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0.01 Technical Data (at genset)

		100%	75%	50%	
Power input	[2]	kW	2.822	2.178	1.535
Gas volume	*)	Nm ³ /h	297	229	162
Mechanical output	[1]	kW	1.234	926	617
Electrical output	[4]	kW el.	1.202	902	599
Heat to be dissipated (calculated with Glycol 30%)		[5]			
~ Intercooler 1st stage (Engine jacket water cooling circuit)	[9]	kW	255	120	32
~ Intercooler 2nd stage (Low temperature circuit)		kW	104	83	67
~ Lube oil (Engine jacket water cooling circuit)		kW	168	159	145
~ Jacket water		kW	329	284	221
~ Surface heat	ca [7]	kW	100	~	~
Spec. fuel consumption of engine electric	[2]	kWh/kWel. h	2,35	2,42	2,56
Spec. fuel consumption of engine	[2]	kWh/kWh	2,29	2,35	2,49
Lube oil consumption	ca [3]	kg/h	0,25	~	~
Electrical efficiency			42,6%	41,4%	39,0%
Fuel gas LHV		kWh/Nm ³	9,5		

*) approximate value for pipework dimensioning
 [] Explanations: see 0.10 - Technical parameters

All heat data is based on standard conditions according to attachment 0.10. Deviations from the standard conditions can result in a change of values within the heat balance and must be taken into consideration in the layout of the cooling circuit/equipment (intercooler; emergency cooling; ...).

Main dimensions and weights (at genset)

Length	mm	~ 6.200
Width	mm	~ 1.800
Height	mm	~ 2.200
Weight empty	kg	~ 12.500
Weight filled	kg	~ 13.200

Connections

Jacket water inlet and outlet	DN/PN	80/10
Exhaust gas outlet [C]	DN/PN	300/10
Fuel Gas (at genset) [D]	DN/PN	125/16
Water drain ISO 228	G	½"
Condensate drain	mm	~
Safety valve - jacket water ISO 228 [G]	DN/PN	1½"/2,5
Lube oil replenishing (pipe) [I]	mm	28
Lube oil drain (pipe) [J]	mm	28
Jacket water - filling (flex pipe) [L]	mm	13
Intercooler water-Inlet/Outlet 1st stage	DN/PN	80/10
Intercooler water-Inlet/Outlet 2nd stage [M/N]	DN/PN	65/10

Output / fuel consumption

ISO standard fuel stop power ICFN	kW	1.234
Mean effe. press. at stand. power and nom. speed	bar	20,20
Fuel gas type		Natural gas
Based on methane number Min. methane number	MZ	80 70 d)
Compression ratio	Epsilon	12,5
Min./Max. fuel gas pressure at inlet to gas train	mbar	80 - 500 c)
Max. rate of gas pressure fluctuation	mbar/sec	10
Maximum Intercooler 2nd stage inlet water temperature	°C	40
Spec. fuel consumption of engine	kWh/kWh	2,29
Specific lube oil consumption	g/kWh	0,20
Max. Oil temperature	°C	~ 85
Jacket-water temperature max.	°C	~ 95
Filling capacity lube oil (refill)	lit	~ 360

c) Lower gas pressures upon inquiry

d) based on methane number calculation software AVL 3.2 (calculated without N2 and CO2)

0.02 Technical data of engine

Manufacturer		JENBACHER
Engine type		J 416 GS-C02
Working principle		4-Stroke
Configuration		V 70°
No. of cylinders		16
Bore	mm	145
Stroke	mm	185
Piston displacement	lit	48,88
Nominal speed	rpm	1.500
Mean piston speed	m/s	9,25
Length	mm	3.660
Width	mm	1.495
Height	mm	2.085
Weight dry	kg	6.800
Weight filled	kg	7.435
Moment of inertia	kgm ²	13,50
Direction of rotation (from flywheel view)		left
Radio interference level to VDE 0875		N
Starter motor output	kW	7
Starter motor voltage	V	24

Thermal energy balance

Power input	kW	2.822
Intercooler	kW	359
Lube oil	kW	168
Jacket water	kW	329
exhaust when cooling down 180 °C	kW	403
exhaust when cooling down 100 °C	kW	561
Surface heat	kW	57

Exhaust gas data

Exhaust gas temperature at full load	[8]	°C	378
Exhaust gas temperature at bmep= 13,5 [bar]	[8]	°C	~ 409
Exhaust gas temperature at bmep= 10,1 [bar]	[8]	°C	~ 441
Exhaust gas mass flow rate, wet		kg/h	6.590
Exhaust gas mass flow rate, dry		kg/h	6.151
Exhaust gas volume, wet		Nm ³ /h	5.221
Exhaust gas volume, dry		Nm ³ /h	4.675
Max.admissible exhaust back pressure after engine		mbar	60

Combustion air data

Combustion air mass flow rate		kg/h	6.395
Combustion air volume		Nm ³ /h	4.948
Max. admissible pressure drop at air-intake filter		mbar	10

basis for exhaust gas data: natural gas: 100% CH₄; biogas 65% CH₄, 35% CO₂

Sound pressure level

Aggregate a)		dB(A) re 20µPa	97
31,5	Hz	dB	84
63	Hz	dB	88
125	Hz	dB	97
250	Hz	dB	95
500	Hz	dB	93
1000	Hz	dB	88
2000	Hz	dB	87
4000	Hz	dB	90
8000	Hz	dB	88
Exhaust gas b)		dB(A) re 20µPa	113
31,5	Hz	dB	101
63	Hz	dB	111
125	Hz	dB	116
250	Hz	dB	105
500	Hz	dB	102
1000	Hz	dB	96
2000	Hz	dB	108
4000	Hz	dB	107
8000	Hz	dB	104

Sound power level

Aggregate	dB(A) re 1pW	117
Measurement surface	m ²	105
Exhaust gas	dB(A) re 1pW	121
Measurement surface	m ²	6,28

a) average sound pressure level on measurement surface in a distance of 1m (converted to free field) according to DIN 45635 and ISO 3744, precision class 3.

b) average sound pressure level on measurement surface in a distance of 1m according to DIN 45635 and ISO 3744, precision class 2.

The spectra are valid for aggregates up to bmep=19 bar. (for higher bmep add safety margin of 1dB to all values per increase of 1 bar pressure).

Engine tolerance ± 3 dB

0.03 Technical data of generator

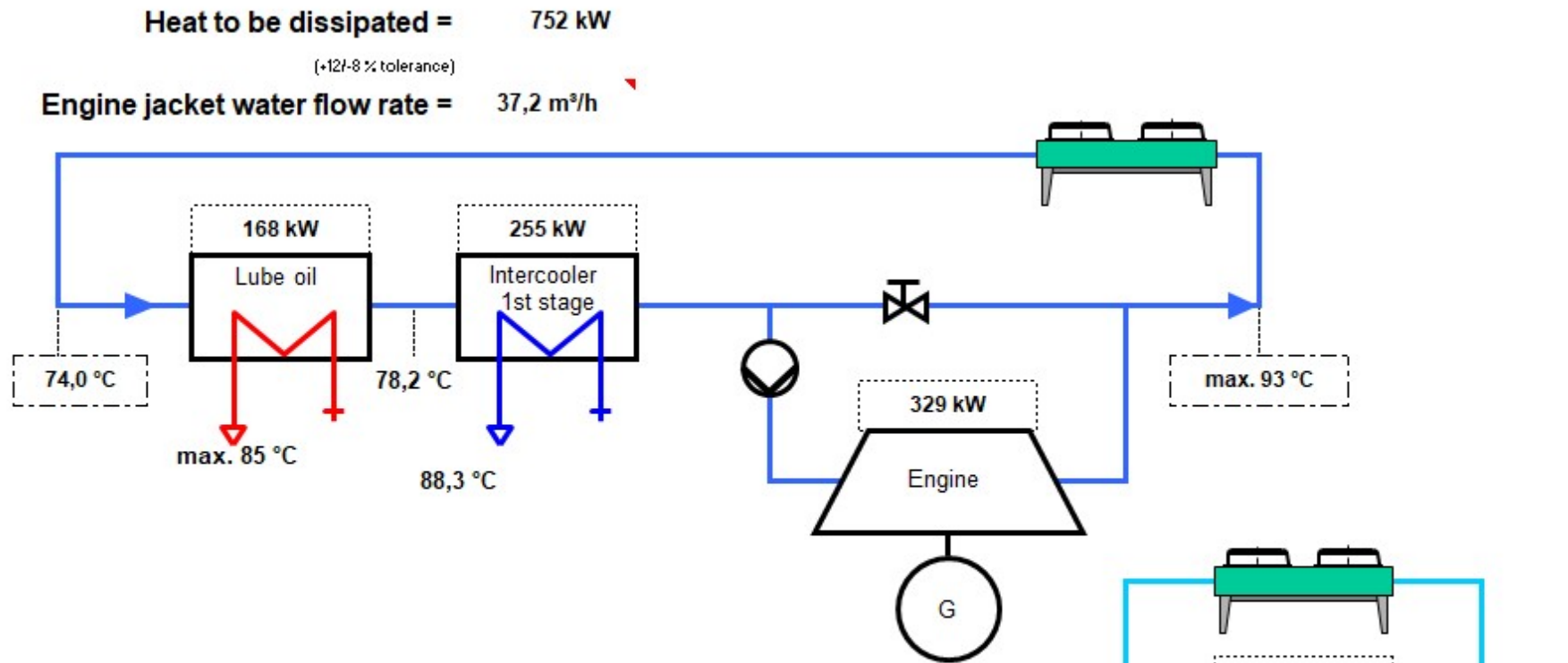
Manufacturer		STAMFORD e)
Type		S7L1D-E42 e)
Type rating	kVA	1.625
Driving power	kW	1.234
Ratings at p.f. = 1,0	kW	1.202
Ratings at p.f. = 0,8	kW	1.191
Rated output at p.f. = 0,8	kVA	1.489
Rated reactive power at p.f. = 0,8	kVar	893
Rated current at p.f. = 0,8	A	2.149
Frequency	Hz	50
Voltage	V	400
Speed	rpm	1.500
Permissible overspeed	rpm	1.800
Power factor (lagging - leading) (UN)		0,8 - 0,95
Efficiency at p.f. = 1,0		97,4%
Efficiency at p.f. = 0,8		96,5%
Moment of inertia	kgm ²	40,08
Mass	kg	3.264
Radio interference level to EN 55011 Class A (EN 61000-6-4)		N
Cable outlet		left
I _k " Initial symmetrical short-circuit current	kA	19,87
I _s Peak current	kA	50,57
Insulation class		H
Temperature (rise at driving power)		F
Maximum ambient temperature	°C	40

Reactance and time constants at rated output (saturated)

x _d direct axis synchronous reactance	p.u.	1,982
x _d ' direct axis transient reactance	p.u.	0,153
x _d " direct axis sub transient reactance	p.u.	0,107
x ₂ negative sequence reactance	p.u.	0,136
T _d " sub transient reactance time constant	ms	20
T _a Time constant direct-current	ms	30
T _{do} ' open circuit field time constant	s	4,29

e) JENBACHER reserves the right to change the generator supplier and the generator type. The contractual data of the generator may thereby change slightly. The contractual produced electrical power will not change.

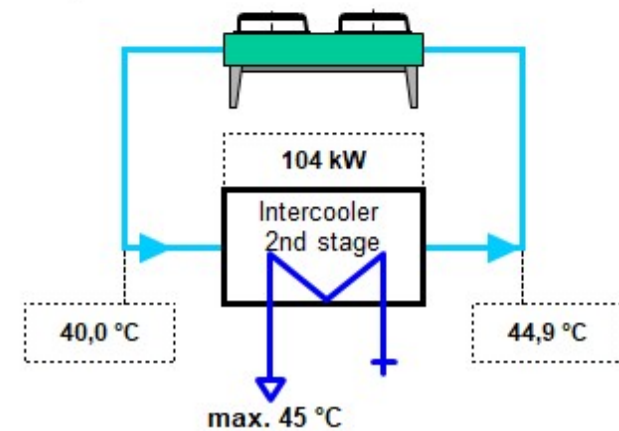
Engine jacket water cooling circuit (calculated with Glycol 30%)



Low temperature circuit (calculated with Glycol 30%)

Heat to be dissipated = 104 kW
(+12/-8 % tolerance)

Cooling water flow rate = 20,0 m³/h



0.05 Cooling water circuit

Oil - heat (Engine jacket water cooling circuit)

Nominal output	kW	168
Max. Oil temperature	°C	85
Loss of nominal pressure of engine jacket water	bar	0,50
Safety valve - max press. set point	bar	2,50

Engine jacket water - heat (Engine jacket water cooling circuit)

Nominal output	kW	329
Max. engine jacket water temperature (outlet engine)	°C	93
Engine jacket water flow rate	m³/h	37,2
Safety valve - max press. set point	bar	2,50

Mixture Intercooler (1st stage) (Engine jacket water cooling circuit)

Nominal output	kW	255
Max. inlet cooling water temp. (intercooler)	°C	78,2
Nominal pressure of cooling water / (max. operating pressure)	PN	10
Loss of nominal pressure of engine jacket water	bar	0,30
Safety valve - max press. set point	bar	2,50

Mixture Intercooler (2nd stage) (Low temperature circuit)

Nominal output	kW	104
Max. inlet cooling water temp. (intercooler)	°C	40
Aftercooler water flow rate	m³/h	20,0
Nominal pressure of cooling water / (max. operating pressure)	PN	10
Intercooler water pressure drop	bar	0,80
Safety valve - max press. set point	bar	2,50

The final pressure drop will be given after final order clarification and must be taken from the P&ID order documentation.

0.10 Technical parameters

All data in the technical specification are based on engine full load (unless stated otherwise) at specified temperatures and the methane number and subject to technical development and modifications.

All pressure indications are to be measured and read with pressure gauges (psi.g.).

[1] At nominal speed and standard reference conditions ICFN according to ISO 3046-1, respectively

[2] According to ISO 3046-1, respectively, with a tolerance of **+5 %**.

Efficiency performance is based on a new unit (immediately upon commissioning). Effects of degradation during normal operation can be mitigated through regular service and maintenance work.

[3] Average value between oil change intervals according to maintenance schedule, without oil change amount

[4] At p. f. = 1.0 according to IEC 60034-1:2017 with relative tolerances, all direct driven pumps are included

[5] Total output with a tolerance of +12/-8 %

[6] According to above parameters [1] through [5]

[7] As a guiding value at p.f. 0.8 and only valid for (engine, generator, TCM). Other peripheral equipment is not considered.

[8] Exhaust temperature with a tolerance of ± 8 %

Note: an optimised operating mode to minimise methane slip can result in changed exhaust gas data (exhaust gas temperature, NOx emissions, etc.) and must be taken into account in the design of the exhaust gas aftertreatment

[9] Mixture temperature at:

If the engine is designed for intake air temperatures of $> 30^{\circ}\text{C}$, then the stated mixture heat of the 1st stage is to be increased from 25°C in $2^{\circ}/^{\circ}\text{C}$ increments. The additional temperature must be added to the resulting full load point.

Radio interference level

The ignition system of the gas engines complies the radio interference levels of CISPR 12 and EN 55011 class B, (30-75 MHz, 75-400 MHz, 400-1000 MHz) and (30-230 MHz, 230-1000 MHz), respectively.

Definition of output

- ISO-ICFN continuous rated power:

Net break power that the engine manufacturer declares an engine is capable of delivering continuously, at stated speed, between the normal maintenance intervals and overhauls as required by the manufacturer. Power determined under the operating conditions of the manufacturer's test bench and adjusted to the standard reference conditions.

- Standard reference conditions:
Barometric pressure: 1000 mbar (14.5 psi) or 100 m (328 ft) above sea level
Air temperature: 25°C (77°F) or 298 K
Relative humidity: 30 %

- Volume values at standard conditions (fuel gas, combustion air, exhaust gas)
Pressure: 1013 mbar (14.7 psi)
Temperature: 0°C (32°F) or 273 K

Loss of engine performance

a) Performance reduction due to gas quality

If the reference methane number is not reached and the knock control responds, the ignition timing at full performance is adjusted in conjunction with the engine management system; only then is performance reduced.

H₂ admixtures in the range of 3–5 Vol% into the natural gas network are generally regarded as non-critical. Prerequisites for this are rates of change according to TA 1000-0300, as well as the knock resistance (minimum methane number) of the natural gas-H₂ mixture according to the specification. For reliable compliance with required NO_x emissions, the JENBACHER LEANOX^{plus} control is recommended (measurement of NO_x emissions and correction of the LEANOX controller). Higher H₂ addition rates into the natural gas network must be assessed on a project-specific basis.

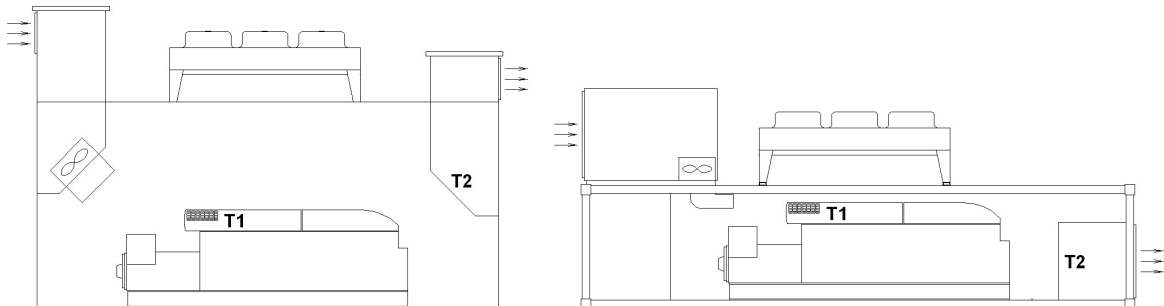
b) Performance reduction due to voltage and frequency limits

If the voltage and frequency limits for generators specified in IEC 60034-1 Zone A are exceeded, performance is reduced.

c) Performance reduction due to environmental conditions

Standard rating of the engines is for an installation at an altitude ≤ 500m and combustion air temperature ≤ 30°C (T₁)

Engine room outlet temperature: 50°C (T₂) -> engine stop



The minimum recommended air change ratio (C) must be observed to maintain the required air quality and prevent unwanted gas accumulations (refer to Section ⇒ Potentially explosive Atmospheres as per TA1100-0110). The calculation is based on TA 1100-0110 and is $C_{min} = 50h^{-1}$ for JENBACHER modules.

Parameters for the operation of JENBACHER gas engines

The genset fulfils the limits for mechanical vibrations according to ISO 8528-9.

The following forms an integral part of a contract and must be strictly observed: **TA 1000-0004, TA 1100 0110, TA 1100-0111, and TA 1100-0112.**

Transport by rail should be avoided. See **TA 1000-0046** for further details

Failure to adhere to the requirements of the above-mentioned TA documents can lead to engine damage and may result in loss of warranty coverage.

Ready for H₂ means a possible adaptation up to 100vol% H₂ operation. Performance data, timeline and costs can be determined on a project-specific basis.

Parameters for the operation of control unit and the electrical equipment

Relative humidity 50% by maximum temperature of 40°C.
Altitude up to 2000m above the sea level.

0.20 Mode of Operation

Grid Parallel and Island Operation - Single Unit (Auto Re-sync)

While Grid connected, the unit load can be adjusted via its power control set point or designated option. In the event of a loss of utility, the unit will be able to continue operating locally without utility power. When the mains monitor relay (protective relay ANSI No. 27, 59, 81, 78- provided either by JENBACHER or the customer) is activated due to a mains failure, the engine is isolated from the mains by opening the mains circuit breaker.

The load adding and shedding capabilities of the genset documented in

- TA 2108-0031 - general island operation
- TA 2108-0027 for type 2 engines
- TA 2108-0025 for type 3 engines
- TA 2108-0029 for type 4 engines
- TA 2108-0026 for type 6 engines
- TA 2108-0032 for type 9 engines

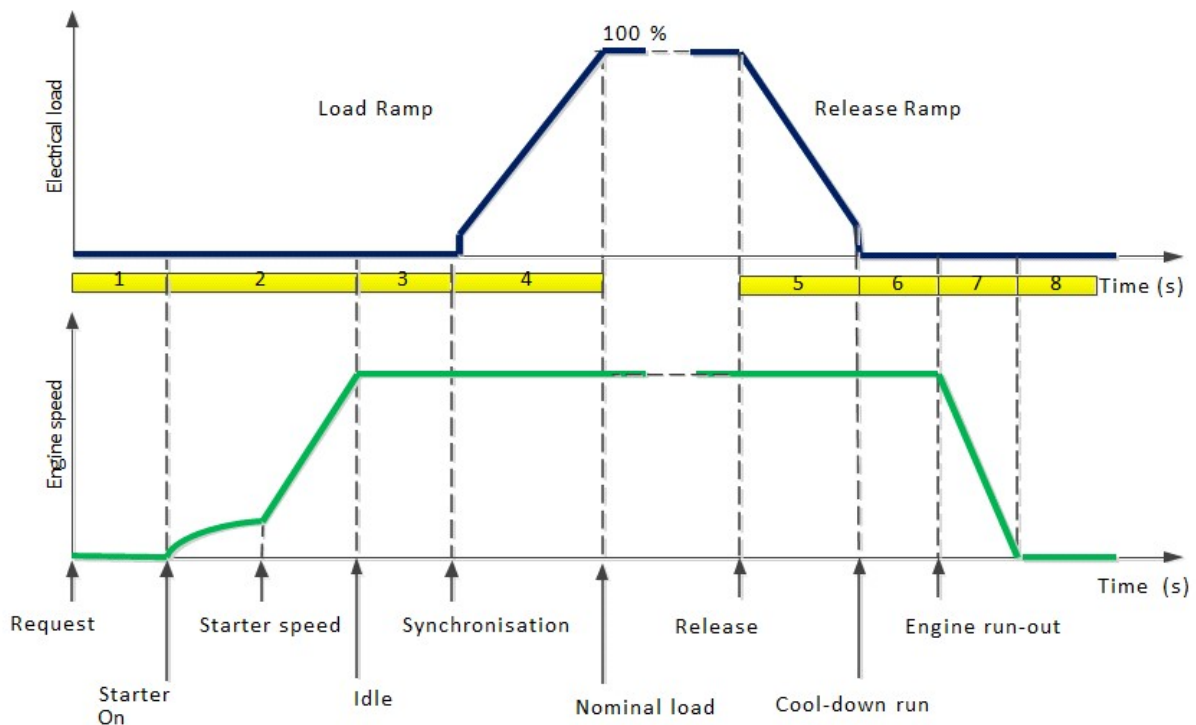
needs to be considered by the customer in order to ensure proper operation of the equipment.

When grid is restored, the unit is provided with an automatic re-synchronization feature which will synchronize the unit back to the utility (limited to one Mains Circuit Breaker, no additional Section Circuit Breaker or the like). The unit(s) can perform "Black-out" start without external auxiliary power supply to the "dead busbar".

0.20.01 Guide values for genset - start/stop times and el. load ramps

Basic boundary conditions for engine start:

Engine conditions	Oil temperature (°C / °F)	Cooling-water temperature (°C / °F)
Fast start release	> 27 / 80.6	> 55 / 131
Start enable automatic start		> 37 / 98.6
synchronization release		> 55 / 131



The following time data of the individual start sections up to the nominal load are **guideline values** for a fully automatic start under preheated conditions for mains parallel operation. Only the total start time is observed under the various engine conditions. The individual time periods specified in the table therefore do not necessarily add up to the specification of the total start time in mains parallel operation.

Deviations are possible for special designs.

	J208	Type 3	Type 4	Type 612 – 620	J624
(1) Start preparation [1] *)	0	0	20	70	90
(2) Engage starter until reaching nominal speed [s] *)	20	20	25	40	40
(3) Synchronisation [s] *) **)	1-50	1 – 50	1 – 50	1 – 50	1 – 50
(4) Load application up to nominal load [s] *) **)	180	180	180	160	160
Total start-up time from request to nominal load [s]	<300	<300	<300	<300	<330

*) The times for start-up preparation and synchronisation can vary greatly and depend on project specifications.

****) Fast start function and faster load ramps are available on request.**

The following **times for unloading the engine** are guide values for engine/generator combination inertia constant $H < 1$ kW/s/kVA (with LS, CGT, TDPS generators) and the hot operating condition.

(5) Load reduction ramp [s]	160	160	160	160	120
(6) Cool-down run [s]	60	60	60	10	10
(7) Run-down [s]	60	60	60	60	60
Total time from nominal load to run-down time [s]	280	280	280	220	180
(8A) gas tightness control [s]	<100	<100	<100	<100	<100
(8B) Flushing time exhaust tract after shutdown [s] ^{***}				100	100
(8C) Flushing time exhaust tract after shutdown with SD and WT [s] ^{***}				180	300
(8D) Flushing time exhaust tract after shutdown with SD, WT, SCR and greenhouse [s] ^{***}				225	400
(8E) Blocking time for restart [s]	30	30	30	30	30

*****)** The exhaust gas purging times apply when the exhaust gas purging fan is installed

The table shows the waiting time between stopping the engine and starting it again, with the gas tightness check (8A), exhaust gas scavenging (8B-D) and blocking time (8E) being carried out in parallel. The flushing times can be extended project-specifically depending on the exhaust system.

It should also be noted that the exhaust gas purge must be performed after each unsuccessful start attempt once the gas valve has been opened. (SD = silencer, WT = heat exchanger)

0.30 General information for connection to the public mains

Technical Instruction TA 1530-0188 describes the - possibly optional - functions and parameters for complying with the boundary conditions defined in the country-specific "Grid Codes".

Network operator-dependent requirements must always be coordinated with JENBACHER.

0.30.10 Generator operating range in mains parallel operation

Frequency:

Normal operation $f_n \pm 2\%$ - without power output reduction

Extended operation: $f_n \pm 4\text{--}6\%$ - with power output reduction between 2 – 10%/Hz

Frequency-measurement resolution: $\leq 10\text{mHz}$ (resolution)

Generator - voltage range: $\pm 10\%$ of generator U_n

Generator power factor $\cos \phi$ at the generator terminals: as specified in "0.03 Generator technical data"

FRT (Fault Ride Through) – capability: at mains connection point

Profile 1: 150ms/30% U_n (applies to natural gas and biogas)

Profile 2 (150ms/5%Un) and Profile 3 (250ms/5%Un) upon request.

Requirement:

- mains short-circuit power must be at least 5 x SrE or 50MVA
- FRT capability of the onsite auxiliaries

Extended project requirements and country-specific design are optionally possible after consultation and approval with JENBACHER.

0.30.20 Possible mains operator requests

To protect the generating unit in mains parallel operation, appropriate mains protection monitoring functions are necessary to disconnect the generator from the mains in case of a mains fault.

The mains operator-dependent specifications such as e.g.: voltage and frequency range, active power limitation, load ramps, reactive power limitation and control, protection concept, necessary certification or declarations, process data and interfaces are to be specified in project enquiries and must be agreed with JENBACHER before conclusion of the contract.

- Selectivity assessment, protection tests and recurring tests: on-site by the system operator
- Control power provision via pool operator: on request e.g., primary, secondary, tertiary
- Black start capability and countering in own use: on request
- Power generation system (EZA) controller or central control: on-site or possible on request
- Process data scope / remote control:
 - System data must be provided by the connectee for the mains operator.
 - Remote control interface to the mains operator: on-site
 - Interface specification!

Billing measurements - installation, operation, maintenance and remote data transmission: on-site.

Models of genset and generator: simplified models executed as effective value models for mains parallel operation optionally available.

Model formats: Powerfactory, or PSS/E (as of PP23)

Validated genset models in Powerfactory according to FGW TR3, TR4 and TR8 by a body accredited for this purpose according to DIN EN ISO/IEC 17065

Functional scope of the models in mains parallel operation:

- static voltage stability
- dynamic mains support
- Provision of reactive power
- Behaviour at active power setpoint
- Active power adjustment in the event of overfrequency and underfrequency (LFSM-O, LFSM-U)
- Protective devices and settings

0.30.20.01 Active power adjustment in the event of overfrequency and underfrequency

The following functions are available:

- LFSM-U: Limited Frequency Sensitive Mode - Underfrequency

- LFSM-O: Limited Frequency Sensitive Mode - Overfrequency
- FSM

Reduced power output at overfrequency: (LFSM-O function)

The frequency threshold is freely adjustable from $f_n + (200 - 500\text{mHz})$ and the static from 2% to 12%.

Unless the relevant mains operator specifies otherwise for the LFSM-O mode, a threshold of $f_n + 200\text{mHz}$ and a static of 5% is set.

Power increase in the event of underfrequency (LFSM-U function) – (OPTIONAL as of XT4.5)

activated according to the mains operator's specifications

The frequency-sensitive active power feed-in has the effect that the generating plant also moves permanently up and down on the frequency characteristic curve ("driving on the characteristic curve") in the frequency range between $f_n - 200\text{mHz}$ (unless otherwise specified by the mains) and $f_n - 2.5\text{Hz}$ with regard to its maximum possible active power feed-in.

The prerequisite for this is a corresponding power setpoint.

Reduced power output at underfrequency:

below 98% of f_n , reduction by standard 10% of maximum capacity per Hz. Reduction up to maximum $f_n - 6\%$.

Lower reduction ramps of 2 - 10%/Hz on request

The FSM function is available as an option

The power generation system is capable of continuing to operate at this minimum power when the minimum power for controllable operation is reached.