Appendix 1A

Technical specification

Project Name:
Randolph Harley Power Plant –
LG Engines

Customer:
USVI Water and Power Authority

USVI Water and Power Authority

Project name: WAPA 2 LG engines

Quotation number: PQ2019-02106A1R-

Date: April 9, 2020

Power generation project

Product type: Modular power plant

Engine configuration 4 x W20V32LG

Wärtsilä

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0 GENERAL

0.1 EXECUTIVE SUMMARY

General

This technical specification provides the reader with the basic technical data required for an evaluation of the plant's technical features.

The proposed Modular power plant is designed and engineered in accordance with this technical specification.

The technical data stated in this document is for guidance and evaluation purposes only. Performance data and related reference conditions are separately stated in the supply contract documents.

The governing law and the procedures of dispute resolution for this technical specification shall be as stipulated in the Agreement Supply Contract. If there is any discrepancy between the English version and a translated version of this technical specification, the English version shall prevail and have precedence over the translation.

Design and construction

The essence of the design is simplicity, safety and reliability.

The equipment is designed to prevent accidental contact with moving, hot or tensional parts and to minimise ingress of dust and dirt.

The structure and layout design of the power plant permits access to all parts for inspection, maintenance and repair.

Wärtsilä quality procedures and test & inspection procedures are applied to ensure product quality throughout the design and manufacturing process. Special attention is paid to the engine and auxiliary unit testing, as well as inspection and testing of the final installation.

Wärtsilä's quality and environmental management systems fulfil, and are certified according to ISO 9001:2000 and ISO 14001:2004.

Main parts and devices such as panels, valves, pumps, etc. are marked with engraved name plates indicating their item codes used in Wärtsilä documentation and manuals.

English is used in all documents, correspondence and nameplates.

SI units and US units of measurement are used in technical documents.

The design and manufacture of power plant equipment supplied by Wärtsilä is subject to constant review, and due to improvements and optimisation of materials, design and tooling techniques, manufactured equipment may be improved from the specification given below.

Deviations to assumptions made in this specification

If the purchaser's requirements, local building codes, zoning requirements, Grid/Interconnection Study, Environmental Impact Assessment, Building Permit Application, Soil investigation, Topographical survey, Contamination evaluation or site Demolition requirements or other conditions deviate from the assumptions made herein and have an impact on Wärtsilä's scope of supply, the scope of work shall be reviewed, and the price adjusted accordingly.

Project Management and Engineering

The delivery of the Modular power plant will be managed by a dedicated project team, comprised of a project manager who has the overall responsibility for the delivery. The project manager is assisted by project engineers for the main technical disciplines.

The project team is the single point of contact with the purchaser's organisation, and has full authority to decide on technical and commercial issues related to the project on behalf of Wärtsilä.

Equipment Technical Data

Wärtsilä uses data gathered from equipment and software to improve and develop our products and services.

0.2 TYPE OF PRODUCT

The proposed Modular power plant is designed for base load operation and is intended for power generation.

The system is designed for parallel operation with the public supply system.

The Modular power plant is designed to use Propane + LFO pilot or LFO as the main fuel.

POWER PLANT DEFINITIONS

Power Plant:

4 x W20V32LG gen-sets make up the Power Plant including common auxiliary systems running on a mix of liquid propane and Ultra Low Sulfur Fuel (ULSD) or with ULSD alone. This technical specification represents the equipment for (EPC) scope of supply for power plant using LG (Liquefied Gas) & LFO (light fuel oil) in LG-engine.

The liquid gas LG-LPG power station will be designed by Wärtsilä who is responsible for overall gas system design including the design of inside & outside Power House. The delivery will be based on the attached scope of supplies.

Propane gas quality will be according to Wärtsilä liquid gas characteristics and delivered at site in liquid phase.

0.3 MAIN DATA AND CONDITIONS

Configuration

Main data and conditions gives the allowed operating range for the finalised Power Plant.

Design ambient conditions

Altitude above sea level	100	M / 328 ft
Design air temperature	35	°C / 95 °F
Maximum ambient air temperature	27	°C / 81 °F
Minimum ambient air temperature	18	°C / 64 °F
Relative humidity	79	%

0.4 OPERATION MEDIA

General

To maintain the components and equipment of the Modular power plant in good operating condition, and to minimise wear and tear, it is of utmost importance that all operating media used are of good quality and within the specifications given by Wärtsilä.

Below are the main parameters for the major operating media of the Modular power plant. The complete specification and requirements for all the operating media needed are given in the Operation and Maintenance Manuals delivered for the Modular power plant.

Fuels

The Wartsila 32LG= engine is designed and developed for continuous operation on liquefied petroleum gas (LPG) without reduction in the rated output on gas qualities according to below tables specification in liquid phase:

Wärtsilä engines are designed and developed for continuous operation on fuels with a quality within the recommended limits below. These values indicate the limits for the power plant and the individual limits for the engines. Fuels having one or several values close to this limit might have a negative impact on the performance and component lifetime.

Ultra -Low Sulphur Diesel - (ULSD)

Low / Ultra Low viscosity fuels include a wide range of both commercially available fuels, like Liquefied Petroleum Gas (LPG) qualities based on various standards, naphtha, kerosene as well as gas and oil condensates with wide hydrocarbon distribution.

Characteristics	Unit	Limit	Test method reference
Kinematic viscosity at 20 °C and before main injection pumps, min. Kinematic viscosity before main injection pumps, max.	mm^2/s [a)] mm^2/s [a)]	0,10 6,00	ISO 3104
Density at 25 °C, min.	kg/m^3	490	ASTM D1657 or D2598 ISO 3675 or ISO 12185
Sulphur, max. [b)]	% m/m	1,0	ISO 8754 or ISO 14596
Hydrogen sulfide, max.	mg/kg	5,00	IP 570
Acid number, max.	mg KOH/g	3,0	ASTM D664
Total sediment by hot filtration, max.	% m/m	0,10	ISO 10307-1
Carbon residue, micro method, max.	% m/m	0,30	ISO 10370
Pour point (upper), max. [c)]	°C	report	ISO 3016
Cloud point, max. [c)]	°C	report	ISO 3015
Cold filter plugging point, max. [c)]	°C	report	IP 309 or IP 612

Water, max. Water bef. engine, max.	% v/v	0,30 0,30	ISO 3733 or ASTM D6304-C
Methane (CH_4) + Ethane (C_2H_6) + C_{18+} content. max.	% m/m	3,0	ASTM D1945, D6730
Hydrogen (H_2) content. max.	% m/m	traces [d]	ASTM D1945, D6730
Content of hydrocarbons from C_3 to C_{18} at any ratio, min.	% m/m	97,0	ASTM D1945, D5134, D5443, D6730, D6839
Lower heating value, min.	MJ/kg	42,0	ASTM D240
Ash, max.	% m/m	0,010	ISO 6245 or LP1001 [e]
Copper strip corrosion, max.	Rating	No. 1	ASTM D130
Used lubricating oil [f] - Calcium, max. - Zinc, max. - Phosphorus, max.	 mg/kg mg/kg mg/kg	 30 15 15	 IP 501 or IP 470 IP 501 or IP 470 IP 501 or IP 500

a) 1 mm²/s = 1 cSt.
b) The purchaser shall define the maximum sulphur content in accordance with relevant statutory limitations.
c) Purchasers shall ensure that cold flow properties are suitable for the equipment at the plant / on board.
d) It's not allowed to have more than trace amounts of hydrogen as H_2 present in fuel. On the other hand it's neither expected that the above specified fuel types would contain hydrogen.
e) Ashing temperatures can vary when different test methods are used having an influence on the test result.
f) The fuel shall be free from used lubricating oil (ULO). A fuel shall be considered to contain ULO when either one of the following conditions is met:
- *Calcium > 30 mg/kg and zinc > 15 mg/kg OR*
- *Calcium > 30 mg/kg and phosphorus > 15 mg/kg*

Distillate fuel / Light fuel oil:

The fuel specification is based on the ISO 8217:2017(E) standard and covers the fuel grades ISO-F-DMX, DMA, DFA, DMZ and DFZ.

The distillate grades mentioned above can be described as follows:

- DMX: A fuel quality which is suitable for use at ambient temperatures down to –15 °C without heating the fuel. Especially in merchant marine applications 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.
- DFA: A similar quality distillate fuel compared to DMA category fuels but a presence of max. 7,0 % v/v of Fatty acid methyl ester (FAME) is allowed.
- DMZ: A high quality distillate, generally designated MGO (Marine Gas Oil) in the marine field. An alternative fuel grade for engines requiring a higher fuel viscosity than specified for DMA grade fuel.
- DFZ: A similar quality distillate fuel compared to DMZ category fuels but a presence of max. 7,0 % v/v of Fatty acid methyl ester (FAME) is allowed.

Distillate fuel specification:

Characteristics	Unit	Limit	Category ISO-F					Test method(s) and reference
			DMX	DMA	DFA	DMZ	DFZ	
Kinematic viscosity at 40 °C [a]	mm²/s [a]	Max	5,500	6,000	6,000	6,000		ISO 3104
		Min	1,400 [l]	2,000	2,000	3,000		
Density at 15 °C	kg/m³	Max	-	890,0	890,0	890,0		ISO 3675 or ISO 12185
Cetane index		Min	45	40	40	40		ISO 4264
Sulphur [b, k]	% m/m	Max	1,00	1,00	1,00	1,00		ISO 8754, ISO 14596, ASTM D4294
Flash point	°C	Min	43,0	60,0	60,0	60,0		ISO 2719
Hydrogen sulfide	mg/kg	Max	2,00	2,00	2,00	2,00		IP 570
Acid number	mg KOH/g	Max	0,5	0,5	0,5	0,5		ASTM D664
Total sediment by hot filtration [c, m]	% m/m	Max	-	-	-	-		ISO 10307-1
Oxidation stability [c, d]	g/m³	Max	25	25	25	25		ISO 12205
Fatty acid methyl ester (FAME) [c]	% v/v	Max	-	-	7,0	-	7,0	ASTM D7963 or IP 579
Carbon residue – Micro method on 10% distillation residue	% m/m	Max	0,30	0,30	0,30	0,30		ISO 10370
Carbon residue – Micro method	% m/m	Max	-	-	-	-		ISO 10370
Cloud point [f]	°C winter	Max	-16	Report	Report	Report		ISO 3015
	°C summer		-16	-	-	-		
Cold filter plugging point [f]	°C winter	Max	-	Report	Report	Report		IP 309 or IP 612
	°C summer		-	-	-	-		
Pour point [f]	°C winter	Max	-	-6	-6	-6		ISO 3016
	°C summer		-	0	0	0		
Appearance		-	Clear and bright [g]					-
Water [c, m]	% v/v	Max	-	-	-	-		ISO 3733, ASTM D6304-C [l]
Ash	% m/m	Max	0,010	0,010	0,010	0,010		ISO 6245
Lubricity, corr. wear scar diam. [d, h]	µm	Max	520	520	520	520		ISO 12156-1

a) 1 mm²/s = 1 cSt.
b) Notwithstanding the limits given, the purchaser shall define the maximum sulphur content in accordance with relevant statutory limitations.

c) If the sample is not clear and bright, the total sediment by hot filtration and water tests shall be required.
d) If the sample is not clear and bright, the Oxidation stability and Lubricity tests cannot be undertaken and therefore, compliance with this limit cannot be shown.
e) See ISO 8217:2017(E) standard for details.
f) Pour point cannot guarantee operability for all ships in all climates. The purchaser should confirm that the cold flow characteristics (pour point, cloud point, cold filter plugging point) are suitable for ship's design and intended voyage.
g) If the sample is dyed and not transparent, see ISO 8217:2017(E) standard for details related to water analysis limits and test methods.
h) The requirement is applicable to fuels with a sulphur content below 500 mg/kg (0,050 % m/m).

Additional notes not included in the ISO 8217:2017(E) standard:

i) Low min. viscosity of 1,400 mm²/s can prevent the use of ISO-F-DMX category fuels in Wärtsilä® 32LG engine's in pilot fuel system unless a fuel can be cooled down enough to meet the specified min. injection viscosity limit.
j) Allowed kinematic viscosity before the main and pilot injection pumps for W32LG engine type is 1,50 – 6,00 mm²/s.
k) There doesn't exist any minimum sulphur content limit for Wärtsilä® 4-stroke diesel engines and also the use of Ultra Low Sulphur Diesel (ULSD) is allowed provided that the fuel quality fulfils other specified properties.
l) Alternative test method
m) Though the appearance of DMZ, DMA, DFA, DMB and DFB category fuels shall be clear and bright and the fuels shall thus not contain any sediment and water. However, in case sediment and / or water is detected from the fuel, the contents shall not exceed the limit values set for DMB and DFB category fuels, i.e. Total sediment by hot filtration: max, 0,10 % m/m and water content: max. 0,30 % v/v.

The fuel should not include any added substance or chemical waste which jeopardises the safety of installations or adversely affects the performance of the engines or is harmful to personnel or contributes overall to additional air pollution.

Equivalent test methods are accepted.

$mm^2/s = cSt$

The requirement is applicable for fuels with a sulfur content below 500 mg/kg (0,05 % m/m).

Note! For the avoidance of doubt, the fuel specification applicable to the Emission Guarantees are the fuel specification set forth in Attachment C to Appendix 1, Emission Guarantee.

40 wt% urea solution (equal to standard ISO 18611-1:2014)

Characteristics	Value
Urea content	39.0–41.0% by weight
Density at 20 °C	1105–1177 kg/m^3
Alkalinity as NH_3	max. 0.5% by weight
Biuret	max. 0.8%
Aldehydes	max. 100 mg/kg
Insoluble matter	max. 50 mg/kg
Phosphate (PO_4)	max. 1 mg/kg
Calcium	max. 1 mg/kg
Iron	max. 1 mg/kg
Magnesium	max. 1 mg/kg
Sodium	max. 1 mg/kg
Potassium	max. 1 mg/kg

Warning: *urea of agricultural quality cannot be used as reducing agent as it might harm the catalyst. Hard water and high concentrations of cations might also harm the catalyst system.*

Engine cooling water

Corrosion inhibiting additives must be used in the engine cooling water. Only additives of the brand and types approved by Wärtsilä are allowed to be used. The additive manufacturer's dosage, pH, and testing recommendations shall be followed.

If a nitrite-based corrosion inhibitor is used, the aim should be to keep a nitrite (NO2) content of approximately 1500 mg/l, calculated as nitrite. The pH shall be between 8.5 and 9.5.

The limits for engine cooling (primary circuit), turbine washing, and separator operating water must meet the following requirements:

pH at 25°C	>6.5	-
Conductivity at 25°C (limit for turbine washing only)	<100	mS/m
Total hardness Ca2+ + Mg2+	<10	°dH
Chlorides Cl-	<80	mg/l
Sulphates as SO_4^{2-}	<150	mg/l

The general appearance should be clear, colourless, and free of undissolved materials.

Water quality for other purposes

See appendix *Water quality requirements for different systems*.

Charge air

The highest allowed concentration of impurities at the charge air inlet is:

Chlorides (Cl-)	1.5	mg/Nm3 [1]
	1.16	mass-ppm
Hydrogen Sulphide (H_2S)	375	µg/Nm3
	0.25	vol.-ppm
Sulphur Dioxide (SO_2)	1.25	mg/Nm3
	0.43	vol.-ppm
Ammonia (NH_3)	94	µg/Nm3
	0.125	vol.-ppm
Filtration grade	ISO ePM10 60%	ISO 16890

Lubricating oil

Only lubricants that are approved by Wärtsilä are allowed to be used. The major lubricating oil suppliers have certain lubricating oils which are approved by Wärtsilä.

[1] Nm3 given at 0 °C and 1013 mbar

The properties of the fresh lubricating oil must meet the following requirements:

Viscosity class		SAE 40	
Viscosity Index (VI)	Minimum	95	
Sulphated Ash Level	Maximum	0.6	% mass
Alkalinity (BN)		4 - 7	mg KOH/g

0.5 SPECIAL FEATURES

Vibration control

Transmission of vibration and structure-borne noise is minimised by having the generating set flexibly mounted on the concrete foundation. The generating set is isolated from the building, the piping and the steel structures.

Torsional vibration in the generating shaft system is minimised by means of a flexible coupling between the engine and the generator.

Noise control

In the design of the building and equipment, noise control has been taken into account by minimising the size of the high noise area, and by minimising the number of wall penetrations that go directly from the high-noise area to the ambient air.

Modular construction

Wärtsilä's modular design concept enables the plant to be optimised for the specific needs of the project, utilising well-proven standard units and components. Pre-fabrication of auxiliary units allows for shop testing of equipment and reduces installation costs and time on-site.

Figure 1 Example of a factory-made and tested auxiliary module (starting-air compressor unit).

Operation and Maintenance support

The operation and maintenance manuals are tailor-made for each project, and cover all the equipment included in the plant, thus enabling the correct operation and maintenance of the plant throughout its lifetime.

0.6 CODES AND STANDARDS

The design complies with the following standards:

Mechanical systems

The mechanical systems are designed, manufactured, constructed and installed according to the appropriate extent of the following standards:

Description	Code
- Engine test run	ISO 15550 except for the fuel consumption calculation, which is based on Wärtsilä's experience of this engine type.
- Vibration	ISO 8528 part 9
- Design	EN 12100
- Pipe design calculations	EN 13480 and DIN 2413
- Welding	EN 1011
- Stairs and platforms	OSHA
- Dimensional standards for installation materials (pipes, beams, etc.)	DIN, ISO, SFS and EN
- Vertical tanks	EN 14015, API 650
- Horizontal tanks	EN 12285, excluding nozzle location
- Typical material standards	DIN, SFS and EN

- Field piping between auxiliary units and between auxiliary units and Engines will be made with Schedule 40 type piping
- Auxiliary units will be equipped with UL Labelled components

Abbreviations

DIN:	German Standard (Deutsche Institute für Normung)
EN:	European Standard
ISO:	The International Organization for Standardisation
SFS:	Finnish Standards Association
API:	American Petroleum Institute
OSHA:	Occupational Safety and Health Administration

Electrical systems

The electrical systems are designed, manufactured, constructed and installed to applicable parts according to the following standards:

Description	Code
- Generator	IEC 60034, Tested and marked according to NEMA MG-1
- Transformers	ANSI C57,UL 1561
- MV switchgear	ANSI C37, UL 1670, NEMA
- LV switchgear/switchgear	IEC 61439-2, UL 891
Auxiliary panels	IEC,UL508A
- Enclosure protection	NEMA1 / NEMA 4
- WOIS workstation hardware	IEC 60950, UL-listed
- WOIS workstation software	Applicable parts of VDE 3699
- Earthing network	IEEE 1100,IEEE 142, NFPA 70.250
- Control panels	IEC 60439-1, UL508A
- PLC software	IEC 61131-3
- Lighting installation	IES
- Fire detection	NFPA72,NFPA70
Gas detection	NFPA72,NFPA54
- Protection against lightning	NFPA780

Abbreviations

UL	Underwriters Laboratories
ANSI	American National Standard Institute
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
IES	Illuminating Eng Society
IEC:	International Electrotechnical Commission
IEEE:	Institute of Electrical and Electronics Engineers
EN:	European Standard
VDE:	The Association for Electrical, Electronic & Information Technologies
WOIS	Wärtsilä Operator’s Interface System

A POWER GENERATION EQUIPMENT

A1 GENERATING SET

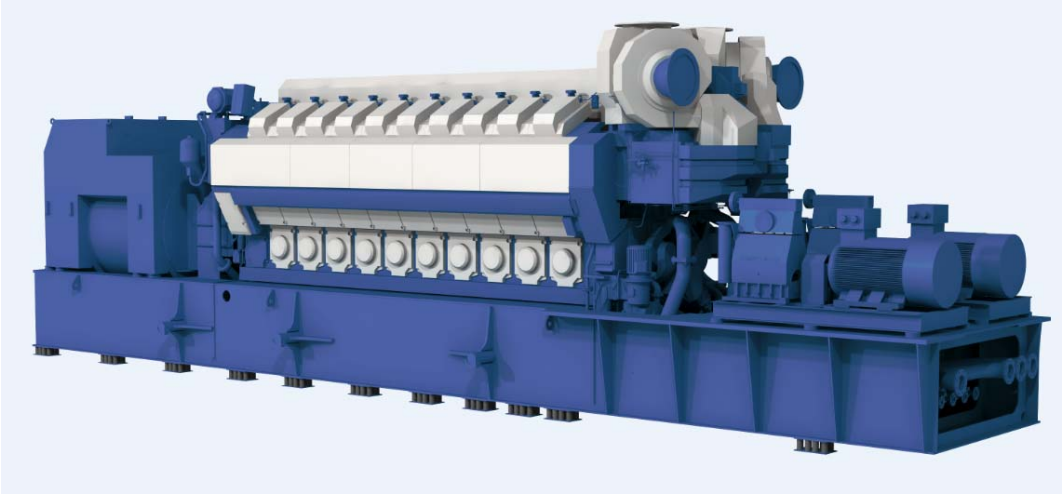


Figure 2 Example of a Wärtsilä 20V32LG generating set arrangement

The W20V32LG engine and generator are mounted on a common base frame. The common base frame is flexibly mounted on a concrete foundation by means of steel springs.

The main dimensions of the W20V32LG generating set are[2]:

Length	15.610	m / 52.214 ft
Width	3.541	m / 11.617 ft
Height	4.535	m / 14.878 ft
Weight (dry)	174,430	kg / 384,552 lb
Weight (wet)	180,430	kg / 397,780 lb

A1.1 ENGINE

4 Wärtsilä 20V32LG engine, 720 rpm with aux. LG pumps, 2 pcs each unit

General engine description

The Wärtsilä 32 is a four stroke engine. The engine is designed for continuous operation on Propane fuel and can be started and stopped on Propane fuel oil if the fuel is heated to the operating temperature. Light fuel oil is an alternate fuel.

Diesel process

The engine works according to the diesel process. In this process liquid fuel is injected into the cylinder at high pressure by camshaft operated pumps. The fuel is ignited instantly due to the high temperature resulting from the compression. Combustion takes place under constant pressure, with fuel injected into the cylinder during combustion. After the working phase, the exhaust gas valves open, and the cylinder is emptied of exhaust gases. The intake air is turbocharged and intercooled.

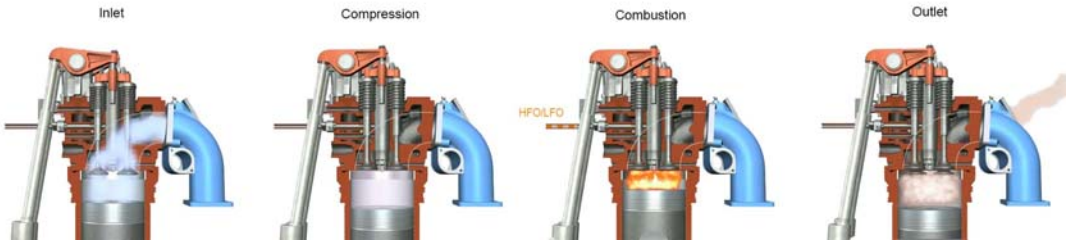


Figure 3 The combustion process

Engine main data

Configuration	V	engine form
Number of cylinders	20	
Cylinder bore	320	mm
Stroke	400	mm
Speed	720	rpm
Mean piston speed	9.6	m/s
Mean effective pressure	24.9	bar
Swept volume per cylinder	32.2	dm3
Compression ratio	16.3:1	
Number of inlet valves	2	
Number of outlet valves	2	
Direction of rotation facing towards flywheel	Clockwise	

Engine block

The engine block is made of nodular cast iron and is of stiff and durable design to absorb internal forces. The engine block carries the under slung crankshaft.

The nodular cast iron main bearing caps are fixed from below by two hydraulically tensioned studs. The caps are fixed sideways by hydraulically tensioned horizontal side studs. Together they provide a rigid crankshaft bearing.

The inlet air receiver and the cooling water and lubricating oil channels are integrated into the engine block. The engine is provided with an oil sump, mounted against the engine block and sealed by an o-ring gasket.

Crankshaft

The crankshaft is made of high tensile steel, and forged in one piece. Counterweights are fitted on the crankshaft webs. The high degree of balance results in an even and thick oil film for all

bearings. The main bearings and the crankpin bearings have a steel backing and a soft running layer with excellent corrosion resistance.

Connecting rod

The connecting rod is made of forged alloy steel and it is partially machined. It is of three-piece design with a horizontal split at the crankpin bearing and a flanged connection to the rod. The oil supply for the piston cooling, gudgeon pin bush and piston skirt lubrication takes place through a single drilling in the connecting rod.

Cylinder liner

The cylinder liner is centrifugally cast iron with special alloy elements to create wear resistance and high strength. The liner is of stiff bore cooled collar design and supported symmetrically at the top of the engine block. It is equipped with an anti-polishing ring at the top, preventing bore polishing.

Piston

The piston consists of an oil cooled steel crown bolted on to a nodular cast iron skirt. The piston crown has two compression rings and one oil scraper ring. The piston skirt and cylinder liner are lubricated by a patented pressurized lubricating system utilizing lubricating nozzles in the piston skirt. This system ensures excellent running behaviour, and constant low lubrication oil consumption.

Cylinder head

The cylinder head is made of nodular cast iron. Ample height and the stiff design allow only four hydraulically tightened studs to fix the cylinder head on to the cylinder block/liner. Each cylinder head has two inlet and two exhaust valves, all equipped with rotators. The exhaust valves are made of Nimonic and the exhaust valve seat rings are water cooled.

Camshaft and valve mechanism

The cams are integrated in the drop forged shaft material. The journal bearings consist of separate pieces, which are fitted to the camshaft pieces by flange connections. This solution makes it possible to remove individual cylinder camshaft pieces sideways. The camshaft bearing housings are integrated in the engine block casting. The camshaft is driven from the crankshaft through a fully integrated gear train.

Fuel Oil System

All the high pressure fuel injection equipment is located in a closed compartment with a removable cover (“hot box”), providing maximum reliability and safety for preheated heavy fuel.

The fuel system is comprised of the following equipment:

- Low pressure pipes made of steel
- High pressure pipes, double wall with common leak alarm
- Injection pumps, individual for each cylinder
- Pneumatic stop cylinder at each injection pump
- Fuel injector in each cylinder
- Fuel limiter to limit smoke at start up

- Solenoid valve for fuel limiter at start up

Lubricating Oil System

The engine has a wet oil sump system. The system lubricates the main bearings and the cylinder liners in the engine. Oil is led through bores in the engine block, and heads to other lubricating points like the camshaft bearings, the injection pump tappets and valves, the rocker arm bearings and the valve mechanism gear wheel bearings. The turbochargers are also connected to the engine lubricating system. Furthermore, the lubricating oil is also cools the piston crowns.

The lubricating oil system built on the engine is comprised of the following equipment:

- Pipes made of steel
- Oil sump of wet type
- Engine-driven main lubricating oil pump with pressure regulating valve
- Pre-lubricating pump with electric motor
- Lubricating oil cooler
- Lubricating oil thermostatic valve
- Lubricating oil automatic back-flushing fine filter, with integrated safety filter
- Lubricating oil centrifugal filter to clean the back-flushing oil from the automatic filter
- Start-up/running-in filters. These are removed after the engine is commissioned
- Non-return valves in oil supply pipes
- Crankcase ventilation pipe

Starting Air System

The engine is started with compressed air, with a nominal pressure of 30 bar. The start is performed by directing air into the cylinders through starting air valves in the cylinder heads.

The starting air system built on the engine is comprised of the following equipment:

- Pipes made of steel
- Starting air master valve, electrically and manually operated
- Start blocking valve to prevent starting when turning gear is engaged
- Starting air distributor
- Starting air valves in A-bank cylinder heads
- Air container for emergency stop system
- Flame arrestors

Cooling Water System

The engine is cooled by a closed circuit cooling water system, divided into a high temperature (HT) circuit and a low temperature (LT) circuit.
Thermostatic valves control the LT water inlet, and HT water outlet temperatures. The cooling water is cooled in a separate cooler in the external cooling water system.
The engines are equipped with a two-stage charge air cooling system. The cooler is built onto the engine.

The engine cooling water system is comprised of the following equipment:

- Pipes made of steel
- Engine-driven circulating water pump for the low temperature cooling circuit
- Engine-driven circulating water pump for the high temperature cooling circuit

- Non-return valves after the circulating pumps

Charge air system

The compressor side of the turbocharger feeds air into the cylinders through the charge air cooler. The engine is equipped with one turbocharger per cylinder bank. The turbocharger is of the axial turbine type.

The engine charge air system is comprised of the following equipment:

- Compressor on the turbochargers
- First stage charge air cooler
- Second stage charge air cooler
- Fresh water cleaning device for the compressor

Exhaust Gas System

The engine mounted exhaust gas pipes are made of cast iron, with separate sections for each cylinder. Stainless steel bellows are installed between the sections to absorb heat expansion. The pipes are fixed by brackets, but are free to move axially. The engine exhaust gas pipes are fully covered by an insulation box.

The exhaust gas system is comprised of the following equipment:

- Single Pipe Exhaust System (SPEX) exhaust manifold with bellows
- Flexibly mounted insulation box
- Turbine on the turbocharger
- Fresh water turbine washing system

Speed & Load Regulating System

Speed control of the engine is provided by using an electronic governor and a hydraulic actuator mounted on the engine. The electronic governor is provided with a starting fuel limiter and load ramp controller which ensures that the air to fuel ratio is kept within acceptable limits at starting and when the load setting is changed, thus limiting smoke during start-up and loading. The engine has an overspeed protection system, working independently from the speed governing system.

The engine is provided with the following control and protection equipment.

- Pneumatic starting fuel limiter and load ramp controller
- Electro-pneumatic overspeed trip device
- Speed measuring system, with magnetic pick-ups for engine an turbocharger speed

Hardware of the engine automation system

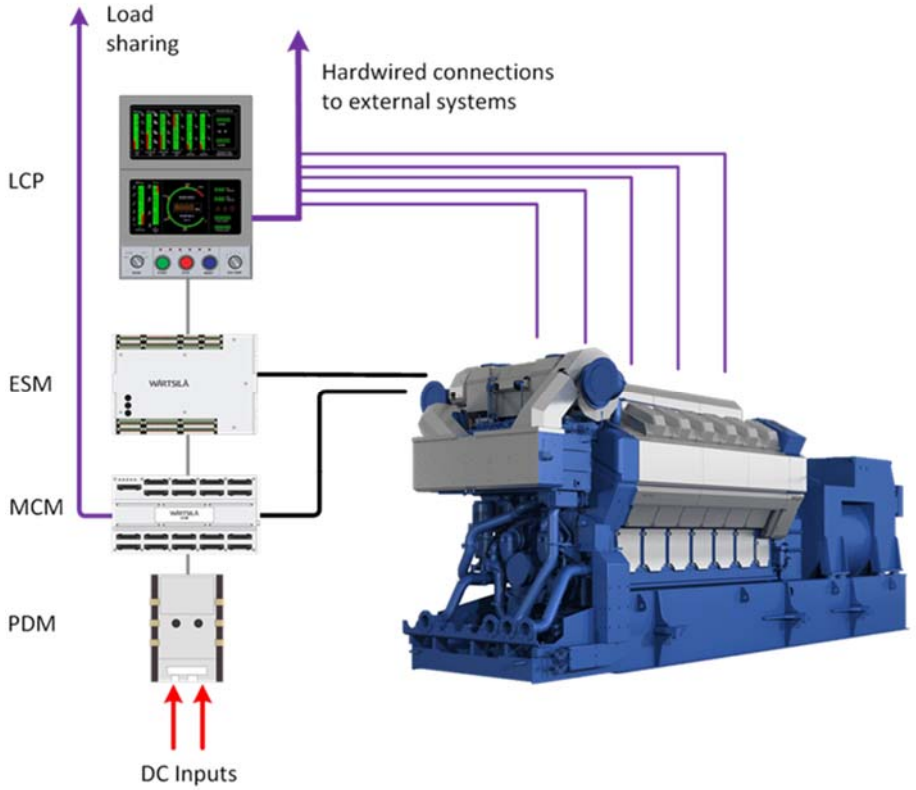


Figure 4 Hardware of the engine automation system

The engine automation system is comprised of the following main equipment:

- LCP – Local Control Panel
- MCM - Main Controller Module, for speed governing, start/stop sequencing (optional)
- ESM – Engine Safety Module, handles the fundamental engine safety.
- PDM - Power Distribution Modules. Distributes, filters and handles fusing of power supply
- Sensors
- Actuators & valves/injectors

Temperature measurements are fitted on the engine for reading following temperatures:

- Fuel oil before the engine
- Lubricating oil before the engine
- Cooling water before engine
- Cooling water after engine
- Cooling water before the charge air cooler
- Cooling water after charge air cooler
- Cooling water after the lubricating oil cooler
- Charge air in the air receiver
- Exhaust gas after each cylinder

Sensors for Alarm and Monitoring

One set of sensors fitted on the engine, which are connected to the external engine control system.

Other Included Items

- Flywheel with fixing bolts
- Electric motor-driven slow turning device
- Counter flanges for pipe connection
- Indicator valves in the cylinder heads
- Safety valves in cylinder head
- Terminal box for electric cables
- The engine has one coat of priming paint and one coat of finishing paint

4 Common base frame

The engine and generator are rigidly mounted on a common base frame. The base frame is a rigid welded steel box type construction, which facilitates straightforward and fast installation and alignment of the engine and generator at site.

4 Base frame fastening equipment and free end pipes

Equipment for fastening the engine and generator to the common base frame, including: bolts nuts, washers and steel chocks.

4 Flexible connections between engine and external piping

To minimise the transmission of engine vibrations to the plant's piping systems, flexible hoses and bellows are provided for installation between the generating set and external piping systems.

Flexible connections are supplied for the following auxiliary systems:

- Starting/control air
- Cooling water
- Lubricating oil
- Exhaust gas
- Fuel
- Crankcase ventilation

4 Generating set assembly

The engine and generator will be assembled and aligned onto the common base frame in the factory and delivered as one piece. On-site, only the alignment needs to be checked, saving time during installation and commissioning.

4 Set steel springs

Steel spring type vibration isolation units are installed between the common base frame and the concrete foundation block. The number of steel spring units for each type of generating set is determined by the weight of the generating set and an analysis of the natural frequency of the

rigid body. A fitting plate is installed between the common base frame and the steel spring packages to adjust to the level of the surface of the foundation block.

4 Engine maintenance platform - prefabricated

Partly prefabricated maintenance platforms are provided for easy maintenance and access to the engine. To minimise vibrations, the platforms and stairs are freestanding on the floor and not connected to the engine.

4 Earthquake dampers

A1.2 GENERATOR

4 Generator - 13800 Volts; 60Hz

Generator type

The generator is of the synchronous, three-phase, brushless, salient pole type.

Generator main data

Generator apparent power	11712	kVA
Rated power factor	0.8	
Nominal voltage	13800	V
Rated current (In)	490	A
Voltage adjustment range	±5	%
Frequency	60	Hz
Speed	720	Rpm
Continuous short-circuit current	>2.5 x In	
Insulation class	F	
Temperature rise stator	B	
Temperature rise rotor	B	
Cooling method	Air cooled	
Enclosure	IP23	
Standard	IEC60034	
Altitude above sea level	<1000	m

Generator construction

The generator is designed to operate together with a reciprocating engine. The stator frame is constructed with a rigid welded steel structure. The stator core is built of thin electric steel sheet laminations. The rotor consists of a shaft and salient pole type main revolving field.

The generator achieves very high efficiency because of the exceptional thermal conductivity created by the tight fit between the coils and the stator core.

Terminals

The six stator winding ends are brought to terminal boxes on the generator sides. Terminals for monitoring and auxiliary equipment have separate terminal boxes.

Damper winding

The generator is provided with a damper winding for parallel operation with other generators and with a separate power grid, if so connected.

Shaft and bearing

The generator is horizontally mounted and provided with two sleeve bearings. The generator rotor is designed to minimise the effect of torsion rotor oscillations due to system disturbances and rapid load changes.

Excitation

The exciter is of the brushless type with a rotating armature/rectifier assembled on the same shaft as the main generator rotating armature. The exciter field is controlled by the automatic voltage regulator (AVR). The rectifiers are of the silicon diode type in a full wave bridge arrangement. The rotating armature and stationary field of the exciter are insulated with Class F materials.

Cooling (air-cooled)

The generator is air-cooled. A fan mounted on the generator shaft takes cooling air from the engine hall, through washable filters, and passes it through the generator.

Automatic voltage regulator

The voltage regulator is a completely solid state type for control of generator voltage by means of controlling the exciter field. The regulator controls the generator exciter field as required to maintain a constant and stable generator output voltage. (The AVR is installed in the generating set control panel).

Voltage regulation accuracy	± 0.5	%
- within power range	0 – 100	%
- within speed range	95 – 105	%
Voltage setting range	90 – 110	%

Accessories

The following accessories are included with the generator:

6	PT-100 elements in stator windings
2	PT-100 elements for bearings
1	Anti-condensation heater
1	Voltage transformer for excitation power and measurement
1	Current transformer for measurement
3	Current transformers for protection

4 Flexible coupling

A flexible coupling is used between the engine flywheel and the generator which transmits the torque from the engine to the generator. By using a flexible coupling, the crankshaft is not loaded by any external bending forces. The elements in the coupling are made of rubber.

4 Flywheel cover

A flywheel cover is installed over the flywheel and flexible coupling to prevent access to the rotating equipment during operation.

A2 MECHANICAL AUXILIARY SYSTEMS

Proper function of the Modular power plant depends on the mechanical auxiliary systems. The proposed systems have been optimised for this particular application. The function of these systems is to provide the engine with fuel, lubricating oil, starting air, cooling water, and charge air, of the required quantity and quality, as well as to dispose of exhaust gases in a proper manner.

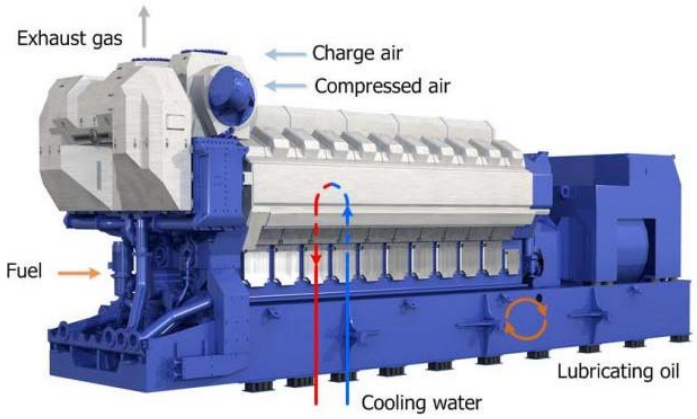


Figure 5 Mechanical auxiliary systems for the engine

A2.1 AUXILIARY MODULES

To ensure installation quality and reduce installation time, Wärtsilä has developed prefabricated auxiliary modules. These modules contain several pieces of auxiliary equipment. This saves significant pipefitting and installation time on-site. The complete module is pressure- and function-tested, then flushed, painted, and corrosion-protected prior to shipment. All external connection points are sealed and covered with steel plates.

4 Engine auxiliary module appendix

4 Engine auxiliary module

The Engine auxiliary module include several pieces of auxiliary equipment (listed below), and handles the flow of lubricating oil, cooling water and compressed air to and from the engine. The Engine auxiliary module is installed in the front end of the engine with flexible pipe connections.

Figure 6 Example of a typical Engine auxiliary module

The Engine auxiliary module includes the following main equipment:

1 Turbo cleaning water supply

2 Charge air silencer

1 High temperature circuit preheating unit

1 Low temperature thermostatic valve

1 High temperature thermostatic valve

1 Auxiliary module panel

1 Set piping

1 Set valves and gauges

4 Engine auxiliary module - platform

A2.2 LIQUID GAS SYSTEM

The fuel system provides the engine(s) with fuel of the correct flow, pressure and degree of purity.

A2.2.6 Liquid Gas system

The purpose of the fuel gas system is to supply the engine with a constant gas feed of suitable pressure, temperature, and cleanness. It should also shut off the gas supply if any problem arises, and provide ventilation of trapped gas.

The power plant is designed for continuous operation on gas, and the gas system is designed for the agreed project gas fuel quality specified in Section 0.4

The gas fuel system consists of the following equipment:

1 Plant isolation valve (manual)

4 EFB booster unit, LG 22-25 bar (g)

1 Isolation valves feeder 20 bar + filtration liquid LG fuel common header for 4 engines

1 Gas collection system 0,6 bar, 5-12 barg, LG 0,9 for liquefying for LG mode

1 Cold vent for safety valves common system

1 Low pressure compressor

1 2nd stage compressor for liquefying

1 LFO pilot feeder unit, with 3 pumps

1 LFO main feeder unit - common

1 LFO transfer unit - common

1 LFO Automatic filter unit - common

1 LFO duplex filter unit - common

1 LFO pilot fuel flow meter -common

1 LFO main flow meter -common

1 LPG Storage tank for RTO

12 Flow meters

Electrical driven pump mounted on the base-frame. Capacity is controlled by speed of the pump, pump cylinder cooling is done by media which is returned to the LG fuel condition system. Engine wise pre-pump maintain the circulation and pressure for the main pump.

Figure 7 Example of a typical LG fuel high pressure pump unit

A2.2.6.1 Gas system piping

4 LG engine piping and valves

4 Flexible connection

1 LPG pipeline from Vitol storage tank to GPRS unit

1 IPOS interconnection

A2.3 LUBRICATING OIL SYSTEM

The lubricating oil system provides required lubrication for all moving parts on the engine. It consists of the engine's lubricating oil system, which handles the cooling and filtration of the lubricating oil for the engine itself, and the plant-related lubricating oil system, which handles storage of new and used lubricating oil.

The lubricating oil system consists of the following equipment:

1 New lubricating oil tank for W32LG

The lubricating oil storage tank stores clean lubricating oil for the engines.

The tank is designed for above-ground installation and is equipped as follows:

	Capacity	20	m^3
	Mounting	Horizontal	
1	Manhole		
1	Valves at inlet and outlet		
1	Ladders, rails and flanged connections		

1 New lubricating oil tank equipment

The following equipment is provided in order to monitor the lubricating oil level in the lubricating oil tank:

1 Level indicator
1 Level switches for high- and low-level alarms

1 Lubricating oil used/ service tank used for W32LG

	Capacity	20	m^3
	Mounting	Horizontal	
1	Manhole		
1	Valves at inlet and outlet		
1	Ladders, rails and flanged connections		

1 Lubricating oil used / service tank equipment

The following equipment is provided in order to monitor the lubricating oil level in the lubricating oil tank:

1 Level indicator
1 Level switches for high- and low-level alarms

1 Lubricating oil transfer pump – stationary

The transfer pump unit pumps lubricating oil from the storage tank to the engines when topping up or changing oil. The transfer pumps and auxiliary equipment are built on a steel frame, which forms a compact skid unit.

The transfer pump unit consists of the following equipment:

2 Electric motor-driven transfer pumps

Pressure	2	bar

Single strainer on pump suction side
Thermometer on pump suction side
Local control panel
Set of interconnection pipes, flanges, seals and valves

1 Lubricating oil transfer pump mobile

The transfer pump unit pumps lubricating oil to and from the engine when topping up or changing oil, or transfers oil to and from drums as needed. The transfer pumps and auxiliary equipment are built on a wheeled dolly.

1	Electric motor-driven transfer pump			
	Capacity	5.8		m^3/h
	Pressure		2	bar
1	Single strainers on pump suction side			
1	Thermometer on pump suction side			
1	Local control panel			
1	Wheeled dolly			
1	Set of interconnection pipes, flanges, seals and valves			

Figure 7 Example of a mobile lubricating oil transfer pump unit

4 Oil mist separator units

4 Lubricating oil heat exchanger (mounted on the engine)

The lubricating oil heat exchanger is of plate-and-frame type.

4 Lubricating oil thermostatic valve (mounted on the engine)

The thermostatic valve controls the oil temperature to obtain the right temperature before entering the engine.

A2.3.1 Lubricating oil system piping

1 Piping and valves - lubricating oil system

A2.4 COMPRESSED AIR SYSTEM

Compressed air is produced by a starting the air compressor unit and stored in starting air bottles, while instrument air of higher quality is produced in an instrument air compressor unit.

The pressure equipment is designed, manufactured and tested according to the European Union directive 97/23/EC “Pressure Equipment Directive.

The compressed air system consists of the following equipment:

1 Instrument air compressor unit

The instrument air compressor unit produces control, instrument and working air. The compressed air is stored in the built-on air bottle until it is distributed to the different consumers.

The following components are built onto a steel frame, which forms a compact skid unit:

Electric motor-driven air compressor		
Capacity, each	144	m^3/h
Pressure	7	bar
Compressed air receiver		
Volume	0.2	m^3
Refrigerated air dryer with control panel		
Dew point	+4	°C
Filter for removal of oil, water and particles		
Common control panel		
Set of interconnection pipes, flanges, seals and valves		

Figure 8 Example of an instrument air compressor unit

A2.4.1 Compressed air system piping (Compressed air is common for whole plant)

1 Piping and valves - compressed air system

A2.5 COOLING SYSTEM

The cooling system provides adequate cooling of critical engine components such as cylinder jackets, cylinder heads and turbochargers as well as to cool the lubrication oil and charge air entering the cylinders.

The engine cooling water cools the low-temperature charge-air cooler, lubricating oil cooler, high-temperature charge-air cooler and engine jackets in a common single-circuit radiator.

The cooling system consists of the following main equipment:

4 Set cooling radiator

The engines are cooled with remote-mounted, horizontal-type radiators with electrically driven induced draft fans.

Each generating set has its own cooling radiator set, with each radiator in the set comprised of the following:

1-C	Radiator cooler circuit(s)		
	Frame and casing material		Galvanized steel
	Tube material		Copper
	Fin material		Copper
	Noise level per radiator at full speed	64	dB(A) at 40 m distance

1 Set cooling radiator ladder and railings

The radiators are supplied with railings and an access ladder to reach the top surface.

4 Low temperature circuit expansion vessel ~~(mounted on the exhaust gas module)~~

The expansion vessel ensures a constant positive suction head at the circulation pump, compensates for volume changes, and acts as a de-aerator for the cooling water system.

	Volume	600	l
1	Level indicator		
1	Level switches for low-level alarms		

4 High temperature circuit preheating unit (mounted on the Engine auxiliary module)

The HT preheating unit heats the engine jacket water prior to start.

The following components are built onto a steel frame, which forms a compact skid unit:

1	Heating coil, electric		
	Capacity	54	kW
1	Alarm switch for too-high heating temperature		
1	Circulation pump		
1	Set of interconnection pipes and flanges		

4 Low temperature thermostatic valve (mounted on the Engine auxiliary module)

The direct acting type thermostatic valve for the LT circuit controls the outlet temperature of the water from the engine. If the operating temperature of the engine is too low, cooling water is bypassed back to the engine.

4 High temperature thermostatic valve (mounted on the Engine auxiliary module)

The direct acting type thermostatic valve for the jacket water circuit controls the engine outlet water temperature. If the operating temperature of the engine is below the set point, cooling water is bypassed back to the engine.

A2.5.1 Cooling system piping

1 Piping and valves - cooling system

A2.6 INTAKE AIR SYSTEM

The main function of the charge air system is to provide the engine with an adequate supply of clean and dry air, and to reduce the air intake noise.

The intake air system consists of the following equipment:

4 Charge air filter - combined oil wetted and dry

The air inlet to the filter is equipped with a vertical weather louvre for removal of water droplets. The combined oil-wetted and dry-filter-type filter has a two-stage filtration. The oil-wetted portion contains filter panels that move vertically inside the filter housing. After a complete revolution the filter elements travel through the oil bath, where the dust particles settle in the oil basin. The next dry filter stage consists of several replaceable filter panels with pleated filter media for increased filtration efficiency. The filter elements are accessed through a maintenance opening.

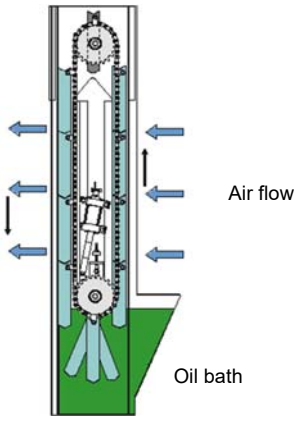


Figure 9 Picture of an oil-wetted filter

4 Rain hood for charge air filters

8 Charge air silencer ~~(mounted on the exhaust gas module)~~

The charge air silencer reduces the noise emission from the engine air intake.

Noise attenuation rating 35 dB (A)

4 Charge air ducting

The charge air ducting includes all necessary ducts, flanges, gaskets, bolts, and nuts for the engine charge air system.

A2.7 EXHAUST SYSTEM

The main function of the exhaust gas system is to lead exhaust gases safely out from the power plant, and discharge the exhaust gas at the required height. The exhaust gas system also reduces the exhaust noise from the engines.

The exhaust system consists of the following equipment:

4 Exhaust gas branch pipe

The exhaust gas branch pipe brings together the exhaust gas flow from the two turbochargers to one common pipe.

4 Exhaust gas silencer

The exhaust gas silencer reduces the noise emission from the engine exhaust outlet.

Noise attenuation rating	35 dB (A)

12 Exhaust gas bellows

The expansion bellows isolate the exhaust ducting from vibrations and also allow for thermal expansion.

1 Exhaust gas ducting - insulated insulation and cladding up to exhaust gas silencer

This includes ducting for the exhaust gas system between the engine and the exhaust gas stack.

Insulation material and cladding for the exhaust gas ducts is included inside the building and in accessible places with a surface temperature of over 60 °C up to the exhaust gas stack.

1 Exhaust gas ducting

This includes ducting for the exhaust gas system between the engine and the exhaust gas stack.

4 Exhaust gas stack pipe

The exhaust gas of the engine is discharged through the exhaust gas stack.

The exhaust gas stack has the following characteristics:

Material	CortenA	
Height above ground level	35	M (114 feet – 10”)

1 Cladding for exhaust gas stack ducting

A2.7.1 Exhaust system piping

1 Piping and valves - exhaust gas system

A2.8 OILY WATER SYSTEM

The function of the oily water system is to collect the oily water and sludge that is produced in the power plant, and store it in a sludge tank for further disposal or transport.

The gas oily water system consists of the following equipment:

A2.8.1 Oily water system piping

1 Piping and valves - oily water system,

A2.9 WATER TREATMENT SYSTEM

The water supply system provides the different plant systems with water of the correct amount, pressure, and quality based on the raw water quality specified in section A0. The system is designed as a closed circuit and sized for plant systems delivered by Wärtsilä.

1 Piping extension only

A2.9.1 Water treatment system piping

1 Piping and valves - for LG engines

A2.10 FIRE PROTECTION SYSTEM

General

The Fire Protection System is a system for protecting the power plant against fires.

The requirements of the Fire Protection System depend on the applicable local codes and requirements of the owner’s insurance company. Systems in this technical specification have been specified in spirit of the standards mentioned below. If local codes or the insurance company requirements call for additional equipment or material, it can be offered at additional cost.

Around the power plant is a Fire Main. The fire main is designed using “NFPA24 Private fire service main” as a guideline.

The fire water pump capacity is chosen according to specific protection requirements.

Although the protection system philosophy is based on widely recognized NFPA standards, piping and equipment may still follow standards used by the fire protection equipment supplier.

The plant should be subdivided into separate fire areas for limiting the spread of fire, protecting personnel, and limiting the consequential damage to the plant. Fire areas should be separated from each other by fire barriers, spatial separation, or other approved means.

The design philosophy described above aims to avoid interruption of power generation due to false alarms and failures in the automation system — and is based on the following assumptions:

- Skilled personnel attend the Power Plant 24 hours a day.
- The personnel operating the plant are trained in correct operation procedures on a regular basis.
- The plant, including installed fire protection equipment, is well maintained and kept in good order. The equipment is periodically tested.

Maintenance work, including welding and cutting, shall be done with appropriate precautions and instructions.

A2.10.1 Fire protection, common

1 Existing system

1 Piping and valves - insulated, fire protection system, pipe route between tank area and engine hall

1 Wärtsilä tie in existing system, and add additional fire protection system

A2.10.5 Fire protection, electrical equipment building

1 Piping and valves - fire protection system, electrical equipment building

A2.11 PIPE SUPPORTS AND CROSSOVERS

1 Cooling water pipe crossover

1 Set pipe secondary supports - pipe route between day tank area and engine hall

A5 EMISSION CONTROL AND MONITORING SYSTEMS

A5.1 NOX CONTROL SYSTEM

4 Selective catalytic reduction system

The Selective Catalytic Reduction (SCR) system is used for control of nitrogen oxides (NOx) emissions. In the SCR process, nitrogen oxides are reduced with the help of a reducing agent to nitrogen (N2) and water vapour (H2O), the major components of the ambient air. The SCR reducing agent is an aqueous urea solution, typically 40 wt-%. The reducing agent is evenly distributed in the mixing duct with the help of mixing element(s). The reduction of nitrogen oxides takes place on the surface of the ceramic or fibre reinforced catalyst elements. The quality of the reducing agent solution must be suitable for the SCR system, and in accordance with the requirements of the operations and maintenance manual of the SCR. The catalyst material is

sensitive to certain components in the flue gas which can poison the catalyst. The maximum concentrations of these harmful components are given in the operation and maintenance manual.

The SCR system includes an automated process control that automatically adjusts the amount of reducing agent injected into the flue gas stream. Moreover, the automation system controls, monitors and protects the components in the SCR system. The feeding unit pumps reducing agent from the storage tank to the reagent dosing unit. The dosing unit controls the amount of reducing agent fed into the exhaust gas stream. Included per selective catalytic reduction system:

The following is included:

4 Mixing duct and mixers

4 Reactor housing

4 Catalyst elements (set)

4 Oxidation catalyst element (set)

4 Reducing agent injection system

4 Reducing agent dosing system

1 Control and automation system

2 Reagent feeding units

The reagent feeding unit pumps reagent from the reagent storage tank to the reagent dosing unit. The pumps and auxiliary equipment are built on a steel frame, to form a compact skid unit.

2 Electric motor driven pumps (1 working, 1 stand-by)
2 Reactant filters
1 Local control panel (loose supply)
1 Steel frame
1 Set of interconnection pipes, flanges, seals and valves

1 Urea storage tank

The urea storage tank stores urea for the emission control of the exhaust.

The tank is designed for above-ground installation and is equipped as follows:

Capacity	500	m^3

1 Manhole
1 Valves at inlet and outlet
1 Ladders, rails and flanged connections

1 Urea storage tank equipment

The following equipment is provided in order to monitor the lubricating oil level in the lubricating oil tank:

1 Level indicator
1 Level switches for high- and low-level alarms

1 Urea unloading station for Urea storage tank

1 Urea filter unit

1 Urea day tank

The tank is designed for above-ground installation and is equipped as follows:

Capacity	50	m^3

1 Valves at inlet and outlet
1 Ladders, rails and flanged connections

A5.2 VOC AND CO CONTROL SYSTEM

8 Exhaust gas bellows

The expansion bellows isolate the exhaust gas ducting is intended to protect equipment and personnel in case of a rapid build-up of pressure in the exhaust gas system.

4 VOC system

Vocsidizer

The Vocsidizer system is used for control of volatile organic compounds (VOC) emissions. Oxidation reactions take in place at high temperatures and reaction products are carbon dioxide (CO_2) and water (H_2O). The system uses a regenerative heat exchanger. In a regenerative heat exchanger a secondary media is used for temporary storage of heat.

Figure X. Example of Vocsidiser.
Initially the bed is heated in the centre height with electrical heaters. After the initial heating, the system can start to treat the VOC emissions. Exhaust gases are passing three stages on its way through the system: 1. In the inlet half of the bed, heated by the hot media up to oxidation temperature 2. Oxidation within the bed of the VOC emissions to CO2 and H2O with energy released. 3. When the gases are leaving the hot zone, in the outlet half of the bed, it's leaving heat to the bed. This means that there is a transport of heat in the flow direction i.e. the temperature profile is moving in the direction of the airflow. To keep the hot part of the temperature profile at centre height, the airflow direction is reversed at regular intervals. The release of energy from the oxidation reaction is in many cases enough, but in some cases additional fuel is needed.

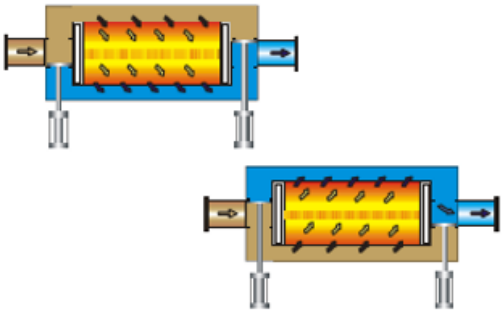


Figure Y. To keep the hot part of the temperature profile at centre height, the flow direction is reversed.
The performance of the Vocsidizer system is in accordance with the Emissions stated in Exhibit B – Performance Figures.

A5.6 CONTINUOUS EMISSION MONITORING SYSTEM

The emission monitoring system is based on the cold-dry sampling principle. The following components are monitored:

- NO_x
- CO
- O_2

Note that emission monitoring requirements can vary from region to region. Compliance with any specific emission monitoring regulation or standard must be discussed and agreed on separately.

4 Container for analyser and sample conditioning system with AC

4 Sample probes and heated sampling line - max 35 meters

The sampling technology in the emission monitoring system is of the extractive cold dry type.

A sample probe with an on-stack filter samples the exhaust gas from the stack. The sample gas is transported through heated sampling lines to the sample conditioning system. The sample conditioning system cools the sample gas and removes moisture and dust from the flue gas to ensure trouble-free operation of the analysers.

All analysers should be operated in favourable ambient conditions, which is why the equipment is put in an air-conditioned space. Sample lines are connected to every exhaust gas stack from this space.

4 Sample conditioning system

4 Gas analyser - NOx, O2, CO monitoring

The measurements are based on optical properties. Specific frequencies of light are absorbed by specific gases. The analyser measures transmission of light at a specific frequency and then determines the gas concentration based on this value.

Oxygen measurements are based on electrochemical properties of the gas.

Calibration gases are needed to ensure measurement quality during plant operation. Calibration gases may already be required during commissioning and same can then be used during operation.

A5.7 EMISSION REPORTING AND DATA ACQUISITION SYSTEMS

The reporting data acquisition and reporting system has two main functionalities:

- Data collection & storage
  - Measured emissions are collected and stored in a database
  - Data is stored for a suitable amount of time.
- Reporting
  - Based on the collected data different kinds of reports can be made, automatically or manually
  - Reporting usually based on 10 minutes, 30 minutes or daily averages
  - E.g. report daily, weekly, monthly and yearly reports

1 HC analyzer + DAHS system

A7 ELECTRICAL SYSTEMS

A7.1 CONTROL SYSTEM

Control and Supervision Concept for Wärtsilä Energy Solutions

The Wärtsilä automation system is designed for safe, reliable, efficient and easy operation of the generating sets, their associated auxiliaries and electrical systems. The modular design of the

control system allows the system to be used for optimal power generation for installations ranging from large multi-generating-set power plants to one-generating-set installations.

The automation system enables centralised operation of the plant from the control room.

WOIS (Wärtsilä Operator's Interface System) is object-oriented, has an easy-to-use process display and fault-diagnostic, and is located in the control room. As a backup, the plant can also be operated from the control panels.

Wärtsilä may collect information and data relating to the technical operating parameters of any equipment delivered, including without limitation information that Wärtsilä may gather from sensors, instruments, monitors, or other industrial control or SCADA devices on the equipment delivered ("equipment data"), and Wärtsilä may use this equipment data for product and solution development or other purposes.

Control mode options in automatic operation

The following control modes are available for generating set control:

By increasing or decreasing the engine fuel supply, the active power can be controlled in:

- MW mode – generating set power is maintained at a pre-set value irrespective of the system load or the frequency. This is the typical operating mode for a base-load power plant supplying an infinite grid.
- Isochronous load sharing – the generating set shares the load with other generating sets at a constant frequency. This is the typical operating mode when running in isolation from the grid.
- Speed droop mode – the generating set shares the load with the grid, or with the other generating sets according to a speed droop curve. This is the typical operating mode for smaller grids, or island operation.

By increasing or decreasing the generator voltage, the reactive power can be controlled in:

- Constant Power Factor control – the generating set's power factor is maintained at a pre-set value, and any changes are produced by the grid or the other generating sets. This is the typical operating mode for a base-load power plant supplying an infinite grid.
- Voltage droop compensation control – The generating set will share the reactive load with the other generating sets (if present) based on digital communication lines between the AVRs when running in island mode. This is the typical operating mode when running in isolation from the grid.
- Voltage droop mode – the generating set will share the reactive load with the grid and other generating sets equally in relation to the size of the units. This is the typical operating mode for smaller grids or island operation.

The system will automatically switch the operating mode based on the "parallel with grid" signal. In Auto mode, the setting values for active and reactive power will be according to operator input in WOIS, while in Manual mode they are determined by the switches in the control panel.

A7.1.1 Operators interface system

The power plant is controlled and supervised from WOIS (Wärtsilä Operator's Interface System). All actions necessary for normal operation, such as start and stop of the generating sets, load increase and load reduction are activated and supervised via WOIS, using a mouse, keyboard

and display. The operator can also observe key data from the plant such as various temperatures and pressures as well as measurements of electrical variables such as generator power, voltage and frequency. The user interface is accessed from the operator station for the WOIS server. The user interface language is English.

WOIS includes the following functionality:

- Process status displays, where the status and operation of the processes are displayed using various dynamic objects, such as images of pumps, valves and other components and units. The statuses of these objects are displayed graphically. By interacting with an object, the function and operational status can be displayed.
- Process trends can be displayed as a free combination of six measured values such as pressure, temperature, speed, generating set load, etc. The operator may combine the values of interest in one graph to get a good view of the total process for further analysis. The trends are stored for one year, and the operator may call back a trend for any time interval within these limits.
- An alarm banner at the bottom displays information about the most recent alarm. The active alarm list informs the operator of possible problems in the process. An alarm will remain on the active alarm list until the process has returned to normal state and the alarm has been acknowledged. Historical alarm and event lists can be called up for further evaluation of events.

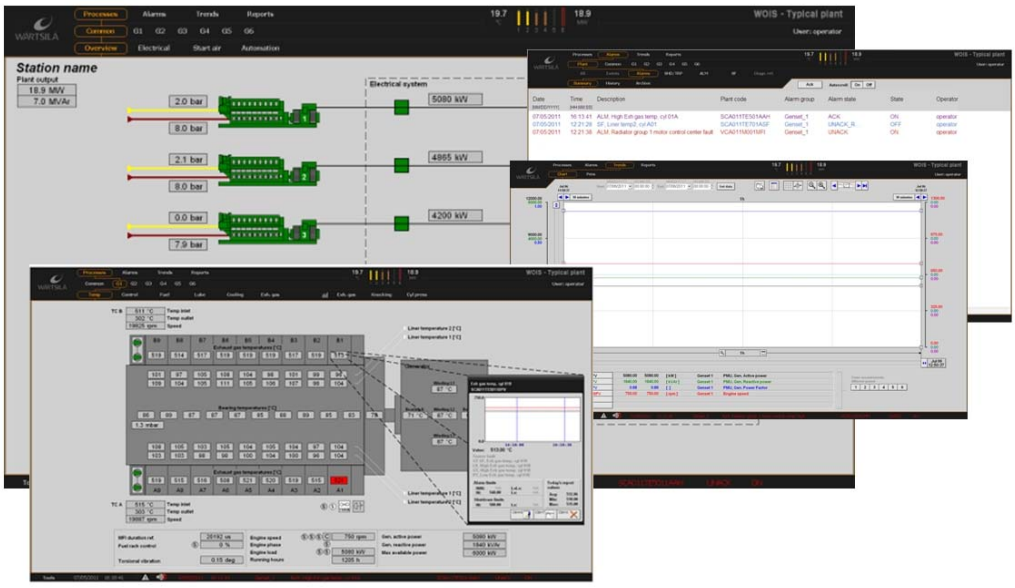


Figure 10 The picture above is an example of a set of typical WOIS displays; The Plant Overview display, a process display, a sensor trend display, an historical trend display and the alarm event display

1 Redundant WOIS server

The redundant WOIS servers handles all tasks related to the operator station, like communication to the process devices, visualization, user management and data storage.

The WOIS system is hardened, incorporates malware prevention and network segmentation.

Servers, UPS, GPS, routers and switches are installed in a server rack.

The WOIS server includes the following equipment:

1	Server rack
2	Server
2	UPS (Uninterruptible Power Supply)
2	Router
2	Switch
1	GPS (Global Positioning System) NTP (Network Time Protocol) server
1	Laser printer
	Operating system
	HMI (Human Machine Interface) software
	Licenses

2 Operator station for WOIS server

The operator station presents the user interface to the operator.

The operator station includes the following equipment:

1	Thin client
1	Display 23”
1	Keyboard and mouse
	Licenses

1 Existing SWOIS system

1 AGC - Communication

1 WOIS anywhere

1 OPC communication enables

A7.1.6 Control panels

1 Common control panel

The common control panel (CFA90_) contains the mimic diagram for the plant's Medium-Voltage system, and operating switches, buttons and meters for manual synchronising. It also contains the common PLC system.

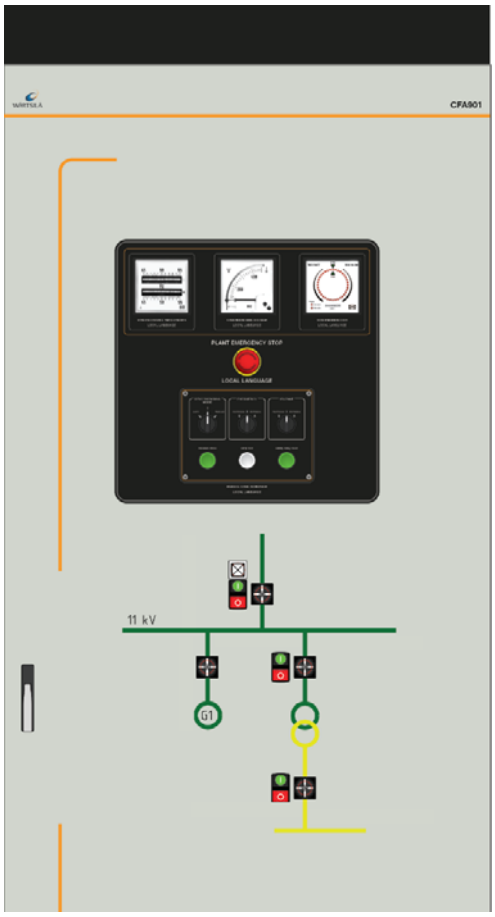


Figure 11 Example of a typical common control panel

The common control panel (CFA90_), contains the following equipment:

1 Programmable Logic Controller (PLC) unit for plant control and supervision of the common systems of the plant. The high-grade PLC integrates the control functions as required by the process and operation sequences.
The PLC includes the following units and devices:
- Power supply for CPU (110 VDC)
- Central Processing Unit (CPU)
- Communication card
- Digital input and output cards
- Analogue input and output cards (project specific)

1 Double frequency meter (for manual synchronising)
1 Double voltage meter (for manual synchronising)
1 Synchronoscope with check synch relay (for manual synchronising)

1 Manual synchronisation control interface unit with:
- Synchronising mode selector switch (auto/manual)
- Generating sets voltage adjustment switch
- Generating sets frequency adjustment switch
- Breaker close control pushbutton

- Safety relay reset pushbutton
- Indication lamp test pushbutton

1	Auto-synchroniser relay
1	Safety relay for plant emergency circuit
1	Mimic diagram for the electrical system
1	Power plant emergency stop push-button
1 set	Ethernet switches & secure routers for plant communication network (project specific)

4 Generating set control panel

The generating set control panel (CFC 0_1) contains selectors for the generating set operating mode, meters, manual control interface for manual control, the Power Monitoring Unit, the protection relay(s) and the hardwired engine-shutdown and breaker-trip circuits. In auto-mode, the PLC system together with the automation system performs the starting and stopping sequences automatically and sets the active load and the power factor references for the primary controls according to the set points entered into the WOIS workstation. The automation system and the PLC supervise the status of the generating set constantly, regardless of the running mode.

Figure 12 Example of a typical generating set control panel

The generating set control panel (CFC0_1), includes the following equipment:

1 Programmable Logic Controller (PLC) unit for control and supervision of the generating set. The high-grade PLC integrates the control functions as required by the process and operation sequences. The PLC also handles the start/stop sequence, process measurements and alarms.
- Central Processing Unit (CPU)
- Communication card
- Analogue measurement Input - Output cards (project-specific)
- Digital Input - Output cards (project-specific)

1 Set of conventional panel-mounted meters for:
- Current meters, one per phase

- Voltage meter
- Power factor meter
- Active power (MW) meter

1 Generating set emergency stop push-button

1 Power monitoring unit (PMU)
The PMU is a digital power monitoring unit where the generating set's electrical measurements can be monitored and supervised.
The PMU includes the following functions:
- Measurement of phase currents, with stored minimum and maximum
- Measurement of main and phase voltages, with stored minimum, maximum and average
- Measurement of frequency
- Calculation of Active, Reactive and Apparent power
- Calculation of Active and Reactive energy, imported, exported and total
- Calculation of harmonic distortion
- Calculation of Power Factor
- Measurement of engine running hours

1 Generator protection relay
The protection relay has the following protection functions:
- Over- and under-voltage protection
- Over- and under-frequency protection
- Reverse power protection
- Over-current and short-circuit protection
- Earth fault protection
- Loss of excitation protection
- Negative sequence (unbalance) over-current protection
- Directional earth fault protection
- Voltage restrained over current protection
- Thermal overload protection
- Residual voltage protection
- Differential current protection

1 Manual control interface with:
- Generating set control mode selector switch (Auto-Manual)
- Active power control mode selector switch (Speed droop-kW control)
- Reactive power control mode selector switch (Voltage droop – power factor control)
- Engine power control switch (decrease-increase)
- Generator voltage control switch (decrease-increase)
- Synchronising select and start of synchronisation control switch
- Engine start pushbutton with engine running indication light
- Engine stop pushbutton with engine stopped indication light
- Breaker close pushbutton with breaker closed indication light
- Breaker open pushbutton with breaker opened indication light
- Engine shutdown indication light with reset pushbutton
- Breaker trip indication light with reset pushbutton
- Indication lamp testing pushbutton

1 Safety relay for generating set emergency circuit
1 set Ethernet switches & secure routers for plant communication network (project specific)

4 Local generating set control panel

The local generating set control panel, CFE0_1, contains the following equipment:

1	Remote Input-Output unit for PLC (project specific) - Power supply unit (110/24 VDC) - Remote communication card - Digital Input - Output cards - Analogue Input - Output cards
6	DC/DC converters for engine (UNIC-system) power supply (project specific)
1	Automatic voltage regulator (AVR) for the generator
1	Generating set emergency stop push-button
1	Ethernet switch

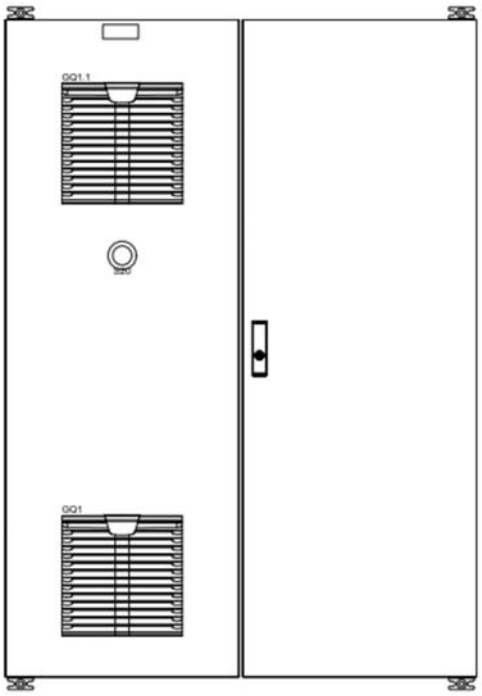


Figure 13 Example of a typical local generating set control panel

4 Auxiliary control panel (mounted on the Engine auxiliary module)

The auxiliary control panel includes breakers and controls for the electric motors and the generating set's heaters as indicated below. It is also equipped with indicator lamps and alarms. The panel controls the following electric motors and heaters (if applicable):

- Generator anti-condensation heaters
- Pre-lubricating oil pump
- Turning gear motor
- Preheating circulating pump
- High-temperature cooling water circuit preheaters
- Exhaust gas ventilation fan
- Charge air filters (if motorised)
- Oil mist separator
- Outlet socket

The auxiliary control panel, BJA0_1, contains the following equipment:

1 Remote Input-Output unit for PLC (project specific)
- Power supply unit (110/24 VDC)
- Remote communication card
- Digital Input - Output cards
- Analogue Input – Output cards

1 Generating set emergency stop push-button
1 Ethernet switch

4 Local generator control panel

1 Instrumentation for LG engine auxiliary

1 Maximo integration

A7.1.9 Cables and accessories

Control and instrumentation cables for the equipment delivered. Necessary joints and fittings are included.

1 Control cables

A7.2 MEDIUM VOLTAGE SYSTEM

(MV system is partly common and partly separated)

1 Main busbar - 13.8 kV, 2000 A, 40 kA

The metal-clad switchgear and all components will be designed, manufactured and tested in accordance with the applicable standards of IEEE, ANSI C37 and NEMA. The MV switchgear is designed to be located in an indoor climate controlled area.

The main switchgear is of the three-phase, metal-enclosed and air-insulated type and provided with a draw-out circuit breakers.

The switchgear assembly consists of individual vertical sections housing various combinations of circuit breakers and auxiliaries, bolted to form a rigid metal-clad switchgear assembly. Metal side sheets shall provide grounded barriers between adjacent structures and solid removable metal barriers shall isolate the major primary section of each circuit. Two rear covers shall be furnished for each vertical section for circuit isolation and ease of handling.

The circuit breakers are of horizontal draw-out type. The breakers are operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts will be silver-plated copper.

The switchgear is designed with the following ratings:

Rated voltage	17.5	kV
Service voltage	13800	V
Rated current for bus bars	2000	A
Rated short circuit withstand current I_{th}/1 sec.	40	kA/s
Enclosure protection class according to IEC	NEMA	1

Switchgear standards	C37.09, C37.20.2
Circuit breaker standards	C37.04, C37.06, C37.10
Circuit breaker type	VCB
Installation	Indoor

The circuit breakers are equipped with auxiliary contacts, charging motors, closing and shunt tripping coils.

The current and voltage transformers have a rated burden to suit the connected measurement and protection devices and have accuracy classification as follows:

Current transformers:

Accuracy class for phase current protection transformers	C100 and C50
Accuracy class for earth fault current transformers	C10
Accuracy class for measuring transformers	C100

Voltage transformers:

Accuracy class for measuring transformers	0.3
Accuracy class for earth fault voltage transformers	1.2

The main switchgear consists of the following equipment:

3 Generator cubicle - 1200 A, 40 kA

The generator cubicle includes the following main equipment:

	Main circuit, consisting of		
1	Circuit breaker		
	Rated current	1200	A
3	Current transformers for measurement and protection		
3	Voltage transformers for measurement and protection		
1	Earthing switch		
1	Cable transformer for earth fault		
	Secondary circuit, consisting of:		
3	Ammeters		
1	Set of miniature circuit breakers		
1	Breaker control switch		
1	Set of auxiliary relays		

1 Step-up transformer cubicle - 2000 A, 40 kA

The outgoing feeder cubicle includes the following main equipment:

	Main circuit, consisting of:		
1	Circuit breaker		
	Rated current	2000	A
3	Current transformers for measurement and protection		
2	Voltage transformers for measurement and protection		
1	Earthing switch		

1	Cable transformer for earth fault
	Secondary circuit, consisting of:
3	Ammeter
1	Voltmeter with selector switch
1	Over current / earth fault protection, 50/51 & 50N/51N
1	
2	Lockout relay (86 and 86T)
1	Set of MCBs, switches, LED lamps, auxiliary relays, terminals and wiring
1	Ammeter

1 Station auxiliary transformer cubicle - 1200 A, 40 kA

The stationary transformer feeder cubicle includes the following main equipment:

	Main circuit, consisting of	
1	Circuit breaker	
	Rated current	1200 A
3	Current transformers for measurement and protection	
1	Earthing switch	
1	Cable transformer for earth fault	
	Secondary circuit, consisting of:	
3	Ammeters	
1	Voltmeter with selector switch	
1	Over current / earth fault protection, 50/51 & 50N/51N	
1	Bus differential relay, 87B	
2	Lockout relay (86 and 86B)	
1	Set of MCBs, switches, LED lamps, auxiliary relays, terminals and wiring	

4 Neutral point cubicle

The neutral grounding resistor will be designed, manufactured and tested in accordance with IEEE 32 standard and includes the following main equipment:

1	Neutral grounding resistor	
	- Ground fault current rating	5 A
	- Max time on	10 s
	- Enclosure	NEMA 4 mill galvanized
	- Max temperature rise	760°C
	- System voltage	13.8 kV
	- BIL	95 kV
1	Manual disconnector switch	
2	Current transformers (single phase) for earth fault protection	
	- CT ratio	50/5A
	- Accuracy	C10

A7.2.1 Medium voltage cables

1 Medium voltage power cables

A7.3 LOW VOLTAGE SYSTEM

LV is separately, but will be connected- together with Phase I ASN Phase II

The low-voltage system distributes low-voltage electricity to electrical consumers included in Wärtsilä's scope of supply.

The low-voltage system includes the following equipment:

1 Station auxiliary transformer

The station auxiliary transformer is a three-phase, two-winding, naturally cooled distribution transformer, and is sized with the following ratings:

Rated power	2000	kVA
Rated incoming voltage ± 2x2.5%	13800	V
Rated outgoing voltage	480	V
Standard	IEC 60076	
Type	Oil	

The transformer includes the following main equipment:

Medium- and low-voltage bushings
Thermometer with two signal contacts
Off-load tap changer, 5 positions, on MV side
Earthing terminal
Rollers
Lifting and towing lugs

Black start unit common for Phase 1 & Phase 2

1 Low voltage switchboard

The low-voltage switchboard is a steel-sheet-enclosed, cubicle-type switchboard that feeds motor control centres, motors and other apparatus of the power plant delivered by Wärtsilä.

The switchboard includes the following main equipment:

1 Incoming feeder(s) with
1 Main switch
1 Voltage meter with selector switch
3 Ammeters
Fused outgoing feeders for local control panels
Motor starters direct on line for supplied electric motors
External protection class: IP3x

4 Frequency converter for cooling radiators

The motors of the radiator fans are controlled by a frequency converter. The setpoint to the frequency converter is based on the cooling water temperature at the inlet line to the radiators.

8 Frequency converter-engine hall inlet ventilation

A7.3.1 Low voltage cables

The low-voltage cables are installed between the station low-voltage switchboard and the various motor control centres and electrical consumers included in the Wärtsilä scope of supply.

1 Low voltage power cables

1 Power & control cables from fire pump unit

A7.4 DC SYSTEM

The DC-system is used to supply DC-power to devices and systems that need to have back-up power supply to maintain safe operation and shutdown of the plant, in case of failure in the main power supply (AC).

The normal DC-consumers of the power plant are:

- Control, automation, protection systems, MV and LV (plant and engine): 110 VDC (floating)

The DC system specifications are based on our standard system and may vary slightly depending on the DC system manufacturer. Battery capacity is given at C_{10} for the 110 VDC system (Cell end voltage 1.8V and 20°C).

2 DC system - 110 V

The DC supply unit includes the following main equipment:

1	Battery set		
	Type	Lead-acid	
	Capacity	200	Ah
	Voltage (DC)	110	V
	System type	Floating	
1	Distribution switchboard containing:		
	- Battery main switch		
	- DC system monitoring unit		
	- Miniature circuit breakers for DC feeders		
	- Earth fault detection for all DC feeders		
	- Surge arrestors for charger inputs		
	- Remove monitoring vie fieldbus (Modbus TCP)		

A7.5 HIGH VOLTAGE SYSTEM

A7.5.1 Step-up transformer

1 Step-up transformer - 50/50/50/ MVA, 69/34.5/13.8Kv,60Hz DETC

The step-up transformer is a 3-phase step-up transformer with conservator, suitable for outdoor installation.

The step-up transformer is sized with the following ratings:

Rated power	50/50/50	MVA
Rated voltage, high-voltage side	69	kV
Rated insulation voltage, high-voltage side	72.5	kV
Rated voltage, medium-voltage side	13800	V
Voltage adjustment range	± 8 x 1.25%	%
Tap changer	On load tap changer (OLTC)	-
Standards	IEC 60076	1...5
Cooling	ONAF	-
Temperature rise oil/windings	50/55	K
Connection	YNd11	-
Losses	< 0.5	%age of rated power (<0.3 for over 70 MVA)

The step-up transformer includes the following main equipment:

- Oil conservator, volume at least 12% of the oil volume
- Valves for filling, draining and taking oil samples
- Valves between the Buchholtz relay and the oil conservator
- Lifting and pulling pins and jacking lugs
- Oil gauge with alarm contacts for high and low level
- Buchholtz relay with alarm and tripping contacts and checking device
- Oil thermometer with alarm and tripping contacts
- Dehydrating breather
- Additional thermometer pocket
- Terminal box with the resistor for heating
- High-voltage bushings
- Medium-voltage bushings
- Winding temperature indicator
- Hot-galvanised radiators with shut-off valves
- Fans with starting and protecting devices
- Flat bottom, reinforced for skidding in any direction

A7.6 PLANT ELECTRIFICATION AND EARTHING

A7.6.1 Cable raceways

1 Cable raceways - gas supply & engine hall

1 Cable race ways to 325 HV breaker

1 Cable raceways from BAO 902 to transformer BTTX

1 Cable raceways to fire pump unit

A7.6.2 CCTV system

The CCTV system (Closed-Circuit Television) provides remote monitoring of different parts of the power plant, indoor and outdoor. The system consists of strategically located digital CCD colour cameras, and a video recorder. A monitor and keyboard controller is located in the control room. The digital video recorder stores the images transmitted from the cameras, the keyboard controller enables selection of cameras, and the monitor displays the images.

The cameras are networked together by a dedicated local area network. A power supply and other accessories needed for a complete CCTV system are provided.

1 CCTV

1 CCTV fix cameras to GRPS, LPG tank, Urea tank

A7.6.3 Earthing above 0-level

The safety earthing system is based on an earthing ring line. The ring line is connected to the main equipment of the plant.

1 Earthing above 0-level - engine hall & outdoor

A7.6.4 Fire detection system

The fire detection system is required for saving lives and minimizing damage to material in case of fire. The detection system is designed to detect a fire and give alarm in a possible early stage and minimizing false alarms in order to give the power plant operator opportunity to take actions to minimize operational disturbances of the power plant.

The fire detection system is a standalone addressable system with its own intelligence not dependent on any other systems integrations. The control panel (fire alarm center) is located in a continuously manned location (typically the main control room) for fastest possible response to any fire detection system alarm.

The fire alarm system typically includes the following main equipment:

- a fire detection control panel
- fire detectors and manual call points
- alarm devices (Alarm bells, sounders and beacons)

Control panel

The control panel is configured to initiate a common system alarm (fire detection, common alarm) in case of panel or system failure such as device or loop failure. In an event of a loop break or

short circuit on the loop, the fault is isolated with isolation devices, while the rest of the loop stay in normal operation.

The fire detection system alarm signals are forwarded (hardwire) to the power plant control system for event registration, control and shutdown purposes.

The control panel is powered 110 or 230 VAC 60/50Hz from the LV supply and has its own in-build battery back-up for 24h standby and 30min alarm.

Fire detectors and manual call points

Optical smoke detectors are used for early detection of smoke fires in clean indoor environments.

Point heat detectors are used where smoke may appear as a result of normal use of the room, typically indoor.

Linear heat detectors are used for different purpose (than point heat detectors) in more challenging environments where the atmosphere may be moist or windy, indoor and outdoor.

Flame detectors are used in larger, more challenging environments where the atmosphere may be greasy or otherwise moist or windy, indoor and outdoor.

Manual call points are used for manual activation of the fire alarm indoor and outdoor along escape routes. Each fire detection zone has at least one push button. There is at least one manual call point within 30 metres travel distance from any spot in the area.

The fire detectors and manual call points are connected to one or more closed loops, starting and ending in the fire alarm control panel. Each detection loop will have a number of isolation devices depending on the detection zoning.

Alarm devices

Combined sounder beacons are used typically indoor, manned or unmanned environment

Xenon beacons are used typically in loud noisy environments

Alarm bells are used typically in outdoor environments

Zones

The fire detection system consists of different detection zones to isolate the affected zone and keep unaffected zones operational and ease the fire location in case of an alarm. All detection zones are provided with a suitable amount and type of detectors.

The fire detection system consists of different alarm zones. Alarm bells, sounders and beacons are located so that they are easily heard or seen (typically separate buildings and different process areas).

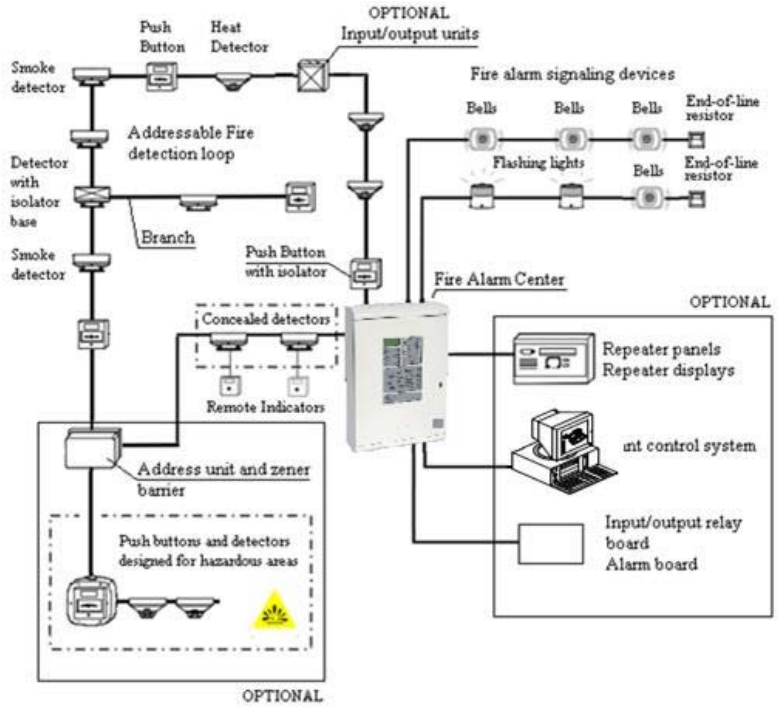


Figure 1 Typical setup of an addressable system

Fire pump rooms, containers and shelters (excl. Fire pump container)

High temp heat detectors are installed in the areas in accordance to applicable standards.

The fire detection system typically includes the following main equipment:

- High temp heat detectors
- Manual call points
- Alarming devices

The fire detection panel in the control room is configured to give a fire alarm (for manual shutdown consideration and emergency actions) if a manual call point in the fire areas is activated or a heat detector reaches its alarm level.

Air compressor rooms (if included)

High temperature heat detectors are covering the area in accordance to applicable standards. In case of access floor (access from compressor room), remote LEDs are used for indicating the location and status of the hidden detectors.

The fire detection system typically includes the following main equipment:

- High temp heat detectors
- Manual call points
- Alarming devices

The fire detection panel in the control room is configured to give a fire alarm (for manual shutdown consideration and emergency actions) if a manual call point in the fire area is activated or a heat detector reaches its alarm level.

Cable trenches (if included)

Linear heat detectors are laid out along the cable route in the area in accordance to applicable standards.

The fire detection system typically includes the following main equipment:

- Linear heat detectors (LHD)
- Alarming devices

The fire detection panel in the control room is configured to give a fire alarm (for manual shutdown consideration and emergency actions) if a linear heat detector reaches its alarm level.

Electrical rooms (if in other buildings than electrical equipment buildings)

Optical smoke detectors are covering the area in accordance to applicable standards. In case of false ceiling and access floor (access from electrical room), remote LEDs are used for indicating the location and status of the hidden detectors. If cable cellar is specified (separate atmosphere and fire area), additionally manual call points are located at escape routes (typically at exit doors) from the cable cellar.

The fire detection system typically includes the following main equipment:

- Optical smoke detectors
- Manual call points
- Alarming devices

The fire detection panel in the control room is configured to give a fire alarm (for manual shutdown consideration and emergency actions) if a manual call point in the fire area is activated or an optical smoke detector reaches its alarm level.

1 Fire detection - day tank area

Manual call points are located at escape routes (typically at boundary stairs) in the day tank area.

The fire detection system typically includes the following main equipment:

- Manual call points
- Alarming devices

The fire detection panel in the control room is configured to give a fire alarm (for manual shutdown consideration and emergency actions) if a manual call point in the fire area is activated.

1 Fire detection - engine hall

Flame detectors are located to overview the hot places in the engine hall where it is most likely to start a fire (typically overlooking hotboxes, turbos and exhaust pipes). Flame detectors are also located in the auxiliary area covering the fuel supply equipment.

The fire detection system typically includes the following main equipment:

- Flame detectors
- Manual call points
- Alarming devices

The fire detection panel in the control room is configured to give a fire alarm (for manual shutdown consideration) if a manual call point in the fire area is activated or a flame detector reaches its alarm level.

1 Fire detection - for LPG bulletin tank and GPRS area

1 Fire detection - power transformer area

Manual call points are located in the area (typically at transformer fencing).

The fire detection system typically includes the following main equipment:

- Manual call points
- Alarming devices

The fire detection panel in the control room is configured to give a fire alarm (for manual shutdown consideration and emergency actions) if a manual call point in the fire area is activated.

A7.6.5 Gas detection system

The gas detection system is required to detect any gas leaks and prevent gas fires and explosions as well as inhalation of toxic gas. The detection system is designed to detect the leak and give alarm at an early stage and minimizing false alarms in order to give the power plant operator opportunity to take actions to reduce operational disturbances of the power plant.

The gas detection system is a standalone system with its own intelligence not dependent on any other systems. The control panels are located in a continuously manned location (typically the main control room) for fastest possible response to any gas leak alarm.

The gas detection system typically includes the following main equipment:

- Gas detection control panel (fixed equipment)
- Gas detection interface panel (fixed equipment)
- Point detector (fixed equipment)
- Open path detector (fixed equipment)
- Combined sounder beacon (fixed equipment)
- Handheld gas detector (portable equipment)

Control panels

The control panel is a safety unit to which all detectors are individually hardwired. The unit handles safety critical outputs, like giving audio visual alarms, outputs to safety relay and possible control of HVAC equipment or similar. The recommended location for the local panel(s) is in the detection area (safe area) close to an entrance door for providing local indication for anyone operating in the area (not in a restricted electrical room).

The interface panel is a visual indication and monitoring unit only which communicate through Modbus with the control panels. The unit gives outputs to control system for indication and monitoring only. The recommended location for the visual interface panel is in a manned control room in a location with good visibility for remote view and indication of the whole gas detection system.

The gas detectors are connected to individual channels in the control panel. A system fault alarm initiates in case of panel or system failure such as device or cable failure.

The control panel is configured to initiate gas leak alarms with gas level readings in specific areas, operating audible and visual alarms in areas that have the problem and advising other locations of the potential problems.

The gas detection alarm signals (typically common fault alarm, common Level1 alarm and common Level2 alarm) are forwarded (hardwire) to the power plant control system for event registration and monitoring. Alarms designated for shutdowns are forwarded separately to safety relays according to the safety engineering. Typically two Level1 alarms or one Level2 alarm is triggering the shutdown output to the safety relay.

Power supply

The panels are powered with 110-120V or 230-240 VAC 60/50Hz and has its own build-in battery back-up for 2h mains failure standby operation and additionally 30 min sounder beacon alarm operation.

Gas detectors

The typical detector is supplied with factory calibrations according to specifications in gas detection system design.

Point IR gas detectors are used for detecting combustible gas leaks from specific leakage points, for example the compact gas ramp (typically Methane).

Open path IR gas detectors are used for detecting combustible gas leaks over a wider area, where leakage points are difficult to determine (typically Methane).

The handheld detectors are used for personal safety when working in the risk area.

The gas detection system does not include any manual call points because the gas leak cannot be determined visually by a person.

Alarm devices

Combined sounder beacons are used typically indoor, outdoor, manned or unmanned environments.

Combined sounder beacons are located at the entrance to the risk area and in the risk area. If there is an alarm, people working in the risk area shall be notified by the sounder beacons and have opportunity to take actions.

1 Gas detection - Engine hall (LPG)

The gas detection system in the engine hall includes the following main equipment:

- Point gas detector(s)
- Open-path gas detector(s)
- Combined sounder beacon(s)

An open path detector is also located up in the ceiling below the exhaust air pipes for detecting gas cloud build-up at a higher level in case of leakage outside of point gas detector range or detection failure due to high ventilation flow and dilution.

The first stage alarm is set at 10% LEL (Lower Explosion Limit) or 0.5 LELm (Lower Explosion Limit meter) for the point gas detectors or open path gas detector respectively and the second stage alarm is set at 20% LEL or 1.0 LELm respectively.

Gas detection methods

Lighter gas detection (typically methane, subject to fuel specification)

Point gas detectors are located where the leak most likely may occur on the fuel gas supply to each engine, typically above flanges (shut-off valve, flow meter, flexible connection to engine) in the compact gas ramp/gas regulating unit for fastest possible detection.

Detector amount is subject to Ex and ventilation layouts and scope of supply.

Heavier gas detection (typically propane, subject to fuel specification)

The gas detection system in the engine room includes the following main equipment:

- Detection panel
- Point gas detector(s)

Point gas detectors are located at floor level at flanges (shut-off valve, flow meter, flexible connection to engine) and around the compact gas ramp/gas regulating unit in case of gas leakage and drop-down to lower levels and collecting pits in connection with the detection area.

A point gas detector is also located in the exhaust air circuit for the hot-box ventilation in case of gas leak and build-up inside the hot-box.

Detector amount is subject to Ex and ventilation layouts and scope of supply.

Typically for heavier gases detection, no overhead, ceiling height detectors are needed.

Combined gas detection (light and heavy gas, subject to fuel specification)

In case of possibility to switch between lighter and heavier fuel gases, or fuel vaporization, a combined detection panel for both methods of gas detection systems is recommended. Please refer to above specifications.

1 Gas detection for LPG bulletin tank and GPRS are

A7.6.7 Lighting and building electrification

1 Lighting and building electrification - day tank area

Power supply for indoor and outdoor lighting and small power outlets comes from a distribution board connected to the station low-voltage switch gear.

All lighting fixtures and small power outlet sockets are of the general type for industrial use.

Illumination levels (Maintained Illuminance E_m)

Area		Illumination level
Engine hall	320	lux
Control room	540	lux
Office	540	lux
Switchgear room	320	lux
Workshop	320	lux
Store	320	lux
Fuel treatment house	320	lux
Outdoor	20	lux
Other rooms	220	lux

Cables are laid on cable trays or in conduits. Cable trays are made of hot-dip galvanised steel or aluminium. Trays inside the building are ladder type without covers, but outside trays are covered.

All wall sockets and cable channels on the walls are surface mounted.

Conduits are made of galvanised rigid steel, aluminium or PVC. The conduits for the cables under the ground floor are made of plastic pipes. The connections between the plastic pipes have a water-proof sealing.

Emergency lighting

Emergency lighting fixtures are divided into lighting and exit lighting.

Emergency exit lighting are installed above exit doors and along escape routes to ensure safe exit.

Emergency lighting are installed in every room where additional lighting is needed during an emergency situation.

Emergency lighting fixtures are provided with built-in battery and charger. Chargers are supplied from the lighting distribution board.

1 Lighting and building electrification - outdoor auxiliary area

A7.6.8 Lightning protection

The lightning protection system is designed to decrease the risk of damage to the building and structures in case of lightning strikes.

The lightning protection system provides a low impedance path to the ground for the lightning current. The lightning protection system for buildings consists of a roof circuit made of steel wires, interception roads and clamps. The roof circuit is then connected to the earthing grid by copper wires. The stack(s) is protected by an interception rod mounted on top of the stack and then connected by down conductors to the earthing grid or earthing rods. The tanks are protected by earthing directly to the earthing grid.

1 Lightning protection for Step up transformer

1 Lightning protection for Exhaust gas stack

A8 TOOLS

1 Set engine maintenance tools

This includes the special tools needed for normal maintenance of the engine.

1 Set engine hand tools

This includes normal hand tools needed for normal maintenance of the engine.

1 Set tools for turbocharger

This includes the special tools needed for normal maintenance of the turbocharger.

B CIVIL

B0.1 PROJECT DATA

Basic information

Project name	USVI Water and Power Authority
Location	St Thomas, US Virgin Islands
Engine configuration	4 x W20V32LG

B0.2 DESIGN DATA

B0.2.1 Design criteria

B0.2.1.1 Explanation to abbreviations

ASHRAE:	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASTM:	American Society for Testing and Materials
AASHTO:	American Association of State Highway Transportation Official
ECCS:	European Convention for Constructional Steelwork
EN:	European Standard
FEM:	European Federation of Materials Handling and Storage Equipment
NFPA:	National Fire Protection Association
ISO:	International Organization for Standardization
SFS:	Finnish Standards Association
AISI:	American Iron and Steel Institute
UBC:	Uniform Building Code
ASCE:	American Society Of Civil Engineers
OSHA:	Occupational Safety and Health Administration
IBC:	International Building Code

B0.2.1.2 Codes and standards

The civil works and structures are designed, manufactured, constructed and installed applicable and according to the following standards:

Description	Code	Note
- Wind load, seismic load	ASCE 7-16	
- Geotechnical design	EN 1997	Eurocode 7
- Reinforced concrete structures	ACI 318-14	IBC 2018
- Steel structures	AISC 341-16	IBC 2018
- Embedded anchor bolts	SFS-EN 1993-1-1 SFS-EN 1992-1-1	Eurocode 3 Eurocode 2
- Self-supporting double skin metal faced insulating panels-Factory made products-Specifications (wall panels)	EN 14509	

-	Road dimensions (road structural design follows AASHTO Low Volume Road Design procedure)	AASHTO	Vehicle WB-15M
-	Subsurface site works and substructures	Applicable ASTM standards	
-	Installation of pre-manufactured buildings	European Norms and ISO standards	
-	Ventilation & Air-conditioning	ASHRAE 62.1-2004 ASHRAE 55-2004	
	Sewage pipes	Polypropylene pipes standard SFS-EN1451-1 or local equivalent Polyvinylchloride standard SFS-EN1401 or local equivalent	
	Water pipes	Polyethylene standard SFS-EN12201 or local equivalent	
-	Crane classification and design	FEM	
-	Day and storage tank areas	NFPA 30	
-	Painting of steel structures Galvanization	EN ISO 12944 EN ISO 1461	
-	Stairs and platforms (standard)	OSHA	Fixed stairs and platforms
-	Exit routes (means of egress)	NFPA 101 is taken into consideration	Safe exit routes (means of egress) from fire or similar emergencies
-	Noise measurement	ISO 1996, Acoustics Description, measurements and assessment of environmental noise, Part 1-3	

B0.2.1.3 Loads

The design loads for the civil structures are the following:

Description	Value	Unit	Code	Note
Wind			ASCE 7-16	IBC 2018
Basic wind speed	175	mph		
Risk Category	III			
Exposure	D			
Earthquake			ASCE-7-16	IBC 2018
Spectral response	Ss=1.22 g S1=0.427 g			
Risk category	III			
Site class	D			
Importance factor	1.25			

Component importance factor	1.0			
Live load				
- Roof	0.96	kN/m^2		
- Floor, ground	10	kN/m^2		
	40	kN		Concentrated 200x200 mm^2
Working platforms	2.87	kN/m^2		5.0 kN/m^2 for engine platforms
- Distributed load	2.0	kN/m^2		
- Concentrated load	1.5	kN		200 x 200 mm^2
Dead load				
- Material				According to material weights
- Equipment				According to Wärtsilä and other manufacturer specifications
Load combinations			ASCE 7-16	IBC 2018

Wärtsilä power plant design fulfils general international requirements for structural safety.

B0.2.1.4 Other design criteria

The works and structures are designed, manufactured and constructed as following:

Description	Value	Unit	Code	Note
Noise				
- Noise level, outside plant boundary	75	dB(A)	ISO 1996	At 100 m distance from plant (standard if not otherwise informed)
- Noise level in Control Room and offices		dB(A)	ISO 1996	
Temperatures and relative humidity				
- Max. ambient air temperature	35	°C		
- Min. ambient air temperature	10	°C		
- Dimensioning relative humidity, RH	65	%		At 30 °C ambient
Rainfall				
- Maximum rainfall	150	mm/h		
Other				
- Altitude above sea level	4	m		Above sea level
- Dust level	Low			
- Frost line	0	m		

*ISO 1996 Acoustics - Description, measurement and assessment of environmental noise, Parts 1-3

B0.2.1.5 Indoor environment

The structures are designed and manufactured as following:

Area	Maximum noise level	Min. (for heating)/ max. (for cooling ventilation) temperature	AC	Ventilation	Illumination level
	dB(A)	°C			Lux
Engine Hall	-	+5 °C / Ambient+10 (except for hot spots)	No	Mechanical	200
Engine hall, maintenance platform, Auxiliary equipment areas	-	+5 °C /Ambient+10 (except for hot spots)	No	Mechanical	300
Fuel treatment house, auxiliary buildings	-	+5°C /Ambient+10 (except for hot spots)	No	Mechanical	300
Switchgear room(s)	85	18/34	Yes	Mechanical	250
Control room, other plant operating rooms	65	18/25	Yes	Mechanical	500
Offices (and corresponding)	65	18/25	Yes	Mechanical	500
Conf. room, Canteen, Kitchen, corridor(s)	65	18/25	Yes	Mechanical	150 – 200
Changing room(s), toilet(s), cleaning cupboard(s)	65	18/25	Yes	Mechanical	150 – 200
Transformer room	85	Ambient+10	Yes	Natural	150 – 200
Battery room	65	18/34	Yes	Mechanical	150 – 200
Workshop(s), Store room(s), Technical rooms	85	18/34	No	Mechanical	150 - 200
Stairs	85	18/30	Yes	Mechanical	150 – 200
Outdoor lighting					
Lighted Outdoor areas					20

B0.3 ASSUMPTIONS AND GENERAL INFORMATION

All assumptions and specifications herein are based on the geotechnical report "**Technical letter on subsoil exploration for proposed Wartsila Power Plant, Harley Power Plan, St. Thomas, USVI. Project: PS-16010. December 15, 2016"**

It is noted that the investigations received are limited and do not cover the site.

B0.3.1 Site, soil and other assumptions

The contract price is based on the following site and soil assumptions, unless otherwise described:

B0.3.1.1 Demolition

It is assumed that on site existing buildings and structures, pipes, overhead lines or any other obstacle, above or below ground, interfering with the work, are identified, demolished, removed or relocated by Owner, prior to issuing site access to contractor.

B0.3.1.2 Contamination

It is assumed that possible soil and ground water contamination is taken care of by Owner. It is assumed that when starting the work the soil is environmentally clean.

B0.3.1.7 Soil properties

- Soil investigation indicate cobbles and boulders at the top layer, and loose sand with some silt below that layer
- Soil load bearing layer is assumed to be on average at 13.5 m depth measured from the existing Engine Hall floor level.
- Groundwater is assumed to be close to MSL (3 m below ground surface)
- No risk for swelling soil
- Liquefaction susceptible soils are estimated to be on site
- Pile supported solution are needed for the project due to possible large scale post seismic settlement of the ground

B0.3.1.9 Access to site

It is assumed that the access to the site is suitable for heavy transportation, and that no access road / access road improvement of any kind is needed.

B0.3.1.10 Connection points

It is assumed that connection points for rain water, water, sewage, fuel or other piping, power (for construction) and other utilities are available and of suitable size the site boundary. No work outside site boundary is included.

B0.3.1.11 Lay down area / logistic issues

Sufficient laydown area and working area will be provided by Owner.

B0.3.1.12 Construction obstacles

It is assumed that no limitations and restrictions of any kind are affecting the construction work (like working time restrictions, noise, traffic etc.).

If the site and soil properties deviates from above listed assumptions 1-12, it will entitle the Parties to issue a Variation Order, causing a change in the Contract price and time schedule. In case of scope increase, Contractor is also entitled to extension of time.

All Variation Orders shall be agreed upon in writing prior to start of actual variation work.

B0.4 SITE PREPARATION

B0.5 UNDERGROUND NETWORK

B0.5.1 Drainage system

The water from roads and other areas with hard paving is lead away, where needed, with either open trenches or with rain water piping and rain water sumps.

No rain water pond or rain water monitoring system is considered.

B0.5.2 Piping systems (underground piping)

The sewage is connected to a septic tank (completed at Phase I)

B0.5.2.2 Oily water sewage

The underground oily water sewage system is made with plastic pipes, generally polypropylene and polyvinyl chloride. Rubber gaskets are made of an oil resistant quality, usually nitrile rubber.

The oily water sewage system from the buildings is connected to an oily water sewage sump outside the building from where the oily water is pumped to storage or treatment (Mech.).

B0.5.2.3 Water

The underground water piping is made with plastic pipes. The pipes are made of High Density Polyethylene, pressure classed 1 MPa.

B0.5.3 Underground conduits, cable ditches and lighting poles

Underground cable conduits are made of plastic, Schedule 40, or equivalent.

B0.5.4 Earthing (grounding) network

The underground earthing system consists of copper wires installed at a depth of minimum 700 mm. The joints and crossings are Cadwelded® or C-clamped. To the system vertically installed earthing rods might be added. Necessary “control pits” will be installed.

B0.6 LANDSCAPING

B0.6.1 Lawns

Owner's obligation.

B0.6.2 Trees and bushes

No trees and bushes nor any other plantations are included.

B0.7 ROADS, PAVING AND SURFACING

B0.7.1 Access road

No access road is included

B0.7.2 Plant roads and parking areas

The structural design of the roads follows the Low-Volume Road Design procedure from AASHTO (AASHTO Guide for Design of Pavement Structures). The structural layers are based on the design parameters mentioned and information gathered from the soil investigation or other received soil information.

Asphalt concrete pavement

The pavement of the main roads and parking area is asphalt concrete. Asphalt pavement is designed according to AASHTO Flexible Pavement Design Methodology. The asphalt concrete is a hot bitumen mix with aggregate # 0-20 mm, the total weight of the layer is 150 kg, corresponding to a thickness of 60 mm (type 20/150).

B0.7.3 Gravel areas

The areas around the outdoor equipment and pedestrian roads are covered with course non dusty granular material.

B0.7.4 Curb stones

The road and parking area edges are where needed protected with curbs.

B0.7.5 Site accessories

B0.7.5.2 Shelters and other site structures

Shelters for protection of electrical panels, e.g. radiator panel and pump unit shelters, will be provided.

The shelters are with steel frame and roof of corrugated steel sheets.

B0.8 FOUNDATIONS

B0.8.1 Excavation

Excavation is made to actual foundation level taking into account possible structural filling thickness and necessary working space. The slope safety is according to the requirements for the actual soil and purpose.

B0.8.2 Filling

Structural filling is made with granular material compacted to the requirements stated for the respective structure.

Backfilling is made using excavated material or other granular material. Compaction according to design requirements.

B0.8.3 Reinforced concrete foundations

B0.8.3.1 Material used

Material characteristics are according to EC2 SFS-EN 1992-1-1.

Description	Grade	Note
- Concrete for buildings and structures (where water tightness not needed)	C20/25, max aggregate size 40 mm	Compressive strength = 20 N/mm^2, at 28 days age; test with cylinder Ø=150mm; h=300mm
- Watertight concrete	C25/30, max aggregate 20 mm	Compressive strength min. 25 N/mm^2, at 28 days age
- Reinforcement (minimum requirement)	F_y (min)=400 N/mm^2	High-yield deformed reinforcing bars

The material might be changed to equivalent according to other international (ACI 318, BS8110) standard.

B0.8.3.2 Surface treatment

The upper surface of engine foundation, slabs and other foundations for similar use is steel troweled (steel floated).

The vertical foundation surfaces are poured against either plywood or steel formwork. For non-visible foundations other material and methods may be used.

B0.8.4 Generating set

N/A

B0.8.5 Buildings and shelters

The building foundations consist of a reinforced concrete ground floor slab strengthened with reinforced concrete beams along the column lines of the superstructure (a mat slab).

Foundations for smaller shelters consist of a ground floor slab only.

B0.8.6 Oil storage and containment areas

B0.8.6.1 Fuel Storage Containment area

Owner’s obligation.

B0.8.6.2 Day Tank Containment area

The tank foundations are made of reinforced concrete ring beams, on a strip footing, alternatively on top of a load bearing slab.

To prevent soil contamination the inside area of the ring beam is made leak tight with a welded HDPE, or equivalent, geomembrane. Alternatively a leak tight concrete slab might be used.

Detection pipes for detection of possible oil leakages will be installed from the tank mid recess to the detection pits outside the ring beam.

The tanks are located inside the day tank containment area. Any possible soil contamination is prevented with a leak tight containment wall and bottom made of reinforced concrete.

The containment area is sloped against open concrete trenches for collecting rain water. For handling possible oil spill the outlet from the trench(es) is monitored with manually operated rain water and oily water valves. The rain water is lead to the rain water system by opening the rain water valve. Possible oily water is lead, by opening the oily water valve to the oily water sewage sump outside the containment area, from where the oily water is pumped to storage or treatment. The oily water pipes are plastic.

B0.8.7 Auxiliary structures

B0.8.7.1 Foundations for auxiliary equipment

Cooling system / radiators on ground

The foundation is made of reinforced concrete.

Stack, exhaust gas pipe supports and boilers

The foundations for stack(s), exhaust gas pipe supports, SCRs, Vocsidizers and other supporting structures are made of reinforced concrete.

B0.8.7.2 Foundations for other auxiliary structures

Foundations for containerized equipment are made as slab foundations.

The underground oily water collecting and other sump(s) are made of watertight reinforced concrete.

B0.8.8.3 Switchyard foundations

N/A

B0.8.8.4 Trenches and cable pulling pits

N/A

B0.8.9 Other foundations

N/A

B0.9 SUPERSTRUCTURES

B0.9.1 Frame, material

B0.9.1.1 Material for building steel frame and other steel structures

The material characteristics are:

Description	Grade	Code	Note
Steel profiles and fasteners			
- Steel plates > 3 mm	S355JO	EN10025	
- I, H and U sections	S355JO	EN10025	
- L sections	S355JO	EN10025	Primary profiles
	S235JO	EN10025	Secondary profiles
- Welded hollow sections*)	S355JO	EN10219	
- Bolts	8.8 A or B	EN ISO 4014	Hot-dip galvanized
- Nuts	8 A or B	EN ISO 4032	Hot-dip galvanized
- Washers	8-100 HV	EN ISO 7091	Hot-dip galvanized
Anchor bolts			
- Threaded bolt, t < 30 mm	f_y=770 N/mm2		High-yield steel
t > 30 mm	f_y=700 N/mm^2		High-yield steel
- Nuts	10 A or B	EN ISO 4032	
- Deformed rebar	f_y=500 N/mm^2	SFS 1215	High-yield steel
- Bottom plate	S235JR	EN10025	

*) Railing (CFCHS) can be of S235JR

The material might be changed to equivalent according to other international and/or accepted code or standard.

The structural steel frame is made of shop painted prefabricated steel profiles. Installation is done with bolted connections whenever possible. The columns are generally fixed with embedded anchor bolts to the foundation.

Surface treatment

Surface treatment is based on the quality document “Anti-corrosive treatment instructions for auxiliary equipment” for Wärtsilä Power Plants. Actual document is made based on ISO standards 8501 (Pre-treatment), 12944 (Corrosion protection of steel structures by protective paint system, 2808 (Determination of film thickness).

The surface treatment for indoor structural steel frame components

The painting system for indoor steel structures, comply with atmospheric corrosivity categories C2M according to EN ISO 12944. The pre-treatment class is FeSa2,5 according to EN ISO 8501.

The surface treatment for outdoor structural steel frame components

The painting system for outdoor steel structures, fulfil atmospheric corrosivity category C5M-M according to EN ISO 12944. The pre-treatment class is FeSa2,5 according to EN ISO 8501. This is used in following structures:

- Superstructures, Exhaust gas pipes

- Superstructures, Other site area shelters and structures
- Superstructures, Outdoor auxiliary area cooling system structures
- Superstructures, Exhaust gas stack
- Superstructures, Outdoor auxiliary area NOx and CO control system
- Superstructures, Outdoor auxiliary area ventilation unit platform or similar other support structures

The painting system for all other outdoor steel structures fulfil C3M according to EN ISO 12944. The pre-treatment class is FeSa2,5 according to EN ISO 8501.

B0.9.2 Frame work for buildings

The steel frame is made of shop painted shop fabricated steel profiles. Installation is done with bolted connections. The columns are fixed with embedded anchor bolts to the foundation.

B0.9.3 Supporting steel structures (outdoor structures) and shelters

Supporting structures means support for auxiliary outdoor equipment

The steel supports are made of shop fabricated steel profiles. Installation is done with bolted connections whenever possible. The columns are fixed with embedded anchor bolts, or expander bolts, to the foundation.

B0.9.4 Stairs and platforms

In the engine hall, on the gable wall, fixed to the steel frame, is a service platform for the overhead crane. Other platforms are ventilation unit / charge air platform and stack platform. Generally platforms are installed where required for maintenance purposes. The surface treatment of the platform frame and railing are comparable to the structural steel frame. The landings and platforms are covered with hot-dip galvanized gratings (Class A, approximately 80 microns – EN ISO 1461).

B0.9.5 External walls

B0.9.5.6 Walls of corrugated steel sheets (shelters, non-insulated buildings)

The wall cladding is made of shop coated corrugated steel sheets, thickness min 0,6 mm. Wall frame is made of cold formed C- or Z-profiles.

B0.9.6 Internal walls

N/A

B0.9.7 Intermediate floor

N/A

B0.9.8 Roof

B0.9.8.5 Non insulated buildings and shelters

The roofing is made of Pural coated corrugated steel sheets.

The roofing steel sheets are fixed to secondary cold formed Z or C-steel joists or directly to primary steel profiles. All overlaps of the roofing steel sheets are provided with sealant strips. Steel sheet flashings for the roof are made of similar steel sheet material as the roofing steel sheet.

B0.9.8.6 Gutters and downpipes

The eave gutters and down spouts are, where used, made of Pural coated metal sheets.

B0.9.11 Finishing and furnishing

B0.9.11.1 External wall finishing

N/A

B0.9.11.2 Internal wall finishing

N/A

B0.9.11.3 Floor finishing

N/A

B0.9.11.4 Ceiling

N/A

B0.9.11.5 Furnishing

N/A

B0.9.12 Heating and sanitary installations (inside buildings)

B0.9.12.1 Sanitary installations (plumbing)

The water pipes are polyethylene or composite pipes. Galvanized steel may be used for cold water pipes. Wash basins in engine hall and workshops are made of stainless steel. Taps are made of chrome-plated steel or brass.

B0.9.12.2 Oily water

Oily water from buildings and other areas is lead to nearest oily water collecting sump.

Oily water underground pipes are plastic.

B0.9.13 Process ventilation, power plant buildings

B0.9.13.1 Engine hall

General

The total ventilation air flow is based on an average temperature rise of 10 °C above ambient air temperature in the occupational zones of the engine hall, with the exception of some hot spots.

The ventilation units are constructed with a painted steel frame and prefabricated sandwich wall panels (please see chapter B0.9.5 EXTERNAL WALLS).

The weather louver, louver frame, silencer frame, filter frame and the bird mesh are made of painted galvanized steel or marine grade aluminium.

Inlet ventilation, generator side

The generator side inlet ventilation air unit(s) supplies filtered air from outside the building and blows it along the engine generator set(s).

The unit includes following equipment:

- ventilation unit 18 m3/s including inlet air grill and silencer 600 C5-M, 4,0 pcs
- Electric motor (frequency converter controlled) driven axial fan
  Static pressure 300 Pa
- Inlet air grille with adjustable and lockable lamells
- Intake air bag filters, G4 according to Eurovent 779:2012
- Sound attenuating baffles, to achieve max 65dB(A) at 100m.
- Air intake weather louvre. Depth 250 mm.

Inlet ventilation, auxiliary side

The auxiliary side inlet ventilation air unit supplies filtered air from outside the building and blows it along the auxiliary equipment towards the engine generator set(s).

The unit includes the following equipment:

- ventilation aux. unit 12 m3/s including silencer 600 C5-M, 4,0 pcs
- Electric motor (frequency converter controlled) driven axial fan
  Static pressure 300 Pa
- Inlet air grille with adjustable and lockable lamells
- Intake air bag filters, G4 according to Eurovent 779:2012
- Sound attenuating baffles to achieve max 65dB(A) at 100m.
- Air intake weather louvre. Depth 250 mm.

Outlet ventilation

<u>Short generator duct</u>

All generators (except for those supplied with an outgoing duct) are supplied with a short duct on top of the outlet opening. The duct is bolted to the generator or assembled on a free-standing steel support. The duct is manufactured from galvanized steel sheets.

B0.9.13.3 Ventilation, other power plant buildings

Other buildings needed for the power production, are equipped with air intake louver(s) and exhaust fan(s). The louvers and fans are made of galvanized steel.

B0.9.14 Comfort ventilation and air-conditioning

B0.9.14.1 Electrical rooms

Electrical rooms (MV-, LV-switchgear rooms) are cooled either using wall units or roof-top units, with direct expansion evaporator and air cooled condenser.

Roof-top units

Electrical rooms are cooled by rooftop package units, with direct expansion evaporator and air cooled condenser, circulating room air through mechanical filters.

Required overpressure in the Electrical room is taken from outdoor environment through mechanical particle filters and fresh air intake dampers on the rooftop units.

Pressure will if needed be released through an overpressure damper in the outer wall construction.

The system consists of minimum 2 rooftop units with one or several refrigerant circuits. If one circuit / unit is under maintenance the other unit or circuits will have a capacity of min 60 % of the total dimensioned cooling need (calculated based on the dimensioning criteria)

Room temperature is controlled by air sensors built in the rooftop unit control panel.

The cooling units will be installed in reserved outdoor area, on a concrete slab or steel frame.

B0.9.14.2 Control room and office areas / office buildings

Control room and office areas are generally air-conditioned using a centralized roof-top unit system.

Control room, office rooms and related areas are air-conditioned (cooled and ventilated) by rooftop package units, with direct expansion evaporator and air cooled condenser, which circulate room air and outdoor over pressurization air through mechanical filters.

The system is equipped with an exhaust fan (toilets etc.). Compensation air is taken from the outdoor environment through mechanical particle filters and fresh air intake dampers on the rooftop units.

Room / area temperature is controlled by a thermostat which is regulating a 2-stage motorized air flow damper.

The system consists of minimum 2 rooftop units with one or several refrigerant circuits. If one circuit / unit is under maintenance the other unit / circuits shall have a capacity of min 60 % of the total dimensioned cooling need (calculated based on the dimensioning criteria).

The air-conditioning units shall be installed either in a reserved outdoor area, on a concrete slab or steel frame or on a roof platform.

The ducting will be designed to be as short as possible to avoid minimize pressure drop. Ducts are of galvanized steel, all ducts are insulated. The duct fittings will be manufactured from material equal to the ducts, the covering sheet of the ducts is air- and water-tight (moisture barrier).

The system is equipped with balancing, shut off, control and fire dampers where needed.

B0.9.14.3 Control and regulating equipment

The air handling units are controlled and regulated by unit wise control equipment. Room and area temperature can be controlled by a thermostat in every each room or alternatively by zone regulation.

B0.9.14.4 Alarm operations

The alarms from the air handling units are collected to one common alarm and transmitted to the HVAC distribution panel or control room.

Following alarms shall be found in the common control unit:

- Common alarms from each Rooftop Unit.
- Common alarms from each overheat protection.

All alarm contact is potential free and are ready made for external signalling to the PLC-system.

B0.9.14.5 Fire alarm and main contactor

The distribution panel is provided with a main contactor and should be operated by the fire alarm. The purpose for the Main Contactor is in case of a fire alarm the main contactor should shut of power supply to all HVAC equipment in the specific area.

B0.9.14.6 Other buildings and secondary areas

For small secondary buildings and areas window units alternatively split units with direct expansion system is used (e.g. Guard house, separate small electrical rooms, possible cooled store and other secondary rooms/areas).

B0.9.15 Equipment (cranes)

B0.9.15.1 Cranes

Overhead cranes

The common technical data for the overhead cranes (Note: small differences due to frequency, type of manufacturer and type of crane)

Description	Value	Unit	Note
Speed	[3]		

[3] The listed speeds may vary slightly depending on the local electrical grid system characteristics

- Hoisting speed	5/0.83	m/min	2-speed
- Traversing speed	20/5	m/min	2-speed+inverter control
- Travelling speed	25/6.2	m/min	2-speed+inverter control
Classification			
- Crane group	FEM 3 (A3)		
- Hoist machinery group	FEM 1Bm (M3)		
- Bridge travel group	FEM 2m (M5)		

Pilar jib cranes

The pillar jib-cranes have the following technical data:

Speed	Value	Unit
- Hoisting speed	4/1[4]	m/min
- Max rotation angle	270°	
- Suspension	Push trolley	

Manually operated chain hoists

Manually operated chain hoists are either double rail or monorail mounted

Amount and capacity of cranes

Engine hall:

- overhead crane, electrically, push button operated, 2 t (span 16-18m), 1,0 pcs
- chain hoist, manually operated, 0,25 t, 1,0 pcs

Other Areas:

For maintenance of heavy equipment in other areas manually operated chain hoist(s) with a lifting capacity of 250-500 kg, is marked in the layouts.

B0.9.15.2 Other lifting equipment

No other lifting equipment.

B1 CIVIL STRUCTURES AND MATERIAL

B1.1 ENGINE HALL STRUCTURES

Process ventilation:
- Inlet ventilation unit at generator side.
- Inlet ventilation unit at auxiliary side.

[4] The hoisting speed may vary slightly depending on the local electrical grid system characteristics

Crane:
- Overhead crane.

B1.5 ANCILLARY BUILDINGS AND STRUCTURES

B1.5.2 Oil waste handling facilities

Substructures: According to chapter B0.8

Superstructures: According to chapter B0.9

B1.5.3 Water treatment tanks and structures

Substructures: According to chapter B0.8

Superstructures: According to chapter B0.9

B1.9 DAY TANK STRUCTURES

Substructures: According to chapter B0.8

Superstructures: According to chapter B0.9

B1.10 OUTDOOR AUXILIARY STRUCTURES

Substructures: According to chapter B0.8

Superstructures: According to chapter B0.9

C ENGINEERING

C1 ENGINEERING MANAGEMENT

1 Engineering management of Wärtsilä engineering scope

General

Engineering management is managing and coordinating the engineering work to fulfil the contractual requirements.

Engineering Planning

Engineering plan is made as part of the project plan and is based on the contract requirements and project time schedules. Included in the plan is the specific schedule for the design packages.

Engineering Execution

Wärtsilä have a well-defined engineering process with clear responsibilities and phases. The engineering for Wärtsilä scope is divided into disciplines: mechanical and process, electrical and automation, and civil. Each discipline is led and managed by a chief project engineer. Additional to managing own discipline the chief project engineers are coordinating the cross-discipline engineering.

Engineering work is done by engineering experts. Detail engineering is done by reliable and long-term partners and suppliers.

Monitoring and Controlling

The engineering activities are monitored and controlled by regular internal review meetings with partners and suppliers. Review meetings with Customer are arranged based on project requirements.

Project team coordinate and control together with Customer the information needed at scope boundaries for the interfaces between Wärtsilä and Customer.

Reporting

Engineering status is reported as part of project reporting.

Basic Engineering

Basic engineering is development of a well-defined design package of Wärtsilä supplied equipment or solution. Basic design is the input for detailed engineering.

Customer to provide the engineering inputs at the interfaces of Wärtsilä supplied equipment and solutions to Customer´s or other suppliers systems and existing structures. Engineering inputs are defined during project planning.

Detailed Engineering

Detailed engineering is further development of basic design, with more technical details that will enable finalising of procurement and proceeding with the construction, installation and commissioning of the system or solution. Detailed design is input for quality assurance and manuals.

Sharing of engineering documents

Wärtsilä will set up an online web-based collaboration platform DCM365 which is used for submission and follow-up of engineering documents and other communication between project internal and external stakeholders.

Document format

- All documents are submitted as PDFs to avoid unintended modifications to the document content
- Editable file formats are not included in any document delivery
- Documents will be shared online from DCM365
- Documentation in paper only as final delivery for commercial operation

Manufacturing drawings of Wärtsilä supplied items are not included in any documentation deliverable.

Only written measurements in drawings can be used for reference.

Wärtsilä expect the Customer to share their engineering with Wärtsilä project team, for information purpose only. Wärtsilä do not take responsibility or have any approval process of any of the engineering made by the Customer.

C2 GENERAL

1 LG engine engineering

1 Engineering management

1 Study

1 Engineering for additional scope

C2.1 EX HAZARDOUS AREA LAYOUTS

1 EX Hazardous area layout design

1 Hazop study for Wapa-2

C2.4 MASTER LAYOUTS

1 Master layouts

C2.5 SAFETY LAYOUTS AND DOCUMENTATION

1 Safety layouts

1 Safety sign layout and material list

C3 MECHANICAL AND PROCESS ENGINEERING OF ITEMS SUPPLIED BY WÄRTSILÄ

C3.1 BASIC ENGINEERING

Basic engineering activities for the Wärtsilä scope include:

- Defining and calculating process values
- Selecting main equipment and materials
- Creating master layouts, section layout & plan layouts
- Creating drawings of main flow diagrams
- Collecting and investigating data and finding best solutions

Basic design package deliverables:

- Main flow diagrams for Wärtsilä scope
  - The process flow diagram depicts a process or a process plant by means of graphical symbols, interconnected by flow lines. The graphical symbols represent equipment and the lines represent flows of mass and energy or energy carriers.
  - Typical contents:
    - Equipment necessary for the process
    - Route and direction of ingoing and outgoing material
- Device lists
  - List of selected process equipment, such as tanks, modules, units and components
  - List of components used in main flow diagram
- Dimensional drawings for process related equipment supplied by Wärtsilä
  - Documentation providing information pertaining to the shape, dimensions, placing and fixing of equipment
  - Input for detailed engineering
- Master Layout
  - Plan Layout
    - Drawing showing the preliminary location of Wärtsilä-supplied main process equipment inside engine hall
  - Section Layout
    - Drawing showing the preliminary section of Wärtsilä-supplied main process equipment inside engine hall
  - Site Layout
    - Drawing showing the location of Wärtsilä-supplied structures and buildings, and spaces

1 Engine generator set

Basic engineering of the engine generator set, as described above.

1 Auxiliary modules

Basic engineering of the auxiliary modules, as described above.

1 Fuel system

Basic engineering of the fuel system, as described above.

1 Lubricating oil system

Basic engineering of the lubricating oil system, as described above.

1 Compressed air system

Basic engineering of the compressed air system, as described above.

1 Cooling system

Basic engineering of the cooling system, as described above.

1 Intake air system

Basic engineering of the air intake system, as described above.

1 Exhaust system

Basic engineering of the exhaust system, as described above.

1 Oily water system

Basic engineering of the oily water system, as described above.

1 Fire protection system

Basic engineering of the fire protection system, as described above.

1 Pipe supports and crossovers

Basic engineering of the pipe supports and crossovers, as described above.

C3.2 DETAILED ENGINEERING

Detailed engineering activities for Wärtsilä scope include:

- Review of process parameters and updating main flow diagrams
- 3D-modelling and system or solution integration of tanks, modules, piping, platforms and support structures
- Technical cross-discipline reviews, including clash-checking
- Creating assembly drawings

Detailed design package deliverables as per equipment scope of supply:

- Main flow diagrams
  - The process flow diagram depicts a process or a process plant by means of graphical symbols, interconnected by flow lines. The graphical symbols represent equipment and the lines represent flows of mass and energy or energy carriers
  - Typical contents:
    - Equipment necessary for the process
    - Route and direction of ingoing and outgoing material
    - Denomination and flow rates of ingoing and outgoing materials or energy flows
    - Characteristic operating conditions
    - Essential valves in the logical process position with respect to their function
    - Functional demands for process measurement and control at essential points
    - Denomination of equipment and characteristic data of equipment

- Device lists, updated based on detailed engineering
  - List of process equipment, such as tanks, modules, units and components
  - List of components used in main flow diagram

- Dimensional drawings for process related equipment supplied by Wärtsilä
  - Document providing information about shape, dimensions, placing and fixing of equipment

- Engine maintenance and auxiliary module platform design
  - Assembly drawings of platform
    - Arrangement drawing representing the three-dimensional position and shape of a group of assembled parts

- Unit location
  - Location drawings of Wärtsilä supplied units

- Support structure design
  - Arrangement and location drawings of pipe supports and structures

- Piping design for Wärtsilä supplied equipment
  - Pipe layout system and area wise
    - Pipe routes and pipe support locations
    - Pipe identification
  - Isometric drawings
    - Pipe size, thickness and material
    - Pipe components

- Charge air and exhaust gas ducting design
  - Assembly drawings of charge air and exhaust gas ducting
    - Arrangement drawing representing the three-dimensional position and shape of a group of assembled parts

- System-wise process description
  - System-wise description of main functionalities and operations

- Residual risk layout
  - Exit routes and direction
  - Emergency meeting points
  - Emergency showers and eye wash facilities
  - Areas where ear protection is needed

- EX (Explosion and flam proved) zones and hazardous areas classification

1 Engine generator set

Detailed engineering of the engine generator set, as described above.

1 Auxiliary modules

Detailed engineering of the auxiliary modules, as described above.

1 Fuel system

Detailed engineering of the fuel system, as described above.

1 Lubricating oil system

Detailed engineering of the lubricating oil system, as described above.

1 Compressed air system

Detailed engineering of the compressed air system, as described above.

1 Cooling system

Detailed engineering of the cooling system, as described above.

1 Intake air system

Detailed engineering of the intake air system, as described above.

1 Exhaust system

Detailed engineering of the exhaust system, as described above.

1 Oily water system

Detailed engineering of the oily water system, as described above.

1 Fire protection system

Detailed engineering of the fire protection system, as described above.

1 Pipe supports and crossovers

Detailed engineering of the pipe supports and crossovers, as described above.

C4 ELECTRICAL AND AUTOMATION ENGINEERING OF ITEMS SUPPLIED BY WÄRTSILÄ

C4.1 BASIC ENGINEERING

Activities when developing basic engineering for all electrical and automation systems in Wärtsilä scope include:

- Collecting and investigating data, such as voltages, currents, frequencies and short-circuit levels at scope limit
- Calculating and defining electrical system values
- Defining system main equipment

1 Medium voltage system

Activities when developing basic engineering for the Wärtsilä scope include:

- Engineering of system layouts
- Creation of single-line diagram drawings

Deliverables of system basic design:

- Single-line diagram
  - A single-line diagram depicts (describes) interconnections and the configuration of the electrical system. The graphical symbols represent equipment or functionality
- Dimensional drawings for main electrical related equipment supplied by Wärtsilä
  - Documentation providing information pertaining to the shape, dimensions, placing and fixing of equipment
  - Input for detailed design
- Technical specifications of main equipment
  - Technical specification with project specific data

1 Low voltage system

Activities when developing basic engineering for the Wärtsilä scope include:

- Engineering of system layouts
- Creation of single-line diagram drawings

Deliverables of system basic design:

- Single-line diagram
  - A single-line diagram depicts (describes) interconnections and the configuration of the electrical system. The graphical symbols represent equipment or functionality
- Dimensional drawings for main electrical related equipment supplied by Wärtsilä
  - Documentation providing information pertaining to the shape, dimensions, placing and fixing of equipment
  - Input for detailed design
- Technical specifications of main equipment
  - Technical specification with project specific data

1 Direct current (DC) system

Activities when developing basic engineering for the Wärtsilä scope include:

- Engineering of system layouts
- Creation of single-line diagram drawings

Deliverables of system basic design:

- Single-line diagram
  - A single-line diagram depicts (describes) interconnections and the configuration of the electrical system. The graphical symbols represent equipment or functionality
- Dimensional drawings for main electrical related equipment supplied by Wärtsilä
  - Documentation providing information pertaining to the shape, dimensions, placing and fixing of equipment
  - Input for detailed design
- Technical specifications of main equipment
  - Technical specification with project specific data

1 Control system

Activities when developing control system basic engineering for the Wärtsilä scope include:

- Engineering of system layouts
- Defining of main system components
- Creation of layout drawings

Deliverables of the control system basic design:

- Automation layout drawing
- Control panel layout drawings
  - Documentation providing information pertaining to shape, dimensions, placing and fixing of equipment.

1 Plant electrification

In basic design of plant electrification typical layout drawings are given. The project specific layouts are given in detailed design package.

Activities when developing plant electrification basic engineering for Wärtsilä scope include:

- Engineering of system layouts

Deliverables of plant electrification basic design:

- Typical layout drawings as per scope of supply

C4.2 DETAILED ENGINEERING

Activities when developing detailed engineering for all electrical and automation systems in Wärtsilä scope include:

- Check process parameters and update single-line diagrams
- Monitoring and controlling of engineering activities of discipline and coordinating the cross-discipline engineering activities including technical reviews
- Creating circuit-diagrams and detailed drawings

1 Medium voltage system

Activities when developing detailed engineering for Wärtsilä scope include

- Review of the control, protection and monitoring of respective system

Deliverables of system detailed design include:

- Single-line diagram
  - Single-line diagram depicts (describes) interconnections and configuration of the electrical system. The graphical symbols represent equipment or functionality
- Dimensional drawings for main electrical related equipment supplied by Wärtsilä
  - Document providing information about shape, dimensions, placing and fixing of equipment
- Technical specifications of equipment
  - Technical specification with project specific data
- Circuit Diagram
  - Diagram providing information on the circuitry of an object
    - Graphical symbols representing the objects
    - Graphical symbols representing the connections among objects
    - Reference designations
    - Terminal designations
    - Signal level conventions (applicable to logic signals)
    - Information necessary to trace paths and circuits (signal designations, location references)
    - Supplementary information necessary for the understanding of functions
- Setting values
  - Protection relay settings
  - Breaker settings
- Small units control panel drawings (for pre-installed panels on mechanical units)
- List of cables
- Cable schedule and material lists

1 Low voltage system

Activities when developing detailed engineering for Wärtsilä scope include

- Review of the control, protection and monitoring of respective system

Deliverables of system detailed design include:

- Single-line diagram
  - Single-line diagram depicts (describes) interconnections and configuration of the electrical system. The graphical symbols represent equipment or functionality
- Dimensional drawings for main electrical related equipment supplied by Wärtsilä
  - Document providing information about shape, dimensions, placing and fixing of equipment
- Technical specifications of equipment
  - Technical specification with project specific data
- Circuit Diagram
  - Diagram providing information on the circuitry of an object
    - Graphical symbols representing the objects
    - Graphical symbols representing the connections among objects

        - Reference designations
        - Terminal designations
        - Signal level conventions (applicable to logic signals)
        - Information necessary to trace paths and circuits (signal designations, location references)
        - Supplementary information necessary for the understanding of functions
- Setting values
    - Protection relay settings
    - Breaker settings
- Small units control panel drawings (for pre-installed panels on mechanical units)
- List of cables
- Cable schedule and material lists

1 Direct current (DC) system

Activities when developing detailed engineering for Wärtsilä scope include

- Review of the control, protection and monitoring of respective system

Deliverables of system detailed design include:

- Single-line diagram
    - Single-line diagram depicts (describes) interconnections and configuration of the electrical system. The graphical symbols represent equipment or functionality
- Dimensional drawings for main electrical related equipment supplied by Wärtsilä
    - Document providing information about shape, dimensions, placing and fixing of equipment
- Technical specifications of equipment
    - Technical specification with project specific data
- Circuit Diagram
    - Diagram providing information on the circuitry of an object
        - Graphical symbols representing the objects
        - Graphical symbols representing the connections among objects
        - Reference designations
        - Terminal designations
        - Signal level conventions (applicable to logic signals)
        - Information necessary to trace paths and circuits (signal designations, location references)
        - Supplementary information necessary for the understanding of functions
- Setting values
    - Protection relay settings
    - Breaker settings
- Small units control panel drawings (for pre-installed panels on mechanical units)
- List of cables
- Cable schedule and material lists

1 Control system

Activities when developing control system detailed engineering for Wärtsilä scope include:

- Check parameters and, create circuit diagrams and detailed panel drawings
- Review of the control, protection and monitoring of the power plant
- Create programmable logic controller (PLC) – application
- Create human machine interface (HMI) – application

Deliverables of detailed system design:

- Circuit diagram
- Diagram providing information on the circuitry of an object
- Graphical symbols representing the objects
- Graphical symbols representing the connections among objects
- Reference designations
- Terminal designations
- Signal level conventions (applicable to logic signals)
- Information necessary to trace paths and circuits (signal designations, location references)
- Supplementary information necessary for the understanding of functions
- List of cables
- Cable schedule and material lists
- Setting values
- Protection relay settings

1 Plant electrification

Activities when developing plant electrification detailed engineering for Wärtsilä scope include:

- Engineering of system layouts
- Create material specification

Deliverables of plant electrification detailed design:

- Layout drawings
- Single-line diagrams
  - Single-line diagram depicts (describes) interconnections in the electrical system. The graphical symbols represent equipment.
- Material lists
- Installation drawings
- Circuit diagram
  - Diagram providing information on the circuitry of an object
    - Graphical symbols representing the objects
    - Graphical symbols representing the connections among objects
    - Reference designations
    - Terminal designations
    - Signal level conventions (applicable to logic signals)
    - Information necessary to trace paths and circuits (signal designations, location references)
    - Supplementary information necessary for the understanding of functions

C7 DOCUMENTATION

C7.1 INSTALLATION AND COMMISSIONING DOCUMENTS

1 Installation documentation

Installation and commissioning documentation contain original equipment manufacturers (OEM) manuals for the equipment supplied by Wärtsilä and detailed design, which is divided into engineering disciplines (civil, electrical & automation and mechanical & process engineering), and each discipline's documentation is divided into system and sections as applicable. The

documents for installation and commissioning are issued prior to start of the concerned installation works.

1 Site Quality Assurance Documentation set

Site quality assurance documentation (SQAD) set is used for execution of site inspections and tests to validate plant installation quality and its performance. Contains test form templates, instructions and performance test procedures. A set of site quality assurance documentation (SQAD) is provided in digital format.

C7.3 MANUALS FOR COMMERCIAL OPERATION

The manuals for commercial operation (O&M) are issued prior to handing over of the power plant. The manuals contain operating and maintenance instructions for the whole installation. Technical documents such as drawings and lists, datasheet and OEM manuals, which are needed for the correct understanding and handling of the power plant, are included. The consolidated manuals are tailor made for the project based on Wärtsilä scope.

1 Operation and maintenance manuals on digital media

The operation and maintenance manuals contains all the information necessary to safely operate and maintain the plant throughout its expected operational lifetime. The content is aimed at the persons who operate and maintain the power plant and can be utilized for training purposes.

The manuals contain consolidated operating and maintenance instructions for the whole installation. Technical documents such as drawings and lists, data sheet and OEM manuals for individual components, which are needed for the correct understanding and handling of the power plant, are included. The consolidated manuals are project specific and subject for review by interest parties.

Referenced standards

The structure and content of the operation and maintenance manuals are based on the following international standards:

- IEC EN 62079 Preparation of instructions, structuring, content and presentation
- ISO 12100, Safety of machinery

Content

- Navigation aid and reading instructions.
- Detailed operating instructions with step by step instructions and technical descriptions of the power plant and its sub systems.
- Instructions for planned maintenance and related spare parts.
- Preparation and maintenance of the plant during seasonal outage.
- Main flow diagrams and layouts in A3 format for quick access and reference.
- Original equipment manufacturers (OEM) manuals giving reference information about subsystems, units and components. This includes data sheet, operation and maintenance instructions, spare part information, quality records and drawings and component lists for sub systems and individual, off-the-shelf components.

Limitations

The operation and maintenance manuals provided by Wärtsilä does not contain:

- Drawings for manufacturing and construction.
- Installation and commissioning instructions.

Manuals on digital media

The complete operation and maintenance manuals are delivered as PDF files on DVD. An off-line browser (Wärtsilä Document Browser) is included for navigation. The electronic file package can be installed on a PC or a tablet device. The user interface is optimized both for touch-screen, and a mouse and keyboard manipulation.

Wärtsilä document browser

Wärtsilä Document Browser (WDB) is designed to enable fast and easy access to documents. To obtain the required information, you can browse for documents in the folder structure or use the free-text search. The search allows you to search for document metadata, such as a document number, title or description, and also search inside all the pdf files in the repository.

The minimum system requirements are:

- .NET Framework 4.0 or higher.
- Windows XP SP3 or newer.
- Pentium 1 GHz or higher with 512 MB RAM or more.
- Disk space depending on number of documents imported but a typical deployment of operation and maintenance manuals requires at least 2 GB of free disk space.
- Screen resolution 1024x768 or higher.

1 Operation and maintenance manuals as hard copy

The final operation and maintenance manuals are delivered in hard-copy, on standard 80g/m2 printing paper. The hardcopy is first generation printouts from original pdf-files. The hardcopy documents are collected in hard cover plastic binder with four ring systems for A4 format paper. The binders are made of welded plastic reinforced with a cardboard.

The binders are protected by plastic bags and transported in carton boxes on wooden pallets.

D TRANSPORTATION OF ITEMS SUPPLIED BY WÄRTSILÄ (DAP, ST THOMAS SITE)

General

Transport management shall ensure that the goods are delivered safely and in a timely fashion according to contractually agreed delivery terms between the Customer and Wärtsilä.

Transport management refers to the planning, leading and managing of all transport-related activities, within the Wärtsilä scope, which are necessary for ensuring that the correct amount of goods is safely delivered within the agreed time schedule and quality and safety requirements.

Dedicated resources shall be assigned to the project focusing on timely deliveries, mitigating risks and optimising the shipments for the project.

The material and equipment shall be of various sizes and may include heavy and out-of-gauge cargo.

Wärtsilä coordinate and manage all the activities mentioned in the scope of the supply list under the section “Transportation of items supplied by Wärtsilä” and marked as Wärtsilä’s responsibility.

Wärtsilä Finland and have the status of Authorised Economic Operator (AEO) certified by Finnish Customs ensuring high standards for export and custom clearance procedure.

Shipment Planning

Shipments shall be planned in order to ensure that the goods are delivered in a safe, timely and effective manner according to contractually agreed delivery terms between the Customer and Wärtsilä.

This shall be created based on the project-specific requirements taking into account the following (but not limited to):

- Specifics of the scope of supply
- Contractual delivery time and/or installation schedule at the construction site
- Number of planned shipments and dates, information and duration
- Inland transportation, information and duration

Freight Forwarder / Carrier

Wärtsilä Energy Solutions have long-term relationships with our approved freight forwarders and carriers (third-party transportation service providers). By working in close cooperation with freight forwarders and carriers and having agreed upon common terms and conditions as well as a common way of working results in the efficient handling of the transportation chain activities, Customers are releases from having to involve their own transportation service providers, management and follow-up of the same activities.

LogWis

LogWis is an online service tool used for transportation management exclusively in Wärtsilä Energy Solutions. LogWis has been developed to enhance and extend the visibility of the logistic chain all the way from production and sourcing to procurement and handing over. LogWis enables proactive and punctual control and visibility over deliveries and information sharing between involved parties.

D1 MATERIAL AND SERVICES FOR LOGISTICS

1 Packing and marking of equipment as per Wärtsilä requirements

Seaworthy packages for Wärtsilä overseas transportation are designed to protect and withstand the whole transport and handling process to the final destination. Seaworthy packing is carried out based on HPE German packing standards and/or SEI French packing standard, and the packing material is according to ISPM standard number 15. For large pieces such as Wärtsilä engines, generators, transformers and exhaust gas boilers, the units are covered by tarpaulin or other material if the equipment so require.

1 Arranging of export license or other export authorisation (if needed)

An Export licence is a document prepared by an authority granting the right to export certain goods to a specified country. Wärtsilä shall arrange an export licence and other export documentation required for the export.

1 Export clearance of goods at the port of loading nominated by Wärtsilä

Export declaration is a document required for export of the goods. Export declaration is required by the customs authorities in the country of origin and country of export to control export and is a source for export statistics.

1 Notification to buyer of time and place of delivery of equipment

Customer will be notified about the estimated time and place of delivery according to the contractual agreement of the project.

D2 COLLECTION TRANSPORT AND LOADING PORT OPERATIONS

1 Loading of equipment at place of manufacturing

Wärtsilä is coordinating and arranging that the equipment will be loaded on the transport equipment at place of manufacturing.

1 Transportation of equipment from place of manufacturing to port of loading nominated by Wärtsilä

Wärtsilä is coordinating and arranging that the equipment will be transported from the place of manufacturing to place of delivery (i.e. port of loading).

1 Transport insurance from place of manufacturing to port of loading nominated by Wärtsilä

The equipment are insured according to Incoterms 2010 from place of manufacturing to place of delivery (i.e. port of loading).

1 Unloading of equipment at port of loading nominated by Wärtsilä

The equipment shall be discharged from the transportation equipment at the place of delivery (i.e. port of loading).

1 Unloading of engine/genset on ground or on stools and beams at port of loading nominated by Wärtsilä

The engine / generating set is discharged onto stools and beams or onto a cassette or onto the ground in order to ensure safe and effective handling of the engines and generating set and efficient usage of outdoor storage places.

1 Shifting of equipment to warehouse/open storage/container yard

The equipment is discharged and transferred from transport vehicle into temporary warehouse or other suitable area waiting for further delivery to final destination.

1 Warehousing at port of loading nominated by Wärtsilä (up to contractual delivery date)

Wärtsilä shall arrange storage of goods at the place of delivery up to the agreed contractual delivery date. In the event that no delivery has taken place due to the Customer's failure to fulfil its obligations or the delivery is postponed due to reasons attributable to the Customer, the equipment shall not be automatically insured nor storage paid for. The Customer must come to a separate written agreement with Wärtsilä and agree on an extension of the warehousing agreement and insurance cost.

1 Containerizing of loose non out of gauge cargo at port of loading nominated by Wärtsilä to the extent reasonable

Goods are to be containerised taking into account the conditions such as method of transportation, nature of the goods (weight and dimensions) and duration of the transportation, as well as agreed delivery terms (see ownership of shipper's own container).

1 Shifting of equipment from warehouse to alongside vessel

Wärtsilä will communicate, arrange and coordinate with the port operator the shifting of equipment from the warehouse at the port of loading to alongside vessel.

1 Onshore stevedoring cost at port of loading nominated by Wärtsilä

Wärtsilä will communicate, arrange and coordinate with the port operator all onshore stevedoring costs that arise at port of loading from activities such as but not limited to manpower during the loading operation.

1 Hooking on charges for equipment when delivered alongside vessel at port of loading nominated by Wärtsilä

Wärtsilä is responsible to arrange and coordinate with the port operator the activities related to securing the equipment to the hook of the crane when lifting the equipment into the vessel or other mean of transport.

1 Loading of equipment on board vessel or any other transport vehicle

Wärtsilä is responsible to arrange and coordinate that the port operator loads the equipment with certified lifting equipment in a safely manner into the vessel or any other mean of transport. Wärtsilä arranges its own surveyor for lashing and securing of heavy items i.e. engines and/or generator set and/or generators.

1 Unhooking charges for equipment loaded on board vessel or any other transport vehicle

Wärtsilä shall be responsible for arranging and coordinating with the port operator that the goods are safely loaded on board the vessel or any other means of transport when they are released from the crane's hook and lifting equipment.

1 Additional pre FOB -Phase 2 material

1 Lashing, securing, dunnage and welding on board vessel or any other transport vehicle

Wärtsilä is responsible to arrange and coordinate its third party service provider that the cargo is lashed, secured, dunned and welded according to applicable standards intended for selected mode of transport.

D3 MAIN TRANSPORT AND UNLOADING PORT OPERATIONS

1 Nomination of vessel or other mean of transport

Wärtsilä will book and arrange the vessel or other mean of transport according to contract between Wärtsilä and Customer.

1 Engaging and instructing freight forwarder

Wärtsilä is contracting a third party transport service provider to be engaged and instructed to handle the transport according to contractually agreed delivery terms between Customer and Wärtsilä. By this contract the service provider is informed about the details of the cargo, delivery term, origin of the goods and other relevant information needed to ensure a safe and timely transport of the goods.

1 Arranging of bill of lading

Wärtsilä shall have the transportation document issued for the carriage of goods from the place/port of loading until the place/port of unloading in the form and method agreed in the contract.

1 Preparation of origin country documents required for destination customs clearance

The country of origin documents refer to such documents, which state the origin of the delivered equipment. The country of origin documents are to be issued according to origin country authority regulations.

1 Transportation of equipment from port of loading to port of destination (offloading quay nominated by Wärtsilä)

Wärtsilä shall be responsible for arranging a contract of carriage for the transportation of the goods. Unless otherwise separately agreed in the contract between the Customer and Wärtsilä, it shall be understood that the sea freight is booked on a part charter basis for the out of gauge cargo.

1 Transport insurance from port of loading to port of destination (offloading quay nominated by Wärtsilä)

Wärtsilä has insured the goods during transport according to Incoterms 2010 and contract between Wärtsilä and Customer.

1 Discharging of equipment from vessel or any other transport vehicle at port of destination (offloading quay nominated by Wärtsilä)

Wärtsilä is responsible to discharge the equipment. Discharging of the goods is to be done with certified lifting equipment in a safely manner from the vessel or any other mean of transport.

1 Unhooking charges for equipment discharged from vessel or any other transport vehicle

Wärtsilä shall be responsible for arranging and coordinating with its appointed third party transportation service provider that the equipment is safely discharged from the vessel or any other means of transport when they are released from the crane's hook and lifting equipment.

1 Onshore stevedoring cost at port of destination (offloading quay nominated by Wärtsilä)

Wärtsilä is responsible to arrange and coordinate with its appointed third party transport service provider activities such as but not limited to manpower during the unloading operation.

1 Shifting of equipment from alongside vessel to warehouse/open storage/container yard inside the port of destination (offloading quay nominated by Wärtsilä)

Wärtsilä is responsible to arrange and coordinate with its appointed third party transport service provider that when the goods is safely discharged from the vessel that it is shifted to a temporary storage area.

1 Shifting of containers delivered by liner vessels to container yard at port of destination

Containers are transferred from vessel to container yard at port of destination as standard procedure by the container liner.

1 Unloading of equipment at warehouse/open storage/container yard at port of destination

Wärtsilä shall be responsible for arranging and coordinating with its appointed third party transportation service provider that the goods are safely unloaded when they are shifted to a temporary storage area.

1 Additional main transp. for phase2 mat

1 Wharfage (Customer responsibility)

A charge asserted by the port, terminal, pier or dock owner for handling incoming or outgoing cargo. The charge made for docking a vessel at a wharf. A user will be subject to a charge, even for limited periods of time.

In the event that the port of destination applies a wharfage, the Customer shall be responsible for these charges.

The Customer shall indemnify Wärtsilä against any claims any delay not attributable to Wärtsilä.

1 Arrange import license or import permit (if required) (Customer responsibility)

An import licence may be required by an authority of the destination country to grant the right to import certain goods to the destination country. The Customer shall be responsible for arranging, coordinating and paying for all required activities and costs with authorities in order to obtain any such import license(s).

The Customer is to indemnify Wärtsilä against claims arising from any delay not attributable to Wärtsilä.

1 Import of goods (Customer responsibility)

Customer arrange and coordinate all related activities and documents related to the import of the goods in the destination country.

Customer to indemnify and hold Wärtsilä harmless for any delay not attributable to Wärtsilä.

1 Import taxes and duties (if required) (Customer responsibility)

Customer is responsible for arranging payment for the import taxes and duties declared by the authorities during the custom clearance process. Customer is responsible for presenting all required documents enabling the import custom clearance.

Customer to indemnify and hold Wärtsilä harmless for any delay not attributable to Wärtsilä.

D4 SITE TRANSPORT

1 Transport route preparation (if required) (Customer responsibility)

Customer to ensure safe delivery of the goods, such as but not limited to strengthening of the bridges structures and pavement, removal of tree branches, traffic signs, lifting of cables, survey to ensure safe berthing of vessel (bathymetry survey), and construction of temporary structures such as jetty and overall control over safety during transport.

1 Transport permit assistance (Customer responsibility)

The Customer is responsible for arranging all required permit(s) for transportation specifically related but not limited to heavy and out-of-gauge cargo. If transport permit assistance is required from Wärtsilä to enable a better and clearer understanding between local authorities and Customer, Wärtsilä will provide such supporting documentation to the Customer in order to facilitate the transport permit(s) process.

The Customer is to indemnify and hold Wärtsilä harmless for any delay not attributable to Wärtsilä.

1 Loading of equipment on truck at warehouse

Wärtsilä arranges and coordinates with the third party transport service provider that the equipment is safely loaded with certified lifting equipment onto the transport vehicle.

1 Transportation of equipment from port of destination to Named Place of Destination

Wärtsilä shall arrange and coordinate with the third party service provider that the equipment is lashed and secured to the certified transport vehicle according to standards applicable to the selected mode of transport and that it is transported to the project site. For destination country to project site, Wärtsilä shall demand a method statement from the third party transportation service provider before the actual transportation takes place as to how the heavy goods (e.g. engines and/or generator set and or generator) transport will be performed during different transport modes and shifting to the final position. During transportation, Wärtsilä shall demand status reports from our third party transport service providers on a regular basis.

1 Transport insurance from port of destination to Named Place of Destination

Wärtsilä has insured the goods during transport according to Incoterms 2010 and contract between Wärtsilä and Customer.

1 Additional transportation for NOx and VOC

1 Equipment at Named Place of Destination for discharging cargo

Wärtsilä arranges equipment, such as crane and forklift truck and any other to discharge cargo from transport vehicles.

1 Unloading of equipment at Named Place of Destination

Wärtsilä shall discharge the goods from the transportation vehicle into the nominated area at the project site according to the instructions of the site personnel.

1 Unloading and final positioning of the EG-sets/engines/generators

Wärtsilä shall arrange to discharge, align and position the engine generating set, engines and generators onto their foundations at the final position.

1 Temporary warehousing in country of destination

Wärtsilä arranges that goods are placed into temporary warehouse if required for duration of customs clearance, lack of space at site or any other reason.

1 Placing, compaction, and removal of fill material

E TAXES, DUTIES, PERMITS AND INSURANCE

E3 INSURANCE

1 General liability and product liability insurance

1 Construction and erection all risk insurance

1 Workers' compensation and employer's liability insurance for Wärtsilä personnel

F PROJECT MANAGEMENT SERVICES

F1 PROJECT MANAGEMENT

General

Project management is service utilizing knowledge, skills, tools and techniques to project activities in order to meet project requirement. This enables to manage the scope of work required to deliver agreed deliverables specified in contract.

The project management process at Wärtsilä Energy Solutions is based on the Project Management Institute's (PMI) standards, the PMBOK® Guide, ISO 21500, and Wärtsilä best practise and experience.

Wärtsilä uses CA PPM as portfolio and project management tool. For scheduling Wärtsilä uses Microsoft Project.

The project will be managed by a dedicated project team, led by a competent project manager. The project manager is fully responsible for achieving the targets set by the contract, empowered to organize and lead the project team, and authorized to make decisions on the supplier's behalf. The project team administers, manages and controls the project in accordance with the contract requirements. The project manager is the interface towards the Customer.

The project management service will cover the time period based on contract delivery schedule (including commissioning).

Project management process

The project team plans the project based on the contract requirements. The team executes the plan by directing and managing the works throughout the engineering, procurement, logistics, construction and commissioning phases of the project. The project phases are planned and executed in accordance with Wärtsilä's project management process as shown in figure below.

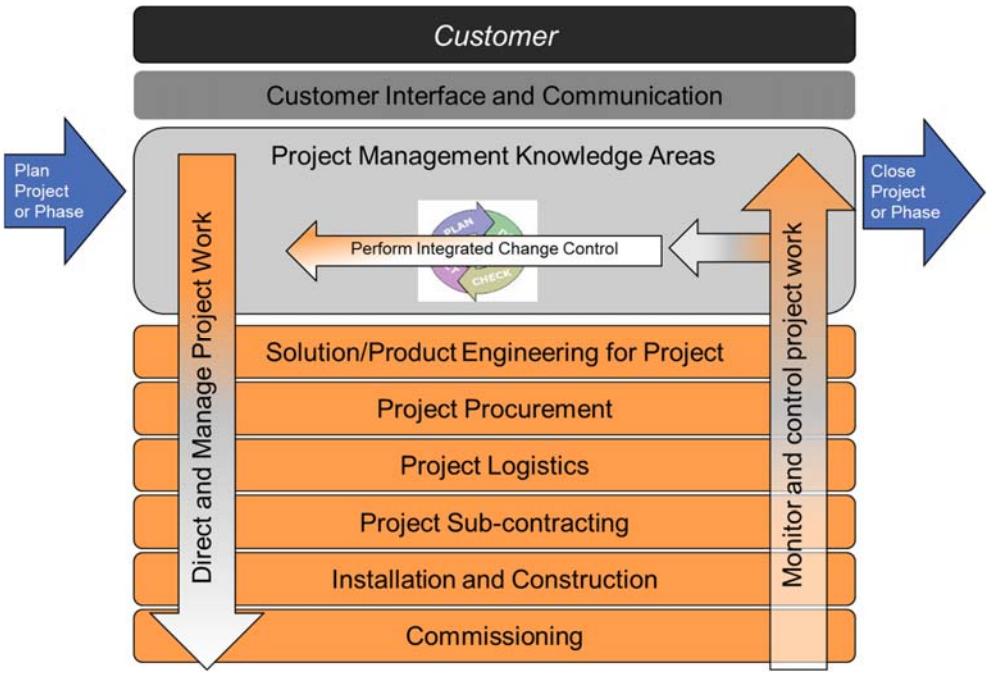


Figure 14 Wärtsilä's project management process

The project phases are managed by means of the project management knowledge areas as described below.

Project Management Deliverables

Project management integrates the project management areas throughout the project management phases. The project management phases are listed below and comprise the deliverables and methods of the project management service:

- Planning
  - Task: In the planning phase all parts of the project are planned in an integrated manner and complied into a project execution plan. The project execution plan will cover the resource -, schedule -, financial -, engineering -, risk -, communication -, quality -, HSSE -, procurement -, permit -, subcontracting -, scope, change and documentation management. A first version of the project execution plan will be given to the customer during the kick-off meeting and after that as progressive elaborations when new information is obtained.
  - Deliverable: Project execution plan
- Execution: Directing and managing project work
  - Task: Directing and managing refers to the daily coordination of the scope of supply and other work tasks across the other project related services (engineering, procurement, logistics and construction management). Problems are proactively addressed and issues related to the scope of supply and its interfaces to other systems are coordinated with the customer (or other assigned parties).
- Reporting: Monitoring and controlling project work
  - Task: The project is continuously monitored as part of the daily coordination. Formal control and monitoring strives to communicate the status of the project in a systematic manner and to identify deviations from the plan or scope.

- Deliverables: Monthly reports

- Change Control
  - If a change to the materials or works specified in the contract or project execution plan occurs during the project, the project team will follow a change procedure specified in the contract or according to general, prevailing contracting practices.
- Project Closure
  - Task: When the delivery is completed, the project team requests formal acceptance of the project.
  - Deliverable: Handing-over certificates as per contract.

Project Scope Management

Under project scope management the team plans the materials and work needed to accomplish the project as per the contract. The team will specify the materials based on the contract requirements and plan the corresponding works according to the needs of the engineering, procurement, logistics, construction, and commissioning phases.

The team checks and ascertains the scope of materials, deliverables and works are as specified in the contract.

Project Organization

The delivery of the power plant will be managed by a project team dedicated to the project. The team is led by a competent project manager.

The project team is resourced with necessary competencies so that the project work can be executed. The project team is formed based on the contract scope and involves resources for engineering, procurement, logistics, installation, civil works, project controls as well as resources from necessary support functions.

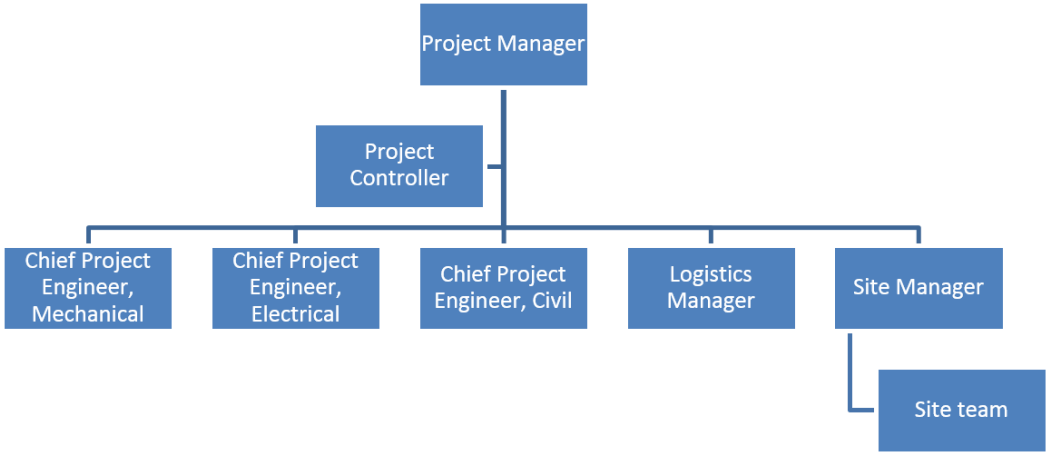


Figure 15 Typical Wärtsilä core project team

Project Risk Management

The project team identifies the risks of the project work for power plant delivery and creates a response plan to mitigate them.

Project Financial Management

The project financial management is done by planning and following the contractual invoices, payments, performance bonds and payment securities.

Taxation and work permits - Customer shall support in obtaining the work permits and other licences required for the employees of Supplier to perform the service in the project site.

Project Handing Over

The project will be handed over as set forth in this contract. Handing over will be done when commissioning activities are completed and requirements set forth in the contract are fulfilled. Warranty period set forth in contract will be handled by dedicated warranty team, led by lead warranty manager.

F1.1 PROJECT EXECUTION PLAN

1 Execution plan for Wärtsilä supplied equipment and services

F1.3 PROJECT TIME MANAGEMENT

Project time management is conducted to plan and control the timing of important project milestones in order to ensure a timely delivery of the project according to the contract.

1 Time management

Time Management is based on Schedule Management System developed within Wärtsilä Energy Solutions. The Schedule Management System includes processes for Schedule Development, Control and Reporting. The aforementioned processes are the same regardless of the work package or project phase. Microsoft Project is used as the scheduling tool following the principles of precedence-diagram-method.

Schedule Development

The purpose of schedule development is to model a schedule that indicates when and in what sequence works are planned to be carried out according to items and work under the responsibility of Wärtsilä. Schedule development is approached by progressively increasing the level of detail as the works progress. The levels of detail are defined as master, coordinating and detailed schedules which represent different levels of decomposition of the project schedule.

A master schedule outlines the entire project and is developed early on in the project. Activities generally span several months and their timing is estimated with lagged logical dependencies.

Coordinating schedules are decomposed of the master schedule in order to coordinate works between project phases or specific work packages. Activities generally span several weeks but they are logically connected without lags to the extent possible making the critical path visible.

Detailed schedules are decomposed of the coordinating schedules in order to control works within project phases or work packages. Activity durations are generally measured in days and are logically connected without lags unless illustrating a pause in sequence.

The project schedule is generally decomposed to coordinating level while increasing the level of detail from coordinating to detailed for phases and work packages only if special attention is required.

Schedule Control

The purpose of schedule control is to determine the progress to date in order to update the schedule for the future. Schedule control is conducted periodically and always on the highest level of detail to which the schedule has been developed to. After each time the schedule is controlled all the works completed are updated the way the works actually took place thus indicated in the past, left of the status date in the Gantt chart. On the other hand, future works are updated to reflect current plan thus indicated in the future, right of the status date in the Gantt chart.

Schedule reporting

Schedule reporting is conducted on monthly basis and is intended to give stakeholders indication regarding the progress and performance of the project. Reports are provided in pdf format.

Progress report is the updated schedule model rolled up to Master level.

Performance report is an S-curve based on Earned Value Management comparing the planned, actual and forecasted performance.

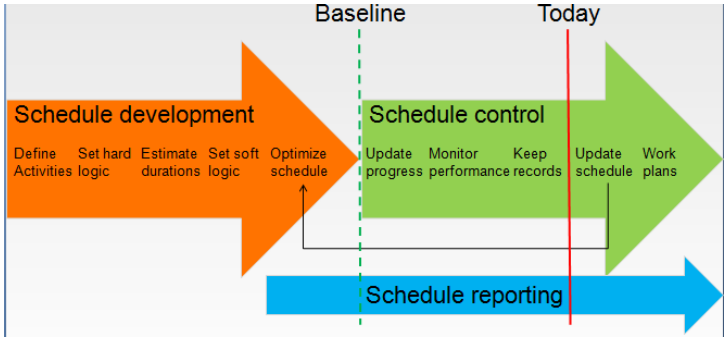


Figure 16 Schedule Management process

F1.4 PROJECT COMMUNICATION MANAGEMENT

The project team communicates with the project's external stakeholders during the entire project lifecycle by establishing and maintaining clear communication with Customer and other stakeholders by managing project correspondence and scheduling and leading project meetings.

Communication practices, project meetings and project progress reporting will be executed as set forth in this contract. The following means are used: reports, meetings (face-to-face and virtual meetings) and e-mails.

Wärtsilä uses its own online collaboration platform DCM365 (described in document control) as a tool for information and document handling.

1 Project execution plan

Based on Wärtsilä template.

1 Project kick off meeting with Customer

1 Monthly report

Based on Wärtsilä template.

F1.5 PROJECT QUALITY MANAGEMENT

The project team ensures that the project is managed in compliance with project policies and procedures set forth in Wärtsilä's delivery model or in the contract concerned.

1 Project quality management plan

The project quality management plan (PQMP) provides a description of the quality management system implemented within the scope of the project. It also defines the quality activities and responsibilities for Wärtsilä's scope of supply. The PQMP is based on ISO 10005:2005 standard.

1 Inspection and test plan

Project inspection and test plan template describes the inspection and witnessing points.

The project inspection and test plan (ITP) describes the major inspection and test activities before the dispatch of equipment, in the scope of supply of Wärtsilä. Its purpose is to identify the acceptance criteria, test methods and surveillance points of the suppliers, Wärtsilä and the Customer as per the contractual obligation. When the witnessing party is not present or waived off, the test or inspection can be executed as described in the ITP.

1 Site quality plan

Site quality plan (SQP) purpose is to specify planned inspections and tests to be performed on site during installation, commissioning and performance tests. SQP also defines responsible party to execute such inspections or tests according to contractual obligations.

Customer will be informed by Wärtsilä about tests and inspections that are specified in SQP and his Representative is invited to witness tests and inspections.

F1.6 TRAVEL, ACCOMMODATION AND LOCAL TRANSPORTATION

1 Travel to/from site for Wärtsilä personnel

1 Accommodation for Wärtsilä personnel

1 Local transport for Wärtsilä personnel

F2 PROCUREMENT MANAGEMENT

1 Procurement management [items and work under the responsibility of Wärtsilä]

Procurement management refers to the processes necessary to purchase or acquire products, services or results for a project. Procurement management includes agreements with the terms and conditions, which are legal documents between Wärtsilä and its suppliers.

Wärtsilä applies a set of mandatory requirements for suppliers, meaning they have to comply with general features and issues related to quality, product-specific requirements, environmental management, occupational health and safety, social responsibility, legal compliance and Wärtsilä's code of conduct. These requirements are included in the standard supply agreements and by monitoring the suppliers Wärtsilä controls regularly that the suppliers comply with these requirements.

The procurements are based on pre-engineered proven products and services for key equipment of the power plants. The suppliers and service providers of these are checked, validated and approved. Long-term agreements are made with selected suppliers. The long-term supplier relationship is to ensure quality, safety and performance of equipment. One-time procurements can be made project wise.

Wärtsilä regularly conducts evaluations for supplier approval. Evaluations are divided into three categories: pre-assessment, auditing and performance reviews. A pre-assessment is done for a new supplier. Audits are conducted for new key suppliers, while performance reviews are carried out to identify and solve deviations from requirements.

A procurement plan is made as part of the project plan and is based on the contract requirements and project time schedules.

The requirements from the contract are converted into requests for quotation to the suppliers. The quotations are technically and commercially evaluated and a purchase order is released to the chosen supplier.

F2.1 WORKSHOP TEST

4 Engine test according to standard programme with LFO

1 Demonstration test on 6L32LG with LPG

F3 DOCUMENT CONTROL

1 Document control [items and work under the responsibility of Wärtsilä]

Project Document Control

The objective of project document control is to:

- Ensure that the all stakeholders, both internal and external, have access to the valid revisions of documents in real time
- Provide means to identify which purpose each document is good for
- Remove the risk of having duplicates in use with different revision and content by applying single source technology
- Reduce unnecessary email communication, and consequently improve project communication and transparency

Wärtsilä Energy Solution use DCM365 as the tool for document control.

Project Collaboration Platform DCM365

DCM365 is the document control platform used in Wärtsilä for online collaboration and document sharing with project stakeholders. The main purpose of the system is to have a comprehensive document control and transmittal management environment which is accessible for both internal and external project stakeholders. It also provides a possibility to keep track of comments and approvals received for every transmitted document.

DCM365 is independent of operating system and accessible from any device anywhere in the world. DCM365 is built on Office 365 SharePoint Online (SPO).

The following functions are included:

- Manage the flow of documents between stakeholders securely and efficiently
- Control the design review and approval processes in different phases of the project
- Maintain comprehensive master document register (MDR) to ensure identification, revision, and status of documents
- Send automated notifications on document activities (status changes, comments etc.)
- Keep track record of formal document transmittals and project correspondence
- Shared e-mail account for the project, which is used for capturing all official e-mail correspondence
- Control the user access to project information based on the users' role in the project

Information security

The platform, Office 365, complies with the ISO 27001 - Information security management and the EU data protection directive 95/46/EC. Furthermore the following security requirements are be met:

- Users authenticated by username and password
- All project stakeholders have access to accurate and correct information based on their role in the project
- Use only European data centres
- Encryption at rest to protect the data on servers
- Traffic between browser and server is encrypted using 128-bit secure sockets layer (SSL) encryption

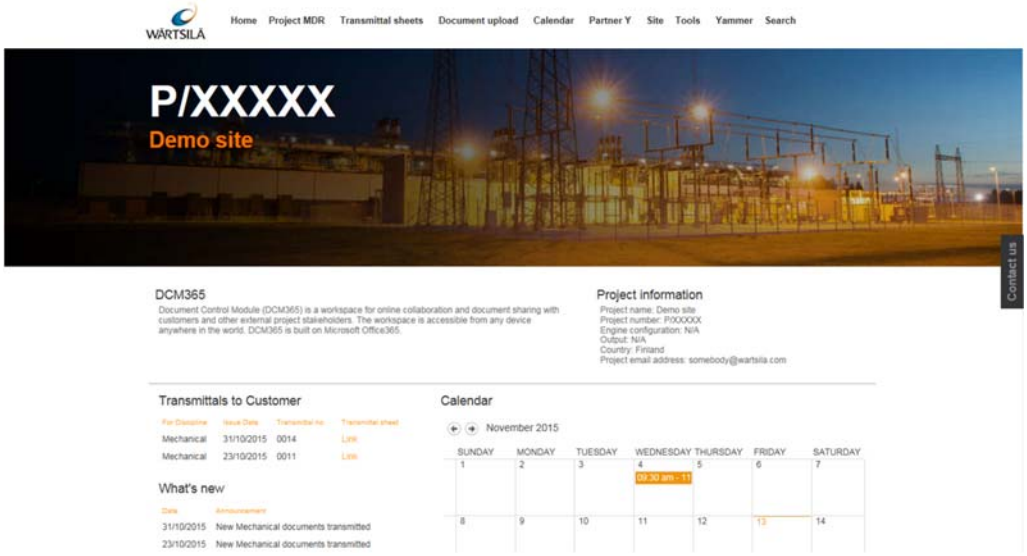


Figure 17 The main page of DCM365

G CONSTRUCTION MANAGEMENT

General

Construction management refers to the planning, leading and managing all activities related to the construction site, which are necessary for ensuring that site activities are performed within the set time schedule and according to the contract and quality and safety requirements of the project.

G1 SITE ORGANISING AND RESOURCING

A Wärtsilä site organisation is set up based on the project needs. The site activities are led by a site manager reporting to a project manager. Needed resources are added on a timely basis to fulfil project requirements. A commissioning team is assigned to the site when commissioning activities begin (ref Commissioning service).

Site manager is Customer's main point of contact at the site during construction. Customer assigns authorised site representative to be main point of contact towards Wärtsilä.

A construction management team is set up in such a way that it ensures legality, timeliness and good working conditions. Wärtsilä and its subcontractors take care of work permits, travelling, and on-site requirements of their personnel. On-site requirements include office space, housing, transportation and medical care. The customer assists and sponsors work permitting for a smooth and timely process.

Lodging and office facilities for Customer's and other parties' personnel are not included in Wärtsilä's scope (if not otherwise specifically stated in the contract).

Site personnel working times are according to laws and regulations, and planned to maintain personnel health and safe working conditions.

1 Site management [items and work under the responsibility of Wärtsilä]

1 Construction/site management team

1 Wärtsilä and Wärtsilä´s subcontractors personnel work permits

G2 HEALTH, SAFETY, ENVIRONMENT (HSE) AND SECURITY MANAGEMENT

Wärtsilä is certified for environmental management system ISO 14001 and occupational safety management system OHSAS 18001. Health, safety and environmental (HSE) management is one of the key elements in construction activities. HSE documentation, including plans, procedures and other HSE documentation, is prepared per project and implemented at the worksite. HSE procedures follow Wärtsilä's internal HSE instructions, contractual requirements, and local legislation. The main purpose of HSE documentation is to identify the occupational health and safety management methods applied to the contractual scope of work by Wärtsilä, the customer and subcontractors. The documentation also provides rules for co-operation between the customer, Wärtsilä, subcontractors and others working in a shared workplace with regard to health, safety and environmental matters. All personnel to perform their activities in strict compliance with Wärtsilä's and contractual safety requirements. The construction management team is responsible for implementing the HSE management system and for monitoring its efficiency.

Worksite personnel are inducted for HSE management system. All incidents are reported, investigated and corrective actions are taken to improve safety. Wärtsilä monitors HSE performance in delivery projects continuously, and sets HSE targets and objectives for continuous improvement.

A site security plan is prepared and implemented, when site security is part of Wärtsilä's scope. If security arrangements are Customer's responsibility, Wärtsilä to review the plans before site activities are started up.

1 Health, safety and environment plan

1 Site safety management and HSE plan implementation

1 HSE reporting and corrective actions

1 Emergency action plan

1 Worksite personnel induction and training for site HSE management system

G3 CONSTRUCTION PLANNING

General planning of the construction works and site is to commence at an early stage of the project. Special requirements together with construction interfaces and interconnections between project stakeholders are to be identified, evaluating their impact on the total installation and construction work.

Thorough construction planning is essential for creating a safe and organised construction site. Construction planning is a continuous process and activities are to be planned individually before commencing the work. Critical activities are to be planned in more detail, by means of method statements and job safety analyses.

The main tool for effective construction planning is the construction time schedule including pre-defined construction milestones. These construction milestones include important cross-discipline dependencies and priority installation items.

The constructability of the power plant is based on Wärtsilä's proven modular design and project specific drawings.

A site manning plan is to be drawn up in cooperation with subcontractors in coordination with the construction schedule. The site manning plan is to include estimated manpower loading and quantity and durations for main construction equipment.

1 Construction planning

1 Construction management plan

1 Site manning plan

G4 SUBCONTRACTING

Construction and installation work is performed by subcontractors selected and managed by Wärtsilä. Wärtsilä's project team is responsible of subcontracting and it follows a defined subcontracting process. Sub-contractors are selected based on proposals requested from a limited number of pre-assessed construction companies. The pre-assessment includes evaluation of construction capabilities, social responsibility, financial stability and quality references of the candidate companies.

The bids are evaluated against common criteria and criteria imposed by potential specific design solutions.

Contracts are negotiated with selected subcontractors. Proper induction for project and training as needed is arranged for subcontractors' personnel. Subcontracts are administered in due manner.

1 Subcontractors pre-assessments

1 Subcontracting planning

1 Preparing bidding documents

1 Bid evaluation

1 Subcontract negotiations and finalisation

1 Subcontracts administration

G5 SUPERVISING AND STEERING THE CONSTRUCTION WORKS

The main task of Wärtsilä construction management team is to safely manage and steer the construction works of the selected subcontractors in order to reach contractual obligations in agreed schedule. Subcontractor performance is continuously supervised and steered to reach planned construction progress and for maintaining high installation quality. Wärtsilä construction management adapt prudent industry best practices together with Wärtsilä internal guidelines to increase the performance of the selected subcontractors.

Construction works are sequenced and prioritised for an optimised workflow in construction phase and also to secure a smooth transition to plant commissioning phase. During construction phase, Wärtsilä construction management team is performing daily operational planning taking into account safety, quality, construction design and material availability. Rapid response and effective change management enable constant progress in all areas of plant construction.

Once the plant construction is approaching mechanical completion then construction activities are sequenced and coordinated to enable early start of selected commissioning activities.

Managing and supervising Customer's or other parties' sub-contracts and contractors is not included in Wärtsilä's scope.

1 Subcontractors management and steering

1 Construction works sequence and prioritisation

1 Daily operational planning during construction

G6 COMMUNICATION AT SITE

Wärtsilä is to coordinate and steer the works between different professional disciplines and different stakeholders (the Customer, sub-contractors and consultants) on the construction site. Wärtsilä is to deploys the necessary processes to ensure timely and appropriate decision making and generation, collection, distribution, storage retrieval, and disposition of project information concerning the site.

Coordination and steering is to be executed by means of establishing and maintaining clear communication with the Customer (or the Customer's representative on site) and other stakeholders in order to minimise risks during construction. Transparent and open stakeholder communication enables smooth project execution and decision making.

The most important steering system at the site is an active meeting procedure. The meetings will be organised in advance, short, well defined and targeted on clear decisions, and are typically to be chaired and documented by Wärtsilä. Minutes of meetings are to be signed by all parties. A schedule for weekly meetings is to be planned and communicated to all parties involved, and is to consist typically of short daily morning briefs, weekly safety meeting, weekly meetings with the Customer, and weekly schedule /progress meetings with subcontractors and coordination meetings with other stakeholders.

The Customer, subcontractors and stakeholders shall have access to information via DCM365, which is Wärtsilä's own online collaboration platform for site information and document handling.

1 Coordination and steering the works between different professional disciplines and different stakeholders

1 Site meetings schedule

1 Site meeting chairing and minutes

1 DCM365 - online collaboration platform for site information and document handling

G7 SITE MATERIALS MANAGEMENT

Professional site logistics and materials management is essential for smooth and timely installation as project includes large quantities of equipment and materials. Wärtsilä plans site logistics and handles and keeps track of all the power plant equipment and materials in Wärtsilä scope coming to, stored and used on site as well as coordinates deliveries with freight forwarders. For this purpose Wärtsilä uses its own logistics and site material management ICT system, named Logwis.

A site storage plan is made which includes plans for laydown areas and storage, as well as for arrangements for material warehousing and handling during construction.

1 Site logistics and site material tracking and management

1 Logwis, ICT (Information and communications technology) system for site logistics and site material management

1 Site storage plan

G8 SITE TIME MANAGEMENT, CONTROLS AND PROGRESS REPORTING

A time schedule (Gantt chart) covering the construction activities is developed and maintained in accordance with Wärtsilä's schedule management system and as per contract requirements. Schedules will be done in Microsoft Project and distributed as pdf. The work will be broken down into sufficient details to enable a correct logical sequence of activities to be established.

Based on schedules the s-curves (progress curves) for each discipline and site progress overall will be directly produced and reported.

Site project status and progress is followed up on a daily basis. Site work coordination and control is performed using weekly detailed construction look ahead schedules. These schedules indicate activities actually completed the previous week in relation to those scheduled, activities planned for the current week and activities planned for the following week. Weekly planning and control is done in weekly schedule meetings with project parties. Daily activities are coordinated in morning briefs.

Construction progress reports will be submitted at agreed intervals and with agreed content. The progress will be reviewed in weekly meetings.

1 Time schedule covering construction activities

1 Progress follow-up, progress S-curves

1 Weekly look-ahead schedules

1 Schedule control and weekly updates

1 Construction progress reports

G9 SITE QUALITY MANAGEMENT

Wärtsilä construction management team is continuously and proactively instructing, following and checking the installation quality during construction. This active monitoring minimizes installation mistakes and rework.

By active construction management and constant quality monitoring Wärtsilä ensures the expected functionality of the plant and sets the base for operational reliability.

1 Organising quality assurance/quality control on site

1 Perform quality control, inspections and tests on-site as per SQP

1 Site quality assurance documentation

Site quality assurance documentation (SQAD) is Wärtsilä's application for execution of site inspections and tests performed to validate plant installation quality and its performance according to contractual requirements. SQAD is the main tool used by Wärtsilä team on site to organize the tests as per site quality plan (SQP) and document the inspection and test results. A set of completed site quality assurance documentation (SQAD) is provided in digital format.

H TEMPORARY INSTALLATION AND ARRANGEMENTS

Temporary facilities consist of items that are needed during construction. A temporary facilities plan is made, which includes locations and dimensions of temporary facilities, utility connections, laydown areas, access and temporary roads.

The temporary facilities will be removed and areas cleaned when demobilization of construction work is completed.

Materials, installation and maintenance of temporary facilities and controls to be in compliance with applicable regulatory requirements.

Contract /scope of work defines what site temporary utilities are included for Wärtsilä's and what to Customer's scope.

H2 UTILITIES

1 Internet connection to site

1 Internet consumption during construction

1 Illumination during construction

1 Sewage during construction

1 Illumination during construction

1 Parking places during construction

1 Construction equipment and tools

H3 SECURITY

1 Security for personnel transport between site and accommodation

H4 HEALTH SAFETY AND ENVIRONMENT

	1	Fire protection during construction and commissioning work on the site
	1	Medical evacuation plans of seriously injured persons
	1	Chemical storage
	1	Sanitary
	1	Hygiene and safe canteen and food preparation (when on-site canteen)
	1	Work permitting at site
	1	Locking and tagging procedures
	1	Dust control
	1	Waste material handling
H5		DEMOBILIZATION
	1	Removal of temporary facilities
	1	Cleaning of areas used by Wärtsilä
	1	Removal of excess imported material

I LOCAL SUPPLY AND INSTALLATION

I1 INSTALLATION OF MECHANICAL EQUIPMENT

1 Installation of mechanical equipment supplied by Wärtsilä

I2 INSTALLATION OF ELECTRICAL EQUIPMENT

1 Installation of electrical equipment supplied by Wärtsilä

I3 INSTALLATION OF CIVIL EQUIPMENT

1 Installation of civil equipment supplied by Wärtsilä

J COMMISSIONING AND COMMISSIONING MANAGEMENT

J1 COMMISSIONING

The purpose of commissioning is to carry out necessary activities to achieve, validate and document that the plant/installation and its systems are designed, installed, tested and capable of being operated and maintained to perform in conformity with the project design and contract requirements.

Commissioning is to be divided into:

1. Installation quality assurance (pre - commissioning)
2. Functional test
3. Performance test

Note: Power plant equipment adjustments and commissioning require sufficient running-in period with load prior to taking SCRs in use. See Project time schedule for details.

J1.2 COMMISSIONING SITE PERSONNEL

1 50 hrs maintenance

J1.3 INSTALLATION QUALITY ASSURANCE (PRE-COMMISSIONING)

1 Installation quality assurance (pre-commissioning)

Installation quality assurance (pre – commissioning) is performed to ensure that plant is ready for start-up and functional tests. The systems and equipment are tested without power and without any media connected to these systems. This step is achieved when plant is mechanically complete.

During installation quality assurance mechanical and electrical systems installation inspections and test are done according to the contract and site quality plan.

Examples of inspections and tests are:

- Piping pressure testing
- Cables insulation resistance tests
- Cables loop checks
- Unit inspections

Deliverables of installation quality assurance include all installation quality related documents as per contract requirements.

J1.4 FUNCTIONAL TEST

1 Functional test

During functional test electrical and control systems are energized, process systems are filled with operation media and engine specific and auxiliary tests are undertaken as per contract

requirements. The functional tests serves to ensure that an item of mechanical or electrical equipment, or control system functions as per design.

Activities during functional test are described in site quality plan and in site quality assurance documentation and include:

- Energizing electrical systems
- Start-up of auxiliary systems
- Equipment no-load tests
- Equipment load tests

Deliverables of functional test are quality related documents as per contract requirements. A notification for starting of performance test will be given to Customer.

J1.5 PERFORMANCE TEST

1 Performance tests

Performance tests are conducted in accordance with the test procedures described in contract to demonstrate and verify compliance with the performance guarantees in the contract.

Deliverables of performance test are quality related documents as per contract requirements. Handing over documents are prepared as per contract requirements.

4 Engine test according to Wärtsilä programme with LPG

1 Control system test

1 Generator unit test

1 Stack testing with CEMS

1 Comm. of protection relays

J1.8 TEST EQUIPMENT

1 Test equipment

J2 COMMISSIONING MANAGEMENT

Commissioning management refers to the planning, leading and managing all activities related to the commissioning work for Wärtsilä supplied systems and solutions, which are necessary for performance of the commissioning service within the set time schedule, and according to the quality and safety requirements of the project.

1 Commissioning planning

General planning of the commissioning works is to start at an early stages of the project as part of project planning. The commissioning plan is to be based on the project requirements.

Commissioning planning is a continuous process, activities are planned in more detail closer to commencement of the work.

1 Commissioning organization and resourcing

The Wärtsilä commissioning organisation is part of the construction management team and is built based on the project needs. The commissioning activities are to be led by the commissioning manager.

1 Health, Safety and Environment during commissioning

Health, safety and environmental (HSE) management is one of the key elements at commissioning activities. During commissioning same HSE management system as during construction (see construction management) will be used in strict compliance with Wärtsilä and contractual safety requirements.

1 Commissioning coordination and meetings

Coordination and steering is to be executed by means of establishing and maintaining clear communication with the Customer (or the Customer's representative on site) and other stakeholders in order to minimise risks during commissioning.

The most important steering system at the site is the active meeting procedure. The meetings are to be organised in advance, short, well defined and targeted on clear decisions, and are typically chaired and documented by Wärtsilä. Minutes of meetings are to be signed by all parties. The weekly commissioning meetings schedule is to be planned and communicated to all parties involved, and consist typically of short daily morning briefs, weekly commissioning meetings and coordination meetings with stakeholders as needed.

Wärtsilä uses its own online collaboration platform DCM365 (described in document control) for site information and document handling. The Customer, subcontractors and stakeholders have access to information via DCM365.

1 Commissioning time management, controls and progress reporting

The commissioning schedule, control and reporting is to follow the methods described under construction management and the project schedule management system.

1 Commissioning and performance test documentation

The site quality plan (SQP), site quality assurance documentation (SQAD), performance test documentation and other contractually required documentation are to be prepared and provided to Customer. The SQP and SQAD are described under the construction management section.

J3 INITIAL FILLINGS

1 Initial fillings of lubricating oil

Initial chemicals for water treatment

K TRAINING

This Modular power plant supply includes the following training programme for the personnel of USVI Water and Power Authority. The programme is intended to give the operation personnel the necessary basic knowledge of how to operate and maintain the supplied equipment.

K1 TRAINING AT WÄRTSILÄ FACILITY

1 Engine operation and practical training course

The purpose of the training is to learn how to operate and maintain the engine in a safe and economical way, and to introduce the participants to evaluation of engine operating values and maintenance planning.

The programme for the training course is:

- General design and function of W32LG Engine
- Liquid Gas engine safety (LPG)
- Liquid Gas regulating system (LPG)
- Function of engine built-on systems
- Fuel oil and or fuel gas, lubricating oil and cooling water requirements
- Engine automation system
- Engine operation
- Engine maintenance operations

Duration	5	days
Participants	Up to 8	

1 Power plant introduction course

The purpose of this training is to familiarise the plant management with the design features of the entire plant, routines strategies for operation and maintenance of the plant.

Place	Training Center
Time	half a year after the power plant has been commissioned
Duration	5 working days
Participant	4 persons from the power plant staff
Course language	English

The programme for the training course is:

- General design of power plant
- Liquid (oil/gas), lubricating oil and cooling water requirements
- Design and function of engine auxiliary systems
- Plant operation principles

Duration	5	days
Participants	Up to 8	

1 Power plant electrification course

The purpose of this training is to introduce the participants to the design features and operation of different electrical systems, thus enabling them to operate the plant in a safe and effective way.

The programme for the training course is:

- Electrification
- Operation modes and principles
- Control and monitoring system
- Alternators and Automatic Voltage Regulators (AVRs)
- Excitation system
- Protection relay
- Operator station program
- Low-Voltage/Medium-Voltage systems
- Local control panels
- Engine control system
- Direct Current -systems
- Engine alarm and protection system

Duration	5	days
Participants	8	

1 Travel - Airfare

1 Travel - Board and lodging

1 Travel - Local transportation

K2 TRAINING AT SITE

1 Power plant introduction on site

The purpose of this training is to familiarise the plant management with the design features of the entire plant, routines strategies for operation and maintenance of the plant.

Place	on-site
Time	half a year after the power plant has been commissioned
Duration	5 days.
Participant	20 persons from the power plant staff (maximum)
Course language	English

The programme for the training course is:

- General design of power plant
- Fuel oil, lubricating oil and cooling water requirements
- Design and function of engine auxiliary systems

- Plant operation principles

During the training course, Wärtsilä will provide course documentation to each participant.

The Customer should provide a suitable conference room with blackboard, lunch and coffee during the course as well as transportation between the hotel and the course location.

Travelling and accommodation for the Wärtsilä trainers is provided by Wärtsilä.

1 Power plant operation and maintenance course on site

The purpose of the training is to introduce the plant operation- and maintenance staff to the daily operation routines, and to give them basic instructions for preventive maintenance measures.

Place	on-site
Time	half a year after the power plant has been commissioned
Duration	10 days
Participant	20 persons from the power plant staff (maximum)
Course language	English

The programme for the training course is:

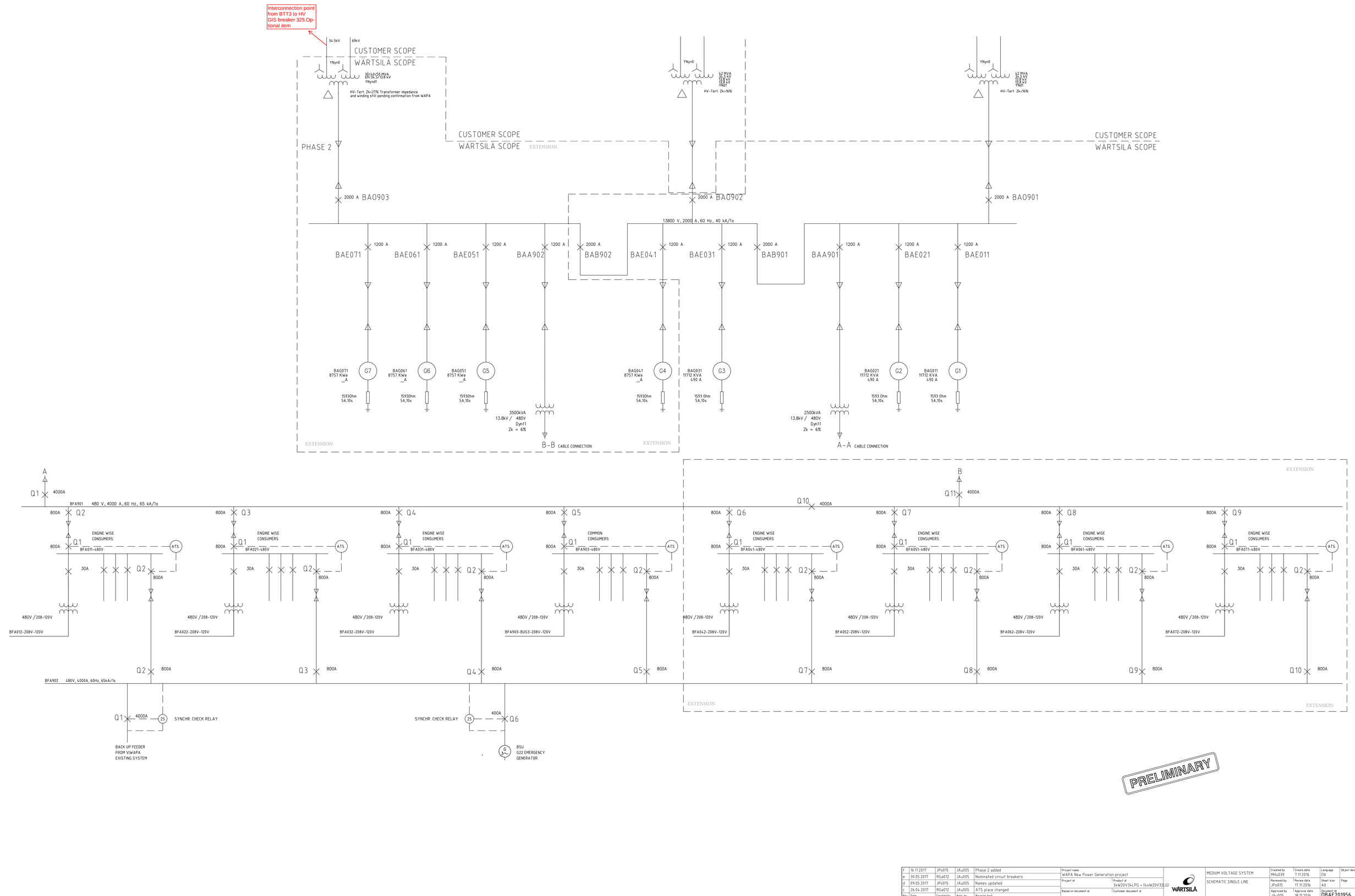
• General design and function of W32LG Engine
• Liquid Gas engine safety (LPG)
• Liquid Gas regulating system (LPG)
• Function of engine built-on systems
• Liquid gas, lubricating oil and cooling water requirements
• Engine operation
• Engine maintenance operations
• General design of power plant
• Function of auxiliary systems
• Auxiliary systems operation
• Auxiliary systems maintenance operations

During the training course, Wärtsilä will provide course documentation to each participant.

The Customer should provide a suitable conference room with blackboard, lunch and coffee during the course as well as transportation between the hotel and the course location.

Travelling and accommodation for the Wärtsilä trainers is provided by Wärtsilä.

APPENDIX 1A - Annex A



Rev.	Date	Created by	Appr. by	Revision text
f	16.11.2017	JPo015	JAu005	Phase 2 added
e	30.05.2017	RGa012	JAu005	Nominated circuit breakers
d	09.05.2017	JPo015	JAu005	Names updated
c	26.04.2017	RGa012	JAu005	ATS place changed

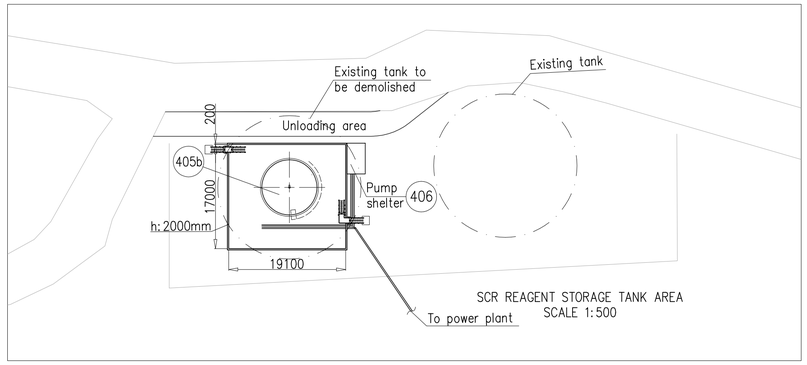
Project name	WAPA New Power Generation project
Project id	Product id: 3xW20V34LPG + (4xW20V32LG)
Based on document id	Customer document id

WÄRTSILÄ

MEDIUM VOLTAGE SYSTEM	Created by: MiHu039	Create date: 7.11.2016	Language: EN
SCHEMATIC SINGLE LINE	Reviewed by: JPo015	Review date: 17.11.2016	Sheet size: A0
	Approved by: JAu005	Approval date: 18.11.2016	Document id: DBAE201956

Page: 1 / 1
Object designation:
Rev: f

ANNEX 1A - Annex B



SCR REAGENT STORAGE TANK AREA
SCALE 1:500

SITE AREA (This list applies to Engine hall plan, Engine hall section and Site layouts.)						
Item No.	Pcs.	Code	Description	Volume [m³]	Weight [kg] Operative	Mounting level (Floor level)
124	4	ZAC	Booster unit		–	–
251	8	VCA	Radiator		7885	+4.000
351	4	NHA	Exhaust gas silencer		4780	+4.761
403	4	YBA	SCR (DeNOx)		–	–
408	1	YMB	CEMS		–	+0.000
414	4	–	Vocsidizer		–	–
659	1	BFB	Station transformer		–	–

TANK YARDS / LO UNLOADING AREA						
Item No.	Pcs.	Code	Description	Volume [m³]	Weight [kg] Operative	Mounting level (Floor level)
113	1	PCA	LFO feeder unit	–	–	+0.600
138	1	PAF	Pilot LFO feeder	–	–	+0.600
142	1	–	LPG Bullet tank	200	–	+1.100
152	1	QAC	Clean lube oil tank	20	22590	+1.100
153	1	QAD	Used lube oil tank	20	22590	+1.100
405a	1	YAB	SCR reagent tank	50	–	+1.100
415	1	–	SCR reagent filter unit	–	–	+0.600

SCR REAGENT STORAGE TANK YARD / REAGENT UNLOADING AREA						
Item No.	Pcs.	Code	Description	Volume [m³]	Weight [kg] Operative	Mounting level (Floor level)
405b	1	YAB	SCR reagent tank	500	–	+0.000
406	1	YAC	SCR reagent pump unit	–	–	+0.000

PRELIMINARY

WÄRTSILÄ

Master layout

Power plant, site

WAPA Phase II

4xW20V32LG

Proj. no.

Product: W20V32LG	ACA	ASLY DRG:	
MADE 23-Mar-2020 André Lassfolk		Units: mm/kg	
CHKD		Page No.	
APPD			

Based on Document: | Customer Document:

Scale: 1:250 1:500 | Size: A1 | Doc. ID: DBAE659709 XX Rev.

Confidential

INTERNAL Specification

Title:	Project Design Basis (PDB)	DocID:	DESA00004422
		Revision:	-.2
Author:	Petteri Mäkinen	Status:	Draft
Draft by:	Petteri Mäkinen / 30 April 2020	Pages:	1 (14)
Organisation:	Wärtsilä Finland Oy Energy Solutions		
Project:	P/17402 WAPA 2		

Project Design Basis - WAPA II St. Thomas

Table of Contents

1 Project information

This design basis presents a summary of initial data and standards to be considered in the engineering of the below mentioned project.

1.1 General

Project Main Data		
Project name	WAPA II St. Thomas	
Project number		
Wärtsilä project delivery system	EPC	
Wärtsilä project class	A	
Project location, country and city	St Thomas, US Virgin Island, USA	
Global coordinates for A/0 point and a second point, coordinate system (WGS 84 / UTM)	UTM	
Plant Data		
Engine type	W20V32LG	
Number of engines	4	
Engine numbering	SQA041 starting from 0 axis	
Identification system for the power plant	Wärtsilä standard	
Plant type	Standby Island mode & Connected to grid	
Plant output	36 MW	
Voltage/Frequency	69 kV/34.5 kV/13.8 kV / 480 V / 60 Hz	
Fuel	LPG/LFO	
Site Conditions		
Altitude, height above sea level (m)	10 meters above sea level	
Ambient min and max temperature (°C)	Min 10°C (50°F) – Max +35°C (95°F)	
Design ambient temperature (°C) and relative humidity (RH)	30 °C (86°F), 65 %	
Noise limitations	Below 75 dB(A) outside site boundary	
Noise simulation document ID	Yes, available in doc DESA00004609 rev c	
Site air quality	Clean, close to sea	
Atmospheric corrosivity category, INSIDE ISO 12944-2	☐ C1 Very low	☐ C4 High
	☐ C2 Low	☐ C5-I Very high (industrial)
	☒ C3 Medium	☐ C5-M Very high (marine)
Atmospheric corrosivity category, OUTSIDE ISO 12944-	☐ C1 Very low	☐ C4 High
	☐ C3 Medium	☐ C5-I Very high (industrial)
	☐ C3 Medium	x C5-M Very high (marine)

1.2 Engineering documentation

Specific Information	
Language in drawings and documents	English
Drawing frame and title block	Wärtsilä standard
Document numbering	Wärtsilä standard

1.3 Technical documentation

Description	Available	Document ID	Imp.order
Technical specification	☐		
Tender documentation	☐		
Wärtsilä standard solutions	x	Wärtsilä design handbooks	1

The importance order of the technical documentation follows an ascending order, with the highest importance being equivalent to the smallest number.

1.4 Master layouts

Description	Available	Document ID / Remarks
Site layout	☒	
Site area layout	☒	
Engine hall, plan	☒	
Engine hall, section	☒	
North direction	☒	
Wind rose and wind prevailing direction	☒	Prevailing wind direction NE
Master layouts documents IDs:	☐	Continue with same document ID as in sales:
	☒	New document IDs to be taken

1.5 Road dimensioning

Description	Vehicle type
Truck type to be considered according to AASHTO	WB-50

1.6 Wind load

According to IBC 2018/ ASCE 7-16

Description	Value	Remarks
Basic wind speed	175 mph	ASCE 7-16 or VIBEC VIBEC adopts latest version of IBC
Risk category	III	
Exposure category	D	To be confirmed based on site locations

1.7 Seismic load

According to IBC and ASCE 7-16

Description	Value	Remarks
Earthquake spectral response acceleration	Ss= 1.22 g S1= 0.43 g	IBC 2018/ASCE 7-16
Site class	D	Unless otherwise provided in Geotech report
Risk category	III	
Importance factor	1.25	Standby plant
Component Importance factor	1.0	Depends on system

2 Safety design and Fire protection

2.1 Safety design

Description		Design Standard / Notes
Explosive atmosphere	☒	NFPA 58, NFPA 70, NFPA 497, API RP500, APE RP505
Working platforms, stairs and ladders	☒	OSHA
Escape routes	☒	National legislations/ IBC 2018/OSHA
Safety markings/signs	☒	ISO 3864-1:2011 & ISO 7010:2011
Emergency showers	☒	ANSI Z358
Electrical safety	☒	NESC, NFPA 70E

2.2 Fire Protection

Description		Design Standard / Notes
Sprinkler	☒	NFPA 13
Hose reels	☒	NFPA 14
Main fire line	☒	NFPA 24
Fire extinguishers	☒	Portable fire extinguishers layout according to NFPA 10, NFPA 58

3 Process and mechanical design

3.1 EG-set and module specifications

Description	Available	Document ID
Engine performance data (PERF).	☐	
Engine IOS specification.	☐	
Pipe Module Specification (MS)	☐	
Small Unit Specification (SUS)	☐	

3.2 Piping and ducting specification

Description		Remarks
Description The piping and ducting will be designed based on the pressure and temperature ranges defined for each system, based on (DBAD535614)		Based on Wärtsilä standard, ASME design. LFO and LPG: non-standard design with higher design pressure
	x	Wärtsilä design directives, Piping according to ASME standards

3.3 Piping and ducting insulation

Description		Remarks
Insulation	x	Wärtsilä standard
	☐	Non standard

3.4 Platforms and over walks

Description		Remarks
Engine/Auxiliary platforms and over walks	☐	EN-Standard
	x	OSHA

3.5 Piping trace heating and freezing protection

Description		Remarks
Trace heating	☐	Steam heated.
	☐	Electrically heated.
Freezing protection		

3.6 System and dimensioning requirements

Description		Remarks
Equipment sizing, redundancy	x	To be specified, redundancy requested in order to start the engine even if the black-start unit is not in operation. During the engineering phase WAPA will review system by system to ensure redundancy in the common system. Engine wise processes and switchgear is excluded from redundancy requirement. Redundancy to be ensured by means of UPS switchboard.
	☐	Non standard

3.7 Standards

Pressure Piping	ASME B31.3
Pressure Vessels	ASME BPVC, Section VIII
Pipe Flanges and Flanged Fittings	ASME B16.5
Factory-Made Wrought Buttwelding Fittings	ASME B16.9
Forged Fittings, Socket-Welding and Threaded	ASME B16.11
Metallic Gaskets for Pipe Flanges	ASME B16.20
Studs	ASME B1.1, Class 2A
Nuts	ASME B18.2.2 and B1.1 Class 2B
Plain washers. Normal series.	ASTM F436/436M
Weld Procedure and Inspection	ASME BPVC, Section IX
Hot rolled structural steels	EN 10025
Seamless Carbon Steel Pipe	ASTM A106 Gr. B ASTM A53 Gr B, or ASTM A333 Gr.6
Welded Carbon Steel Pipe	API 5L, API A53 Gr. B
Wrought Carbon Steel Fittings	ASTM A234 Gr. WPB-S/W
Forged Carbon Steel Fittings	ASTM A105N
Carbon Steel Studs	ASTM A193 B7
Carbon Steel Nuts	ASTM A194 Gr. 2H
Seamless and Welded Stainless Steel Pipe	ASTM A312/A312M Grade TP304L
Wrought Stainless Steel Fittings	ASTM A403/A403M Grade TP304L
Forged Stainless Steel Fittings	ASTM A182/A182M Grade TP304L
Stainless Steel Studs	ASTM A193 Gr. B8, Class 2
Stainless Steel Nuts	ASTM A194 Gr 8
Piping in modules	EN
Fiberglass Tanks (Reagent)	API 12P
Vertical tanks	EN 14015, API 650 or API 12F
Horizontal tanks	EN 12285, API 620

Exhaust gas ducts, technical delivery conditions	material: Corten with cladding

4 Electrical design

4.1 Earthing system

Description	Details			
Earthing / Grounding grid below Zero	Bare Copper	☒		☐
Earthing / Grounding grid joints	C-Clamps	☐	Cad weld	☒
Equipment grounding	Insulated YG copper wire	☐	Bare Copper	☒
Design Standards	IEEE 80 & 81	☐	IEEE80,81,665 &NFPA 70	☒
Design/ installation Basis	(DBAD300903)	☐	Underground Electrical Installation Specification (DBAE782501)	☒
Local Requirements (to be specified)		☐		☐

4.2 Cable conduits

Description	Details			
Cable conduits	Schedule 40, PVC, Diameters used 6", 4" and 2"	☒	Any Other	☐
Conduit bends	Schedule 40, PVC, Minimum bending radius 800mm	☒	Any Other	☐
Conduit Material list based on	DAAB508823 rev:h Cable Conduits	☒	Any Other	☐
Design/ installation Basis		☐	Underground Electrical Installation Specification (DBAE782501) WAPA Cable and underground installation specification to be reviewed during engineering phase.	☒
Local Requirements (to be specified)		☐		☐

4.3 Lightning protection system

Description	Details			
Conductor material	Steel	☐	Copper	☒

Class of LPS	Level IV less than 80 thunderstorm/Level II More than 80 Thunderstorm	☒	Verified by Wärtsilä	☐
Design Standards	IEC62305-3	☐	NFPA 780-2018	☒
Design/ installation Basis	DBAB725968 rev:d	☐	Underground Electrical Installation Specification (DBAE782501)	☒
Local Requirements (to be specified)		☐		☐

4.4 Cable ladders

Description	Details			
Design Standards	NEMA VE-1 and VE-2	☒		☐
Cable ladder type	Meka KS-80	☐	BLINE	☒
Material	Stainless Steel/ similar for outdoor (C5-M), hot dip galvanized for indoor	☒	Anything else, Specify: Aluminium	☐

4.5 Lighting system

Description	Details			
Standards Lighting of indoor work places	ISO 8995-1:2002/Cor 1:2005	☐	IES RP-1-12 (office) IES RP-7-17 (indoor industrial)	☒
Emergency escape lighting system	EN 50172	☐	NFPA 101: Life Safety Code	☐
Local standard is any specify	IRAM-AADL J 20-06	☐		☐
Lighting materials	European materials	☐	USA materials	☒
Outlet sockets	European	☐	Local	☒
Emergency and Exit lights	Built-in batteries	☐	Central system	☐
Lighting panels	Wiring diagram drawings	☐	Excel lists	☐
Lux Levels	IEC	☐	Local	☒
Design basics			Project Specific Specification DBAF346717	☒

4.6 Fire detection system

Description	Details	Details USA/Project Specific		
Standards to follow	EN54 NFPA 72 IEC 60331-21 IEC 60332-1-2 IEC 60332-3-22	☐	- NFPA 70 - NFPA 72 - NFPA 101 - NFPA 58	☒
Connected to firefighting system	Yes	☒	No	☐

Material type/brand	Acc. To Wärtsilä standard supply, (to be same model as RH Phase 1) - Smoke detectors - Heat detectors - Flame detectors	☒	Project specific	☐
Design basis		☐	Project Specific Specification	☒

4.7 Cables

Description	Details		Details USA	
Design Standards	IEC 60305	☐	IEEE 525	☒
MV Cables - Conductor - Insulation - Metallic shield - Outer sheath - Rated voltage - Dimensions	Wartsila preferred cable types		DBAE782490 rev:-	Medium Voltage, Single and Multi-Conductor Cable to 15kV
LV Cables - Conductor - Insulation - Outer sheath	Wartsila preferred cable types		DBAE782498 rev:-	Low Voltage, Single and Multi-Conductor Cables
Control Cables - Conductor - Insulation - Outer sheath	Wartsila preferred cable types & Spec		DBAE782498 rev:-	Low Voltage, Single and Multi-Conductor Cables
Instrumentation cables - Conductor - Insulation - Outer sheath - Construction			DBAE782498 rev:-	Low Voltage, Single and Multi-Conductor Cables

4.8 Calculations and system studies

Description	Details		Details USA	
Design Standards	IEC	☐	NEC/IEEE	☒
Grid code Requirements	To be Followed	☐	Not To be Followed	☒
Grid code Requirements specific	Project specific	☐	PRC 25/26	☐

Local Requirements (to be specified)		☐		☐

4.9 Others

Description	Details	Details USA		
IT system - Phone & Data - CCTV - Clock system - PA system	IEC 60364	☐	CCTV: Exacq vision system Building access: S2 security system	☒
HVAC		☐	USA design	☒

5 Civil design

5.1 Standards

Description	Design	Manufacturing
Geotechnical design	As provided by USVI Licensed Geotechnical Engineer	
R/C foundations Load combinations Structural (Strength) design	ASCE 7-16 ACI 318-14	
Steel frame Load combinations Strength design	ASCE 7-16 AISC 360-16 AISC 341-16	
Vehicular surcharge loads	AISC 7-16, Ch.4 Live loads. Section 4.10.1. Notes a : (2) for mechanical parking structures without slab or deck that are used for storing passenger car only, 2,250 lb (10 kN) per wheel.	
Structural steel	Yield strength 355 N/mm² (~51 ksi) S355JR for steel inside buildings S355J2 for steel outdoors S355J2H for hollow-sections	In general EN 10025-2 hot-rolled EN 10025-2 hot-rolled EN 10219-1 cold-formed
Steel shapes	Hollow sections, cold-formed I-profiles Channel profiles Plates	EN 10219-2 EN 10365 EN 10365 -
Structural bolting assemblies		EN 15048-1
Bolts		EN-ISO 4014, 8.8 A, B or EN-ISO 4017, 8.8 A, B BS EN-14399-3 (pretensioned assemblies), 8.8/8, 8.8/10 or 10.9/10
Nuts		EN-ISO 4032, A, B, C BS EN 14399-3 (pretensioned assemblies)
Washers		EN-ISO 7091, A, C,

		100 or 300 HV BS EN 14399-5 or 14399-6 (pretensioned assemblies)
Water and sewage	International Plumbing code -2018	
HVAC	ASHRAE 55-2004 ASHRAE 62.1-2004 Wärtsilä Design Directives	

5.2 Live Loads

Description	Value	Unit	Remarks
Ground floor, qk	12	kN/m^2	ASCE 7-16 value 250psf (11.97kN/ m^2) CIRSOC value 12kN/m^2
Ground floor, Qk	40	kN	Wärtsilä standard
Roof, qk	0.75	kN/m^2	ASCE 7-16 value 20psf (0.96kN) Not simultaneously with snow
Working platforms, qk	5.0	kN/m^2	ASCE 7-16 value 100psf (4.79kN)
Working platforms, Qk	2.82	kN	ASCE 7-16 4.79kN/m2 applied on 762x762 mm2, equals to 2.78kN
Stairways, qk	5.0	kN/m^2	ASCE 7-16 value 100psf (4.79kN)
Stairways, Qk	1.35	kN	ASCE 7-16 value 300lb (1.33kN)
Engine platforms, qk	5.0	kN/m^2	ASCE 7-16 value 100psf (4.79kN) Wärtsilä standard value 5kN

5.3 Soil

Description	Available	Document ID
Soil investigation report	☐	
Foundation type	☐	Shallow foundations
	☐	Deep foundations

5.4 Concrete

Description	Data	Remarks
Concrete grade	C20/25 (4000 psi)	According to Exposure Class for the structure To be checked by CPE Civil
Reinforcement grade	ASTM A615, Grade 60	According to Exposure Class for the structure To be checked by CPE Civil

5.5 Buildings materials

Buildings	Load bearing structure	Roof	Walls
Power House / Engine hall	☒Steel	☒Load bearing steel sheets, insulation and corrugated steel sheets	☒Sandwich panels

	☐Concrete pre-cast elements	☐Roof elements and liquid roofing	☐Concrete pre-cast walls
	☒Concrete cast-in situ	☐Roof elements and steel corrugated sheets	☒Blocks/bricks
		☐Concrete pre-cast slabs	
Other buildings	☒Steel	☒Load bearing steel sheets, insulation and corrugated steel sheets	☒Sandwich panels
	☐Concrete pre-cast elements	☐Concrete pre-cast slabs	☐Concrete pre-cast walls
	☐ Concrete cast-in situ		☐Blocks/bricks

5.6 Process ventilation

Rooms/buildings		System preference
Engine hall	☒	Air inlet units and roof monitors
	☐	Air inlet units and roof fans
	☐	Extract wall fans and intake air louvers
	☐	Air inlet and outlet ventilation units
Heating	☐	Applicable

5.7 AC and heating

Rooms/buildings		System preference
Electrical rooms UB & Control room	☐	Split units
	☐	Wall mounted units
	☐	Roof top units
Administration building	☐	Split units
	☐	Roof top units
Gas Compressor building	☐	Split units
Heating	☐	Applicable for continuously manned rooms
	☐	Applicable for all rooms where HVAC is needed

5.8 Rain water drainage system

Rainfall Intensity	☒	50 mm/hour
Rain Water System	☒	Pipe system
	☒	Open drains and ditches
Rain water from containment areas, roads and parking areas to be treated	☐	Oily water separating system

5.9 Sewage system

Septic sewage system	☐	Septic tanks, emptied by trucks,
	☐	Connection to the sewage treatment plant
Septic sewage treatment	☐	Septic separating system
	☐	Sewage treatment plant connected to the rain water system
	☐	Infiltration field

5.10 Oily water system

Oily water treatment system	☒	Oily water underground collecting to sumps, pumped to sludge tank and emptied by truck
Chemical waste water system Chemical waste water comes from the Workshop and Warehouse washing area.	☐	Oily water underground collecting pits, emptied by trucks
	☐	Underground collecting sump, emptied by trucks