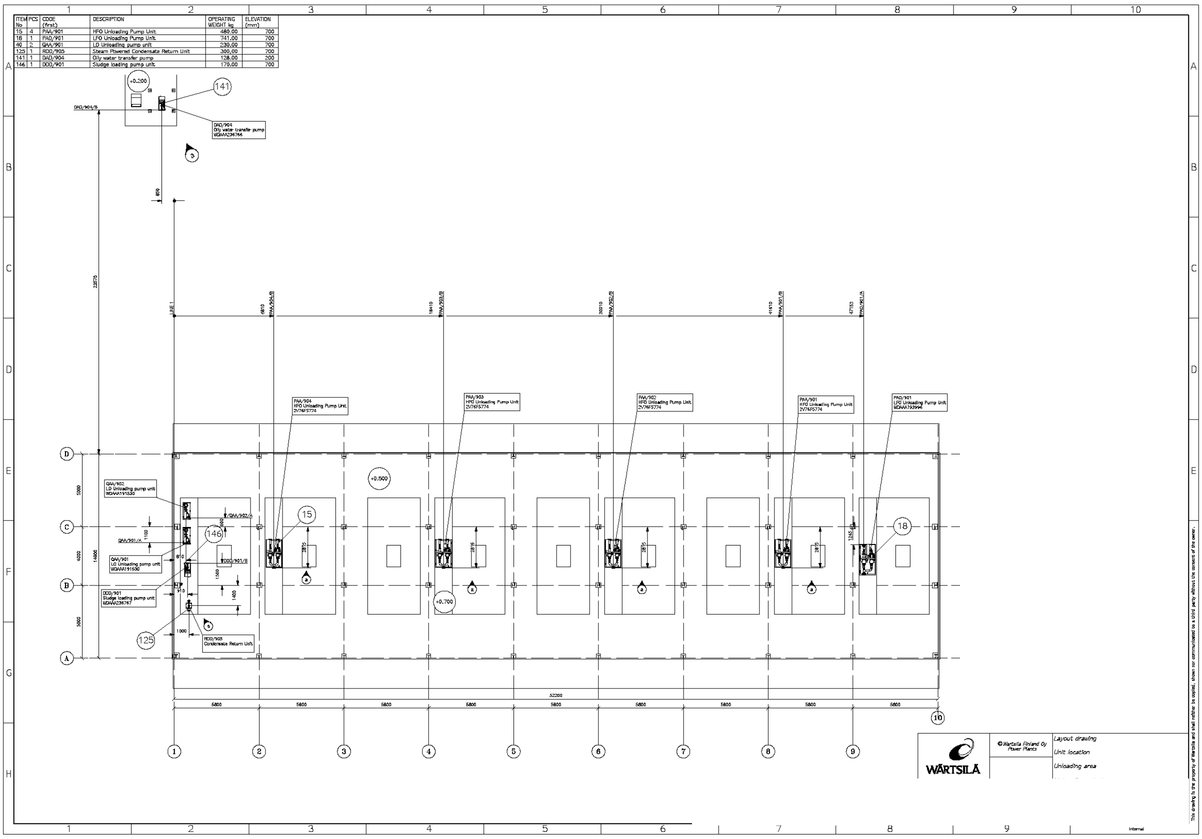

Figure 6. Design drawing of the possible standard layout

One question was whether it would be safe to reduce number of the pump units. Two pumps of the unloading unit, the other pump is in use and the other is for standby to avoid interrupted unloading process. In planned layout there would not be a standby pump in the same pump unit, since both pumps would be in constant use.

A solution to this problem was found in the LFO pump unit. The usage of the LFO pump unit is 1-2 percents of HFO units and one of the guidelines tells that LFO pumps should select as same type as HFO pumps. Therefore the LFO pump will serve as a standby unit for HFO units.

The fuel unloading stations were divided in three sizes to cover fuel consumption from 0.6 m^3/h to 55 m^3/h. Fuel consumption of 0.6 – 14 m^3/h of the power plant is covered by two lane design of the fuel unloading station. The fuel consumption 14 – 29 m^3/h is covered by four lane and 29 – 55 m^3/h fuel consumption covered with six lane designs of the fuel unloading station.

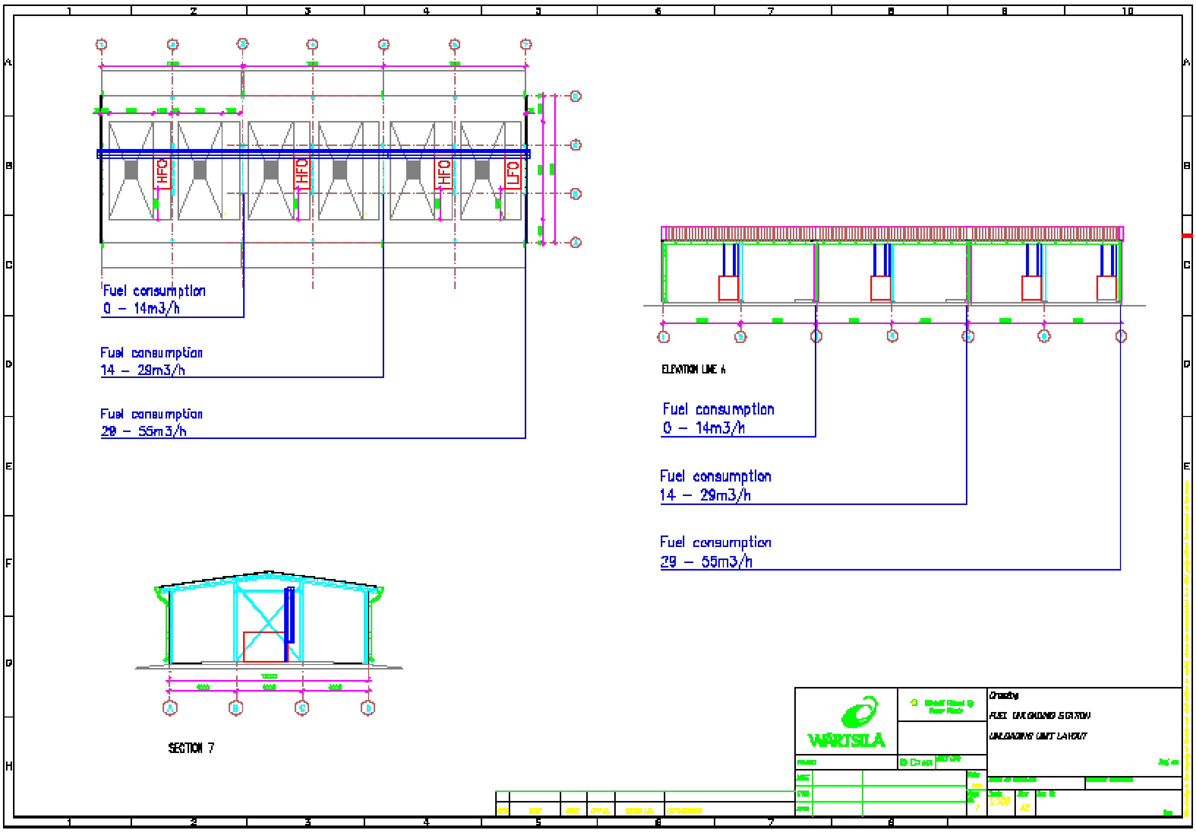

Figure 7. General layout drawing

Modules in the fuel unloading station were decided to place in the same location where they usually are in the layouts of the fuel unloading stations. The fuel unloading unit is located in the concrete platform next to the unloading lane. The numbers of the platforms are the same as the unloading lanes. Additional platforms can be used as a location of the extra pump modules and the control panel modules.

The oil pit location and dimension were already satisfactory and there was no reason to change them.

The piping would come above of the metal structures of the fuel unloading station shelter in the same line as the outlet of pipes of the fuel unloading unit.

The overall dimensions in unloading lane of the fuel unloading station were correct and were not changed.

7.2 Fuel unloading unit

Input parameters define rules of the fuel unloading unit. In study of the fuel unloading unit was noticed various number of the fuel unloading units. With a small modification it was possible to reduce the number of unloading units to one. The modification would change the connection pipes of the unloading unit. The present model of the unloading units has connection pipes inside of the fuel unloading unit frame therefore having a large number of the fuel unloading units. If connection pipes were changed outside from the frame to own connection pipe module, it would be possible to use only one model of the fuel unloading unit.

During the search of the fuel unloading unit one unloading unit was found to be most reasonable to use as a standard unit. The connection pipes were decided to be moved outside of the unit frame to keep the unit as simple as possible. One of the Wärtsiläs standard fuel unloading units was ideal for standardization of the fuel unloading unit.

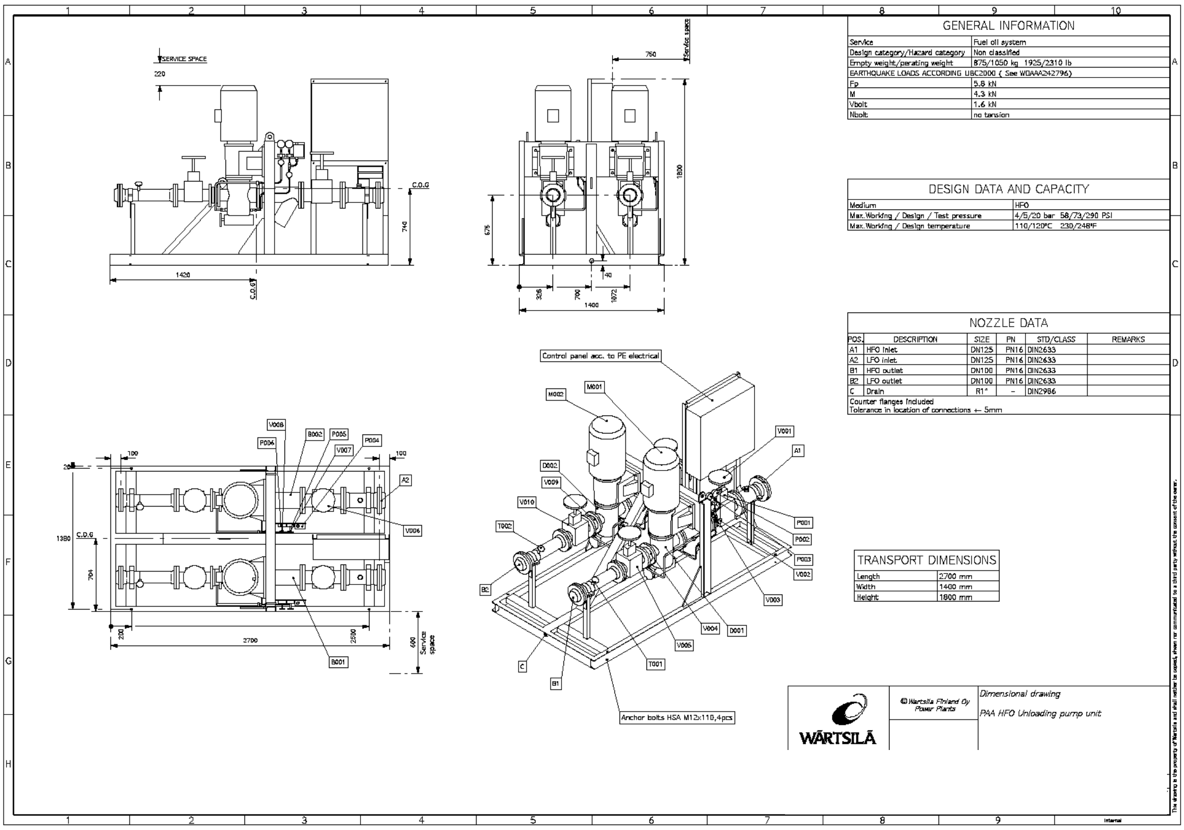

Figure 5. The standardized fuel unloading unit

The units design is simple and it gives an opportunity to install different type of pumps with small modifications. The design is ideal for installing connection pipe modules in the output pipes.

7.3 Connection pipe module

Three models were designed for the connection pipe modules. No design models were created for modules they were designed as principle drawings.

The types of the connection pipe modules are separate pipe module, united pipe module and a hybrid module from these two with closing valves. Different types can be used depending on the fuel unloading process. Connection pipe module with closing valves can be used mainly with LFO unloading unit. The pipes can be connected into HFO main lines and LFO main lines. Using closing valves in the right order can unload process be directed in the required main line. Principle drawings of the connection pipe modules can be found in appendix 1.

7.4 Configuration tool

A configuration tool was created to help designers to use standardized layouts and modules of the fuel unloading station. The tool was designed to be easy to use and to prevent copy-paste operation from old designs of the fuel unloading stations in power plant design.

The configuration tool was made using the excel spreadsheet software. From the tool table the user can choose engine selection or insert the fuel consumption. The tool selects by fuel consumption the right unloading station layout design drawing, unloading unit type, pump module layout, unloading pump flow drawing and the connection pipe module drawing. Parameters of the fuel consumption were taken from the minimum scope of supply. Selection of the flow meter and selection of connection pipe module type to the installation make a difference in to the drawings.

Overall rules and guide lines are gathered in the same excel table. Rules are always effective no matter what kind of engine selection the user makes. In appendix 2 is a picture of an unloading station configuration tool.

7.4.1 Tool program

Excel spreadsheet software have a possibility to record macros for making a code to help build up the program. The tool consist two sheets, a data sheet and a tool sheet. All the information which the tool needs to function is located in the data sheet. In appendix 3 is a picture of the data sheet.

From the first two columns are gathered the information for engine selection drop down list of the tool sheet. The engine options have different fuel consumption which is listed next to the engine list.

The table determines the right sector of the fuel consumption by minimum and maximum values. In the same row where the value is selected there are cells where values and document numbers can be copied to the tool sheet.

The minimum and maximum value requirements were made based on the fuel unloading unit capacity. The pump units were divided into seven groups depending on the fuel consumption. The defining table can be found in appendix 4 and tool-macro1 code can be found from appendix 5.

7.4.2 Rules

To fabricate a configuration tool it was necessary to make rules which will determine the fuel unloading station. A basic rule comes from Wärtsiläs minimum scope of supply table. The table of the minimum scope of supply determines all the minimum requirements of the power plant. Also minimum requirement for unloading station can be found on same table. From the minimum scope of supply table it was easy to select pump unit which determines number of the pump units, number of the pumps and type of the pump. Everything in the table is selected depending on the engine selection and the selections fuel consumption.

By given rule from minimum scope of supply it is possible to determine the size of the fuel unloading station. It was decided that for one fuel unloading unit would have to be two truck lanes. Every engine selection from minimum scope of supply was covered in three unloading station sizes depending of the fuel consumption.

8 RESULTS AND FURTHER STUDY

8.1 Result

As the result most feasible fuel unloading station layout was selected to standardize from the group of the fuel unloading station layouts. The layouts were divided in three sizes depending on the fuel consumption. Several fuel unloading station layouts were left out from standardization. Layouts of the fuel unloading station could be utilized better in special power plant designs and it is up to project team personnel to decide which layout to use.

The most feasible fuel unloading unit layouts was selected to be standardized and connection pipe modules were created outside the fuel unloading unit. Three types of the connection pipe modules were created depending on the fuel unloading process.

The configuration tool was manufactured to enable the selection of the right fuel unloading station layout and modules into the fuel unloading station.

In power plants where the fuel consumption is 0.6 - 55m^3/h and the building conditions are basic, the biggest effort can be obtained from the standardization and configuration tool.

The following estimated calculations are based on the design work of the Citec Oy designing of the fuel unloading station, when designing is done from the beginning:

Process design	66 h
Mechanical designing	100 h
- Piping design	
- Units	
Electrical	100 h

Civil	102 – 127 h
- Building design	17 h
- Frame design	50 h
- Envelope design	10 h
- Foundation design	25- 50 h
Totally:	**368 - 393 h**

In the next table are estimated calculations of the savings.

Process design	66 h via standardization 50% down to 33h
Mechanical design:	100 h via standardization 50% down to 50h
Electrical:	100 h via standardization 50% down to 50h
Civil:	102- 127h via standardization 95% down to 5 – 6.5h
Totally:	**138 - 140 h**

Projects which are designed from the start standardization can save design hours approximately 230 – 253 hours. /06/

8.2 Conclusion

Wärtsilä has approximately 100 power plant projects in year and from these maybe 75% are produced with the fuel unloading stations. Approximately one in five of the fuel unloading stations are designed from start. In one year savings can be achieved roughly 3500 hours./04/

The configuration tool was created to get standardized layouts and modules in the use. The tool can be used in design and sales process of the fuel unloading stations. False estimations in sales and useless designing of the fuel unloading stations can be avoided by using configuration tool.

8.2.1 Future research

During the research work, subjects such as minimum fuel unloading station and research of the fuel unloading unit pumps were left out from the thesis scope. These subjects can be taken into consideration in improving the configuration tool and future standardization.

8.2.2 Fuel unloading station layout

The fuel unloading station layout can be made smaller for example fuel unloading station with only one lane. This can be used in the power plants where fuel consumption is low for example dual fuel and gas power plants.

In order to reduce costs of concrete foundation of the fuel unloading station, the design and layout of the oil pit should be recalculated.

To find out how much space is needed to get easy access and exit of the tank trucks, the dimensions of the surroundings should be studied.

8.2.3 Fuel unloading station modules

The fuel unloading units standards should be advanced to more functional concept where all items are take into account and useless items are disposed of.

8.2.4 Configuration tool

Configuration tool should be improved and more items should be discovered which can be used in the configuration tool of the fuel unloading stations. The fuel line dimensioning should be added into the tool. Calculations should be made in order to decide when it is realistic to change pump specific flow meters into the tank truck scale measuring.

8.2.5 Other matters

Different fuel unloading pump models should be compared to find out the best pump type to be used for the fuel unloading.

Fuel unloading hoses between the fuel unloading pump and the tank truck outlet should be studied. To find out what are the variables in defining the right type of the hose to achieve successful fuel unloading process.

Drawings of the connection pipe modules based on the principle drawings of the connection pipes should be made. Standards of the connection pipe modules should be devised and design more variations for the connection pipe modules.

9 SUMMARY

The subject of the thesis was standardization and optimization of the fuel unloading station of the power plants. I have worked in Wärtsiläs power plant as a mechanical supervisor and my work experience was great help in study of the thesis. Thesis scope was defined to make principle drawings of the standardized modules. Standardized modules drawings shall be create at later stage. A configuration tool was created to introduce standardized modules and rules for designing of the fuel unloading station.

The study was started by gathering the definitions of the fuel unloading design and familiarizing the modules of the fuel unloading station. From gathered definitions the scope of the thesis was specified as standardization and optimization of layout of the fuel unloading stations and fuel unloading units. During the work connection pipes from fuel unloading unit were also optimized.

A configuration tool for the fuel unloading stations was made to have easy introduction of the optimized and standardized modules. The designer obtains right documents for designing the fuel unloading station by inserting parameter values in the configuration tool.

Thesis was challenging and interesting. I had opportunity to become familiar with different areas of engineering in Wärtsilä which was good for me. I was able to get a lot of experience from the field of standardization, optimization, modularization and configuration. From my own point of view the thesis was successful and the employer is also very satisfied to obtained outcome of the thesis.

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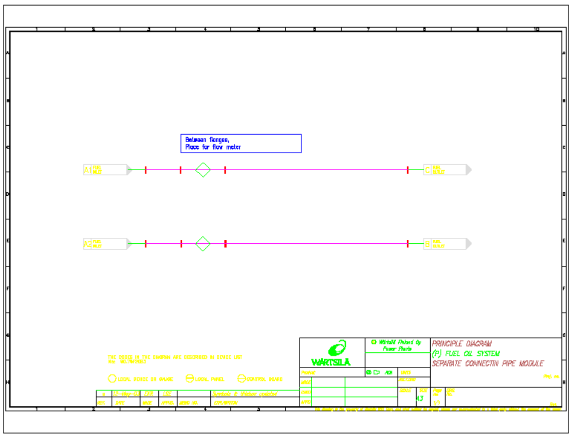
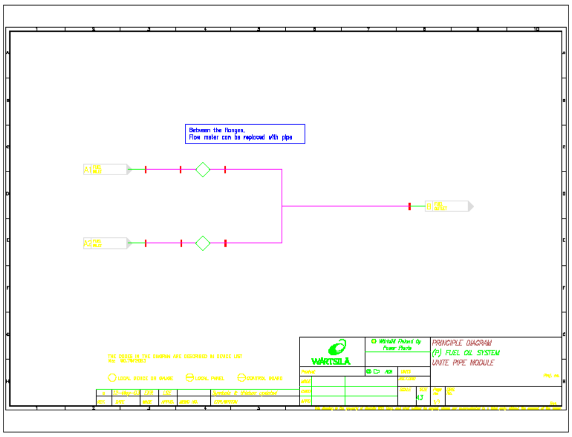
LIST OF APPENDIXES

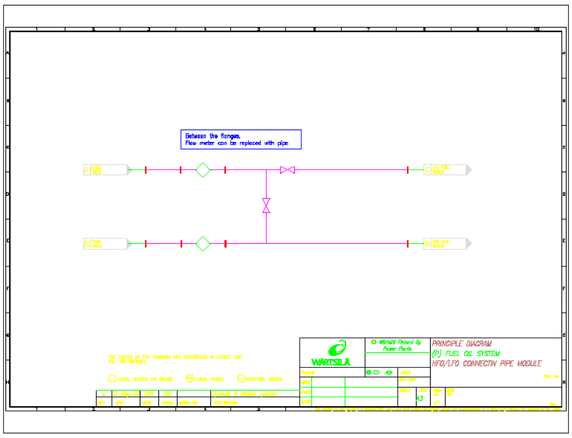
Appendix 1



Separate lines of the connection pipe module



United lines of the connection pipe module



Separated and united HFO/LFO lines of the connection pipe module

Appendix 2

WÄRTSILÄ

Unloading station configuration tool

1. Select engine selection from the drop down list or insert fuel consumption in the cell.
2. Make selection of flow meter in to the installation.
3. Make selection of connection pipe model between unloading unit and main fuel line.

Result

- Layout design principle drawing
- Unloading unit type (number of the units * number of the pumps * capacity of pump)
- Unloading unit layout drawing
- Unloading pump flow diagram
- Connection pipe principle drawing

Rules and guidelines for design of the fuel unloading station

Mechanical

Unloading unit

- Basic inputs for unloading pump unit WDAAA122863

Pump

Pump type	50 Hz / 60 Hz
AGC060	16.2 / 19.7m^3/h
ACG070	25.9 / 31.5m^3/h
ACF090	28.6 / 34.4m^3/h

Piping

- Sizing of the fuel pipes **WDAAA122859**
- Trace heating according **WDAAA122859**

Connection pipe model in LFO fuel unloading unit

- DBAB304730 (flow meter)
- DBAB304726

Civil

Wind load (UBC 1997):

- 110 mph fastest mile
- Exposure C

Earthquake input (UBC 1997)

- Zone 4
- Near fault distance min 10 km
- Earthquake type 3
- Occupational category 3
- Importance factor 1
- Soil profile: Sd

Other loads (including equipment loads) according to Wärtsilä instructions and input.

Electric

- Lighting selected on requirements of the customers or Wärtsilä
- Cables dimensioned on requirements of the electric motor and lighting

Engine selection	10x W18V32	
Flow meter	☑ Selected	
Connection pipes	○ Uniting pipes	
	◉ Divided pipes	
Fuel consumption	17,12	m^3/h

Unloading station shelter, principle drawing

DBAB304182

Pump unit type

unit*	2	pump*	2	pump capacity	25,9	m3/h

Pump module layout

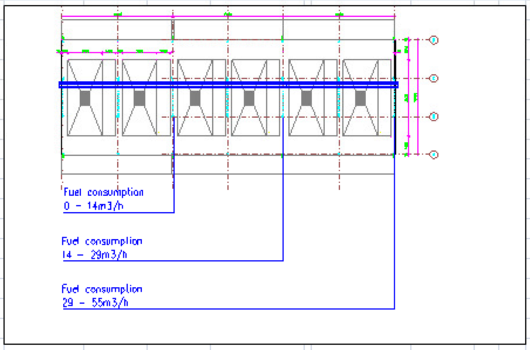
DBAA549905

Pump module flow diagram

DBAA549890

Connection pipe module, principle drawing

DBAB304739



Note.

Layout design is for the standard unloading station of the power plant. Special occasions should be designed separately.

Hyperlinks from rules and guidelines

WDAAA122863

WDAAA122859

DBAB304730

DBAB304726

Appendix 3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Engines**	**Fuel cons. [m^3/h]**	**HFO unloading**			Consumption m^3/h		Flow meter	Number of units	Number of pups	Pump capacity m^3/h	pump capacity/4*fuelcons.	Shelter layout	Pump module layout	Pump module flow diagram	Pipe connectin module	Pipe connectin module
2						MIN	MAX										
3	1 x W6L32	0,6	1 x 2 x 16.2 m^3/h		max13	8,10	12,95	false	1	2	25,9	12,95	DBAB304163	DBAA549905	DBAA549890	DBAB304726	DBAB304726
4	2 x W6L32	1,2	1 x 2 x 16.2 m^3/h		max13f	8,10	12,95	true	1	2	25,9	12,95	DBAB304163	DBAA549905	DBAA549890	DBAB304730	DBAB304730
5	3 x W6L32	1,7	1 x 2 x 16.2 m^3/h		max14	12,96	14,29	false	1	2	28,6	14,3	DBAB304163	DBAA549905	DBAA549890	DBAB304726	DBAB304726
6	1 x W8L32	0,8	1 x 2 x 16.2 m^3/h		max14f	12,96	14,29	true	1	2	28,6	14,3	DBAB304163	DBAA549905	DBAA549890	DBAB304730	DBAB304730
7	2 x W8L32	1,5	1 x 2 x 16.2 m^3/h		max26	14,30	25,89	false	2	2	25,9	25,9	DBAB304163	DBAA549905	DBAA549890	DBAB304623	DBAB304742
8	3 x W8L32	2,3	1 x 2 x 16.2 m^3/h		max26f	14,30	25,89	true	2	2	25,9	25,9	DBAB304182	DBAA549905	DBAA549890	DBAB304739	DBAB304745
9	1 x W9L32	0,9	1 x 2 x 16.2 m^3/h		max29	25,90	28,59	false	2	2	28,6	28,6	DBAB304182	DBAA549905	DBAA549890	DBAB304623	DBAB304742
10	2 x W9L32	1,7	1 x 2 x 16.2 m^3/h		max29f	25,90	28,59	true	2	2	28,6	28,6	DBAB304182	DBAA549905	DBAA549890	DBAB304739	DBAB304745
11	3 x W9L32	2,6	1 x 2 x 16.2 m^3/h		max39	28,60	38,85	false	3	2	25,9	38,85	DBAB304185	DBAA549905	DBAA549890	DBAB304623	DBAB304742
12	4 x W9L32	3,5	1 x 2 x 16.2 m^3/h		max39f	28,60	38,85	true	3	2	25,9	38,85	DBAB304185	DBAA549905	DBAA549890	DBAB304739	DBAB304745
13	1 x W12V32	1,1	1 x 2 x 16.2 m^3/h		max55	38,86	55,00	false	3	2	28,6	42,9	DBAB304185	DBAA549905	DBAA549890	DBAB304623	DBAB304742
14	2 x W12V32	2,3	1 x 2 x 16.2 m^3/h		max55f	38,86	55,00	true	3	2	28,6	42,9	DBAB304185	DBAA549905	DBAA549890	DBAB304739	DBAB304745
15	3 x W12V32	3,4	1 x 2 x 16.2 m^3/h		max8	0,00	8,09	false	1	2	16,2	8,1	DBAB304163	DBAA549905	DBAA549890	DBAB304726	DBAB304726
16	4 x W12V32	4,6	1 x 2 x 16.2 m^3/h		max8f	0,00	8,09	true	1	2	16,2	8,1	DBAB304163	DBAA549905	DBAA549890	DBAB304730	DBAB304730
17	1 x W16V32	1,5	1 x 2 x 16.2 m^3/h	4	5	6	7	8	9	10	11	12	13	14	15	16	17
18	2 x W16V32	3,0	1 x 2 x 16.2 m^3/h														
19	3 x W16V32	4,6	1 x 2 x 16.2 m^3/h														
20	4 x W16V32	6,1	1 x 2 x 16.2 m^3/h														
21	5 x W16V32	7,6	1 x 2 x 16.2 m^3/h														
22	6 x W16V32	9,1	1 x 2 x 25.9 m^3/h														
23	7 x W16V32	10,6	1 x 2 x 25.9 m^3/h														
24	8 x W16V32	12,2	1 x 2 x 25.9 m^3/h														
25	9 x W16V32	13,7	1 x 2 x 28.6 m^3/h						2.3.2010	https://fiidm01.wnsd.com/kronodoc?action=start&project=2502&root=3384284							
26	10 x W16V32	15,2	2 x 2 x 25.9 m^3/h						DBAB304745	-.1 **Uniting connection pipe module_flowmeter** UNLOCK LOCKED							
27	1 x W18V32	1,7	1 x 2 x 16.2 m^3/h						DBAB304742	-.1 **Uniting connection pipe module** UNLOCK LOCKED							
28	2 x W18V32	3,4	1 x 2 x 16.2 m^3/h						DBAB304739	-.1 **Separate connection pipe module_flowmeter** UNLOCK LOCKED							
29	3 x W18V32	5,1	1 x 2 x 16.2 m^3/h						DBAB304730	-.1 **Connection module HFO_LFO_flowmeter** UNLOCK LOCKED							
30	4 x W18V32	6,8	1 x 2 x 16.2 m^3/h						DBAB304726	-.2 **Connection module HFO_LFO** UNLOCK LOCKED							
31	5 x W18V32	8,6	1 x 2 x 25.9 m^3/h						DBAB304623	-.4 **Separate connection pipe module** UNLOCK LOCKED							
32	6 x W18V32	10,3	1 x 2 x 25.9 m^3/h						DBAB304185	-.2 **Unloading station** UNLOCK LOCKED							
33	7 x W18V32	12,0	1 x 2 x 25.9 m^3/h						DBAB304182	-.2 **Unloading station** UNLOCK LOCKED							
34	8 x W18V32	13,7	1 x 2 x 28.6 m^3/h						DBAB304163	-.4 **Unloading station** UNLOCK LOCKED							
35	9 x W18V32	15,4	2 x 2 x 25.9 m^3/h						2.3.2010	Ute viana							
36	10 x W18V32	17,1	2 x 2 x 25.9 m^3/h						DBAA549905	**PAA HFO Unloading pump unit** UNLOCK LOCKED							
37	1 x W20V32	1,9	1 x 2 x 16.2 m^3/h						DBAA549890	**PAA HFO Unloading pump unit** UNLOCK LOCKED							
38	2 x W20V32	3,8	1 x 2 x 16.2 m^3/h														
39	3 x W20V32	5,7	1 x 2 x 16.2 m^3/h														
40	4 x W20V32	7,6	1 x 2 x 16.2 m^3/h														
41	5 x W20V32	9,5	1 x 2 x 25.9 m^3/h														
42	6 x W20V32	11,4	1 x 2 x 25.9 m^3/h														
43	7 x W20V32	13,3	1 x 2 x 28.6 m^3/h														
44	8 x W20V32	15,2	2 x 2 x 25.9 m^3/h														

Appendix 4

	A	B	C	D	E	F	G	H
1	W32 / W46							
2	HFO Unloading pump	1 x 2 x 16.2 m³/h	1 x 2 x 25.9 m³/h	1 x 2 x 28.6 m³/h	2 x 2 x 25.9 m³/h	2 x 2 x 28.6 m³/h	3 x 2 x 25.9 m³/h	3 x 2 x 28.6 m³/h
3	Capasity m³/h (approx. 4 x fuel cons.)	32,4	51,8	57,2	103,6	114,4	155,4	171,6
4	W32 Fuel consumption(minimun scope of supply)	0,6 - 7,6 m³/h	9,1 - 12,0 m³/h	13,3 - 13,7 m³/h	15,2 - 19,0 m³/h			
5	W46 Fuel consumption(minimun scope of supply)	1,7 - 6,9 m³/h	9,1 - 11,5 m³/h	13,7 - 13,8 m³/h	16,1 - 24,2 m³/h	27,3 - 27,7 m³/h	31,1 - 36,4 m³/h	41 - 54,7 m³/h
6								
7	W6L32	1 x W6L32						
8		2 x W6L32						
9		3 x W6L32						
10								
11	W8L32	1 x W8L32						
12		2 x W8L32						
13		3 x W8L32						
14								
15	W9L32	1 x W9L32						
16		2 x W9L32						
17		3 x W9L32						
18		4 x W9L32						
19								
20	W12V32	1 x W12V32						
21		2 x W12V32						
22		3 x W12V32						
23		4 x W12V32						
24								
25	W16V32	1 x W16V32	6 x W16V32	9 x W16V32	10 x W16V32			
26		2 x W16V32	7 x W16V32					
27		3 x W16V32	8 x W16V32					
28		4 x W16V32						
29		5 x W16V32						
30								
31	W18V32	1 x W18V32	5 x W18V32	8 x W18V32	9 x W18V32			
32		2 x W18V32	6 x W18V32		10 x W18V32			
33		3 x W18V32	7 x W18V32					
34		4 x W18V32						
35								
36	W20V32	1 x W20V32	5 x W20V32	7 x W20V32	8 x W20V32			
37		2 x W20V32	6 x W20V32		9 x W20V32			
38		3 x W20V32			10 x W20V32			
39		4 x W20V32						
40								
41								
42	W9L46	1 x W9L46						
43		2 x W9L46						
44		3 x W9L46						
45		4 x W9L46						
46								
47	W12V46	1 x W12V46	4 x W12V46	6 x W12V46	7 x W12V46			
48		2 x W12V46	5 x W12V46		8 x W12V46			
49		3 x W12V46			9 x W12V46			
50								
51	W18V46	1 x W18V46	3 x W18V46	4 x W18V46	5 x W18V46	8 x W18V46	9 x W18V46	
52		2 x W18V46			6 x W18V46		10 x W18V46	
53					7 x W18V46			
54								
55	W20V46	1 x W20V46F	2 x W20V46F	3 x W20V46F	4 x W20V46F	6 x W20V46F	7 x W20V46F	9 x W20V46F
56					5 x W20V46F		8 x W20V46F	10 x W20V46F
57								11 x W20V46F
58								12 x W20V46F
59	**UNLOADING PUMPS**							
60	HFO cap. (50 / 60 Hz)	LFO cap. (50 / 60 Hz)	Pump type					
61	16.2 / 19.7 m³/h	14.2 / 17.7 m³/h	ACG060					
62	25.9 / 31.5 m³/h	23.2 / 28.8 m³/h	ACG070					
63	28.6 / 34.4 m³/h		ACF090					
64								
65								

```
Sub toolmacro1()
' toolmacro1 Macro
  On Error GoTo ErrorHandler
  arvo = Sheets(2).Cells(10, 14).Value
  totuusarvo = Sheets(2).Cells(3, 3).Value
  'MsgBox ("arvo " & arvo & " totuusarvo " & totuusarvo)
  If totuusarvo = True Then
  totuusarvo = 1
  Else
  totuusarvo = -1
  End If
    If arvo = 0 Or arvo > 55 Or arvo = "" Then
    Sheets(2).Cells(19, 12).Value = ""
    Sheets(2).Cells(19, 14).Value = ""
    Sheets(2).Cells(19, 17).Value = ""
    Sheets(2).Cells(16, 12).Value = ""
    Sheets(2).Cells(22, 12).Value = ""
    Sheets(2).Cells(25, 12).Value = ""
    Sheets(2).Cells(28, 12).Value = ""
    Else
  r = 3 'row which have first minimum value
  s = 6 'column which have first minnimum value
  a = -1
  While a < 0 And r < 50
    amin = Sheets(1).Cells(r, s).Value 'min value
    amax = Sheets(1).Cells(r, s + 1).Value 'max value
    tot = Sheets(1).Cells(r, s + 2).Value
    'MsgBox ("amin " & amin & " amax " & amax & " tot " & tot)
    If arvo >= amin And arvo <= amax And tot = totuusarvo Then
      a = r
    Else
      r = r + 1
    End IF
```

```
 Wend
  If a > -1 Then
    Sheets(2).Cells(19, 12).Value = Sheets(1).Cells(a, 9).Value 'number of units
    Sheets(2).Cells(19, 14).Value = Sheets(1).Cells(a, 10).Value 'number of pumps
    Sheets(2).Cells(19, 17).Value = Sheets(1).Cells(a, 11).Value 'pump capacity
    Sheets(2).Cells(16, 12).Formula = "=HYPERLINK(""https://fiidm01.wnsd.com/kronodoc/PP/"" & sheet2!c16,sheet2!c16)"
    Sheets(2).Cells(16, 3).Value = Sheets(1).Cells(a, 13).Value 'shelter layout
    Sheets(2).Cells(22, 12).Formula = "=HYPERLINK(""https://fiidm01.wnsd.com/kronodoc/PP/"" & sheet2!c22,sheet2!c22)"
    Sheets(2).Cells(22, 3).Value = Sheets(1).Cells(a, 14).Value 'pump module layout
    Sheets(2).Cells(25, 12).Formula = "=HYPERLINK(""https://fiidm01.wnsd.com/kronodoc/PP/"" & sheet2!c25,sheet2!c25)"
    Sheets(2).Cells(25, 3).Value = Sheets(1).Cells(a, 15).Value 'pump module flow diagram
    If Sheets(2).Cells(5, 3).Value = True Then
    Sheets(2).Cells(28, 12).Formula = "=HYPERLINK(""https://fiidm01.wnsd.com/kronodoc/PP/"" & sheet2!c28,sheet2!c28)"
    Sheets(2).Cells(28, 3).Value = Sheets(1).Cells(a, 16).Value
    Else
    Sheets(2).Cells(28, 12).Formula = "=HYPERLINK(""https://fiidm01.wnsd.com/kronodoc/PP/"" & sheet2!c28,sheet2!c28)"
    Sheets(2).Cells(28, 3).Value = Sheets(1).Cells(a, 17).Value 'connetion pipe module
    End If
  End If
    End If
  Exit Sub
ErrorHandler:

End Sub
```