Wärtsilä 20V34DF,

Brand New Dual Fuel

8700 kW each, 750rpm, 11kV

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Wärtsilä multi-fuel power plants

Wärtsilä multi-fuel power plants are based on engines that are able to run on natural gas, light fuel oil, heavy fuel oil or a number of other liquid fuels, offering the ultimate in fuel flexibility.

The ability to switch to the most economical, or readiest available, fuel is of great value in a time of fluctuating fuel prices. Furthermore, the fuel can be switched whilst the engine is operating, for example if the gas supply is interrupted. This operational flexibility is a real advantage with the multi-fuel system.

The benefits of multi-fuel power plants include:

Fuel and operational flexibility
High efficiency
Low emission rates
Excellent reliability
Operational cost advantages
Easy adaptation to grid load variations.

2 Main data and conditions

Configuration

The Stationary power plant is equipped with 6 engines of the Wärtsilä 20V34DF type, as the prime mover.

3 Operation media

Fuels

Wärtsilä engines are designed and developed for continuous operation on fuels with a quality within the Recommended Limits described in the column “Engine” below. These values indicate the individual extreme limits for the engines only. Fuels having one or several values close to this limit might have a negative impact on the component lifetime.

Gas fuel

Parameter	Gas quality limit			
	Engine		Plant	Unit
Lower heating value (LHV)1	Minimum 24,000		37,2 27	kJ/m³ N
Methane number2	Minimum 77,5			
Methane contents, CH4	Minimum 70		87,8	vol-%
Hydrogen sulphide, H2S	Maximum 0.05		0	vol - %
Total sulphur3	Maximum 5		TBA	mg/k g
Hydrogen, H2	Maximum 3		0	vol - %
Carbon dioxide	Maximum 20		2,93	vol-%
Water and hydrocarbon condensates before the engine	Not allowed			
Ammonia	Maximum	25	TBA	mg/ m^3N
Chlorine + Fluorine's	Maximum	50	TBA	mg/ m^3
Particles or solids, content	Maximum	50	TBA	mg/ m^3
Particles or solids size	Maximum	5	TBA	l-m
Gas inlet temperature	Min / Max	0 / 50	5 4	^oC
Gas pressure to gas regulating unit inlet	Minimum	-	5	Bar (g)
Gas pressure to engine	Minimum	45		Bar (g)

1 Values given in m^3N are at 0 °C and 101,3 kPa

2 Methane number (MN) determined by the program AVL 3.2 with engine specific corrections
Minimum value dependent on receiver temperature.

3 Applies when CO catalysator is used

4 Min. 15°C above fuel gas dew point

5 Dependent on lower heating value (LHV) of the gas

Light fuel oil (LFO)

		Fuel quality limit			Test Method reference
		Engine	Plant	Unit	
Viscosity	Minimum		2.46	CSt at	ISO 3104
	Maximum		11	40°C	
Injection viscosity	Minimum	2.06		Cst	ISO 3104
Density	Maximum	900	890	kg/m³ at 15 C	ISO 3675 or 12185
Water	Maximum	0.3	0.5 (assumed)	% Vol.	ISO 3733
Sulphur	Maximum	2	0.5 (assumed)	% mass	ISO 8754or 14596
Ash	Maximum	0.01	TBA	% mass	ISO 6245
Carbon Residue	Maximum	0.03	TBA		ISO 10370
Flash point (PMCC)	Minimum	60	60	°C	ISO 2719
Pour point	Maximum	6	TBA	°C	ISO 3016
Cetane Index	Minimum	35	TBA		ISO 4264
Total sediment existent	Maximum	0.17		% (m/m)	ISO 10307-1 (see 7.5)

The limits above are based on the demands of ISO 8217:2005(E) standard and covers the fuel categories ISO-F-DMA and DMB.

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

6 Additional properties specified by the engine manufacturer

7 If the sample is clear and with no visible sediment or water, the total sediment existent and water tests shall not be required.

Heavy fuel oil (HFO)

Heavy fuel oils are blended products based on the residues from various refinery distillation and cracking processes. They are black viscous liquids which require heating for storage and combustion. Heavy fuel oils are used for diesel engines mainly in base load power plants. The **fuel specification** “HFO 2” is based on the ISO 8217:2005(E) standard and covers the fuel categories ISO-F-RMA 30 – RMK 700. Additionally, the engine manufacturer has specified the fuel specification “HFO 1”. This tighter specification is an alternative and by using a fuel fulfilling this specification, longer overhaul intervals of specific engine components may be expected (see the Engine Manual of a specific engine type).

Property	Unit	Limit HFO 1	Limit HFO 2	Test method reference
Viscosity at 50 / 100°C, max. at 100°F, max.	cSt Redwood No. 1 sec.	700 / 55 7200	700 / 55 7200	ISO 3104
Viscosity before injection pumps [4]	cSt	20±4	20±4	
Density at 15°C, max.	kg/m³	991.0/ 1010.0 [1]	991.0/ 1010.0 1)	ISO 3675 or 12185
CCAI, max. [4]		850	870 [2]	ISO 8217, Annex B
Water, max.	Vol-%	0.5	0.5	ISO 3733
Water before engine, max. [4]	Vol-%	0.3	0.3	ISO 3733
Sulphur, max.	% m/m	1.50	4.50 [5]	ISO 8754 or 14596
Ash, max.	% m/m	0.05	0.15	ISO 6245
Vanadium, max. [3]	mg/kg	100	600	ISO 14597 or IP 501 or 470
Sodium, max. [3] [4]	mg/kg	50	50	ISO 10478
Sodium before engine,	mg/kg	30	30	ISO 10478

max. [3) 4)]				
Aluminium + Silicon, max.	mg/kg	30	80	ISO 10478 or IP 501 or 470
Aluminium + Silicon before engine, max. [4)]	mg/kg	15	15	ISO 10478 or IP 501 or 470
Carbon residue, max.	% m/m	15	22	ISO 10370
Asphaltenes, max. [4)]	% m/m	8	14	ASTM D 3279
Flash point (PMCC), min.	°C	60	60	ISO 2719
Pour point, max.	°C	30	30	ISO 3016
Total sediment potential, max.	% m/m	0.10	0.10	ISO 10307-2
Used lubricating oil [6)]				
-Calcium, max.	mg/kg	30	30	IP 501 or 470
-Zinc, max.	mg/kg	15	15	IP 501 or 470
-Phosphorus, max.	mg/kg	15	15	IP 501 or 500

1) Max. 1010 kg/m³ at 15°C, provided the fuel treatment system is designed accordingly.

2) Straight run residues show CCAI values in the 770 to 840 range and are very good ignitors. Cracked residues delivered as bunkers may range from 840 to – in exceptional cases – above 900. Most bunkers remain in the max. 850 to 870 range at the moment.

3) Sodium contributes to hot corrosion on exhaust valves when combined with high sulphur and vanadium contents. Sodium also strongly contributes to fouling of the exhaust gas turbine blading at high loads. The aggressiveness of the fuel depends on its proportions of sodium and vanadium, but also on the total amount of ash. Hot corrosion and deposit formation are, however, also influenced by other ash constituents. It is therefore difficult to set strict limits based only on the sodium and vanadium content of the fuel. Also a fuel with lower sodium and vanadium contents than specified above, can cause hot corrosion on engine components.

4) Additional properties specified by the engine manufacturer, which are not included in the ISO specification.

5) Following sulphur limits of the liquid fuel content or equivalent SO_2-levels will apply in Non-Degraded Airsheds (NDA) for reciprocating engine plants according to the “Thermal Power Plants EHS Guidelines” issued by International Finance Corporation (IFC) in 2008:

50 .. 300 MWth: maximum 2% m/m S

>300 MWth: maximum 1% m/m

For smaller plants there are other limits. There may also be other national/local variations.

Operation on HFO.

This equipment is currently set up to run on Natural Gas and Diesel

The power plant can be configured to use HFO with the addition of a Fuel Treatment Module and some adjustments on the engine/control panel.

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 (NO_2) content of approximately 1500 mg/l, calculated as nitrite. The pH shall be between 8.5 and 9.5.

Limits for engine cooling (primary circuit), turbine washing, and separator operating water:

pH at 25°C	>6.5	-	
Conductivity at 25°C (limit for turbine washing only)	<100	mS/m	
Total hardness Ca2+ + Mg2+	<10	°dH Silica as SiO_2	<50 mg/l
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.

Charge air

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

Chlorides (Cl-)		mg/Nm3 8 mass-ppm 1.5 1-g/Nm3 vol.-ppm 1.16
Hydrogen Sulphide (H2S)	375 0.25	mg/Nm3 vol.-ppm mg/Nm3 vol.-ppm
Sulphur Dioxide (SO2)	1.25 0.43	
Ammonia (NH3)		
94	0.125	
Minimum filtration class	F5	EN 779:2002

4 Special features

Vibration control

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

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

Modular construction

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

5 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 fuel consumption calculation, which is based on Wärtsilä's experience of this engine type
- Vibrations	ISO 8528 part 9
- Design	EN 12100
- Pipe design calculations	EN 13480
- Welding	EN 1011
- Stair and platforms	AS 1657-1992
- Dimensional standards for installation materials (pipes, beams, etcetera)	DIN, ISO, SFS and EN
- Vertical tanks	API 650 or EN 14015
- Horizontal tanks	EN 12285
- Typical material standards	DIN, SFS and EN
- Pressure vessels	PED 97/23/EC or ASM

Explanation to abbreviations

DIN: German Standard (Deutsche Institute für Normung)
EN: European Standard
ISO: The International Organization for Standardization

SFS: Finnish Standards Association
AS: Australian Standard
API: American Petroleum Institute
ASME: American Society Of Mechanical Engineers
PED: Pressure Equipment Directive

Electrical systems

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

Description	Code
- Generator	IEC 60034
- LV switchgear	IEC 60439-1
- Enclosure protection	IEC 60529
- WOIS workstation hardware	IEC 60950
- WOIS workstation software	Applicable parts of VDE 3699
- Control panels	IEC 60439-1
- PLC software	IEC 61131-3
- Wiring rules (except internal wiring on engine and generato	AS 3000-2007

The equipment shall comply with the following standards to the extent applicable to the equipment and/or the application or to the extent exemption is received from relevant authorities:

AS 2381: with respect to the electrical equipment installed within the hazardous area specified according to AS-NZS 60079.10

AS 3814

AS 3007

AS4041/ ASME B31.3: except internal piping on engine and prefabricated auxiliary units

Relevant ANSI standard with respect to interconnecting flanges on external piping. As a clarification, design and material of piping on engines and internal piping on modules will be according to EN standard and equipped with flanges according to DIN.
Any exemption to standards received from relevant authorities shall also be available to the
Buyer.

Explanation to abbreviations

IEC: International Electrotechnical Commission
AS: Australian Standard
IEEE: Institute of Electrical and Electronics Engineers
EN: European Standard
VDE: The Association for Electrical, Electronic & Information Technologies

A POWER GENERATION EQUIPMENT A1

GENERATING SET

The Wärtsilä 20V34DF engine and the 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 Wärtsilä 20V34DF generating set main dimensions are9:

Length	12.535	m
Width	3.345	m
Height	4.908	m
Weight	124,690	kg

9 The dimensions and weight may vary depending on the generator make and type.

A1.1 ENGINE

6 Wärtsilä 20V34DF engine

General engine description

The engine is of a four stroke, dual fuel, trunk piston, turbocharged and intercooled design. The engine is designed for operation either on natural gas with light fuel oil (LFO) as pilot fuel (gas mode) or on Diesel oil only (diesel mode).

In gas mode, the engine works according to the lean burn Otto process, in diesel mode the engine works according to the Diesel process.

Engine combustion process

In gas mode, the combustion air and the fuel gas are mixed in the inlet port of the combustion chamber and the ignition is provided by injecting a small amount of pilot fuel (light fuel oil). The injected light fuel oil ignites instantly, which then ignites the air/fuel gas mixture in the combustion chamber.

In diesel mode, the dual fuel injection valve injects the total amount of fuel oil at the appropriate time. When

the engine runs in diesel mode the pilot fuel injection is also in operation in order to keep the needle clean.

The engine combustion process is controlled and monitored by the embedded engine control system.

The engine can be started either in gas mode or in diesel mode. In gas mode the engine is started with pilot fuel injection only, without gas admission, and when combustion is stabilized in every cylinder, the gas admission is activated.

The engine is designed for continuous operation in gas mode at any load between 15 -100%. At lower loads, the engine will automatically be switched over to diesel mode.

The engine is capable of continuous operation in diesel mode at any load between 20-100%; however, operation at loads between 5 – 20 % is limited to 100 hours.

Engine main data

Configuration	V	engin
Number of cylinders	20	
Cylinder bore	340	mm
Stroke	400	mm
Speed	750	rpm
Mean piston speed	10	m/s
Mean effective pressure	19.8	bar
Swept volume per cylinder	36.3	dm3
Compression ratio	12:1	
Number of inlet valves	2	
Number of outlet valves	2	
Direction of rotation faced towards flywheel	Clockwise	
Length	9.3	m
Width	3.1	m
Height	4.2	m
Weight	75,0	kg

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 cooling water and lubricating oil channels are partly integrated into the engine

block. The engine is provided with a wet oil sump, mounted against the engine block.

Crankshaft

The crankshaft is forged from one piece of high tensile steel. Counterweights are fitted on the crankshaft webs. The optimum balancing 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 a drop forged, totally machined type. The connecting rod 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 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 valves are made of Stellite heat resistant steel and the exhaust valve seat rings are water cooled.

Camshaft and valve mechanism

The cams are integrated in the drop forged camshaft material. The bearing journals are made of separate pieces that are fitted to the camshaft sections by means of flanged connections. This design allows lateral dismantling of the camshaft sections. The camshaft bearings are located in integrated bores in the engine block casting. The camshaft is driven from the crankshaft through a fully integrated gear train.

Gas fuel admission system

The gas is supplied via header pipes along the engine, continuing with individual feed pipes to the solenoid operated gas admission valves mounted on each cylinder head. The gas admission valves are controlled by the embedded engine control system.

The gas fuel admission system comprises the following equipment:

- Low-pressure fuel gas common rail pipe
- Gas admission valve for each cylinder
- Safety filters at each gas admission valve
- Common rail pipe venting valve
- Double wall gas piping

Pilot fuel oil system

Pilot fuel oil is injected via the dual fuel injection valves, which are actuated by electronically controlled solenoids. Fuel is delivered by the engine driven pilot fuel pump through a common rail system. The common rail pipes are located in a clos

compartment with removable covers (“hot box”), providing maximum reliability and safety.

The pilot fuel system comprises the following equipment:

- Low pressure pipes made of steel
- Electronically actuated dual fuel injection valve (for back-up and pilot fuel injection).
- Common rail high pressure pump
- Double walled common rail pilot fuel pipes
- Pilot fuel oil filter

Back-up fuel oil system

Fuel oil is delivered to the dual fuel injection valves by the main injection pumps, driven off the engine camshaft. All the high pressure fuel injection equipment is located in a closed compartment with removable covers (“hot box”), providing maximum reliability and safety.

The fuel oil system comprises the following equipment:

- Low pressure pipes made of steel
- High pressure double wall pipes with common leak alarm
- Injection pumps, individual for each cylinder
- Pneumatic stop cylinder at each injection pump
- Electronically actuated dual fuel injection valve (for back-up and pilot fuel injection).
- Fuel oil pressure regulating valve

Lubricating oil system

The lubricating oil system lubricates the main moving parts of the engine and also cools the piston tops. The engine has a wet lubricating oil sump.

The lubricating oil system comprises the following equipment:

- Pipes made of steel
- Oil sump of wet type
- Engine driven screw type main lubricating oil pump with pressure regulating valve
- Start up / running in filters

Starting air system

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

The starting air system comprises the following equipment:

- Pipes made of steel
- Starting air master valve
- Start blocking valve to prevent starting when turning gear is engaged
- Starting air distributor
- Starting air valves in each cylinder heads
- Slow turning device
- Air container for emergency stop system
- Flame arrestors

Cooling water system

The engine cooling system is divided into three circuits, the jacket cooling circuit, the 1st stage charge air cooler circuit and the 2nd stage charge air cooler circuit.

The cooling water system comprises the following equipment:

- Pipes made of steel
- Engine driven pump for low temperature cooling circuit
- Engine driven pump for jacket cooling circuit
- Non-return valves after circulating pumps

Combustion air system

The compressor side of the turbocharger feeds air into the cylinders via the charge air cooler. The engine is equipped with one turbocharger per cylinder bank. The turbocharger has an axial turbine and a radial compressor and is equipped with sleeve bearings.

The combustion air system comprises the following equipment:

- Compressor on the tuRBOCHARGER

- 1st stage charge air cooler
- 2nd stage charge air cooler
- fresh water cleaning device

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 comprises the following equipment:

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

Turbocharger and Air to Fuel Ratio Control System

The turbocharger is driven by the exhaust gas flow. The compressor wheel is mounted on a common shaft with the exhaust gas turbine.

The exhaust gas waste gate bypasses a portion of the exhaust gases past the turbocharger. In this way, the rotational speed of the rotor shaft and hence the charge air pressure is controlled. This results in an appropriate air/fuel ratio for the cylinders, regardless of variations in load, fuel gas and ambient conditions (barometric pressure, temperature etc.) The air by-pass routes part of the air flow from the TC compressor outlet to the TC turbine inlet, thus part of the suction air by-passes the cylinders

The waste gate valve and the air by-pass valve are actuated by compressed air and controlled by the engine control system.

Wärtsilä Engine Automation

The engine automation system is a complete embedded management system, integrated with an engine control system for electronically controlled fuel injection. The engine control system is a distributed and bus based system where the monitoring and control function is placed close to the point of measurement and control. By this, both the on and off engine wiring is significantly simplified, advanced diagnostics and control functions provides an outstanding performance and the need for off engine systems is significantly reduced.

The system meets even the highest requirements on reliability, with selective redundancy and fault tolerant designs.

Hardware of the engine automation system

The engine is equipped with following main components:

- Engine safety Module, ESM
- Local Display Unit, LDU graphical display for complete on-engine monitoring and communication interface to plant automation system
- Main Controller Module, MCM, for speed governing, start/stop sequencing and overall engine management
- I/O Modules for, IOM, distributed data acquisition
- Cylinder Control Modules, CCM, for injector/gas valve control and real-time diagnostics
- Power Distribution Modules, PDM, distributes, filters and handles fusing of power supply
- WCD ignition system module
- Sensors
- Actuators & valves/injectors

The engine control system is designed to:

- Provide a compact embedded engine control and management system for space-saving applications.
- Reduce installation and commissioning time by providing a very simple field bus based interface that is delivered pre-tested and fully working from factorY

- Achieve highest possible reliability with components, e.g. sensors, designed specifically for the on engine environment.
- Highly reduced cabling on and around engine through a bus based architecture, with a clear point of interconnection and with a standardized hardwire and field bus interface
- High performance with optimized and pre-tested controls
- Easy and convenient calibration and service tool for on-line tuning and system diagnostics, based on tool training from Wärtsilä

With regards to the field bus interconnection, Wärtsilä is committed to open standards. The engine control system physical interface is a standard Ethernet connection for general process data to both WOIS and PLC systems.

Sensors for alarm and monitoring

One set of sensors fitted on the engine connected to the engine control system.

Other Included Items

- Flywheel with fixing bolts
- Electrical motor driven turning device
- Counter flanges for pipe connection
- Crankcase safety valves with flame trap
- The engine has one coat of priming paint and one coat of finishing paint

A1.2 GENERATOR

6 Generator: 11,000 Volt; 50 Hz

Generator type

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

Generator maiN DATA

Generator apparent power	10,913	k
Rated power factor	0.80	
Nominal voltage	11,000	V
Rated current (In)	573	A
Voltage adjustment range	±5	%
Frequency	50	H z
Speed	750	r p m
Overspeed	900	
Continuous short circuit current	>2.5 x In	
Insulation class	F	
Temperature rise	B	
Cooling method	Air cooled	
Enclosure	IP23	
Standard	IEC 600	

Generator construction

The generator is designed to operate together with reciprocating engines. The stator frame is constructed with a rigid welded steel structure. The stator core is build 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 the 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.

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 of 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 engine generator set control panel).

Voltage regulation	±	%
- within power range	0 – 100	%
- within speed range	95 – 105	%
Voltage setting range	100 – 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 transforms for protection

Flexible coupling

A flexible coupling between the engine flywheel and the generator 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.

A1.3

BASE FRAME FOR ENGINE AND GENERATOR

Common base frame for engine and generator

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

Steel springs (set)

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 generator 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.

Fastening equipment (set)

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

A1.4

CONNECTIONS

Flexible connections between engine and external piping

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

Flexible connections are supplied for the following auxiliary systems:

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

The following is included:

1 Flexible hoses and gaskets (set)

1 Cooling water bellows (set)

2 Exhaust gas bellows

2 Charge air bellows compensator

A1 E GINE PLATFORMS

.5 N

Engine maintenance platform

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

A2 MECHANICAL AUXILIARY SYSTEMS

The proper function of the stationary 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.

A2.1 AUXILIARY MODULES

To secure installation quality and reduce erection time, Wärtsilä has developed a prefabricated auxiliary module which is installed at the front end of the engine. This module contains several pieces of auxiliary equipment (listed below) which are completely installed and fitted at the shop, which saves significant pipefitting and installation time at site. The complete auxiliary module is pressure and function tested, and then flushed, painted, and corrosion protected prior to shipment. All external

connection points are sealed and covered with steel plates.

Engine auxiliary module

The following is included:

1 Fuel oil filter
1 Fuel feed pump
1 Return fuel pump
1 Return fuel tank
1 Pre heating unit
1 Thermostatic valve high temperature water system
1 Thermostatic valve low temperature water system
1 Pressure increasing pump
1 Piping and insulation
1 Valves and gauges
1 Module control panel

Exhaust gas module

To secure installation quality and reduce erection time, Wärtsilä has developed a prefabricated exhaust gas module. This module contains several pieces of exhaust gas equipment (listed below) which are completely installed and fitted at the shop. Some of the components will be separated from the module during transportation and installed again at site. This saves significant pipefitting and installation time at site. The complete exhaust gas module is function tested, and then flushed, painted, and corrosion protected prior to shipment.

The following is included:

1 Low temperature expansion tank
2 Charge air silencer
1 Exhaust gas branch pipe
1 Purge fan unit
1 Safety vent piping
1 Piping and insulation
1 Oil mist separator

A2.2 FUEL SYSTEM

The main function of the fuel system is to provide the engine with fuel of correct flow, pressure and degree of purity.

A2.2.1 LIGHT FUEL OIL SYSTEM

Light Fuel Oil System is used in case of operation disturbances and flushing of the system before maintenance work, before longer stoppages and during start up when the HFO system is not heated to operation temperature

1 Light fuel oil feeder unit

2 Electric motor driven fuel feed pump (1 working, 1 stand by) Capacity, each 15.90 m3/h Pressure 4 bar
1 Strainer on return fuel pump suction side
1 Local control panel for manual and automatic operation
1 Set of interconnection pipes, flanges, seals and valves
1 Base frame of steel

Light fuel oil cooler

The function of the light fuel oil cooler is to keep the LFO viscosity within the allowed limits at the engine inlet. The cooler is located in the return line after the engine.

Light fuel oil flow meter for total fuel consumption measurement

The meters are of mass flow type with totalizing

display. Accuracy 0,5 %

A2.3 LUBRICATING OIL SYSTEM

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

The lubricating oil system consists of the following equipment:

Lubricating oil transfer pump unit (mobile)

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

1	Electric motor driven Capacity, each Pressure	4.80 2
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	

A2.5 COOLING SYSTEM

The main task of the cooling system is to provide 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 after it has been compressed by the turbocharger.

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:

Cooling radiator

The engines are cooled with remote mounted, horizontal type radiators with electrically driven induced draft fans. Each engine generator set has its own cooling radiator package comprising:

1	Radiator cooler (with	
	Frame material	Hot dipped galvanized steel
	Tube material	Copper
	Fin material	Aluminium

Cooling radiator ladder and railings

Radiators are supplied with railings and inspection ladder.

Maintenance water tank unit (fresh water)

During maintenance of the engine, cooling water from the engine is drained and stored in the maintenance water tank and is pumped back after maintenance. The maintenance water tank is also used for mixing chemicals which are needed for the engine cooling water. The following components are built on a steel frame, which forms a compact skid unit.

1	Water tank made of steel	
	Volume	6 m3
1	Level indicator	
1	Discharge pump	
	Capacity	9 m3
	Pressure	1 bar
1	Steel frame	
1	Set of interconnection pipes and flanges	

A2.6 CHARGE AIR SYSTEM

The charge air filter protects the engine against impurities in the inlet air and the charge air silencer reduces the air intake noise from the engine

Charge air filter

The air inlet to the filter is equipped with a vertical weather louver for removal of water droplets. The combined oil wetted and dry filter type filter have 2-stage filtration. The oil wetted contains filter panels that move vertically inside the filter housing. After a complete revolution the filter elements are soaked in

oil 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.

Weather hood

The weather hood is protecting the charge air filter from excessive amounts of water or snow. In case the hood should protect expressly against rain, it is always to be assembled in combination with a droplet separator louver.

A2.7 EXHAUST SYSTEM

The exhaust gas of the engine is discharged at the required height through the exhaust gas silencer and stack pipe. The exhaust gas silencer reduces the exhaust noise from the engine

Exhaust gas silencer

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

Noise attenuation	35 dB(A)

Bellows for exhaust gas silencer

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

Bellows for exhaust gas ducting

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

Safety vent counter flanges including rupture disk (for exhaust gas ducting)

The safety vent and rupture disk arrangement is intended to protect equipment and personnel in case of rapid build up of pressure in the exhaust gas system.

A7 AUTOMATION SYSTEM

Advanced Control and Supervision Concept for Wärtsilä Power Plants

The control and supervision system is designed for safe, reliable, efficient and easy operation of the generating sets, their associated auxiliaries and electrical systems. A modular design allows easy extension of the system.

The power plant can be controlled from either the Wärtsilä Operator's Interface System (WOIS workstations, CWA901), from the central control panel/common and generating set sections (CFA 901 and CFC0_1).

The WOIS workstation and the common and generating set control panels are located in the control room where all the main supervision of the plant takes place.

Control modes

The following control modes are available for the generating set control.

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

- MW mode - the generating set power is maintained at a preset value irrespective of system load or 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. This operating mode requires that all the generating sets have speed

controllers suitable for isochronous load sharing.

- Speed droop mode – the generating set shares the load with the grid or other generating sets according to a speed droop curve. This is the typical operating mode for smaller grids or in island operation.

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

- Constant Power Factor control – the generating sets power factor is maintained at a preset value and any changes are produced by the grid or 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 based on digital communication lines between the AVR's when running in island mode. This is the typical operating mode when running in isolation from the grid. This operating mode requires that all the generating sets have voltage controllers suitable for voltage droop compensation control.

- 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 in 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 workstation, while in Manual mode they are determined by the switches in the control panel.

A7.1 OPERATOR'S STATION

2 WOIS workstation

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

mouse, keyboard and display. The operator can also supervise 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 WOIS workstation also includes a hardcopy laser printer.

WOIS workstation 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 status of these objects is 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 (6) measured values such as pressures, temperatures, 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 analysing. The trends are stored for up to 180 days, and the operator may call back a trend for any time interval within these limits.
- An alarm banner in the uppermost part of the displays informs about the latest occurred 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.
- Any of the displays and the alarm list can be printed to the hard copy printer.

The WOIS workstation contains the following equipment:

1 Desktop PC computer with sufficient processing and memory capacity
1 Display, TFT flat screen 24”
1 Keyboard and optical mouse
1 Laser printer for hard copy and report printing
1 Operating system
1 Human-Machine-Interface (HMI) software

WISE workstation

The Wärtsilä Information System Environment (WISE workstation) handles the long term data storage and reporting functions of the power plant. The operator can view and print out the daily, monthly and yearly reports produced by the reporting program. WISE workstation keeps
the engine and production reports available for later study and archiving. WOIS workstation is the provider of information to the WISE workstation.

WISE workstation includes the following functionality:

- Daily engine and plant reports of plant analogue measurement values. Daily minimum, maximum and average values are generated and stored for one year.
- Long term engine and plant performance tracking throughout trend displays of the reported analogue measurements.
- Daily production reports of generated active and reactive energy as well as hourly fuel consumption are generated and stored for one year.
- Monthly production reports (on daily level) are stored for 5 years and yearly production reports are generated and stored for 10 years.
- The production reports include minimum, maximum, average and total sum calculations for the period.
- Electronic log book with search possibilities for recording of operation and maintenance activities.

The WISE workstation contains the following equipment:

1 Desktop PC computer with sufficient processing and memory capacity
1 Display, TFT flat screen 24”
1 Keyboard and optical mouse
1 Operating system software
1 Reporting interface software

Uninterrupted power supply (UPS)

Uninterrupted power supply is used for control room operator stations.

A7.2 CONTROL PANELS

Central common control panel (CFA)

The central common control panel (CFA 901) contains the operating switches, buttons and meters for synchronising and the mimic for the plant Medium Voltage system. It also contains the common PLC system.

The engine related signals are handled by the engine control system and communicated over the data bus to WOIS workstation and the PLC in the central control panel.

The generator and generating set auxiliary related Input/Output signals are connected to the PLC remote Input/Output modules which are located in the engine auxiliary module panel BJA 0_1.

The central common control panel (CFA901), contains the following equipment:

1 Programmable Logic Controller (PLC) unit for 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 (24 VDC)
- Central Processing Unit (CPU)
- Communication card
- Digital Input - Output cards
- Analogue input cards

1 P1 Double frequency meter (for synchronising)
1 P2 Double voltage meter (for synchronising)
1 P3 Synchronoscope (for synchronising)

1 M2 Manual synchronisation control interface unit with:

- Synchronising mode selector switch (auto/manual)
- Synchronising breaker selector switch for generator and for incoming breaker
- Generating set voltage adjustment switch
- Generating set frequency adjustment switch
- Synchronising breaker close control pushbutton
- Synchronising order pushbutton for automatic synchronising

1 Auto-synchroniser
1 Check synchroniser relay
1 Safety relay for emergency circuit
1 Mimic diagram for the electrical system
1 S20 Power plant emergency stop pushbutton
1 S10 Safety relay reset pushbutton

Central generating set control panel (CFC)

We will provide hard wired 4-20 mA signals from each unit for speed, voltage, kVAr, kW and provision in our control panel to be able to raise/lower speed/load and voltage to each unit.

Differential protection relay

Auxiliary module panel

The engine auxiliary panel includes breakers and controls for the electrical motors and heaters of the engine generator set as indicated below. It is also equipped with indicating lamps and alarms. The panel controls the following motors and heaters (if applicable):

- Generator anti-condensation heaters
- Pre lubricating oil pump
- Fuel booster pump
- Turning gear motor
- Preheating circulating pump
- High temperature cooling circuit preheaters
- Air filters (if motorised)
- Outlet socket 16A