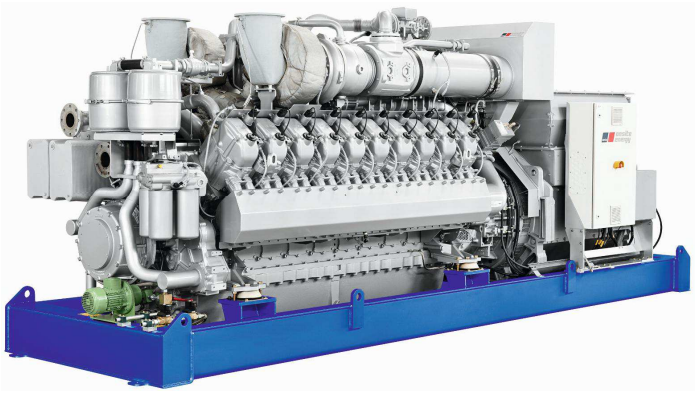
Peter Barr



Technical Specification

and

Scope of Supply

MTU 20V4000 GS
GG20V4000A1

Customer:	Peter Barr
MTU Project:	020210132
Quotation:	MME 210134-Q01-1
	12.10.2016

I. System Description

Product type	GG20V4000A1 MTU 20V4000 GS
Application Group	3A - Heavy duty service, unrestricted

Power values

	Unit	Nominal
Electrical power, 100% CP	kWel	1948
Power factor (cos f)	-	1.0
Frequency	Hz	50
Voltage	V	400
Engine rated speed	rpm	1500
Thermal output, engine (Engine block, engine lube oil, 1st stage intercooler) – 100% CP (± 8%)	kW	1035
Thermal output, engine (Engine block, engine lube oil) – 100% CP (±8%)	kW	1035
Thermal Output in exhaust gas cooled (to reference temperature in °C) – 100% CP (± 8%)	kW	1101
Reference temperature, cooling, exhaust gas	°C	120
Thermal output, 2. stage mixture cooler – 100% CP (± 8%)	kW	78
Output, thermal, total – 100% CP (± 8%)	kW	1035
Energy input in accordance with ISO 3046 - 100% (± 5%)	kW	4577
Intake air temperature	°C	35
Site altitude above sea level	m	100
Relative air humidity	%	60
Gas type: natural gas	-	X
Methane number (MN), min.	-	80
Cooling water temperature, inlet	°C	78
Cooling water temperature, outlet	°C	90
Mixture cooler, 2. stage water inlet temperature	°C	53
Nitrogen oxides (NOx), emissions (dry, referred to reference value residual oxygen)	mg/m³n	500
Carbon monoxide (CO) Emission (dry, referred to reference value residual oxygen)	mg/m³n	1000
Reference value residual Oxygen	%	5

Technical Data:

1. DATA-RELEVANT DESIGN

Technical data sheet		-	93800050093
Technical description		-	MS61016
Planning drawing plant		-	93406008005
Planning drawing heat recovery unit		-	-
Flow chart (Piping and Instruments) German		-	93200008621
Fuel, fluid and lubricants specification		-	A001067
Load step diagram		-	-
Methane number derating diagram		-	DK-DR-0003
Combustion air derating diagram		-	DK-DR-0005
Foundation requirement		-	93800050093BI
Island mode capability		-	X
Extraction 1st stage intercooler (high temperature circuit)		-	-
Extraction 1st stage intercooler (connection in series 2. stage intercooler)		-	-
Built type		-	GB
Maintenance schedule		-	MS50198
Overhaul schedule		-	MS50198
Flow chart (Piping and Instruments) English		-	93200008622

2. POWER-RELATED DATA, ELECTRICAL

Voltage		V	400
Frequency		Hz	50
Grid regulations		-	-
Electrical power, 100% CP		kWel	1948
Electrical power, 75% CP		kWel	1461
Electrical power, 50% CP		kWel	974
Engine power ISO 3046-1 – 100% CP	A	kW	2000
Engine power ISO 3046-1 – 75% CP	A	kW	1499
Engine power ISO 3046-1 – 50% CP	A	kW	1003
Power factor (cos f)		-	1.0
Generator efficiency at cos f = 1 – 100% CP		%	97.4
Generator efficiency at cos f = 1 – 75% CP		%	97.4
Generator efficiency at cos f = 1 – 50% CP		%	97.1
Electrical efficiency, 100%		%	42.6
Electrical efficiency, 75%		%	41.5
Electrical efficiency, 50%		%	39.2
Total efficiency incl. thermal output from exhaust, 100%		%	89.2
Total efficiency incl. thermal output from exhaust, 75%		%	89.3
Total efficiency incl. thermal output from exhaust, 50%		%	88.6

3. POWER-RELATED DATA, THERMAL

Thermal output, engine (Engine block, engine lube oil, 1st stage intercooler) – 100% CP (± 8%)	A	kW	1035
Thermal output, engine (Engine block, engine lube oil, 1st stage intercooler) – 75% CP (± 8%)	A	kW	788
Thermal output, engine (Engine block, engine lube oil, 1st stage intercooler) – 50% CP (± 8%)	A	kW	561
Thermal output, engine (Engine block, engine lube oil) – 100% CP (±8%)	A	kW	1035
Thermal output, engine (Engine block, engine lube oil) – 75% CP (± 8%)	A	kW	788
Thermal output, engine (Engine block, engine lube oil) – 50% CP (± 8%)	A	kW	561
Thermal Output in exhaust gas cooled (to reference temperature in °C) – 100% CP (± 8%)	A	kW	1101

Thermal Output in exhaust gas cooled(to reference temperature in °C) – 75% CP (± 8%)	A	kW	891
Thermal Output in exhaust gas cooled (to reference temperature in °C) – 50% CP (± 8%)	A	kW	667
Reference temperature, cooling, exhaust gas	A	°C	120
Output, thermal, total – 100% CP (± 8%)	A	kW	1035
Output, thermal, total – 75% CP (± 8%)	A	kW	788
Output, thermal, total – 50% CP (± 8%)	A	kW	561
Thermal output, 1. stage mixture cooler – 100% CP (± 8%)	A	kW	-
Thermal output, 1. stage mixture cooler – 75% CP (± 8%)	A	kW	-
Thermal output, 1. stage mixture cooler – 50% CP (± 8%)	A	kW	-
Thermal output, 2. stage mixture cooler – 100% CP (± 8%)	A	kW	78
Thermal output, 2. stage mixture cooler – 75% CP (± 8%)	A	kW	50
Thermal output, 2. stage mixture cooler – 50% CP (± 8%)	A	kW	32

4. CONSUMPTION

Energy input in accordance with ISO 3046 - 100% (± 5%)	A	kW	4577
Energy input in accordance with ISO 3046 - 75% (± 5%)	A	kW	3517
Energy input in accordance with ISO 3046 - 50% (± 5%)	A	kW	2486
Lube oil consumption	R	dm³/h	0.68

5. COMBUSTION AIR / EXHAUST GAS

Combustion air volume flow – 100% CP – at Reference heating value		m³n/h	7594
Combustion air volume flow – 75% CP – at Reference heating value		m³n/h	5716
Combustion air volume flow – 50% CP – at Reference heating value		m³n/h	3922
Combustion air mass flow - 100% CP – at Reference heating value		kg/h	9807
Combustion air mass flow - 75% CP – at Reference heating value		kg/h	7382
Combustion air mass flow - 50% CP – at Reference heating value		kg/h	5065
Reference heating value fuel for combustion air		kWh/m³n	10.10
Exhaust volume flow, wet - 100 % CP		m³n/h	7848
Exhaust volume flow, wet - 75 % CP		m³n/h	5912
Exhaust volume flow, wet - 50 % CP		m³n/h	4062
Exhaust volume flow, dry - 100 % CP		m³n/h	7243
Exhaust volume flow, dry - 75 % CP		m³n/h	5448
Exhaust volume flow, dry - 50 % CP		m³n/h	3732
Exhaust mass flow, wet - 100 % CP		kg/h	10144
Exhaust mass flow, wet - 75 % CP		kg/h	7641
Exhaust mass flow, wet - 50 % CP		kg/h	5249
Exhaust temperature after turbocharger - 100 % CP		°C	472
Exhaust temperature after turbocharger - 75 % CP		°C	497
Exhaust temperature after turbocharger - 50 % CP		°C	529

6. GENERAL CONDITIONS AND FUELS

Relative air humidity	A	%	60
Intake air temperature	A	°C	35
Site altitude above sea level	A	m	100
Barometric pressure	A	mbar	1000
Gas type: natural gas		-	X
Gas type: biogas		-	-
Methane number (MN), min.	L	-	80
Gas type: Sewage gas		-	-

Gas type: Landfill gas		-	-
Range of heating value: design min.	L	kWh/m³n	10.0
Range of heating value: design max.	L	kWh/m³n	10.5
Range of heating value: operation range min.	L	kWh/m³n	8.0
Range of heating value: operation range max.	L	kWh/m³n	11.0

7. EXHAUST EMISSIONS

Nitrogen oxides (NOx), emissions (dry, referred to reference value residual oxygen)	L	mg/m³n	500
Carbon monoxide (CO) Emission (dry, referred to reference value residual oxygen)	L	mg/m³n	1000
Reference value residual Oxygen	A	%	5

8. OTTO GAS ENGINE

Engine type		-	20V4000L32
Engine rated speed	A	rpm	1500
Number of cylinders		-	20
Cylinder configuration: V angle		degrees (°)	90
Cylinder configuration: in-line vertical		-	-
Bore		mm	170
Stroke		mm	210
Displacement, total		liter	95.3
Compression ratio		-	12.1
Mean piston speed		m/s	10.5
Mean effective pressure (MEP) (at peak torque engine speed)		bar	16.8
Exhaust back pressure, min.	L	mbar	30
Exhaust back pressure, max.	L	mbar	60

9. GEARBOX

Transmission ratio		-	-
Geabox heat output (water cooled)		kW	-
Efficiency – 100% CL		-	-
Efficiency – 75% CL		-	-
Efficiency – 50% CL		-	-

10. GENERATOR

Manufacturer		-	CU
Type		-	LVSI804S2Wdg12
Rating power (temperature rise class F)		kVA	2560
Temperature rise class		-	F
Insulation class		-	H
Winding pitch		-	2/3
Protection		-	IP 23
Max. admissible cos f inductive (overexcited)	L	-	0.80
Max. admissible cos f capacitive (underexcited)	L	-	1.00
Voltage tolerance		%	+/- 5
Frequency tolerance		%	+/- 5
Alternator specification		-	93231006264

11. COOLANT SYSTEM ENGINE (HIGH-TEMPERATURE CIRCUIT)

Cooling water temperature, inlet	A	°C	78
Cooling water temperature, outlet	A	°C	90
Cooling equipment: coolant flow rate	A	m³/h	80.4
Coolant pressure after engine, max. (based on Pmax = 1.5 bar before coolant pump)	L	bar	2.23

Flow coefficient value (CV value)	A	m³/h	54.7
Pressure in cooling system, max.	L	bar	6.0

12. COOLANT SYSTEM (MIDDLE-TEMPERATURE CIRCUIT)

Mixture cooler, 1. stage water inlet temperature	A	°C	-
Intercooler 1nd stage: Water temperature (outlet)	A	°C	-
Intercooler 1nd stage: Coolant volumetric flow	A	m³/h	-
Intercooler 1nd stage: Coolant volumetric flow, min	L	m³/h	-
Intercooler 1nd stage: Pressure drop	A	bar	-
Intercooler 1nd stage: Flow coefficient value (CV value)	A	m³/h	-
Intercooler 1nd stage: Operation pressure, min	L	bar	-
Intercooler 1nd stage: Operation pressure, max (outlet)	L	bar	-

13. COOLANT SYSTEM (LOW-TEMPERATURE CIRCUIT)

Mixture cooler, 2. stage water inlet temperature	A	°C	53
Intercooler 2nd stage: Water temperature (outlet)	A	°C	55.1
Intercooler 2nd stage: Coolant volumetric flow	A	m³/h	34.3
Intercooler 2nd stage: Pressure drop	A	bar	0.60
Intercooler 2nd stage: Flow coefficient value (CV value)	A	m³/h	45.3
Intercooler 2nd stage: Operation pressure, max (outlet)	L	bar	6.0

14. EXHAUST GAS HEAT EXCHANGER

Exhaust gas heat exchanger: Cooling water temperature (inlet)		°C	-
Exhaust gas heat exchanger: Cooling water temperature (outlet)		°C	-
Exhaust gas heat exchanger: Coolant volumetric flow		m³/h	-
Exhaust gas heat exchanger: Coolant volumetric flow, min	L	m³/h	-
Exhaust gas heat exchanger: Pressure drop	A	bar	-
Exhaust gas heat exchanger: Flow coefficient value (CV value)	A	m³/h	-
Exhaust gas heat exchanger: Operation pressure, min	L	bar	-
Exhaust gas heat exchanger: Operation pressure, max.	L	bar	-
Exhaust gas temperature downstream of exhaust heat exchanger – 100% CP		°C	-

15. HEATING CIRCUIT INTERFACE

Heating circuit: engine coolant temperature, inlet	A	°C	-
Heating circuit: engine coolant temperature, outlet	A	°C	-
Heating water temperature, return	A	°C	-
Heating water temperature, feed side	A	°C	-
Heating water flow rate		m³/h	-
Heating circuit: Pressure Drop	A	bar	-
Heating circuit: Flow coefficient value (CV value)	A	m³/h	-
Heating circuit: Max. operation gauge pressure (heating water)	L	bar	-

16. ROOM VENTILATION

Room ventilation: Genset ventilation heat – 100% CL		kW	113
Room ventilation: Combustion air temperature	A	°C	35
Room ventilation: Combustion air temperature, min.	L	°C	30
Room ventilation: Combustion air temperature, max.	L	°C	40
Engine room temperature, min.	L	°C	15
Engine room: Temperature difference ventilation air (inlet/outlet),	L	K	20

max.			
Supply air volume flow rate (combustion+ventilation), max.	L	m³/h	23500

17. STARTING (ELECTRIC)

Starter, rated voltage (standard design)	R	V=	24
Starter, rated power (standard design)	R	kW	18

18. CAPACITIES

Engine coolant (withtout external cooling system)	R	liter	310
On-engine cooling water capacity, mixture-cooler side (without cooling equipment)	R	liter	23
Engine oil capacity, initial filling (standard oil system)	R	liter	350
Gear oil filling capacity	R	liter	-
Heating water filling capacity	R	liter	-

19. GAS TRAIN

Gas train - normal size		DN	100
Gas pressure at inlet of gas train, min	L	mbar	180
Gas pressure at inlet of gas train, max.	L	mbar	250

20. ACOUSTICS

Engine sound level – 63 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	84.6
Engine sound level – 125 Hz (free-field sound-pressure level Lp, 1m distance,ISO 6798)	R	dB	91.9
Engine sound level – 250 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	88.9
Engine sound level – 500 Hz (free-field sound-pressure level Lp, 1m distance, ISO 8528-10)	R	dB	92.4
Engine sound level – 1000 Hz (free-field sound-pressure level Lp, 1m distance, ISO 8528-10)	R	dB	92.9
Engine sound level – 2000 Hz (free-field sound-pressure level Lp, 1m distance, ISO 8528-10)	R	dB	89.8
Engine sound level – 4000 Hz (free-field sound-pressure level Lp, 1m distance, ISO 8528-10)	R	dB	84.6
Engine sound level – 8000 Hz (free-field sound-pressure level Lp, 1m distance, ISO 8528-10)	R	dB	92.9
Sum of pressure levels	R	dB	99.8
Sum of pressure levels	R	dB(A)	98.1
Sound power level	R	dB(A)	118.0
Undampened exhaust noise – 63 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	109.0
Undampened exhaust noise – 125 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	110.2
Undampened exhaust noise – 250 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	104.2
Undampened exhaust noise – 500 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	98.1
Undampened exhaust noise – 1000 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	92.5
Undampened exhaust noise – 2000 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	89.1
Undampened exhaust noise – 4000 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	84.6
Undampened exhaust noise – 8000 Hz (free-field sound-pressure level Lp, 1m distance, ISO 6798)	R	dB	72.3

Sum of pressure Levels exhaust noise	R	dB	113.5
Sum of pressure Levels exhaust noise	R	dB(A)	101.1
Sound power Level exhaust noise	R	dB(A)	113.1

21. MASSES / DIMENSIONS

Plant length (with standard accessories)	R	mm	5900
Plant width (with standard accessories)	R	mm	2000
Plant height (with standard accessories)	R	mm	2400
System dry mass (with Standard accessories)	R	kg	18000
System mass, wet, (with standard accessories)	R	kg	18700
Length heat recovery unit	R	mm	-
Width heat recovery unit	R	mm	-
Height heat recovery unit	R	mm	-
Gross mass (dry mass) heat recovery unit	R	kg	-
Gross mass (wet mass) heat recovery unit	R	kg	-

* = contract value, L = limit value, G = guaranteed value, R = guideline value

II. Selection Criteria for the Scope of Supply

Criteria	*Selection*	*for Product No.*
Application group	3A - continuous power	1,
Instruction for exhaust emission	See technical data	1,
Power	See technical data	1,
Speed	1500 rpm	1,
Frequency	50 Hz	1,
Generator voltage	400 V	1,
Engine type	20V4000L32	1,
Generator manufacturer	Stamford	1,
Gas type	Natural gas	1,
Island operation capability	Yes	1,
Operating mode	Mains parallel-operation	1,
Build type	Genset without heat recovery (GB)	1,
Cooling water-/Heating water temperatures	78/90	1,
Auxiliary drive voltage	400 V	1,
Control panel	MIP and MMC control system	1,
Operation in combination	MIP and MMC control system	1,
grid type generator	MIP and MMC control system	1,
grid type auxiliary supply	MIP and MMC control system	1,
Altitude	Altitude up to 1000 m	1,
Ambient temperature MIP	>=40°C up to 55°C	1,
High temperature extraction	without extraction of high temperature circuit	1,
Country of operation	outside Germany	1,
Flexible connections	with flexible connections	1,
Acceptance Testing	Factory acceptance	1,
Packing	Standard commercial	1,
Shipment	FCA Augsburg	1,

III. Scope of Supply

		valid for product no.
1	**SYSTEM CONFIGURATION**	1,
1.1	**System Description**	1,
	Note Emission Compliance	1,
	Please note that the engines and systems (only) comply with the country or region specific emission requirements and have appropriate emission certification(s) which are explicitly stated in respective RRPS/MTU defined technical specifications. Any Export / Import / Operation of the engine in countries or regions with different applicable emission law requirements is therefore at your own responsibility	
	The compact design genset consist of the following basic assemblies: – Engine (including gas train) – Alternator and coupling – Base frame – MIP (MTU Interface Panel) as interface to engine management, control and diagnostic system	1,
	Engine and alternator are rigidly connected via a direct coupling and housing. The engine-alternator unit is isolated from the base frame via resilient mounts. The alternator is mounted on two rails to facilitate replacement of the coupling element. For further details, refer to the attached technical description of the scope of supply. With integrated coolant preheating including temperature control as well as lube oil pump as prelubricating and waste oil pump with safety valve for forced feed lubrication and piston cooling. The hardware and software in the MIP control cabinet ensure closed-loop genset control functions, open-loop control and monitoring features as well as the communication to and from external systems. A cogeneration control system with visualization and user interface is required in addition to MIP to operate the genset (e.g. MTU MMC or on site customer's control).	
	Flexible connections	1,
	Flexible connections are supplied to compensate thermal expansion and to provide vibrational isolation. 3 x hose connections for lube oil supply and disposal and extended oil circulation volume 2 x flexible connection for engine coolant circuit with flange connection 2 x flexible connection for mixture coolant circuit with flange connection	
	2 x exhaust bellows with flange connection and companion flange	1,
	Genset preservation	1,
	Standard corrosion protection is provided for long-distance transport and/or extended storage for maximum of 12 month from readiness for dispatch. The specified preservation period applies to unopened packing and dry, normal storage conditions as follows:	

– Frost-free, closed, heated, clean rooms

– Storage temperature between 10°C and 40°C.

– Monthly average relative humidity not above 65%

– Re-preservation required after 12 months

Safety standards 1,
MTU Onsite Energy GmbH within its system borders of the scope of supply delivers all required safety components according to the valid Safety Standard DIN EN ISO 13849 (Safety of Machinery - Safety-related Parts of Control Systems). For the peripheral system not included in MTU's scope of supply, the principal has to make sure that any required safety component also complies to DIN EN ISO 13849 (refer also to "Component Quality Guideline DIN EN ISO 13849" attached).

Further applied harmonized standards:
EN ISO 12100:2010
EN 12601: 2010
EN 1679-1:1998+A1:2011
EN 60204-1:2006

Antifreeze measures 1,
In case of frost damages MTU-OEG will not be liable for components, which after delivery have not been filled with a suited antifreeze according to MTU-OEG specifications. The client must make sure that functioning heating mechanisms reliably prevent freezing.

Remaining and site conditions 1,

Continuous power, no overload capability, refers to mains parallel operation, at nominal speed and standard reference conditions according to technical datasheet.

The nominal power output specified in the datasheet is available at site altitudes up to 400 m above sea level without power reduction. For further details, refer to the attached datasheet.

In case of knocking due to low methane number or increased mixture temperature the ignition timing of the affected cylinders is adjusted. If knocking persists, the power output is reduced automatically

Definition of operating modes 1,

Mains parallel operation: 1,
The genset is synchronized to the public mains.
Mains is defined as a power source with at least ten times the output power of the generator to be connected.

1.2 Starting Aids 1,

– Without 1,

1.3 Base Frame 1,

Base frame designed as welded steel profile structure including lifting eyes; with integrated safety oil sump for the oil volume contained in the engine, with oil leakage monitoring. 1,

1.4 Vibration Isolation 1,

The engine-alternator unit is mounted on the base frame with resilient mounts. This design isolates the vibrations generated by the engine and/or alternator from the base frame. 1,
To minimize the remaining residual vibration level, resilient mats are provided between base frame and foundation (sylomer straps, supplied as loose parts, for installation on site).

2 ENGINE CONFIGURATION 1,

2.1 Engine System 1,

Series 4000 four-stroke turbocharged Otto gas engine with mixture cooling - compact, high-performance, reliable, maintenance-friendly and extremely economical. 1,

Lean mixture technology, state-of-the-art electronic ignition system with individual ignition timing and automatic ignition power control, anti-knock control as well as highly responsive mixture and load control ensure economical and safe genset operation with optimum use of the energy input.

Basis

- counter-clockwise rotation engine
- coolant cooled
- lean mixture supercharging
- two-stage mixture cooling
- open combustion chamber
- microprocessor-controlled high-voltage ignition system
- exhaust turbocharging
- two cooling system circuits
- piston cooling

Core engine

- Gray cast iron crankcase with assembly holes, gray cast iron oil pan,
- Forged crankshaft, forged connecting rods,
- Individual, cylinder heads with four valves each

1. Crank drive

The crank drive is installed in the crankcase. It is supported in sleeve bearings and locked in axial direction. Engine oil from the crankcase is used to lubricate the bearings, vibration damper and pistons. Carefully matched components ensure high performance and minimum wear.

Crankcase with oil pan

The oil pan is attached to the bottom of the crankcase; gearcase, coolant distribution housing and flywheel housing are bolted to the front.
The cylinder heads and engine lifting points are mounted left and right on the top decks.
Technical data

- Single-cast crankcase

– Integral coolant ducting

– Main oil gallery integrated in top cover

– Replaceable, wet cylinder liners

– Split sleeve bearings for crankshaft

– Sleeve bearings for camshaft

– Crankshaft bearing caps secured vertically and horizontally

– Integrated oil supply for piston cooling

– Crankcase ventilation (closed circuit)

– Large inspection port covers

Benefits
– High rigidity

– Low noise and vibration levels

Pistons
– Piston with integral cooling duct

– Piston cooling though oil-spray nozzles

Connecting rods
– Forged

– Machined as one piece, providing high rigidity and weight optimization

Crankshaft
– Forged

– Bolted counterweights

– Pressed-on crankshaft gear

– Low-wear sleeve bearing, oil supply from lube oil system

– Locked in axial direction

Flywheel (driving end)
– PTO flange

– Ring gear for starter pinion

Crank drive benefits:
– High performance

– Minimum weight

– Long service life

2. Cylinder head with add-on components
The cylinder heads with valve drive and spark plug are mounted on the crankcase.
Coolant for cylinder head cooling as well as engine oil for valve gear lubrication are supplied from the crankcase.
Technical data
– Individual cylinder heads

– Two inlet and exhaust valves

– Centrally arranged spark plug

Benefits
– Designed for high ignition pressures

– Low exhaust emissions

– Long maintenance intervals

3. Mixture formation, turbocharging 1,

Venturi gas mixer with gas supply through electronically controlled metering valve.

Mixture cooling
– Two-stage mixture cooling

– 1st stage is either integrated as high temperature stage (HT) in the engine cooling system or designed as HT circuit integrated in the heating system

– 2nd stage is designed as low temperature stage (LT) with external cooling circuit

Charging
– Mixture compression by exhaust turbocharger

– Throttles between mixture coolers and mixture distribution lines

4. Engine cooling system with 2 separate circuits
– HT circuit with integrated oil cooling, first-stage mixture cooling and cylinder cooling

– Integrated coolant preheating

5. Starting equipment 1,
– Electrical starter

– Two starters (16V and 20V)

6. Ignition system
– Microprocessor-controlled high-voltage ignition system with low-voltage distribution, no moving parts, wear-free

– Automatic ignition power control

– One ignition coil per cylinder

– High-performance sparkplugs

7. Engine monitoring
Measurement and monitoring of the following values:
– Engine oil pressure, engine oil temperature and engine oil level

– Coolant pressure and coolant temperature before and after engine

– Intake air pressure and intake air temperature

– Mixture pressure and mixture temperature

– Crankshaft speed, camshaft speed, turbocharger speed

– Crankcase pressure

– Exhaust bulk temperature

– Cylinder exhaust temperatures

8. Control
Engine governor
– Controls the starting, stopping and emergency stop sequence

– Monitors the engine operating parameters

– Controls throttles and sets gas mixture for requested speed/power

– Monitors the first gas solenoid valve the gas train to the engine

Engine monitoring
– Evaluation unit for PT 1000 temperature sensor to determine and monitor exhaust temperatures of individual cylinders

– Monitors the second gas solenoid valve the gas train to the engine

Ignition system
– Cylinder-selective adjustment of ignition voltage and ignition timing

Anti-knock control AKR
– Controls the cylinders with regard to the knock characteristics.

Gas control valve
– Controls the required amount of gas

valid for product no.

2.2 Exhaust System 1,

The exhaust system consists of the following: 1,

- 1 turbocharger 8V, 12V, 16V
- 2 turbochargers 20V, two exhaust pipes / outlets,
- Uncooled, insulated exhaust manifolds in engine Vee, arrangement ensures protection against accidental contact

2.3 Fuel System 1,

The gas train is supplied in accordance with the pressure equipment directive (DGRL as amended), with CE declaration of conformity in accordance with DGRL. One hose connection is supplied loose for installation on site. 1,

The gas train consists of aluminum pressure die casting, sealing material NBR and completely pre-assembled. 1,

Components of the gas train include:

- Gas filter
- Double solenoid valve
- Balanced pressure regulator
- Valve tightness check
- Pressure monitor
- Flexible stainless steel hose assembly for direct connection of the gas train to the gas control valve

Cabling between MIP and gas train according to the basic MTU wiring diagrams.

2.4 Oil System 1,

Lubrication Oil System 1,

The lubrication oil system consists of the following:

- Engine-mounted gear-type lube oil pump with safety valve for forced-feed lubrication and piston cooling and connection to an extended lube-oil circulation volume
- Lube oil heat exchanger, engine-mounted
- Paper-type lube oil filter with exchangeable filter cartridges
- Oil float switch with Reed contacts to control the solenoid valve to control automatic oil replenishment system
- Oil level dipstick

– Crankcase ventilation via oil separator with discharge to the mixture line before the turbocharger

– Connections for oil replenishment and oil extraction

The lube oil system comprises an integrated waste oil pump, which is used for **emptying and prelubricating** the genset. Pipe connections on site:

– Oil sump under the genset (without WHG approval)

– Waste-oil/oil priming pump with three-way solenoid valve mounted on the base frame

– Oil sump under the pump assembly (without WHG approval)

– Solenoid valve for fresh-oil replenishment and prepared for an extended oil volume

2.5 Air Intake System 1,

Intake air system 1,

The Air Intake System includes the following:

– Air intake through dry-type air filters mounted on engine or intake housing

– Intake air filters designed as dry-type filter cartridges

– 1 intake air filter 8V, 12V, 16V

– 2 intake air filters incl. intake housing 20V

– incl. service indicator and sensor for automatic pollution monitoring

3 GENERATOR CONFIGURATION 1,

3.1 Generator Specification 1,

Highly efficient, self-excited brushless synchronous alternator 1,

General data:

– Housing

– 2/3-pitch winding to prevent high harmonic neutral currents and reduction of 3rd order harmonics

– 2-bearing alternator, lubricatable bearing

– Dynamically balanced as per BS 6861-1 stage 2,5

– Self ventilated alternator IC 0A1

– Protection class IP23

– Alternator terminal box for main and auxiliary power circuit (for medium voltage alternators: medium and lower voltage separated)

- Outlet for power cable at left from drive end view, including non magnetic inlet cover
- Alternator suitable for operation mode S1, for mains parallel operation and in parallel or island operation among other alternators
- Excitation system: PMG (permanent magnet machine)
- Sustained short circuit current at 3-pole terminal short circuit is minimum 3 times rated current for 10 seconds
- Maximum overspeed 2250 rpm, for maximum 2 minutes
- Digital voltage regulator
- Protection transformer xxx/1A 5P10
- Measuring transformer xxx/1A
- 2 times PT100 winding temperature monitoring for each phase integrated in stator winding
- 1 time PT100 bearing temperature monitoring per bearing
- Alternator anti condensation heater integrated

Norms and regulations:

- IEC 60034-1
- EN 61000-6-2 Criteria B
- BS 5000-3
- ISO 8528-3
- AS 1359

Regulations for static and dynamic grid support (grid guideline) 1,

The alternator does not comply with eventual regulations for static and dynamic grid support

3.2 Power Transmission 1,

The torque produced by the engine is transmitted to the alternator via a highly resilient flange coupling. 1,

5 CONTROL PANEL CONFIGURATION 1,

5.1 Genset Control 1,

The MIP including cooling unit (instead of fan) is designed for an control panel temperature of 40°C to 55°C 1,

Fire detecting sensor 1,

Sensor with mounting base for fire detection in the plant room; supplied loose, for assembly and wiring

to the MTU Module Control (MMC) panel on site.

Gas leakage detection sensor 1,

The Methane (CH4) sensor will trip at approximately 15% lower explosion limit to avoid explosive mixture in the machine room; supplied loose, for assembly on site; analysis device integrated in MMC; Calibration and test required on site prior to commissioning (by third party).

Alarm indicator flash light 1,

Alarm indicator flashlight. Supplied loose for assembly on site.

6 EXHAUST AFTERTREATMENT 1,

6.1 Aftertreatment Specification 1,

Optionally an oxidation catalyst per genset is available to reduce the carbon monoxide and formaldehyde emissions, supplied loose for installation on site. 1,

8 HEAT EXTRACTION 1,

8.1 Heat Extraction Jacket Water 1,

Heat recovery from jacket water is not included in the scope of supply. 1,

11 MISCELLANEOUS 1,

11.1 Documentation 1,

Standard Publications in English-Language 1,

Set of standard operating, maintenance documentation and test run certificate

- Hardcopy
- CD-Rom

Supplementary documentation 1,

This delivery specification is only valid together with the following enclosures:

– Assembly Instructions	M060775/01E 2015-06
– Installation Conditions	MS65032/00E 2015-05
– Billing rates	vers. 2014-1
– Component Quality Guideline	DIN EN ISO 13849

1,

Completed Machinery
The selected Scope of Supply meet the requirements “completed machinery” of the machinery directive (EC Directive 2006/42/EC).

Declarations of conformity are only issued for the scope delivered by MTU Onsite Energy which meet the requirements for safety-relevant functions defined for this scope, so that safe operation is ensured. This scope of supply has to be fully integrated into the MTU Onsite Energy control system in order to issue declaration of conformity.

MTU Onsite Energy issues a declaration of incorporation when partly completed machinery is supplied.

The following directives have been taken into account:
2006/42/EC (Machinery Directive)
DIN EN ISO 12100 (Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology)
DIN EN ISO 13489-1 (Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design)

11.2 Painting 1,

Standard painting of the genset components as follows: 1,

- Engine, alternator, heat recovery unit RAL 9006
- Base frame RAL 5002
- Control cabinet / MIS / MIP RAL 7035

11.3 Packing 1,

Standard packing 1,

- Genset covered with plastic sheet, MMC on pallet, accessories packed in carton or wooden box

11.4 EXCLUSIONS 1,

Please mind: 1,
Additional auxiliary systems are required to complete the system ready for operation on-site.
Since costs will depend on the local conditions and requirements of the particular installation site, these items are – unless specifically mentioned above or in attached specifications* - not included in our offer:

- Components to be installed at plant site, for e.g.: fuel supply, lube oil supply and disposal; air ventilation; cooling systems with radiators, pumps, expansion vessels etc.; preheating units; transformers; silencer, sound enclosure, exhaust systems; load banks or any other
- Mechanical and electrical erection i.e. any piping, ducting and cabling for the auxiliary systems at plant site, foundations or other civil works
- Overall plant load management systems in case of multiple gensets plant
- Commissioning of other components than offered
- Gas pressure reduction / increase unit for constant flow pressure or gas treatment systems if required
- Heat insulation on genset or supplied lose items
- Generator circuit breaker, switchboard, auxiliary drive panel, power cables
- Batteries with starting cables or mains starting unit
- Earthing material/connections and lightning protection

- Installation materials, civil works and tanks (water / lube oil)
- Operating media, including first filling
- Engineering, supervision and technical support for not contracted scope / specifications
- Any necessary permits / working permits
- Special synchronization devices as per local standard
- Any necessary certificates, reports or approvals as required in the country of operation
- All external connections

12 FUNCTIONAL TESTING 1,

12.1 Acceptance Testing 1,

The genset is tested on the test bench using natural gas as gaseous fuel; the test run includes NOx and CO emission measurements. The measured values and operating parameters are documented in the acceptance protocol. 1,

13 SHIPPING CONDITIONS 1,

13.1 Freight 1,

FCA Augsburg (Incoterms 2010) 1,

15 AUTOMATION CONFIGURATION 1)

15.1 Automation Description 1)

MIP and MMC 1)

The MIP (MTU Interface Panel) contains the genset control including alternator monitoring and synchronization equipment and is the standard interface between genset control system and MMC (MTU Module Control)
The MMC contains the cogeneration control system including mains monitoring, visualization and user interface. On site, the MMC control cabinet is attached separately on the floor.

The MIP (MTU Interface Panel) mainly includes the following components:

- Control elements (EMERGENCY STOP button)
- PLC central unit (Programmable Logic Control with various interfaces and input / output modules)
- EMM (Generator and mains protection, synchronizer) VDEW conformity
- Communication with ADEC engine controller and engine monitoring EMU via hardware signals and CAN bus
- Control of genset mounted auxiliary drives
- Basic-Hardware-Interfaces for connection to external systems
    - Measured line voltage (synchronization / power system protection)

- Bus bar voltage (synchronization / power system protection)
- Generator circuit-breaker checkback (On, Off, alarm)
- Mains circuit-breaker checkback (On, Off, alarm)
- Differential protection, ground fault protection external
- Mains protection from outside
- Mains failure test from outside
- Manual EMERGENCY STOP feedback circuit from outside
- Generator voltage at medium voltage

– **Output signals:**

  – Generator circuit-breaker activation (MCB On, MCB Off)

  – Mains circuit-breaker activation (MCB On, MCB Off)

  – Start request for auxiliary drives, general

  – Open back-up switch

  – Manual EMERGENCY STOP to outside

PLC (Programmable Logic Control)
Integrated functions:

– Recording of all measured data (analog and digital) of the basic scope

– Start / Stop procedure

– Control of genset mounted auxiliary drives

– Further control functions (power control)

– Evaluation of all alarm and status messages

– Monitoring of analog values

– Backup of parameters, measuring and operating data

Monitoring functions

Generator protection:

– Overfrequency (ANSI: 81, IEC: f>)

– Underfrequency (ANSI: 81, IEC: f<)

– Overvoltage (ANSI: 59, IEC: U>)

- Undervoltage (ANSI: 27, IEC: U<)
- Normally dependent overcurrent (ANSI: 51, IEC: I>t>)
- Overcurrent (ANSI: 50, IEC: I>>)
- Overload (ANSI: 32F, IEC: Pf>>)
- Reverse power (ANSI: 32R/F, IEC: Pr>, Pf>)
- Unbalanced load (ANSI: 46, IEC: I2>)

Synchronization functions
- Synchronization (ANSI: 25, IEC: --)

The MMC (MTU Module Control) mainly includes the following components:
- IPC (**I**ndustrial **PC** with 15" touch display) for visualization and user interface
- Control elements (key-operated switches, pushbuttons, EMERGENCY STOP button)
- Peripheral assemblies of the PLC control with digital and analog inputs and outputs
- Battery charger for providing the control voltage
- Basic-Interfaces for connection to external systems
  - Operating mode requirements (three inputs for the selection of operating modes: variable setpoint, fixed value 1 and 2)
  - Three external EMERGENCY STOP buttons
  - "Active power setpoint" (4-20 mA corresponds to 0-100 %) for variable setpoint operating mode
  - Status messages: Operational readiness for external selection, engine is running, group alarm
  - WAN interface for connection to the MTU remote monitoring system

PLC (Programmable Logic Control)
The PLC uses the Ethernet to communicate with the IPC.
Integrated functions:
- Recording of all measured data (analog and digital) of the basic scope and the selected options
- Optionally selected control of the external auxiliary drives
- Optionally selected control functions
- Evaluation of all alarm and status messages (storage and display at the IPC)
- Monitoring of analog values

– Backup of parameters, measuring and operating data

Monitoring Functions

Mains protection:

– Overfrequency (ANSI: 81, IEC: f>)

– Underfrequency (ANSI: 81, IEC: f<)

– Overvoltage (ANSI: 59, IEC: U>)

– Undervoltage (ANSI: 27, IEC: U<)

Control cabinet dimensions (WxHxD)

Control cabinet dimensions for MMC basic scope:

– 800 x 2000 x 600 mm

Deviating cabinet dimensions depending on selected options.

For further details refer to enclosed technical description MS61015.

Operating conditions 1)

– Air humidity: 10 to 80 %, non-condensing

– Control cabinet IP54

– Ambient temperature up to 30 °C 1)

– Installation height above msl (mean sea level) 1000 m 1)

15.2 Power mode 1)

Floating power control 1)

The power set point signal is provided from external (4-20mA signal or Bus-interface) variable between minimum and maximum value.

Fix value 1+2 1)

The default power set point is adjusted via touch screen or from external (bus connection).

15.3 Operating mode 1)

Multiple genset operation - Usage of common functions, when operating multiple gensets in parallel 1)

Mains parallel operation 1)

– Without connection to common control system

15.4 Electrical integration 1)

Grid type generator feed/supply 1)

		valid for product no.
	– TN-S-grid generator feed/supply	1)
	Grid type auxiliaries supply	1)
	– TN-S-grid type auxiliaries supply	1)
	System structure	1)
	– Low voltage-site without stepup-transformer	1)
	Additional protection devices	1)
15.5	**control of circuit breaker**	1)
	Generator circuit breaker	1)
	– Control: via dry contact	1)
	– Control of an external power breaker	1)
	Mains circuit breaker	1)
	– Control: via dry contact	1)
	Backup-function (in case of generator circuit breaker failure)	1)
	– Basic function: backup-function acting on mains circuit breaker	1)
	– Additional function: Backup-function not until "drag operation" (standard)	1)
15.7	**Auxiliary systems**	1)
	ENGINE COOLING WATER SYSTEM	1)
	Control engine cooling water pump	1)
	– Without	1)
	Warming-up ramp	1)
	– Activate warm-up ramp	
	HEATING WATER SYSTEM	1)
	Control heating water pump	1)
	– Without	1)

		valid for product no.
	MIXTURE COOLING WATER SYSTEM	1)
	TEMPERATURE CONTROL SYSTEM FOR ENGINE ROOM	1)
	Control for engine room ventilation	1)
	– Signal input temperature sensor for engine room control	
	– Position sensor: temperature engine room	
	GAS/FIRE ALARM SYSTEM	1)
	Gas alarm system	1)
	– Gas detection system type GMA041 with 1 sensor	
	Fire alarm system	1)
	– Fire detection system type ORS 144K	
	Signaling	1)
	– Signal output to extern at gas-/fire alarm	
	LUBE OIL SYSTEM	1)
	FUEL SYSTEM	1)
	Operation mode gas	1)
	– Single gas operation	
15.8	**SPECIAL FUNCTIONS ELECTRICAL EQUIPMENT**	1)
	Counter / meter evaluation	1)
	– Without	1)
15.9	**SOFTWARE CONFIGURATION**	1)
	Software interfaces	1)
	– Without	1)
	Remote access	1)
	– Remote access via internet (DSL/UMTS/LTE) with customer router	1)
	Visualization	1)
	– Additional third language: without	1)

		valid for product no.
15.10	**SWITCH BOARD CONFIGURATION MMC**	1)
	Painting of cabinet	1)
	– RAL 7035	
	Labeling	1)
	– Labeling: MMC	
	Size of panel	1)
	– Size of panel: W800 x H2000 x D600 mm	
	Panel door	1)
	– Door hinge right	
	– With Door locking device	1)
	Pedestal	1)
	– Without pedestal	
	Side panels	1)
	– With both side panels	
	Air conditioning	1)
	– Without cooling unit	
	Fan	1)
	– Fan size 105 m³/h	
	Air outlet	1)
	– 1 outlet filter in door, at the top centered (max. IP54)	
	Lock	1)
	– Comfort handle with dual-bit lock	
	Scope	1)
	– Standard lamp in cabinet	
	– Support roll for door	
	– Control battery	1)
	Cable inlets	1)

		valid for product no.
–	Control cable total: at the top through cover (flange plate)	1)
16	**MISCELLANEOUS AUTOMATION**	1)
16.1	**Documentation**	1)
–	Standard Publications in German-Language	1)