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ENVIRONMENTAL MANAGEMENT PLAN FOR WÄRTSILÄ POWER PLANTS

Tekniikka ja Liikenne

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FOREWORD

I started working full-time on my thesis in January 2010. Wärtsilä Power Plants recruited me earlier in autumn 2009 to carry out an assignment, which would also act as my final thesis for Vaasa University of Applied Sciences in study program of Environmental Technology.

I would like to thank all Wärtsilä personnel for great help and Riitta Niemelä, who was my supervisor representing the University. Especially I want to thank my Wärtsilä supervisors Kaarina Mäkynen and Carl-Johan Måsala from Quality Management department, who generated the original idea of this thesis and helped me a lot along with my work.

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ABSTRACT

Author	Mikko Hautio
Topic	Environmental Management Plan for Wärtsilä Power Plants
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The aim of this thesis is to provide a public environmental management plan for the Wärtsilä power plants, which covers its whole lifecycle. Environmental management plan includes general information about Wärtsilä's environmental policy, training, responsibilities, instructions, description of the plant operations and the environmental impacts. The purpose of this project is to replace old templates and create a new dynamic revision, which can be utilized and modified in the future. The aim was also to point out differences between different power plant solutions and fuel types.

The thesis is divided into four main chapters: Construction, Commissioning, Operational and Decommissioning phase, which describes operations and impacts in each phase. The Operational and Decommissioning phases consist mainly of general instructions how the customer should run the plant in environmentally friendly way.

The thesis will be utilized and developed further in the Wärtsilä. The Environmental Management Plan will be united with new revision of health and safety handbook, transformed in the electrical form and finally uploaded in the Wärtsilä documentation system.

Keywords: Environmental management plan, environmental impact, power plant, lifecycle

VAASAN AMMATTIKORKEAKOULU

Ympäristöteknologian koulutusohjelma

TIIVISTELMÄ

Tekijä	Mikko Hautio
Opinnäytetyön nimi	Environmental Management Plan for Wärtsilä Power Plants
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Kieli	Englanti
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Ohjaaja	Riitta Niemelä

Tämän opinnäytetyön tavoitteena oli laatia Wärtsilän voimalaitoksille julkinen ympäristösuunnitelma, joka kattaisi laitoksen koko elinkaaren. Ympäristösuunnitelma sisältää Wärtsilän ympäristöpolitiikan, koulutuksen, vastuut, ohjeistuksen, kuvauksen laitoksen toiminnoista sekä mahdolliset ympäristövaikutukset. Työn tarkoituksena on korvata vanhat ajastaan jälkeenjääneet ympäristösuunnitelmat ja luoda uusi dynaaminen versio, jota voidaan hyödyntää ja muokata tulevaisuudessa omien tarpeiden mukaan. Tavoitteena oli myös osoittaa eroja eri laitos- ja polttoainetyyppien välillä.

Työ rakentuu neljästä pääkappaleesta: rakennus-, käyttöönotto-, toiminta-, ja purkuvaiheesta. Näistä kukin kuvaa toimintoja ja ympäristövaikutuksia laitoksen sen hetkisen elinkaaren kohdalla. Toiminta- ja purkuvaihe koostuvat pääasiassa yleisistä ohjeista asiakkaalle, kuinka voimalaitosta tulisi hoitaa mahdollisimman ympäristöystävällisellä tavalla.

Työtä tullaan jatkamaan ja käyttämään hyödyksi tulevaisuudessa Wärtsilässä. Ympäristösuunnitelma tullaan yhdistämään uuden työturvallisuuskäsikirjan kanssa yhdeksi kokonaisuudeksi ja siirtämää sähköiseen muotoon Wärtsilän dokumentinhallintajärjestelmään.

Asiasanat	Ympäristösuunnitelma, ympäristövaikutus, voimalaitos, elinkaari

CONTENTS

GLOSSARY

API 650	American Petroleum Institute standard for welded steel tanks for oil storage
Base load	Generating power for continuous use
BAT	Best available technology
EIA	Environmental impact assessment
EN 12285	Workshop fabricated steel tanks standard
EMP	Environmental management plan
HFO	Heavy fuel oil
IDM	Wärtsilä Integrated Management System
ISO	The International Organization for Standardization
LFO	Light fuel oil
LCA	Life cycle assessment
NBR	Nitrile butadiene rubber
NFPA 30	National Fire protection association (US) standard

1. Introduction

I started my project in January 2010 at Wärtsilä Power Plants. My task was to provide an extensive environmental management plan for power plants, which covered its whole lifecycle from construction phase all the way to decommissioning phase. Environmental management plan means in this case an extensive research about environmental impacts, plant operations and work procedures. The environmental impacts consists for example of discharges to environment, pollution risks, impacts to landscape, hazardous material storage and handling, waste management, noise etc. The plan will also include information about facilities and a general section, which defines Wärtsilä's environmental policy, responsibilities and objectives. The aim of this plan is to create a new revision to replace the old templates and support the customer and foreign authorities.

Priorities are the basic power plants: base load, peak load and emergency power plant solutions which are powered by heavy fuel oil, light fuel oil or gas. Because of the lack of time I have to cut out from inspection all specialized solutions for example fuel cubes, fuel treatment containers, barge power plants, offshore power plants etc. At the end plan will be transformed to electrical form and uploaded to IDM (Wärtsilä Integrated Document Management). The basic idea of this is that the environmental plan consists of base parts such as fuel type, purpose of use and operation phase. Accordingly the user is able to choose parts step-by-step and get a specific, individual plan according to their needs. Next, the figure illustrates how it works in practice.

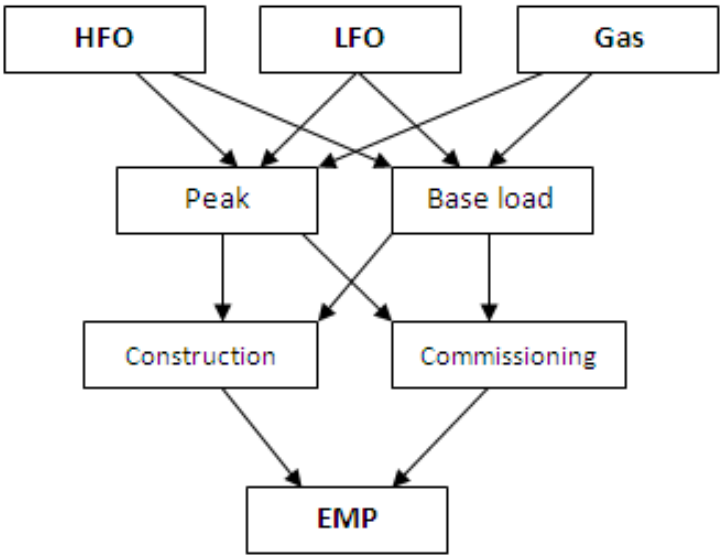

Figure 1 Construction of EMP

1.1. Research methods

In the beginning we sketched with my supervisors' the main viewpoints for the project and decided what kind of power plants we want to emphasize in this work. After when the task was defined I started to familiarize myself with the IDM, which is the documentation system of company. I used during the research many different technical handbooks from Wärtsilä database and utilized them in my work. Another source of my work was World Bank Group's Environmental, Health and Safety guidelines (30th of April 2007), which is recognized worldwide as minimum requirement for environmental plans. The Environmental, Health and Safety Guidelines is a technical reference document with general and industry-specific examples of Good International Industry Practice. The Guidelines contain the performance levels and measures that are normally acceptable to International Finance Corporation and are generally considered to be achievable in new facilities at reasonable costs by existing technology. It contains information on cross-cutting environmental, health, and safety issues potentially applicable to all industry sectors. I also made several interviews with Wärtsilä engineers and site managers. /10/

1.2. Structure of this thesis

This thesis consists of seven chapters. The first chapter consists of the general information about thesis, purpose of the work and theory about environmental management. The second chapter introduces Wärtsilä and Power Plants. The chapters 3-6 consist of my research and comprise the Environmental Management plan for power plant projects. I divided my work in the four parts: construction, commissioning, operational and decommissioning phase. The construction chapter defines Wärtsilä's environmental policy and includes general information about environmental systems, responsibilities and training. This part will also specify the environmental impacts caused by construction works and some general guidelines. The commissioning chapter introduces how the every section of facility works and I tried to bring out some detailed information about the process which helps to define environmental impacts. The operational- and decommissioning chapters will give information about Wärtsilä Services operations and gives some general guidelines how to act environmentally friendly way after when Wärtsilä has left the site and handed plant over to the customer. The last chapter presents conclusions and summary of thesis and some future prospects how the EMP will be utilized in Wärtsilä.

1.3. Purpose of environmental plan

Kentucky Division of Compliance Assistance (DCA) defines environmental plan as: "EMP describes the processes that an organization will follow to maximize its compliance and minimize harm to the environment." /12/ Provincial Government of the Western Cape: Department of Environmental Affairs and Development planning defines EMP as "An environmental management tool is used to ensure that undue or reasonably avoidable adverse impacts of the construction, operation and decommissioning of a project are prevented; and that the positive benefits of the projects are enhanced." /16/ In summary, its purpose is to reduce adverse impact to sensitive environmental resources and to minimize disturbance for neighborhood.

An EMP is sometimes even referred as pollution prevention plan because often the main focus of plan is preventing certain pollutions. It might be also a useful tool for companies to help address a variety of environmental issues such as managing air emissions. EMP has also similar features with normal life cycle analysis, because EMP should also include life cycle aspects for continual improvements to assist best practice in environmental management. This project is a good example of this kind of manner of plan. Health and safety issues are also stated in EMP and these have to cover all prescribed legal requirements. It might also serve own personnel on environmental issues such as guiding personnel in organization towards certain objectives and increase safety issues. EMP should also define exact roles and responsibilities for supervisors inside organization and point out clearly required inspections and maintenance in practice. In the end EMP should be reviewed occasionally to ensure it reflects the current situation. In an ideal world EMP should continuously improve. The review of EMP should include at least these things: any significant changes to activities or legislation, result of inspection and maintenance programs and public complaints. Nowadays environmental issues have gained a big role in business and importance of good EMPs has grown vastly. Companies with good product and ecological footprint will be succeeded, because customers require high quality products and services, but they also expect environmental friendly products. /2/ /8/

1.4. Environmental management

Environmental management system is the company response to the growing concern about the state of environmental impacts caused by company activities. Environmental management systems can be seen as extension of the quality management systems, which were developed in the 1980's. The environmental management system is the basis for the actions that the company takes to manage its environmental effects. The environmental management system aims to following goals:

- Minimizing environmental-, health and safety impacts and risks.

- Reduce pollutions and resource consumption.

- Develop more environmental efficient products in the future.

Environmental management includes an environmental policy of the company, environmental assessments, environmental objectives, environmental programs and environmental auditing. The environmental policy states company's commitment to improve its environmental performance and strategies. The environmental assessments are divided to assessments for the company, product and process. Environmental objectives express in which way the company is intending to develop in the future. Environmental program means implementation of environmental standards such as ISO 14001. /18/

The benefits of the environmental systems are first of all reducing the environmental impacts and hazards but in the long run it will contribute economical growth also. The environmental friendly image of the company will improve the public image and raise asset value. It also ensures meeting the tightening environmental requirements in the future.

1.4.1. Sustainable development

Sustainable development is defined usually according Brundtland Commission (1987) "Enabling development that meets today's needs without prejudicing the ability of future generations to meet their own needs"/14/. As the world moves through the twenty-first century, it faces an important challenge to protect and preserve the earth's resources to ensure healthy environment for the future generations. Over the last several decades of environmental policy, the focus has been to achieve environmental quality by reducing pollutions to a level that is acceptable to society. In the late 1980's policymakers realized that decision making should be driven towards a much broader goal: sustainable development. In 1992 in Earth Summit in Rio de Janeiro nations outlined guidelines how to act in line with sustainable development, which contributes both: global environmental protection and economic development in the long run. /14/

Regulations of economic activity have changed a lot of evolution of environmental policies around the world, where command-and-control approach

has developed a new problem. The end-of-pipe regulations are not adequate methods to control long-term implications of environmental damage and furthermore this approach does not full-fill entire objective of sustainable development. The comprehensive goal of sustainable development requires changes in attitudes how society make market decisions. The challenge is to achieve economic prosperity but change market activity so that natural resources and environment are protected. /18/

The sustainable development is an ambitious goal. The broader goal of sustainable development aims towards to industrial ecology concept, where entire life cycle of the product, including all the materials and energy flows should be considered in efforts to improve the environment. The primary purpose of industrial ecology is to promote the use of recycled wastes from one industrial process as inputs in another. It also supports optimal materials flows, which means efficient use of materials and energy in production. On the other hand more familiar approach to achieving sustainable development is pollution prevention. Pollution prevention refers to initiatives that reduce or eliminates waste rather than deal with them at the end of product cycle. Although the aims are different above, pollution prevention and industrial ecology shares a common view that end-of-pipe policy controls are not sufficient for achieving goals. In the end a quote from Albert Einstein (1879-1955) condenses the whole message in a few words: “Intellectuals solve problems, genuine prevent them.” /18/

1.4.2. Life cycle assessment

Industrial companies often calculate environmental impacts by using the life cycle assessment (LCA). LCA is a process used to evaluate environmental load associated with a product, process or activity. The process takes into account the whole life cycle of the product, packages, processes and activities. It also includes assessment of raw material production, manufacture and transporting. The process begins by indentifying and quantifying energy and material usage and environmental releases. The collected data is used to assess the impact of material usage, energy consumption, and releases to environment. Furthermore the data will be evaluated and modifications for the process can be implemented to achieve

environmental improvements. The benefit of this method is that environmental improvements can be seen in seen in each step in the LCA process, which exposes the hot spots from the process. For example the raw materials alone may be used to identify opportunities for reducing emissions, energy and material use. In summary LCA provides help to decision making to incorporate consideration of energy and material use, transportation and disposal. LCA represents a detailed framework of the products and benefits of the changes in the process can be easily calculated, evaluated and combined with existing pollution control and prevention approaches. /15/

1.4.3. ISO 14000 standards

The International Organization for Standardization (ISO) was established in 1947. During its 50-year history ISO has published more than 3000 technical and non-technical standards in all fields. The history of ISO 14000 began in 1990 with creation of an organization of 50 business leaders with an interest in environment and development issues. The ISO 14000 is a standard for environmental management systems that is applicable to any business, regardless of size, location or income. The aim of the standard is to minimize harmful environmental impacts caused by business activities, for example decreasing the pollution and wastes to achieve continual improvement of environmental performance. It is important to underline that ISO 14000 standards are environmental management not performance standards. That is why it focuses on the core element of an environmental management without defining specific performance targets. The ISO 14000 series also covers standards on environmental auditing, audit procedures, auditor criteria, audit management, initial environmental reviews, environmental site assessment, environmental labelling, performance evaluation and life cycle assessment. /3/ /17/

1.4.3.1. ISO 14001 standard

ISO 14001 standard is probably the most well-known environmental management system standard. The important distinction between ISO 14001 and ISO 14000 is that ISO 14001 is the specification, describing the core elements for certification

or self-declaration of an environmental management system, while ISO 14000 is a non certifiable guidance standard. The specification of ISO 14001 shares common management system principles with the ISO 9000 series of quality standards and the company might use an existing management system as a basis for environmental management systems. The ISO 14001 standard defines requirements for an environmental management system how to develop and implement a policy and objectives, which takes into account legal and other requirements and environmental impacts. According the scope of ISO 14001, the standard is applicable to company who wishes to accomplish:

- Implement, maintain and improve an environmental management system

- Assure itself of conformance with its own environmental policy

- Demonstrate conformance to others

- Seek certification by an external organization

- Make a self determination and declaration of conformance with ISO 14001

The company has liberty to choose if they want to implement ISO 14001 throughout the entire organization, or only for specific units or activities. /17/

2. Wärtsilä

2.1. General information

Wärtsilä is a Finnish manufacturer of large diesel and gas engines for use in powering ships and electricity generation. The company offers also operation and maintenance services for the ship power and power plants. Wärtsilä has operations in 160 locations in 70 countries and 19,000 employees around the world. Headquarter is located in Helsinki, furthermore there are operations in Vaasa, Turku, Raisio and Espoo. Mission and vision of Wärtsilä is to provide lifecycle power solutions to enhance customers business, whilst creating better technologies that benefit both the customer and the environment. Wärtsilä aims to be the most valued business partner of its customer's /20/

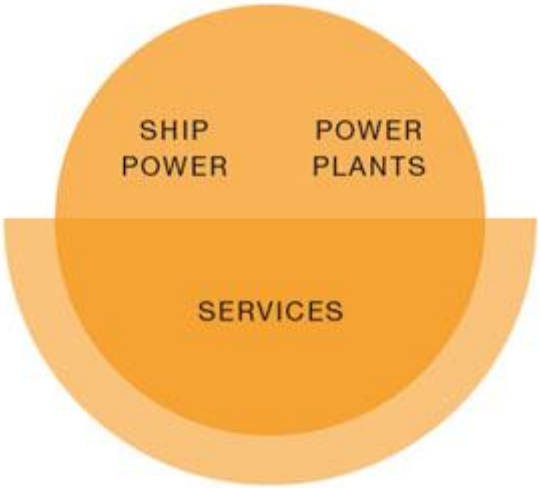

Figure 2 Areas of business in Wärtsilä /20/

2.2. Power plant types

Wärtsilä Power Plants is a leading supplier of power plants for decentralized power generation. The solutions cover power plants for steady base load operation. Balancing peak loads, emergency operations and covering the needs of own energy production for example in cement, petroleum- and gas industry.

The assets in power plant market are strong and wide product range, a high efficiency rate and fuel flexibility deliveries, all-inclusive turnkey packages, full operations support and a distinctive product offering.

2.2.1. Heavy- and light fuel power plants

Wärtsilä oil power plants are suitable for stationary and floating base-load plants, stand-by applications for decentralized power production and for emergency plants. Oil power plants are powered by heavy-, light- crude fuel oil or bio fuels. The product range comprises oil- and multi-fuelled power plants with outputs ranging from 1 to 300 MW. Wärtsilä has delivered almost 4000 oil power plants all over the world. Principal layout of oil power plant can be seen in figure 3 below. /28/

Figure 3 Oil Power Plant

2.2.2. Gas Power plants

Wärtsilä gas power plants are designed for optimal performance in a wide variety of decentralized power production applications such as stationary and floating base-load plants, stand-by applications for decentralized power production and for emergency plants. The gas engine plants are based on gas engine units. The engines are designed for continuous operation on natural gas or in dual fuel mode with gas and oil. They can run in island mode or parallel with the grid depending on the operational demand. Wärtsilä has delivered close to 600 gas power plants around the world. Principal layout of gas power plant can be seen in figure 4 below. /26/

Figure 4 Gas Power Plant

3. Construction Phase

From now on the chapters 3-6 consists of construction, commissioning, operational and decommissioning phases, which comprises the Environmental Management plan itself.

3.1. General

Wärtsilä has systematically worked for a long time to reduce the consumption of energy and materials, lower various emissions and increase the recycling of waste. The high efficiency, long life cycle and low emissions of Wärtsilä products helps to reduce the consumption of natural resources and air pollution. Well-managed environmental protection enhances business in all ways and allows society to approve of and support Wärtsilä operations. The contribution of each and every Wärtsilä employee is essential, as everything they do has an impact on both the environment and the people around us.

Wärtsilä's minimum requirement is compliance with the laws and regulations related to environmental issues. It is Wärtsilä's aim to cover the whole supply chain and support our suppliers and customers in developing efficient procedures for environmental management. Environmental performance is developed according to the continuous improvement principles. The management of Wärtsilä sets objectives and targets for environmental issues and regularly monitors how these are achieved. The Environmental Management Plan complies with the Wärtsilä's policy and directives as well as ISO 14001 standard. /25/

3.1.1. Environmental policy

Wärtsilä considers environment protection to be one of its greatest responsibilities and accordingly Wärtsilä undertakes to minimize the risk from hazards in all aspects of its work and highlights the safe working procedures to protect the property and natural environment. Power solutions of Wärtsilä are reliable, safe, efficient and compliant with applicable legal requirements and regulations. The

end of official environmental declaration states that Wärtsilä's skilled organization acts as a responsible global citizen /22/

To achieve these aims of the Wärtsilä will:

1. Continually improve performance and reduce adverse environmental impact.

2. Provide where necessary adequate instructions, training and supervision of work practices.

3. Ensure that necessary procedures to deal with emergencies and incidents are known and that suitable and sufficient facilities are available at location.

4. Develop internal company standards for safe work procedures, health, and environmental protection

5. Develop and maintain a safe work environment and system of work procedures within the scope of legislative provisions, as far as is reasonably possible

Wärtsilä recognizes that achievement of an effective environmental management program demands active and positive involvement of all levels of management, and requires the full participation and support of all employees. Attitude is the key factor and all employees are encouraged to develop a positive and continuing concern for the environment by making environmental concerns a matter of personal commitment. Each and every employee can make a significant contribution. /25/

3.1.2. ISO standards

The environment and the sustainable development are important factors in the business of Wärtsilä. Wärtsilä Finland has ISO 9001 certificate for quality management systems, ISO 14001 certificate for environmental management and OHSAS 18001 certificate for occupational health and safety management.

The List of Contents of Wärtsilä Finland Oy Environmental and Occupational Health & Safety Manual is harmonized with standards ISO 14001 and OHSAS 18001.

According the ISO 14001-standard the focus of human resource development is to improve Wärtsilä employee's management skills, general skills and task- specific skills. Each year the environmental and work safety team assesses the significance of environmental and work safety aspects and risks in accordance with the risk evaluation instructions. Based on this evaluation the significant environmental and work safety aspects and risks are defined. After when the aspects and risks are identified the team will prepare objectives and targets how to improve these issues in the future and all actions will be documented and published. /39/

3.1.3. Training

Wärtsilä informs and educates personnel on environmental care and protection as well as risk management within their areas of responsibility. Site person will be given general environmental training. The training is carried out according to Basic training instructions. Environmental training is given with the intention to ensuring that each employee has general and specific environmental knowledge and ability to act according to the EMP.

The contents of environmental training:

1. Basic education and training

2. Wärtsilä's environmental policy

3. The main principles of the environmental system

4. Health and safety issues

5. Storage and handling chemicals

6. Waste and hazardous waste management

8. Instructions for emergency situations

9. Taking care of environment

Wärtsilä encourages its personnel to take full advantage by participating in other orientations as well and also keeps record about given education. The new workers will be given a compulsory orientation about management systems.

Visitor orientation:

In the beginning visitors shall be provided with required personal safety equipments. The site visitors should be given a compulsory orientation about health and safety, waste sorting and other general issues on the site. Visitors should also sign an agreement, which states that they understand health and safety regulations and are committed to obey these rules.

3.1.4. Responsibilities

Site organization at Wärtsilä construction site is responsible to ensure that the site activities are performed in an environmentally responsible way. The following figure illustrates the site hierarchy of Wärtsilä. In some big projects construction manager might also be included in the site organization.

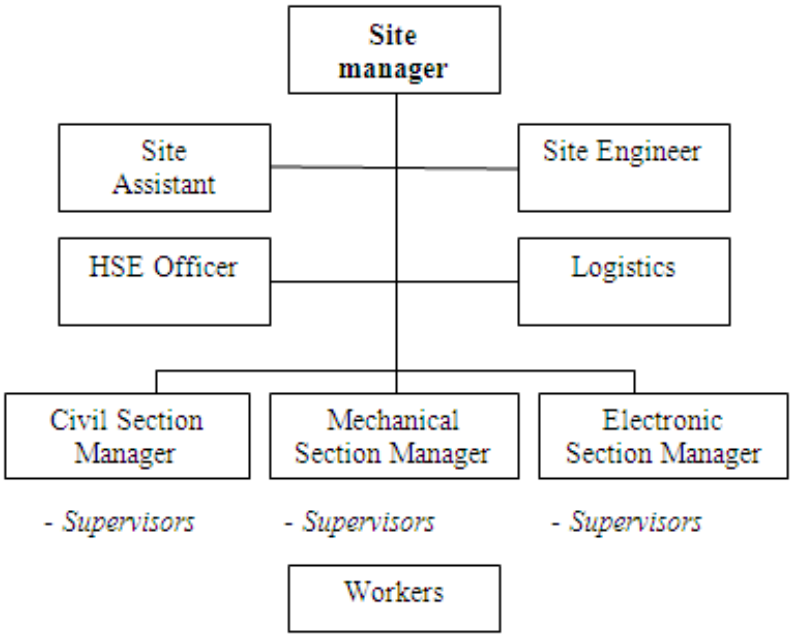

Figure 5 Site hierarchy of Wärtsilä

3.1.4.1.Construction manager

Construction manager observes and manages work on site. He is responsible for following the safety policy and ensuring that every Wärtsilä's employee on site understand and comply with the policy and safety procedures. He communicates with the Site manager, authorities, client, site personnel, subcontractors and other project participants to make sure that the environmental incident prevention instructions are followed.

3.1.4.2. Site manager

Site manager ensures that all employees, supervisors and subcontractors are informed about environmental requirements, precautions and procedures. Site manager should also implement the environmental protection and spill prevention plan at site and make sure that oils, paints and chemicals, etc. are properly stored transported, protected and handled to avoid spillages and safety risks to the site personnel or property. He supervises that environmental incident prevention plan is followed generally in all areas. He communicates with authorities, clients and neighbors about the issues relating to construction site. In the end he assures that demobilization activities have been properly taken care of by responsible persons and all activities has been finalized according the site safety rules.

3.1.4.3. Commissioning Manager

Commissioning manager is the leader of the commissioning phase of power plant. He ensures that all commissioning supervisors and subcontractors are informed of environmental requirements, precautions, and procedures. He also assists in implementing the environmental protection and spill prevention plan at site. He supervises that all materials are properly stored, transported and protected to avoid accidents and ensures that waste management plan is followed. After commissioning phase he ensures that site has been cleared out properly before the plant is handed over to the customer.

3.1.4.4. Section Manager

Section manager supervises his own area of operation and health and safety issues. He also assists in implementing the environmental protection and spill prevention plan at site. He supervises that oils, paints and chemicals, etc. are properly stored transported, protected and handled to avoid any spillages or and safety risks to the personnel or property.

3.1.4.5. Health and Safety Officer

Nominated safety supervisor will ensure that safety is carried out in daily activities. Safety supervisor is responsible to ensure that all employees receive adequate information, instructions and equipments according the safety regulations of the project. Safety supervisor is responsible for the implementation and co-ordination of the occupational health & safety manual and spill prevention and control plan for the project. He maintains accident log recording all pertinent accident information. He is also responsible for orientating of the safety rules and regulations for new employees.

3.1.4.6. Section Supervisor

Specialized supervisor supervises his own area of operation and assists in implementing the occupational health & safety manual, spill prevention and control plan at site. He supervises also general issues such as waste management, transportation, health and safety issues and general cleanliness of the site etc.

3.1.4.7. Workers

Subcontractors and their employees are committed to follow Wärtsilä's safety policy and are responsible for reporting accidents, injuries, hazards, failures of tools and other issues of safety matters.

In summary all the site personnel are responsible for following the environmental, health and safety instructions of Wärtsilä.

3.1.5. Reporting

All accidents, spills, near-miss and sickness situations shall be reported and investigated properly. After the investigation, the preventive actions are performed. According Wärtsiläs's Occupational HSE handbook safety reports and statistics will be collected once in a month as the 14001 standard requires. /27/

3.1.6. Precautions

Every power plant will have a specific emergency and evacuation plan in case of natural catastrophes, which might occur in its area. For example if power plant is located in area with high risk of earthquake or flood it will have a plan how to operate and be evacuated in that situation. Plan should also include other possible accident scenarios, such as fires, explosions, chemical spills etc. the primary objectives are to save lives, avoid injuries and minimize damage to property

3.1.7. Risk analysis

Inspection of products has been evaluated and categorized according the ISO 14121-stadard and will be updated yearly. Risk analysis itself has been made according the instructions of corporation.

Risk analysis is a tool for calculating probabilities of accidents at the site. The risks have been evaluated with numbers from 0-5 depending how likely particular risk is going to happen. So that number zero represents no risk and number 5 represents very high risk. According the calculations the most likely accidents to happen at the site are: different kind of fires, for example ignition of oil or engine, oil leakages from tank or engine, falling splashes outdoor tank or filling vessel, different kind of crashes, for example truck or crane control error and high noise levels caused by construction works. /32/

3.2. Environmental aspects

Usually a third party has drawn up for a power plant project an EIA (Environmental Impact Analysis), which is a smaller-scale plan than EMP. It has been made for identifying and assessing possible environmental impact associated

by the power plant. EIA is can be utilized when implementing a full-scale EMP. Wärtsilä assumes that customer has taken all presumable environmental issues into account in EIA already when choosing location of plant. That is why it is justified that environmental permissions for power plant are in the first place on customers responsibly.

3.2.1. General guidelines

In the beginning of construction works one general rule must be underlined to all personnel: To keeping up general cleanliness all around the site. Personnel have to maintain the tools, materials, equipments, vehicles and properties clean and in order, and when tools are used them should be stored in order to safe location. These principles concern all employees regardless one's position in every phase during the power plants lifecycle.

3.2.2. Transporting and traffic

During the construction period traffic and transports will increase substantially at the site area, which increases air emissions, dust, noise and probabilities of accidents. Hence speed limits and well organized traffic are required at the site area. Special arrangements shall be done for refueling and maintenance vehicles. They are allowed to drive along marked roads to specify unloading area only and vehicle idling will be minimized preventing exhausting gas emissions. In order to prevent oil spills all vehicles will be provided with the trip tray if they are found to be leaking oil. In case of accident construction- and health and safety manager will perform an extensive inspection, and make changes to prevent similar accidents in the future.

3.2.3. Hazardous material storing

Hazardous materials and construction chemicals for example solvents, fuel, cement additives and reactive chemicals will be stored in ventilated, separated, isolated area and will be handled according to the material safety data sheets. All the fittings, pipes and hoses etc. shall be also made from dedicated materials. All refilled containers must be marked clearly, so that their identification will be easy.

All the hazardous material shall be stored indoor away from the direct sunlight and heat. Storage area should be provided with proper spill sink to ensure that spilled chemicals cannot reach regolith. Due to the reason that spilled hazardous chemicals might cause contamination of land, health or fire risks. Spill kits should be available in visible place on the site for cleaning up possible minor spills. Regular inspection will be made by health and safety manager to prevent possible accidents and maintain specific documentations of all hazardous materials at the site.

3.2.4. Waste management

Global waste management plan aims to reduce generated waste and recycle. Wärtsilä is committed to these regulations, which are united with its own environmental policy. Waste management including sorting, hazardous waste, transportation and disposal of waste will be done in accordance with existing rules and regulations of local legislation. Wärtsilä practices good housekeeping and operating practices, including inventory control to reduce the amount of waste from materials that are out-of-date, off-specification, damaged or excess to plant needs and try to recognize opportunities to return usable materials such as containers.

The following waste will be generated during the construction:

- Waste associated with clearing the site, ground excavation and demolition
- General construction site waste: containers, wood, metal, etc.
- Dangerous waste: waste oils and polluted containers
- Ordinary waste: office and food waste etc.

Hazardous waste will be delivered to approved disposal site and shall store in a manner that prevents contact between incompatible wastes and allows inspection between containers for monitoring leaks or spills. Waste oil and chemicals will be stored in isolated containers in a separate place. The storage area shall be provided

with proper fence and warning signs to prevent unauthorized accesses and accidents.

3.2.5. Emissions to air

Exhaust gases from heavy trucks, oil tankers, and construction machinery will pollute the atmosphere during construction phase. Also particular matter will be produced due to construction and digging activities. This leads to fugitive dust emissions and reduces air quality locally. Only way to reduce these emissions is to avoid unnecessary traffic and idle running in the area.

3.2.6. Noise and vibration

Noise will be generated by plant and equipment associated with the construction activities such as main civil works, piling vehicle movements etc. Construction works will result in elevated noise levels on and close to the site. In some cases noise levels might be very high caused by temporary noise peaks. Local residents and authorities will be notified beforehand if it is considered necessary.

Based on British Standard 4142 survey of human response to noise, changes in noise levels of 5 dB or less are unlikely to result in complains of nuisance, while 10 dB or more are likely to lead to complains. All vehicles and equipment should be equipped with proper silencers and mufflers to reduce noise at the site. /5/

Construction works will also cause minor vibration to environment, which has not significant impacts to neighborhood. According a British study that the nuisance from ground vibration and building damage is unlikely to occur if the operation is conducted at distances greater than 50 meters. Based on guideline for major construction made by Victoria state of Australia says that Complains about air vibrations from blasting have been received from people 100m away from the activity. /6/ /9/

3.2.7. Impact to landscape

The facility construction works will have an adverse impact on the local landscape character as a result of vehicle movements, construction activity and by the plant

itself. Wärtsilä will exercise care to the natural landscape and conduct construction operations as to prevent any unnecessary destruction, scarring or defacing of the natural surroundings in the vicinity of the work sites. This will also include minimizing impact to flora and fauna. According to Wärtsilä environmental policy all debris, spillages etc. should be removed and cleaned up if possible. After completion of construction all temporary structures and roads will be removed and rehabilitated as good as possible. Contractor should also made disquisition about ground water issues to make sure that power plant will not disturb hydrological cycle or contaminate ground water. Most of the cases power plant does not have significant impacts to the quality and quantity of ground water if the power plant is not situated in sensitive ground water area, and if the contractor will dispose of its treated effluent within permissible limits of regulations into wastewater carrying drain.

3.2.8. Contaminated land and erosion

Land is considered contaminated when it contains hazardous materials or oil concentrations above background or naturally occurring levels. Construction activities may pose the potential release of petroleum based products, such as lubricants, hydraulic fluids, or fuels during their storage, transfer or use in equipment. These are the main factors, which might cause contamination of land. Trying to prevent these incidents Wärtsilä aims for using, impervious surfaces on refueling areas and take extra care when transferring oil and hazardous fluids.

Before starting construction there has to be done a survey about the topography of the area. The survey will identify critical areas for protection such as highly erodible soils, steep slopes or bare areas and simulate presumable and maximum rainfall. There is a risk that removed soil might cause faster erosion and can lead to dust problem especially in desert locations. At the site sediment run-off should be minimized by reducing storm water on the site. It will be done with efficient storm water drainage system, which will be installed before any land disturbance activities commence. Sediment mobilization and transports should also be scheduled to avoid heavy rainfall periods. After construction of plant loose soil will be removed or covered with vegetation to avoid particulate dispersion into

air. The excavated soil will be utilized for example in the leveling, grading and pavement of the roads within the plant area.

3.2.9. Dust

Construction works can generate locally significant quantities of dust during activities such as earthmoving operations on site, wind blow and traffic movements. Wärtsilä aims to arrange adequate equipments for collecting or preventing dust during the operations, for example roads will be provided with adequate road drainage based on road with, surface material and maintain artificial watering in sensitive areas.

3.2.10. Drainage system

Drainage system will be done accordance with local legislation. System will be scaled up to be capable of dispersing maximum predicted rainfall, to ensure its functionality in a storm. Sanitary wastewater might discharge in varying quantities during construction. That is why adequate portable and permanent sanitation facilities will be provided at the site. Contaminated water facilities will be separated from rainfall drainage and if possible the sewage drainage will be connected to municipal sewer system. Sludge will be collected and pumped to the sludge tanks and will be treated either at the site or by some local company. System will be designed to minimize continuous slopes where flowing water can scour. To prevent scouring, drainage lines may need to be lined on velocity-reducing structures, which reduces water velocity and prevents leakages of pipes. One serious possible threat for environment is, if rain water and oil will be mixed cause of leakage. That is why drainage system requires regular inspection all the time.

3.2.11. Oil and chemical spills

Oil and chemical spills are one of the most likely accidents to happen in construction phase. Spillages can come from construction equipment, motor vehicles or temporary bulk oil storage areas. To prevent spillages adequate equipments such as spill kits shall be kept on-site to deal with occurred spills. One useful and relatively cheap method is to equip normal, empty shipping container to an oil spill prevention container.

Figure 6 Spill prevention container in Brazil

The picture above is a great example from Brazil how the spill prevention container looks like. The container includes tools for absorption of 2000 liters of oil. It includes 200 liter lidded barrels, which are full-filled with absorption material. The barrels are easy to roll in place in case of spill and after when oil has soaked the barrel can be refilled with contaminated absorption material, sealed, stored in the container and transported away.

3.2.12. Physical hazards

At construction phase there are lots of different kinds of physical hazards. For example welding and hot works, working at heights, traffic and tools might cause serious accidents. Wärtsilä is responsible for site's health and safety and has nominated officers to supervise these issues at the site. Health and safety issues are also stated in the HSE handbook.

3.2.13. Maintenance and inspection

Ongoing surveillance is needed and required to ensure that the new risks are identified as they rise. Aim of this plan is to be adjusted to ensure that any new risks are adequately identified and managed.

3.2.14. Rehabilitation plan

Rehabilitation plan will be developed as soon as possible after design is finalized. The site will be rehabilitated with above-mentioned methods so the impact on the environment is minimal.

3.2.15. Instructions for exceptional situations

Exceptional situations refer to disturbances or accidents that may cause exceptional emissions or effluents to the environment. Exceptional emissions or effluents may be caused by damaged containers or pipes, problems in equipment or machine operations, over-filling of containers, black-outs, neglected maintenance or the human factor. Exceptional situations can also be planned, like stopping and restarting of a process. Preventive measures must always be taken to control exceptional situations. Preventive measures include, among others, the following: identification of hazardous factors and situations, following prevention procedures, training, orientation and information for employees and maintaining of protection readiness

In case of accident or emergency situation plan of action is: Protect human life and health in the first place. Secondly protect property and prevent environmental damage. /24/

3.2.16. In case of spilling

All site personnel's are responsible for taking all actions needed to prevent spills at the site. In case of major spill it is mandatory to report as soon as possible after discovery to the Construction Manager or Health and Safety Officer.

The following information has to be gathered as soon as possible after the spill has been discovered and first reported: Seriousness of spill, estimation of the quantity of released spill, location of the spill and proposed control methods and actions. /36/

Procedures if spill incurs contamination of soil: Usually there are three general approaches to cleaning up contaminated soil. At first Soil can be excavated from the ground and be either treated or disposed, which is usually the best option in case of oil spill. Soil can also be left in the ground and treated in place. This procedure works usually when dealing with minor spills. Third option is to leave the soil in the ground to prevent contamination from spreading, which is usually done by placing a large plastic cover over the contaminated soil to prevent contact with soil and rain water.

Treatment approaches can include: flushing contaminants out of the soil using water, chemical solvents, destroying the contaminants by incineration or adding material to the soil to encapsulate the contaminants and prevent them from spreading.

The following general instructions shall be given to personnel if a spill occurs:

1. If possible try to stop outflow immediately. In case of fuel spill, the risk of fire must be prevented if possible.

2. Inform the supervisor and other personnel and call assistance.

3. Remove vehicles and material from the risk zone

4. Arrange bund wall around the spillage with soil or sand to prevent liquid spreading

5. Depending on consistency of liquid, spill can be covered with absorbent material such as sawdust. Then let the oil/liquid be soaked and remove after few hours. The method works for example with oil spills.

6. Contaminated materials and water shall be disposed with approved way and ensure that further pollution is not caused during the cleaning works and transportation.

After the cleaning of the spill it is necessary to restore and return all spill response equipment. /7/

4. Commissioning Phase

4.1. General

The commissioning phase ensures that equipments are brought from mechanical completion to a safe operational status. During and after commissioning phase the number of personnel working at the site will be significantly reduced. Full site commissioning works will involve the progressive testing of plant components, units and system up to a full plant test run. Commissioning works involves installation inspections and functional testing of each components, device and unit to ensure safe operation, quality standards and contractual obligations. In installation tests phase, civil, mechanical and electrical systems are checked and started. In start-up phase each system performance is verified in predefined sequence of tests. As the last phase of commissioning, each contractual performance test is executed to demonstrate and prove to customer guaranteed parameters. Depending on actual contract definitions of required performance, the tests may include, for example: fuel consumption, electrical power output, heat rate, lubrication oil consumption, and exhaust gas emissions levels etc. Successfully tested and commissioned power plant will be handed over officially to the customer. /23/

4.2. Environmental aspects

4.2.1. Emissions to air

Atmospheric emissions during commissioning period may be higher than normal emissions due to the reason engines are driven with maximum capacity, however these emissions will be temporary hence their impact will be minimal. Atmospheric emissions comprise mainly carbon dioxide, oxides of nitrogen, sulphur dioxide, carbon monoxide, particulate matters, and volatile organic compounds.

4.2.2. Noise

Temporary noise peaks levels might be high during the commissioning phase. One possible high level source of noise is pipe purging activities, where compressed air is blew by high pressure through to pipe lines to remove impurities from the system. Before the steam purging it is necessary to inform neighborhood for disturbance and to ensure that all the persons in the vicinity of the facility are provided with adequate hearing protection and given appropriate warnings prior to event.

4.2.3. Oil Spills

Different kinds of oil spills might happen during the commissioning phase. The common reasons for leaks is when starting the commissioning phase: valves are in wrong position or loose, pipe connections are not tighten or malfunction in the system, and due that reason spills to the environment might occur. Minor spills can be easily avoided by following safety regulations. Procedures in case of oil spills are the same as above.

4.2.4. Gas leaks

The gas power plant does not have any actual fuel tanks. The gas in conveyed directly by pipes to the engine hall from the supplier. The only tanks in the area are lubricating and service oil tanks, which are relatively small, compared to main fuel tanks in oil power plant and thus the oil spills are rare. The gas powered power plants are powered by natural gas, which consisting primarily of methane. The gas itself is not toxic for human, but it could cause suffocation, head ache and narcotic effects if inhaled big amounts. However the gas is easily flammable and hence risks of explosion and fires are always present in case of leak. In the first place all employees should be aware of basic conditions, which contribute ignition of gas: adequate relation between air, amount of gas and an ignition source. Gas leak can be detected by smell, noise and alarm from gas detector.

The following general instructions shall be given to personnel if a leak occurs:

1. If lives are not in danger try to shut down engine and gas supply. Closing the gas supply main valve ensures that gas flow will stop.

2. Evacuate personnel and inform supervisors.

3. Try to ventilate the area as good as possible by opening doors, windows, hatches etc. In case of fire, try to isolate area, which reduces the amount of available oxygen.

- Avoid use of switches or electrical equipment to prevent sparks and other sources of ignitions.

- Do not attempt to suffocate fire with water or extinguishers

After an accident or risk situation, safety supervisor shall write a report together with plant managers to evaluate causes of the accident and make repairing actions to prevent similar situation in the future.

4.3. Facility

4.3.1. Unloading station

The fuel unloading system contains pump units for unloading fuel from tankers or fuel trucks to the storage tanks. When unloading fuel from the trucks or tankers minor spills on the unloading area are common. Usually spills are caused by leaking seals when connecting transfer hose to tanker or rupture on the delivery hose. Drip cans should be placed under all connections to collect spills during unloading and a safety barrier should be placed in front of the truck when unloading fuel from the truck to prevent truck driving away while connections are still in a place. Unloading area, especially HFO station must be roofed and equipped with protecting ground layer to ensure that fuel cannot escape from area to the environment. Used oily rags should be also removed immediately when unloading is done and disposed according with waste disposal regulations. It is very important when unloading fuel, there must be always at least one employee

in the vicinity of fueling area who is monitoring the pumping and is able to break off pumping immediately if anything happens.

4.3.2. Tanks

Oil tanks are located in the vicinity of engine hall. The main purpose for the tanks is to store and ensure the fuel reserve for the power plant. Tanks are usually built according to the API 650 or EN 12285 standards and Fire protection has been designed in compliance with NFPA 30. In some cases customer already has own tanks, hence the customer is responsible that the tank area fulfils all required safety regulations.

Heavy- and light fuel storage tanks will be located at approved plant yard. A protection wall surrounds the area, which protects the rest of the area in case of oil spill. The capacity of protection wall will be designed to be bigger than volumetric capacity of the largest tank. The protection wall and oil tank area shall be constructed with impermeable material to ensure that oil will not be able to escape from the area. The valves and flange adaptors shall be oil resistant such as nitrile butadiene rubber (NBR) when using rubber valves. The oil tanks have been designed with sufficient buffering capacity into the tank for special situations. Storage area will be enclosed by a security fence and be provided with proper safety signs. These procedures will minimize substantially the risk of oil spills.

The quality of the fuel delivered has to be always in accordance with required specification. The bad quality of HFO may lead to pump damage of filter blockage, which might cause pump damages or oil spills. Impurities and water in the fuel tank increases the risk of corrosion. That is why the tank must be drained of water and settled impurities regularly. Another risk is too high fuel flow to the tank during refilling, which causes overpressure and might even lead to tank ruptures. Every project has unique specifications regarding these issues and as long as the construction works and safety structures are done according the safety regulations it is assumable that probability of accident is very small.

Venting fumes from the tank with source of ignition can cause the risk of flame; to minimize this hazard the roof storage tank is equipped with ventilation hatch, which releases the flammable vapors. Day and buffer tank has been equipped with flame protectors, due to reason temperature of fuel, which has risen over its own flash point. /33/ /37/

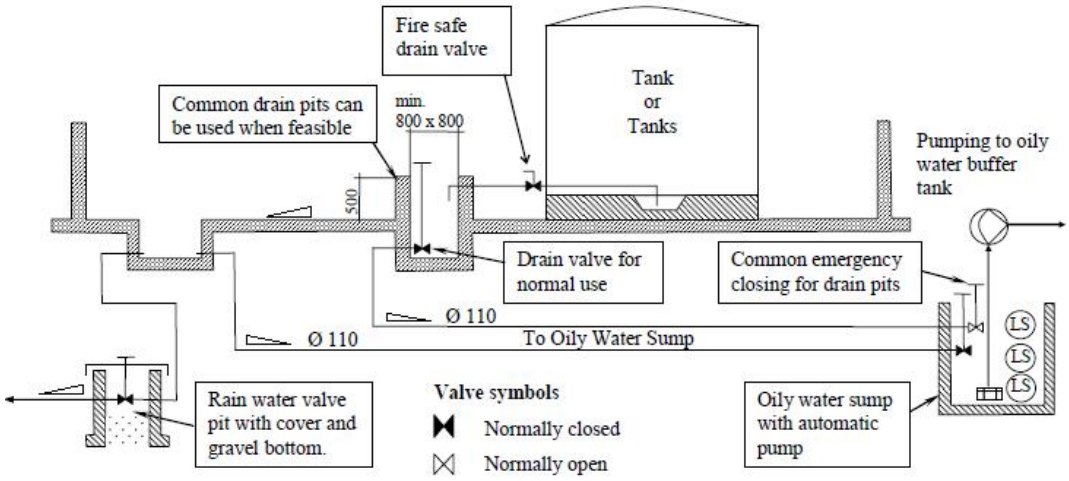

Figure 7 Tank area drainage system /37/

4.3.3. Water treatment

The purpose of water treatment system is to minimize the volume of water contaminated with oil by keeping rain- and oily water unmixed. This is a problem for drainage design, because the oily water from the bottom drainage of the fuel oil tank have been able to enter to the area from where clean rain water are collected. To keep pure rain water and oily drain water separate even in a storm situation 0.5m height wall surrounds the tank drain pit. Minor amount of rain, which drops directly to the tank drain pit, shall be led to oily water collection. Principle layout can be seen above in Figure of tank area drainage system. When installation of drainage system is completed, the first test drive is done by pure water to ensure that system works properly and all valves are open.

The standard oily water treatment system for small plants consists only of oily water collection and storage in a sludge tank. In this concept it is cheaper to transport small amounts of oily water produced in the plant to appropriate disposal site than to install treatment system. In bigger plants an oily water treatment unit

is usually included. The principles of the collection and treatment systems are presented in figure below. When choosing an external company for disposal of sludge environmental aspects shall be taken into account, and ensure that company is approved by local authorities.

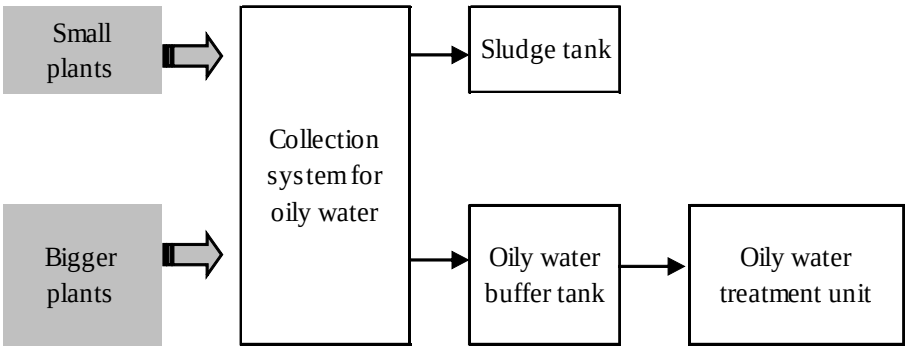

Figure 8 Principles of collection and treatment systems /29/

The oily water is collected in oily water collection sumps around the plant and oily water transfer pumps transfer the oily water from the sumps either to an oily water buffer tank or a sludge tank. The main areas where the oils are collected are presented in figure below. In normal situation, connections from tank area are closed and rain water is drained to separate rain water drainage only if necessary. In case of oil leakage on the tank yard, water will be led to the oily water treatment system.

4.3.3.1. Oily water collection with treatment unit

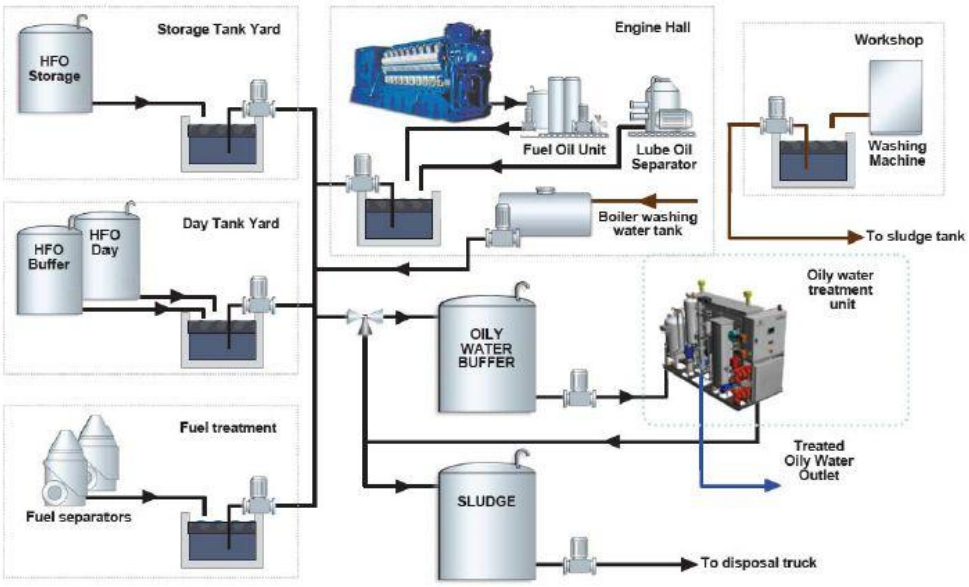

Figure 9 Diagram of oily water collection and treatment unit */29/*

The oily water treatment is usually done by Senitec Oily Water Treatment Unit, which is based on dissolved air flotation enhanced by chemical treatment, and activated carbon filtration. Main contaminants of untreated wastewater are oil, grease, suspended solids and metals.

The quality of treated water fulfills the World Bank requirements and can be disposed to sewer. In the system there are three main chemicals, which are used in the process:

- Coagulant: Aluminium chloride $AlCl_3$ (pH < 2)

  Aluminium is classified as hazardous according to the EU directives. It irritates eyes, skin and may cause also irritation to the respiratory system. If ingested seek medical attention immediately. In case of spill methods for cleaning up are: Soak up with inert absorbent material and sweep up, shovel into suitable containers for disposal and neutralize pH-value. Spilled chemical will cause acidification of environment and waters and due that reason flushing chemical into surface water, sewer or ground water system is strictly forbidden. /31/

- Flocculant: Adipic-acid $C_6H_{10}O_4$

Adipic-acid is not classified as hazardous. It may cause some slight skin, eye and respiratory irritation. If ingested seek medical attention immediately. In case of spill methods for cleaning up are: Sweep up and shovel into suitable containers for disposal. Small spills can be washed away with plenty of water. The chemical does not cause long-term adverse impacts to environment /30/

- Sodium hydroxide NaOH

Sodium hydroxide is classified as hazardous. It causes skin burns and serious eye damage and if ingested seek medical attention immediately. NaOH shall not be allowed to enter drains of water courses, because it causes an increase of pH in the aquatic environment. In case of spill area shall be covered with sand, soil or other suitable material and collect. After collection wash residues with plenty of water. /1/

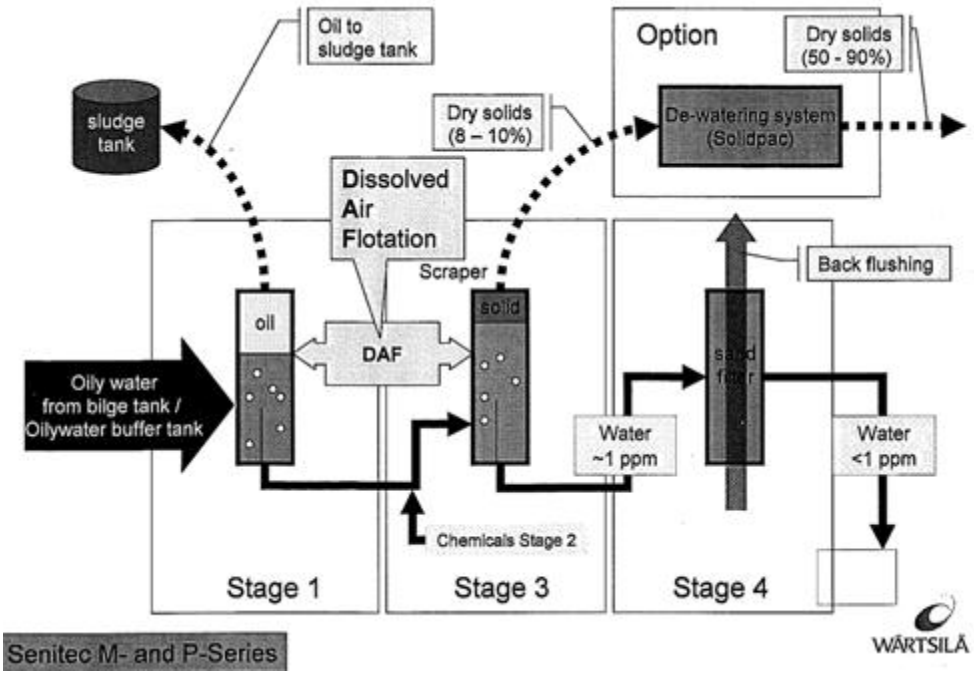

Figure 10 The process diagram /38/

The figure above illustrates the principles how Senitec treatment unit works. In the first flotation stage micro bubbles in the tank helps oil to rise to top of the tank and from there separated oil is pumped into sludge tank.

From the oil separation stage the emulsified water is lead through series of mixers and treatment chemicals are dosed. The purpose of chemical treatment is to break the emulsified oil in the water particles and produce a large flock. First the coagulant chemical breaks the charges around the particles so that they can form small flocks with each other. In the second phase flocculant sweeps the coagulated small flock into a large flock, which can be easily separate from water in the flotation. After that clear water passes a series of baffles and a flock trap, which separates the smallest particles before is pumped to a filter unit, which clarifies water and lead water further to municipal sewer. /38/

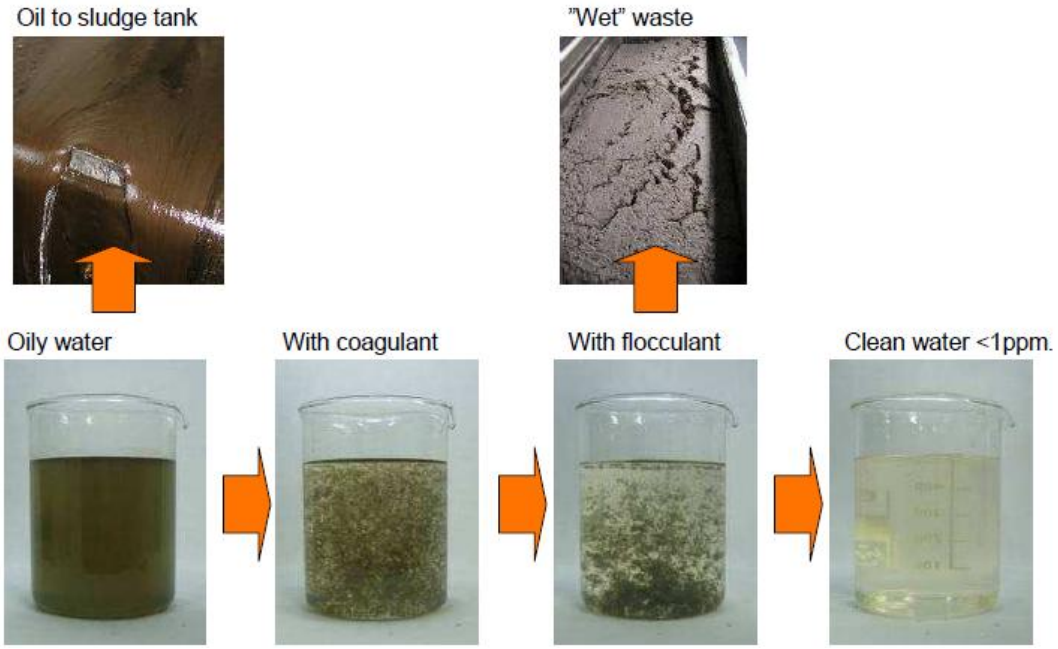

Figure 11 The process diagram in practice /38/

The pictures above represent how the water treatment process proceeds in practice and how the stages affect clarification of water.

4.3.3.2.Oily water collection without treatment unit

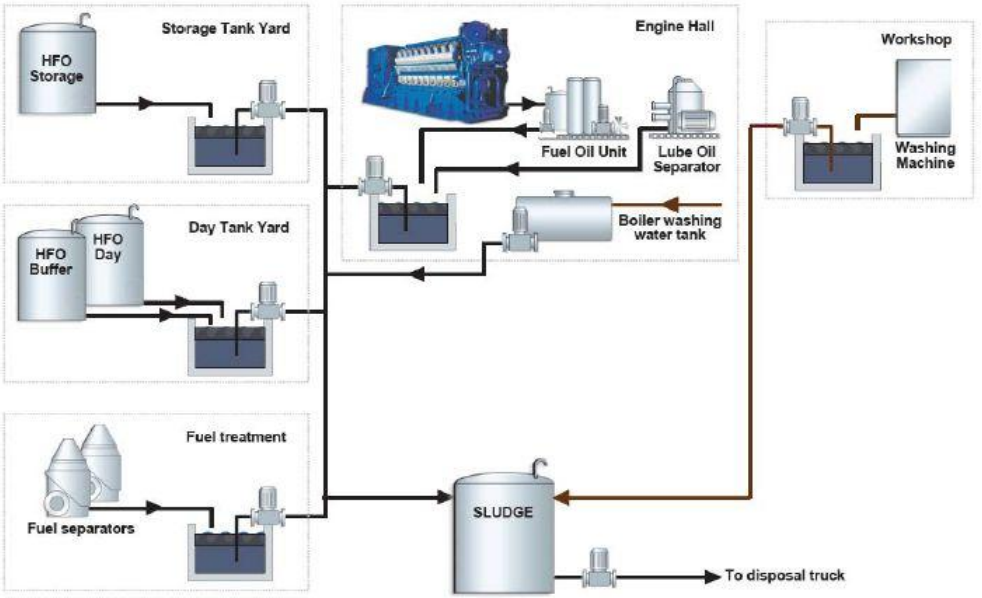

Figure 12 Diagram of oily water collection system /29/

The figure above represents water collection system without treatment unit. In this system all generated waste liquids are stored in the sludge tank and transported to treatment. The sludge tank is usually made of carbon steel and placed above the ground. The tank is also equipped with instrumentation for monitoring the sludge level and heating system. Environmental aspects are related to sludge tank for example if an instrument failure causes overflow and due that reason sludge escapes to the environment. However these accidents are very unlikely, if safety instructions are followed.

Two important rules shall be underlined to the personnel:

-Normally closed valves shall be open only under supervision.

- Keep up general cleanliness especially in the tank yard to avoid drain blockages

4.3.4. Separator

The separator unit maintains the quality of the fuel by removing water and solid impurities. Malfunction in a separation unit may lead to overheating causing a

mechanical damage. Reason for malfunction might be for instance incorrectly closed valves, fuel feed interruption or pump failure. Malfunction in the pressure system might also damage separator. However probabilities of these accidents are minimal. /33/

4.3.5. Lubricating oil system

Lubricating oil system is a vital part for an engine. Without a correct flow and temperature of the lubricating oil engine will not work. The lubricant oil tanks can also cause an overflow in case of malfunction of interceptors, which can lead to oil spill to the environment. Procedures in case of spill are the same as presented earlier.

4.3.6. Cooling system

The main purpose of cooling system is to remove generated heat from the engine and keep the intake air receiver and lubricating oil temperature stable. Designed cooling system is always project-specific. When planning the power plant cooling system local ambient conditions and availability of water have to be taken into account. Temperature as well as ambient humidity etc affects to the feasibility of the different cooling methods.

Maintenance water tank is a vital part of the cooling water system, where the cooling water from engine can be drained for the time of maintenance. Additive chemicals for cooling water are also mixed in the tank. Main reason for mixing additive chemicals with cooling water is to prevent corrosion and freezing in the system. Used raw water must also fulfill following quality requirements:

pH	min. 6.5
Hardness	max 10 dH
Chlorides	max. 80 mg/l
Sulphates	max 150 mg/l

For locations where temperature goes below -0°C an anti-freeze chemical must be added to the cooling water to prevent freezing. Usually this is done with ethylene glycol $C_2H_6O_2$, which is a toxic organic compound. Due to reason its harmful impact to environment more environmental friendly alterative propylene glycol is recommended to be used. Amount of anti-freeze chemical shall be minimized especially when using ethylene glycol, because it cannot be drained in the storm water pits or in the sludge system. The maximum allowed glycol content is 50 mass-percent of cooling water. Spills are unlikely happen, however if a spill occurs outside of power hall or in the radiator area spilled liquids drains in the storm water drainage but the assumable environmental impacts will be minimal if liquid does not contain ethylene glycol. Maintenance water tank is another spot where minor spills might occur especially during the refilling, however environmental impacts in this case will be minimal also. If spill contains ethylene glycol storm water valves shall be closed immediately. Procedures after spill shall be to attempt collect spilled material with inert absorbent, for example with sawdust or peat, and place in suitable, sealable containers. Contaminated area must be flushed with large amounts of water and contact an approved waste hauler for disposal of contaminated material. /13/ /21/

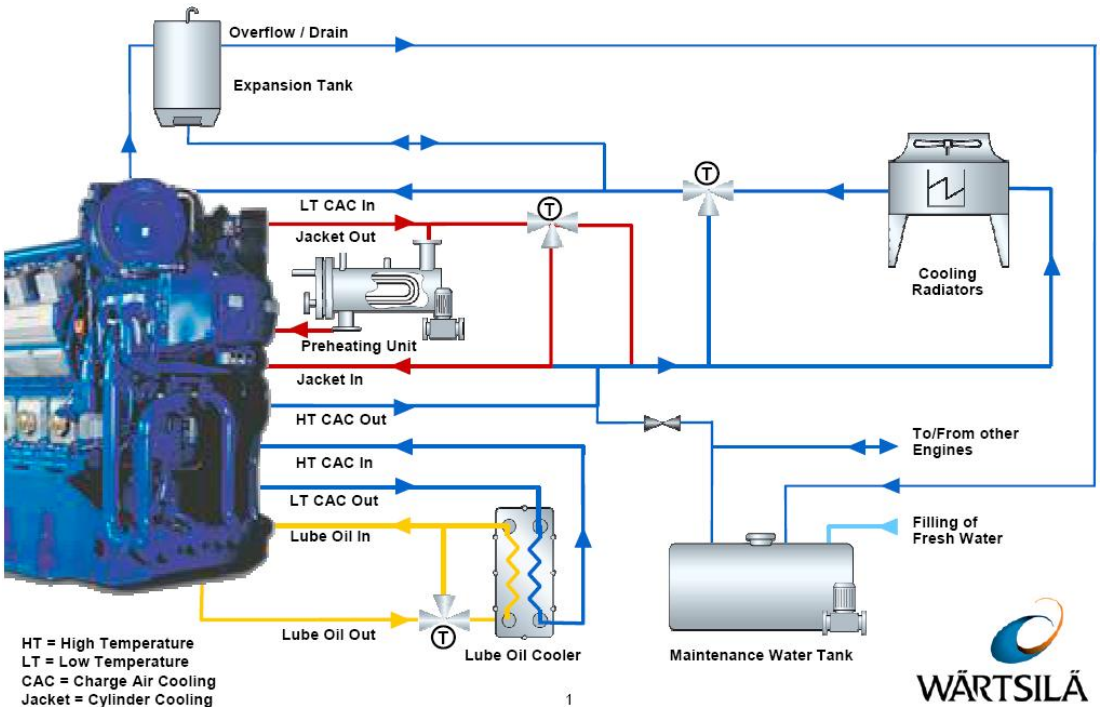

Figure 13 Diagram of typical cooling water system with radiator /21/

4.3.7. Pickling steel pipes

The commissioning process includes in installation testing phase also pickling and flushing of pipes. Purpose of this is to remove impurities from the pipe system, for example rust, slag, spatters and protect against corrosion. There are three different pickling chemicals, which can be used in pickling works: citric acid, hydrochloric acid and phosphoric acid. Wärtsilä recommends the use of citric acid as the first choice in site conditions.

Safety rules must be underlined and followed: The pickling must be done outside of the powerhouse, because of toxic fumes. If pickling is done with hydrochloric or phosphoric acid then proper protection must be used: rubber gloves and boots, protection glasses.etc. /19/

4.3.8. Flushing

Flushing will be done with flushing oil and the purpose of the flushing is to remove all debris and foreign material from the pipelines, which could cause damage to engines, or to auxiliary equipments. Flushing process must be done under the supervision of commissioning manager and observe the system all the time in case for possible oil leaks. /19/

5. Operational Phase

5.1. General

Wärtsilä offers different kind of agreements to the customers. In basic agreement Wärtsilä leaves the site right after the plant has been commissioned and handed over to the customer. In addition Wärtsilä Services offers different kind of Operation and Maintenance agreements, which can cover partial or full time maintenance support during the commercial operation phase. Wärtsilä service agreement range cover: /34/

- Service agreements

  Service agreements are designed to be tailored to customer's exact needs, letting customer choose from different levels of partnership, or a day-to-day business relationship.

- Operation and Maintenance agreements

  Operation and maintenance agreements typically mean that Wärtsilä personnel take care of the operation of the power plant. Agreements usually cover also overhauls at regular intervals, technical support during major overhauls, maintenance reports and recommendations.

- Support agreements

  Support agreements include extensive customized training and development of site routines and assistance in planning different routines. Agreement might also cover participation in site reporting and staff management.

- Parts supply agreements

  Parts supply agreements include supply of parts and materials to a designated location with guarantee and information on upgrades.

- Reconditioning agreements

Reconditioning means restoring operational performance of older engines and equipments. Usually the old parts are brought to the closest Wärtsilä workshop where they will be dismantled and components replaced until the engine has reached the required status. As a result the performance, efficiency and reliability of the engine will probably raise and emissions decrease because of product development and general improvements. Reconditioning can also help to meet new environmental requirements, reduce fuel and oil consumption and restore operational availability.

5.2. Environmental aspects

Wärtsilä encourages its customers to establish own environmental policy and guidelines how to operate environmentally friendly way according the local legislation. Operating according to the principles of sustainable development, will also cut expenses in the long run and contribute life time of the power plant.

General cleanliness, which is the basis of good environmental way of action, should emphasize to the personnel during the whole lifecycle of power plant.

5.2.1. Ambient air quality

Atmospheric emissions comprise mainly carbon dioxide, oxides of nitrogen, sulphur dioxide, carbon monoxide, particulate matters and volatile organic compounds. However when considering the entireness it is relevant to take into account the local ambient air quality and how presumable air emissions will affect on it, therefore the spot emissions from the stack only will not tell the absolute truth of environmental impacts.

Wärtsilä will not take responsibly of air emissions, which are generated during the operation phase. As mentioned before Wärtsilä assumes that customer has taken all presumable environmental issues including air emissions into account already when applying environmental licence to the plant.

The air emissions consist of:

- Sulphur Dioxide SO_2

The sulphur dioxide is a toxic acid gas. SO_2 and NO_X are the main factors of acid rain, which acids environment and harms ecosystem. It has also direct effects to human health causing for example respiratory illnesses. SO_2 also causes formation of microscopic aerosols, which according the latest knowledge reduces the greenhouse effect.

- Oxides of Nitrogen NO_X

Combusting produces oxides of nitrogen's, of which NO_2 is a major product. NO_2 is a toxic gas, even at relatively low concentrations. Nitrogen oxides have harmful environmental impacts, such as eutrophication of water systems, acid rains and like SO_2 it also forms microscopic aerosols in atmosphere, which cools the climate. NO_X compounds irritate also the lungs and lower resistance to respiratory infection.

-Carbon Dioxide CO_2

Carbon dioxide is a major greenhouse gas, which contributes the climate change.

-Carbon Monoxide CO

Carbon monoxide is a colorless, odorless, tasteless and poisonous gas produced primarily in incomplete burning. CO does not have direct environmental effects but it is lethally toxic for human. Even a short period of exposure can cause unconsciousness, which can even lead to death.

-Particulate Matter PM_{10}

Particulate matter is the general term used for a mixture of solid particles. It includes aerosols, smoke, fumes, dust and ash. Particulate matter has serious health effects. Long term contact has been linked to several respiratory illnesses, for example asthma, different kind of lung illnesses and even cancer.

- Volatile Organic Compounds

The volatile organic compounds are a common name for methane and for other gaseous organic compounds. Non-methane VOC's forms in atmosphere troposphere ozone, which is greenhouse gas as well along with methane.

5.2.2. Waste management

It is recommended that customer will establish own waste management plan, which aims to prevent the amount of generated waste, encourages employees to sort waste and emphasize importance of recycling. Plan should also include regular monitoring program about consistency and amount of generated waste. The record of solid and hazardous waste disposal form is attached in the end of plan to the appendices, which can be utilized when implementing project specific plan and record keeping.

Operational phase will typically generate:

Maintenance and industrial waste (wood, soiled rags, used filters, metal, plastic etc.), office waste, containers and barrels (contaminated by oil or chemicals), laboratory waste, used batteries, chemicals

Waste is recommended to be sorted and stored in special receptacles, which are marked by different colors and written description to facilitate sorting. Usually each color represents own waste class. Typically used colors are: red, brown, blue, green, grey and white. Following sorting principles can be utilized as an example

guideline, because sorting must be done according the local legislation. Separate receptacles should be provided for:

- Non-dangerous domestic waste (plastic, food scraps, boxes, small articles, wrappings etc.)

- Hazardous waste (oily and greasy rags, used filters, batteries, chemicals, contaminated containers etc.)

- Waste paper (clean paper, newspaper, magazines etc.)

- Waste metals

- Wood waste

- Used oil and chemical containers for contaminated liquids.

- Waste Glass

All generated waste should be handed over to the approved contractor, who is able to safely recycle or decimate collected waste. Especially this goes for hazardous waste, which can be very harmful for both environment and human health.

5.3. Precautions, health and safety

Wärtsilä highly recommends that customer obeys and continually maintain established fire prevention and protection guidelines and other emergency plans. Also health and safety handbook should be written and placed in visible place and ensure that all workers are aware about written guidelines and committed to follow them.

5.4. Traffic

In the operational phase traffic flow will probably decrease from construction phase. However it is recommended to prepare traffic plan for the plant, which includes for example: driving lines and directions, speed limits, routes for refueling vehicles and safety issues.

5.5. Site security

Wärtsilä also highly recommends that site security issues will be ensured and security plan for site be produced depending on the local circumstances and legislation. It is recommend that plant should be surrounded by a security fence designed to keep out all unauthorized persons and provided with security lightning. Security guards should be on the duty 24 hours a day at the main gate and depending on risk assessment more security posts might be considered. It is recommended that the guards are also required to patrol around the plant routinely. During the patrol the guard should be also responsible to report any unusual events like spills, safety hazards, fires and vandalism etc. Also all incoming vehicles should be registered at the gate when arriving and leaving. In addition all suspicious packages, briefcases and bags should be opened for inspection if necessary. It is recommended that personnel and visitors are required to carry an identification card.

6. Decommissioning phase

6.1. General

After the operational phase when customer wants to run down facility the decommissioning works will be done. Decommissioning is defined as the end of the plant life or just a short-term shutdown. The aim of this phase is to minimize impact to environment, contribute the sustainable development and generally ensure safe dismantle of the used facility. The decommissioning works shall be done in line with local regulatory requirements and according with BAT-principles (best available technology) prevailing at the time. In practice this means that whole site area including structures, engines equipments etc. are cleaned, secured or demolished so that the plant will not pose a risk to public health or the environment now or in the future. Power plant itself is a complex ensemble and Wärtsilä advices its customers to contact Wärtsilä Services for assistance in decommissioning activities.

6.2. Facilities

After when the plant has been shut down safely the dismantling works can be executed. Basically this procedure means full scale closure and dismantling of existing facilities. Wärtsilä encourages dismantling facilities in environmentally friendly way by recycling materials, equipments and preventing and minimizing contamination of surrounding environment. Before starting the dismantling works some essential activities should be performed:

Make sure that fuel, oil and chemicals are unloaded and taken out from the system. Pipes and should be flushed with pure water to remove hazardous liquids from the system and exhume with care all underground pipes and tanks.

The facilities including structures, engine area, stacks etc. should be dismantled according the health and safety regulations and consider the available re-using and recycling possibilities. For example some materials might be re-used in other

sectors of economy such as in construction works, metal fabrication and energy production etc. Before demolition it is important to check structures especially engine hall in case of oil spills inside. If so, spillages should be cleaned before demolition.

In addition Wärtsilä Services offers reconditioning agreements for engines, which might be restored and re-sell and thus also benefit economically the owner. The ditches should be re-filled with fresh soil after exhuming the pipes and equipments to contribute natural rehabilitation. The operational and decommissioning waste material should be treated, stored and transported with the appropriate way. /4/

Dismantling of the facilities and demolishing of the constructions will generate huge amount of waste. It will be also owner's advantage to establish a waste management plan for demolition waste. Systematical action will contribute efficiency, recycling, health and safety, positive reputation of the company and in the end cut waste disposal expenses.

Following types of waste is typically generated in demolition works. /11/

- Recyclable metallic waste
    - Non-ferrous metals such as aluminium, copper, lead etc.
    - Carbon and stainless steels from pipes, parts on equipments, doors, steel wires, from radiators etc.
    - Steel structures from buildings
- Building materials.
    - Concrete waste
    - Prefabricates and staircases, which might be suitable for re-use.
- Re-usable material for collection such as electric installation copper and aluminum cables.

- Other waste
    - Wood waste
    - Glass waste and glass fibers from insulations
    - Ceramic materials
    - Plastic waste
    - Other unsorted garbage from the demolition such as textiles, pasteboards, non-recyclable cables, roof coverings etc.
- Hazardous materials
    - Material contaminated by chemicals and oils
    - Impregnated wood
    - Batteries, fluorescents
    - Asbestos material
- Liquid waste
    - Oil, chemicals, cooling waters, sludge etc.

6.3. Environmental aspects

The biggest environmental threats during and after decommission phase are: different oil and chemical spills, which may result contamination of land, erosion, damage to natural landscape or biodiversity and contamination of ground water. To prevent spills and other contaminations the same methods presented earlier can be utilized. In some cases contaminated land in the area is referred as brown land, which means that land has became contaminated already during the operational phase. These so called brown lands should be treated or disposed also. When the plant has been completely dismantled, the plant area should be restored as good as possible by using the best available techniques prevailing at the time. The

rehabilitation works involves re-vegetation the area with fast growing species to ensure fast natural landscaping and prevent soil from further damage through erosion.

Figure 14 Dismantling power plant in Turkey, Sabodala Mining Company

6.4. Short-term shutdown

In some cases customer wants shutdown power plant for a temporary period of time. When considering shutdown it is very important to know length of shutdown and also take into account ambient conditions and make a specific plan for every section of the power plant. These include shutdown, standby and maintenance procedures during and after shutdown for generating set, auxiliaries (fuel, lube oil, cooling, air, exhaust and water treatment systems), plant support systems, electrical and control systems and civil issues. The significance of investigation of actual ambient conditions (humidity, temperature, dust etc.) shall be emphasized when choosing the methods for de-activating. Poorly prepared plan may lead to serious damages to the engine and other equipments and thus cause problems when re-activating the plant again. The shutdown requires also record keeping and extensive documentation of all performed actions and logs. These logs and documents provide vital information to re-activate safely the plant. Wärtsilä highly recommends to contacting to Wärtsilä Services for assistance in case of plant shutdown. /35/

6.5. Relocation

In some cases customer wants to relocate the power plant. Reasons for relocation may vary a lot. For example, the customer's power plans can not follow new emission regulations. The price of electricity has decreased and the plant owner wants to move plant to a more attractive area to increase earnings. The political status in the country has become unstable and the owner wants to move plant to a safer location. Usually after relocation the plant will be upgraded with new technology and equipments to improve its efficiency. For relocation projects the same guidelines should be applied. In the picture below the site has almost being cleared and given back to the state. The steam cycle was left behind and sold to a local company.

Figure 15 Decommissioning works in Ghana-Benin 19x 12V22 Relocation Project

7. Summary and Conclusions

The aim of the plan was to identify environmental aspects of different power plant solutions and locations. During my research I found it very difficult to point out differences between base load, peak load and emergency power plants. Due to reason that this will document will be public it is important to point out, which responsibilities are on Wärtsilä's and customer's responsibly. Especially this must be emphasized when dealing with air and noise emissions. Wärtsilä will give, of course typical emission rates but as a result of several interviews with Wärtsilä engineers they convinced me that the spot emissions are not significant for our environmental management plan, because usually the customer has taken these issues into account already when applying the environmental license to power plant. Wärtsilä can give only some general guidelines for operational and decommissioning phase, because Wärtsilä cannot influence how customer runs the plant after when it has officially handed away.

After all, in my opinion I succeeded well from the project and especially construction and commissioning parts were successful. I think the structure and content of my thesis is very logical, easy to follow and read. However one aim of this project was to create a variable tool, where user can choose parts for the EMP depending on plant type. In some point of research we realized with my supervisors that this classification will be impossible, so we decided to concentrate on general functions and environmental aspects of power plants.

I really enjoyed working with this project. The project taught me very much, I literally went through all the basic operations of power plant and learned lots of practical things, which I could never learn in the school. I think my weakness was that I did not have earlier work experience in power plant sector and I had not opportunity to visit real power plant and make observations by my own, so I had to resort only to photos and interviews.

In the future my work in Wärtsilä will continue, and development of EMP will continue as well. We had a thought to split my EMP into four pieces: construction, commissioning, operation and decommissioning part, unite them with new version of health and safety instructions. More information should be gathered also and if possible to specify more differences between different plants. In the end the final plan will be transformed to electrical form and programmed, so that the user is able choose, which parts he wants in the EMP. The plan will be also available for updates in the future and as stated in the introduction chapter the EMP should continuously improve and follow the development.

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APPENDICES

Appendix 1: Records of Solid Waste Disposal

Appendix 2: Det Norske Veritas, Management System Certificate

Appendix 3: Wärtsilä Policy for Quality, Health, Safety and Environment

Records of solid waste disposal

A) SOLID WASTE DISPOSAL NON-HAZARDOUS

Sl. No.	Variable	Unit	Used per month/year	Disposed through	Remarks
1	Used Paper	Kg			
2	Waste Food stuff	Kg			
3	Scrap metal/spare parts	Kg			
4	Wood	Kg			
5	Cartoon/Boxes	Kg			
6	Used Tube Lights	Pcs.			
7	Empty lube oil drums	Pcs.			

B) SOLID WASTE DISPOSAL - HAZARDOUS

Sl. No.	Variable	Unit	Used per month/year	Disposed through	Remarks
1	Auxiliary boiler soot	Kg			
2	Oily Rags	Kg			
3	Incinerator Soot	Kg			
4	Empty Chemical drums	Pcs.			
5	Empty paint container	Pcs.			
6	Printer Cartridge/Tonner	Pcs.			
7	Battery Dry Cell	Pcs.			
8	Used Filters	Pcs.			
9	Mercury Lamps	Pcs.			

Safety/ Environmental Officer/ Plant Manager_____
Date:_____

DET NORSKE VERITAS

MANAGEMENT SYSTEM CERTIFICATE

Certificate No. 44122-2008-AE-FIN-FINAS

This is to certify that

WÄRTSILÄ FINLAND OY

at

Tarhaajantie 2, 65380 Vaasa; Finland

has been found to conform to the Management System Standard:

ISO 14001:2004

This Certificate is valid for the following product or service ranges:

PRODUCT DEVELOPMENT, DESIGN, SALES, PROJECT MANAGEMENT, MANUFACTURE AND SERVICING OF POWER PLANTS AND MARINE ENERGY PACKAGES.

Initial Certification dates between:
28 January 2001 and 24 August 2006

This Certificate is valid until:
31 October 2011

The audit has been performed under the supervision of
Isto Ruuskanen
Lead Auditor

FINAS
Finnish Accreditation Service
S001 (EN ISO/IEC 17021)

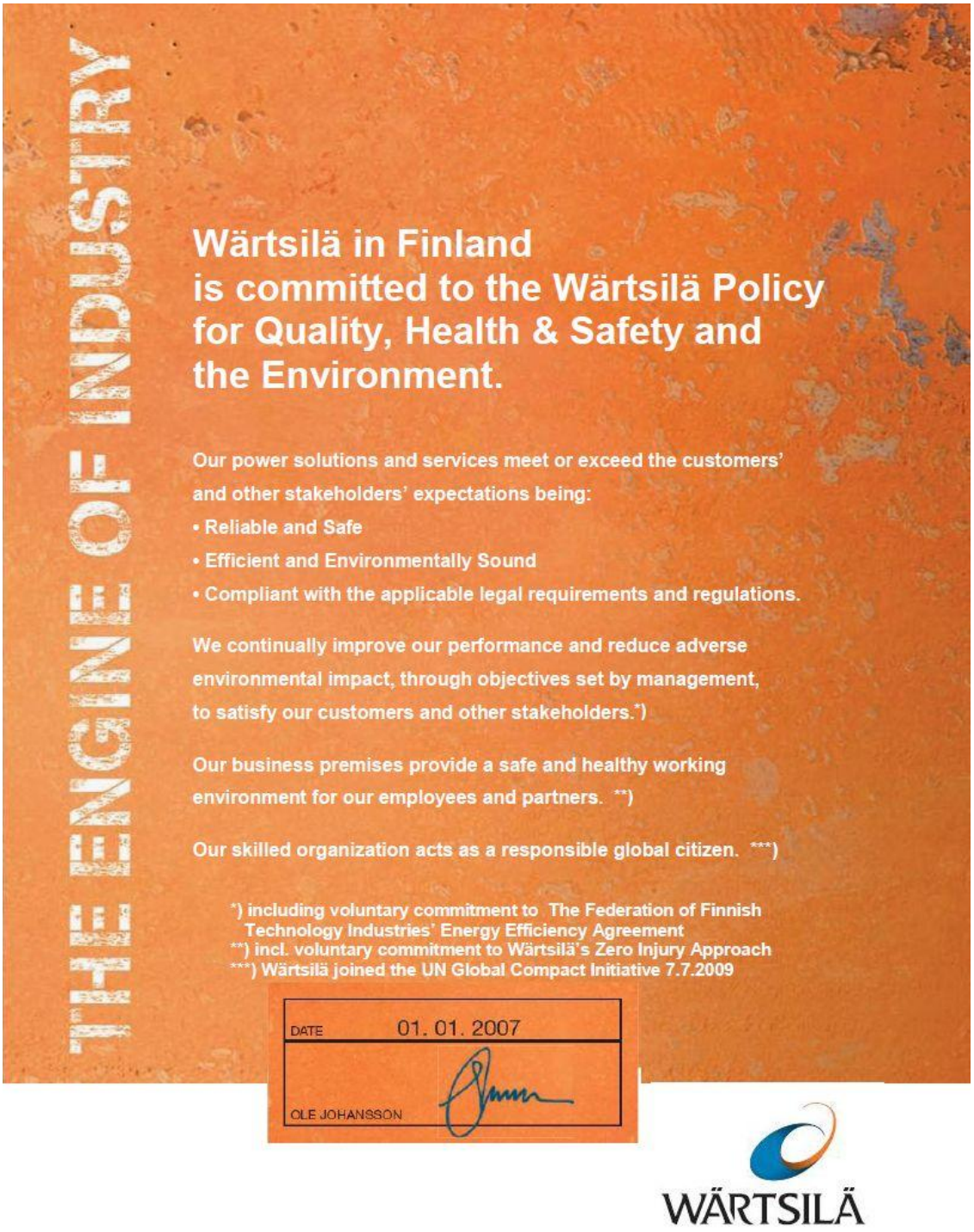
Place and date:
Espoo, 14 December 2008

for the Accredited Unit:
DNV CERTIFICATION OY/AB, FINLAND

Osmo Flink
Management Representative

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.

HEAD OFFICE: Det Norske Veritas AS, Veritasveien 1, 1322 Høvik, Norway. Tel: +47 67 57 99 00 Fax: +47 67 57 99 11 www.dnv.com


THE ENGINE OF INDUSTRY
Wärtsilä in Finland
is committed to the Wärtsilä Policy
for Quality, Health & Safety and
the Environment.
Our power solutions and services meet or exceed the customers'
and other stakeholders' expectations being:
• Reliable and Safe
• Efficient and Environmentally Sound
• Compliant with the applicable legal requirements and regulations.
We continually improve our performance and reduce adverse
environmental impact, through objectives set by management,
to satisfy our customers and other stakeholders.*)
Our business premises provide a safe and healthy working
environment for our employees and partners. **)
Our skilled organization acts as a responsible global citizen. ***)
*) including voluntary commitment to The Federation of Finnish
Technology Industries' Energy Efficiency Agreement
**) incl. voluntary commitment to Wärtsilä's Zero Injury Approach
***) Wärtsilä joined the UN Global Compact Initiative 7.7.2009
DATE 01. 01. 2007
OLE JOHANSSON
WÄRTSILÄ