
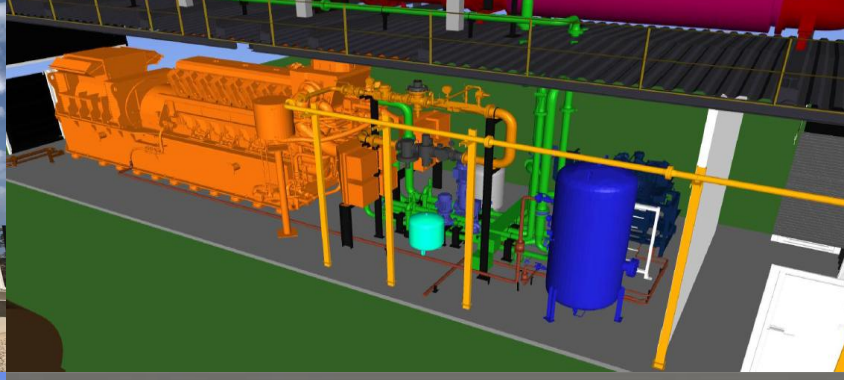
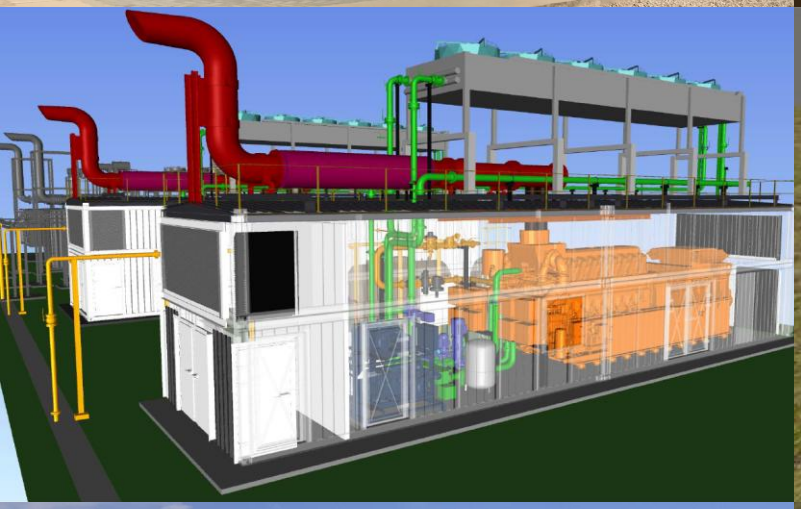

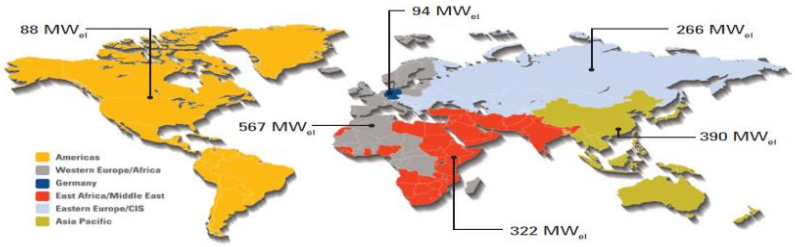

Unatrac CAT

- Ref: QG014-MF-IT-26
- Scope: 14 X CG260-16 GENSETS + Auxiliaries

Index

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1 Scope of Supply

1.1 Power Plant Scope of supplies:

- **Fourteen (14)** New Caterpillar Natural Gas Operation Gen-set CG260-16 - 4300ekW @ 1PF at ISO Conditions 10,500 V - 50 HZ -1000 RPM – Continuous Power – Open Package with the below attachments:
    - Base engine and MV alternator.
    - TEM engine Control System (Engine Control Panel).
    - Lube oil Heat Exchanger.
    - Air Starting Motor.
    - Zero-pressure gas Controlled system.

- **Fourteen (14)** Balance of plant includes the following:
    - Remote Cooling radiators sets.
    - Exhaust Gas Silencer.
    - HT and LT Circuits Pumps.
    - HT and LT Circuits Expansion Vessels.
    - HT and LT Circuits Three-way valves.
    - Air Bottle 2000L.
    - Electric air compressor 30bar (total of 1 for each 3 gensets).
    - Pre-pressure Gas Train Max. 2-6bar.
    - Neutral ground resistor (NGR) one for each genset bus section.
    - Auxiliary & Synchronization Panel (HAS).

1.2 Services

- Sea-Worthy Packing.
- Project Management of our scope of supplies.
- Commissioning of our scope of supplies.

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2 Installed Projects

Genset / Engine
5x CG260-16

Segment / Fuel Type
Industry / Solution Gas

Customer / Operator
Genalta Power

Total Output
20,000 kW_{el}

Installation / Commissioning
2015


Peace River Power Centre – Modular Power Plant

Genset / Engine
10x CG260-16
10x CG260-16

Segment / Fuel Type
Industry / Natural Gas

Customer / Operator
AHMSA

Total Output
40 MW_{el} +40 MW_{el}
=80 MW_{el}

Installation / Commissioning
FENIX I end of 2014
FENIX II end of 2015


FENIX I/II, Mexico

Genset / Engine
13 x CG260-16

Segment / Fuel Type
Electricity / Natural gas

Customer / Operator
Ywama PP, Myanmar

Total Output
52 MW_{el}

Commissioning
2014


Ywama Power Plant, Insein Township, Yangon, Myanmar.

3 Modular Power unit enclosure

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4 TECHNICAL OFFER FOR CG260-16

4.1 Power Plant Overview

Design Conditions

- Engine Room Maximum Inlet air temperature: 37°C.
- Air Rel. Humidity: Max. 40%.
- Altitude: 100 mASL.
- NOx emission: 500 mg/Nm³ @ 5% O_2

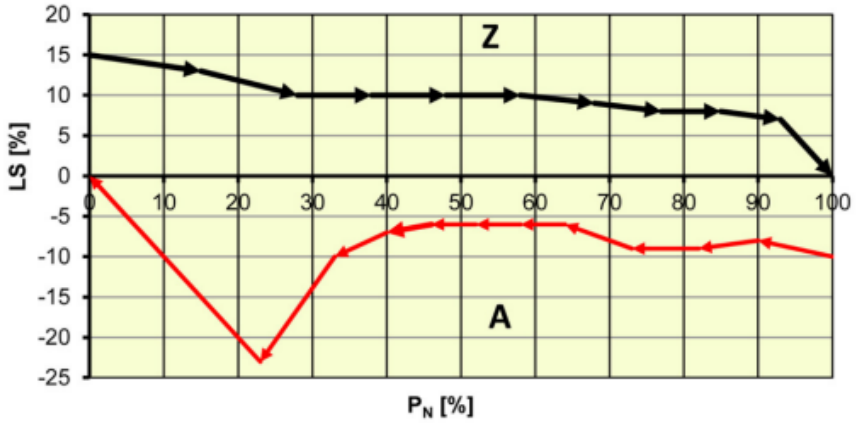
Combustion Gas

- Type: Natural Gas.
- Methane Number: 80 MN
- LHV: 10.17 kWh/Nm3
- Denisty: 0.79 kg/Nm3

Gen-set Configuration

- Genset Model: CG260-16 4300ekW 1PF@ ISO Condition
- Configuration: 14 X CG260-16 Continious operation
- Voltage: 10.5kV with +/- 10% range.
- Speed / Frequency: 1000 rpm / 50 Hz
- Operation Mode: Island Parallel operation.

Transient Response



Z Load acceptance **A** Load rejection **PN [%]** Actual power in percent, in relation to rated power
LS [%] Maximum permissible load acceptance and load rejection in percent, in relation to rated power.
*Final Gen-set Rating will be advised after getting Customer 100% gas composition and site operating conditions. For more details, please check Gen-set performance date in each case. Please check Technical Bulletin 0199-99-3017 for the approved combustion gas qualities for the operation of CAT CG engines. **Values may be changed if gas analysis or site conditions changed.

4.1.1 CG260 – Highest Availability and Reliability

High Availability
Long maintenance intervals and general overhaul only after 80,000 Oh allow an operation of 10 years without general overhaul

High Reliability
Anti-knock-control and cylinder balancing protect the engine from overload and ensure a reliable operation

Lowest Lube Oil Consumption
Improved components reduce lube oil consumption and save up to 4000 l compared to other engines.

High Profitability
Miller valve timing and optimized compression ratios ensure high efficiency and low fuels costs – more profit for your plant.

Varieties of Gases and Gas Qualities
Highly efficient operation with every type of gas due to adapted pistons, gas-mixer and latest control systems

High Performance under Every Condition
State-of-the-art turbocharger A140 with Waste gate ensures full performance even under high temperatures and higher altitudes

4.1.2 CG260 – Lowest Maintenance Cost

Maintenance plan		Gas Quality High
First service*	Oh	4,000
Spark plug change	Oh	4,000
Cylinder heads overhaul (latest)	Oh	40,000
general overhaul	Oh	80,000

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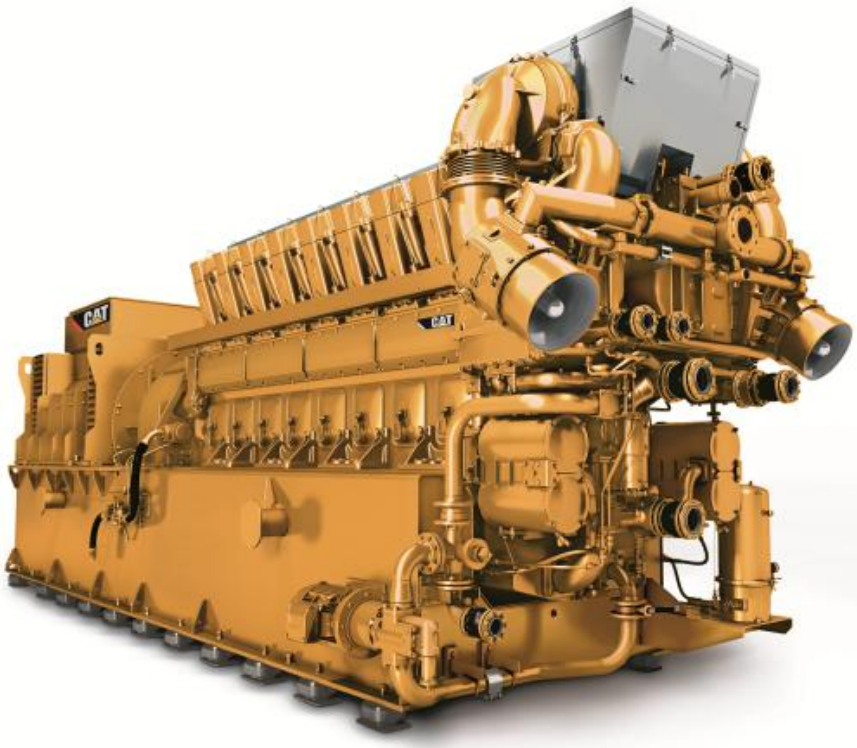
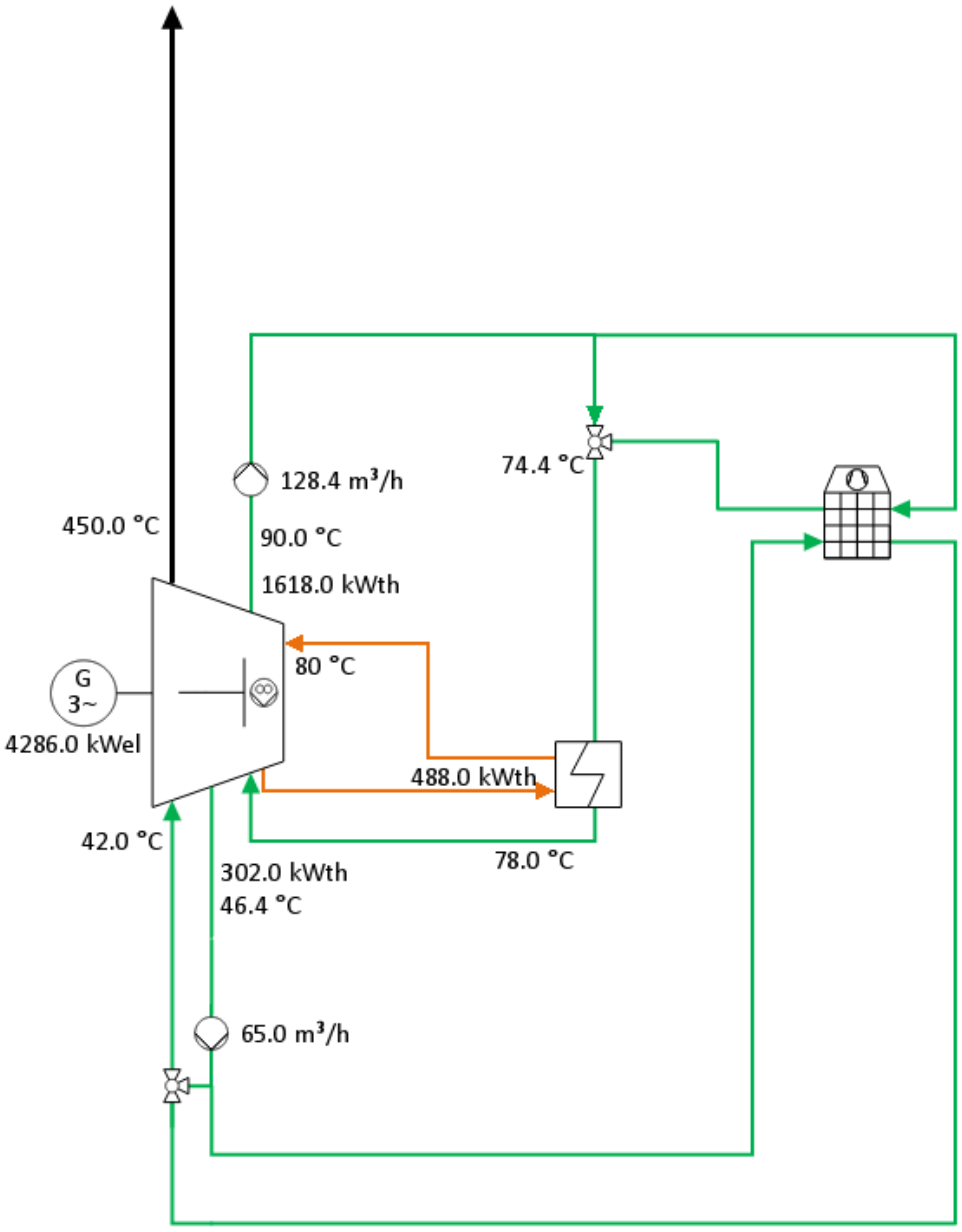
4.2 CATERPILLAR GAS GENERATOR: CG260-16



Picture may differ from actual gen-set

4.2.1 Preliminary Process flow diagram



Notes:

The P&I diagram is simply showing the hydraulic embedding of the aggregate.
All heat data is based on assumed standard conditions. 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; JW cooling; ...).

4.2.2 Engine Specifications

Make:	Caterpillar.
Type of Engine:	Four-Stroke, Natural Gas Fired Fuel
Application:	Power Generation, Continuous Power*
Aspiration:	Turbocharged Aftercooled
Arrangement - No. of Cylinders:	V-16
Bore:	260 mm
Stroke:	320 mm
Displacement:	272 L
Compression Ratio:	12:1
Gen-set Rated Power:	4300ekW @ unity PF at ISO Conditions
Rated Speed:	1000 RPM
Mode of Operation:	Island parallel Mode
Setting Up System:	Powerhouse

* Output available without varying load for an unlimited time.
** Please check the attached GAS ENGINE SITE SPECIFIC TECHNICAL DATA.

4.2.3 Air Inlet System

- Microfiber dry air filter with a visual service indicator, in cassette design, Lateral air supply with console, supplied as loose parts.
- Special hoses with accessories for connection between gas-air mixer and air filter.

4.2.4 Exhaust System

- Exhaust turbocharger.
- Exhaust Silencer – **Industrial grade 15dB(A)** (shipped loose).
- Exhaust backpressure sensor.
- Stainless steel expansion joints with counter flange (shipped loose).

4.2.5 Fuel System

- Multi-gas mixer for dosage of the gas-air mixture for each cylinder bank.
- Throttle organ (rotary valve) with electric actuator for the speed and power control.
- Electronic control and monitoring of the air-gas mixture at the mixer-actuator with the TEM system.
- Flexible connection of the gas line to the gas-air mixer.
- Zero-Pressure Gas Control Train, designed for an inlet pressure of 150 mbar with a permissible accuracy of AC 10 with a pressure fluctuation frequency < 10/ h.
- Pre-pressure Gas Train with Max. Inlet of 2-6bar.

4.2.6 Ignition System

- Non-wearing, high-voltage ignition system controlled by microprocessors with low-voltage distribution, one ignition coil per cylinder.
- Anti-knock control with knock sensor monitoring (one sensor per two cylinders).

4.2.7 Lubrication System

- Gear type lube oil pump.
- Lube oil heat exchanger, Installed.
- Oil filter in the mainstream.
- Immersion probe for oil level monitoring (min. /max.)
- Electrical pre-lubrication pump used also for engine emptying for oil change by switching a three-way valve.
- Two solenoid valves with connection parts for lube oil inlet.
- Flexible hoses for lube oil inlet and outlet connections.
- One Oil separator for ventilation of the crankcase with integrated filtering of the oil, Shipped loose.
- One vacuum regulator for mounting on the oil separator, Shipped loose.
- Integrated oil temperature sensor.
- Integrated oil pressure sensor.

4.2.8 Mounting System

- Non-flexing, torsion-resistant steel construction for supporting the engine and generator.
- One set of maintenance-free steel spring elements with height adjustment for easy alignment of the gen-set on the on-site foundation, Shipped loose.

4.2.9 Starting System

- Compressed air starting motor with inlet pressure 20 – 30 bar, attached air bottle and air compressor. (total of 2 compressors for each 3 gensets)

4.2.10 General

- Paint according to industrial standards - Caterpillar Yellow.
- One Can Repair Paint - Cat-yellow EATY008.
- Torsion-elastic, axial plug-in flange coupling for connection of engine and generator.

4.2.11 Cooling System

- Two-stage mixture cooler for re-cooling (low temperature level in a separate cooling circuit).
- HT & LT Cooling Circuit Pumps electrically operated (Shipped loose).
- HT & LT Cooling Circuit Expansion Vessels (Shipped loose).
- Lube Oil Heat Exchanger (Shipped loose).
- Mixture cooling circuit three-way valves with electric actuator - 24V DC (Shipped loose).
- Engine cooling circuit three-way valves with electric actuator - 24V DC (Shipped loose).
- Remote horizontal cooling radiator –Ambient Temperature 35˚C (Shipped loose).
- Electric Preheating.
- Engine HT Circuit Sensors and Accessories:
  - Temperature Sensor.
  - Differential Pressure Switch.
- Mixture aftercooler LT Circuit Sensors and Accessories:
  - Temperature Sensor.
  - Water low level switch
  - Differential Pressure Switch.

4.2.12 Literature

- Language on the labelling of the gen-set: English (US)

4.2.13 Genset Acceptance Test:

- After quality tests and setting up on the test bench, the following test runs are carried out:

Measuring Point	Duration in minutes	Number of measurements
100 % ISO - power at rated speed	up to operation value within the tolerance range	1

- The following measured values are provided:
  Power, speed, lubricating oil pressure, gas consumption at methane number 80, efficiency, intake air temperature, exhaust gas temperature after turbine, receiver pressure, O2 dry, exhaust gas emission NOx (Reference: 5% O2 in dry exhaust gas), frequency, voltage, power factor.

4.2.14 Generator Technical Data

Brand*	TDPS, Marelli, or Equivalent (depending on supply chain)
Rating (Continous) at ISO Conditions	4300ekw @ Unity Power Factor at ISO Conditions
Voltage	10,500 V (Nominal voltage setting ±10 % U_N).
Frequency	50 Hz
Speed	1000 RPM
Insulation	Class "F"
Excitation	Self-Excited
Protection degree	IP23 acc. to IEC 60034-5.
VentilationType	IC01 acc. to IEC 60034-6
Winding Pitch	5/6
Voltage Regulator:	Digital Voltage Regulator.
Generator Winding Temperature Monitoring:	Included (2 Sets of 3 PT100) (One Per Phase + One Spare Set)
Anti-Condensation space heaters:	240 V ±5%, 4 x 150 W

*CES reserves the right to change the alternator supplier and type during offer period. The genset data may thereby change slightly. The power output will not change. CES will confirm the alternator type, brand and alternator data sheet with the order confirmation.

4.2.15 Engine control TEM EVO system

The **Total Electronic Management (TEM)** system involves controlling and monitoring all functions of a gas engine, as well as the engine auxiliary drives in one unit. Its monitoring functions protect the engine against impermissible boundary conditions and guarantee a long service life.

The TEM EVO system comprises three components:

- I/O Controller (installed in Auxiliary Switchgear).
- Operating computer (15" TFT monitor and the graphic user interface, installed in Auxiliary Switchgear).
- Gen-set switch cabinet ("AGS").

Functions:

- Automatic program flow for starting and stopping the gas engine gen-set
- Exhaust emissions Control at low NOx values
- Integrated digital engine speed and power control.
- Monitoring of all sensors in the gen-set.
- Monitoring of the engine cooling water.
- Control and monitoring of the lube oil circuit.
- Test mode for verification of connected actuators, sensors and auxiliary gen-set.
- Electronic line recorder for measured values for control and diagnostic purposes.
- Electronic operating log to record warning, fault and operating messages.
- Electronic operating hour meter with breakdown into five load ranges.
- Option to connect an operating computer.
- Engine cooling water control: the cooling water circulation control actuates a three-way valve to ensure an optimum cooling water temperature. At partial load, the cooling water inlet temperature is increased.
- Mixture cooling circuit controls the mixture cooling water outlet temperature by actuating a control valve in the mixture cooling water circuit; monitors the receiver temperature
- Serial coupling for data exchange
- Anti-knock control.
- Monitoring of the generator bearing temperatures.
- Recording and Monitoring of bearing temperature (main engine bearing temperature in the TEM EVO to protect the engine. If the threshold value is exceeded, depending on the magnitude of the exceedance, a warning is triggered first and then a fault.
- Activation of the exhaust gas waste gate, measurement of the position of the control device and operation of the actuator
- Table cooler control for mixture cooling and engine cooling circuit.

4.2.16 Auxiliaries Switchgear (HAS)

Gen-set auxiliary panel with synchronization facility and to supply power to Gen-set's auxiliaries.

Auxiliaries Control

- Pre-lubrication pump.
- Intercooling Circuit Water Pump.
- Engine Cooling Circuit Water Pump.
- Electric Pre-heater
- Control and Starter Battery charger.
- Control valve Mixture cooling circuit.
- Control valve Engine cooling circuit.
- Radiator fan motors.
- Alternator anti condensation heater
- TEM AGS Panel

Synch Module:

- Its function is to perform Synchronization and load sharing between Gen-sets used for automatically start and stop the engine, indicating the operational status and fault conditions by means of an LCD display.

Protection Relays:

- Overcurrent (50/51)
- Over/Under voltage (27/59)
- Over/Under frequency (81 O/U)
- Reverse Power (kW) (32)
- Overcurrent (50/51)

Measurements:

- Generator voltage (L1-L2, L2-L3, L3-L1, L1-N, L2-N, L3-N).
- Generator current (L1, L2, L3).
- Generator frequency.
- Generator power (VA, W, var).
- Battery control voltage.
- Breaker status.

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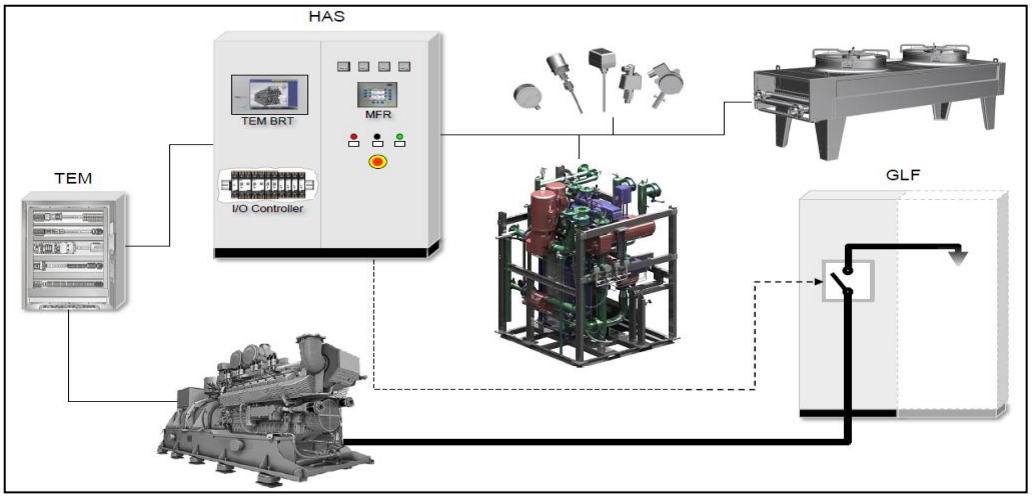
Genset Control Overview:



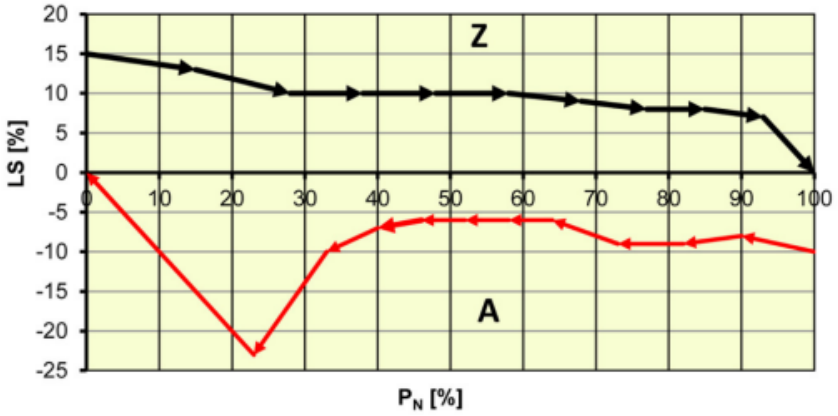
4.2.17 Neutral Grounding Panel

- Switchboard: free standing, metal enclosed
- Cable entry: from bottom
- Door hanging side: Standard right
- Limiting earth fault current
- 11 KV Line to Line
- Operating Voltage, 6.35 Kilovolts Line to Neutral.

5 GENERAL NOTES

- Our offer doesn't include any Electrical, Mechanical materials and installation such as (Power & control cables, piping.... etc.) / civil works or any related materials.
- Supplying DC and AC source required for service are out of our scope.
- Please note that standard Caterpillar product has been quoted and their design specifications will apply. Any items, which are not listed in the standard specification, are not included.
- **Definition of Continuous power:** Output available without varying load for an unlimited time. Average power output is 70 – 100% of the continuous power rating. Typical peak demand is 100% of continuous rated ekW for 100% of operating hours. Continuous power is in accordance with ISO8528. Fuel stop power in accordance with ISO3046
- **Standards**: Caterpillar products in this Quote Meets or Exceeds International Specifications: AS1359, CSA, IEC60034-1, ISO3046, ISO8528, NEMA MG 1-22, NEMA MG 1-33, UL508A, 72/23/EEC, 98/37/EC, 2004/108/EC
- Our offer is limited to what is mentioned, please note that any items not mentioned explicitly in our offer is not included in our scope.
- **Generator transient response:** Please note that generator set transient response is solely dependent on customer load characteristics and cannot be guaranteed on a general basis. Please submit your loads for calculation of transient response for the genset system
- **Exhaust Emissions** are as per manufacture factory standards of emissions and this quote does not include any emissions treatment.
- **Our offer does not include potential or current transformers.** Potential transformers are not included as they are assumed to be a part of the customer Switchgear. No Measuring or Protection Current transformers are provided with our offer. No Differential current transformers are provided with our offer.
- Offer does not include load bank for testing.
- **This Quote** doesn't include below unless otherwise stated clearly in the offer:
    - Electromechanical & installation works.
    - Power plant complete earthing system.
    - Power plant lightning protection system.
    - Power plant lighting system.
    - Spare parts.
    - Fluids first fill of Gen-sets.
- First fill Oil and coolant are not included in this offer.
- Our offer is limited to what is mentioned, please note that any items not mentioned explicitly in our offer is not included in our scope
- This Quote does not include Synchronization with Grid

- Site conditions considered:
    1. Ambient: 35C
    2. Altitude: 152m
    3. Relative humidity: 60%
- Genset painting is according to CATERPILLAR standards.
- Genset packing and preservation is according to CATERPILLAR recommendations and standards.
- Customer shall advise available area at site to check gensets applicability to fit in place.
- Hydrogen sulfide (H2S) in gas shall not exceed 10 PPM.
- This Quote does not include Natural Gas Flow meters for Gen-set.
- Quote is based on safe area installation; no hazard location requirements is considered in the offer
- Please send load details, nature and sequence to check genset applicability to handle it.
- Gas pressure at 30 bar is not applicable, max inlet pressure is 2-6 bar.
- Power source is required as genset is not capable of black starting
- GENSET Loading shall follow below loading steps



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PERFORMANCE DATA AT 37 ambient and 1 P.F According to CAT standard gas analysis

Design conditions

Inlet air temperature / rel. Humidity:	[°C] / [%]	37 / 60
Altitude:	[m]	152
Exhaust temp. after heat exchanger:	[°C]	120
NOx raw emissions genset (tolerance -8 %):	[mg/Nm³ @5% O_2]	500

Fuel gas data: 1)

Methane number:	[-]	80
Lower calorific value:	[kWh/Nm³]	10,17
Gas density:	[kg/Nm³]	0,79

Standard gas: Natural gas, MN = 80

Genset:

Engine / Configuration code:	**CG260-16**	R
Speed / Mean piston speed:	[1/min] / [m/s]	1000 / 10,7
Configuration / number of cylinders:	[-]	V / 16
Bore / Stroke / Displacement:	[mm] / [mm] / [dm³]	260 / 320 / 272
Compression ratio:	[-]	12,0
Mean effective pressure:	[bar]	19,3
Mean lube oil consumption at full load:	[g/kWh]	0,2
Generator:	**TDPS TD 145 or similar (*)**	
Voltage / voltage range / cos Phi:	[V] / [%] / [-]	10500 / 10 / 1,00
Speed / frequency:	[1/min] / [Hz]	1000 / 50

*CES reserves the right to change the alternator supplier and type during offer period. The genset data may thereby change slightly. The power output will not change. CES will confirm the alternator type, brand and alternator data sheet with the order confirmation.

Energy balance

Load:	[%]	100	75	50
Electrical power COP acc. ISO 8528-1:	[kW]	**4286**	**3215**	**2150**
Engine jacket water heat:	[kW ±8%]	1618	1201	849
Intercooler LT heat:	[kW ±8%]	302	219	153
Lube oil heat:	[kW ±8%]	488	393	343
Exhaust heat with temp. after heat exchanger:	[kW ±8%]	2302	1904	1465
Exhaust temperature:	[°C ±25°C]	450	476	506
Exhaust mass flow | wet / dry:	[kg/h]	23108 / 20971	17608 / 15959	12455 / 11268
Combustion mass air flow:	[kg/h]	22339	17012	12023
Radiation heat engine / generator:	[kW ±8%]	215 / 96	207 / 81	205 / 72
Fuel consumption:	[kW+5%]	9857	7638	5535
Electrical / thermal efficiency:	[%]	43,5 / 44,7	42,1 / 45,8	38,8 / 48,0
Total efficiency:	[%]	88,2	87,9	86,8

System parameters 2)

Ventilation air flow (comb. air incl.) with ΔT = 15K	[kg/h]	119900
Combustion air temperature minimum / design:	[°C]	7 / 37
Exhaust back pressure from / to:	[mbar]	30 / 50
Exhaust volume flow | wet / dry:	[Nm³/h]	17840 / 15900
Maximum pressure loss in front of air cleaner:	[mbar]	5
Zero-pressure gas control unit selectable from / to: 1)	[mbar]	20[3)] / 200
Pre-pressure gas control unit selectable from / to: 1)	[bar]	0,5 / 10
Air bottle, volume / pressure	[dm³] / [bar]	2000 / 30
Starter motor:	[dm³/s] / [bar]	800 / 16
Lube oil content engine / base frame:	[dm³]	1850 / -
Dry weight engine / genset:	[kg]	24890 / 54300

Cooling system

Glycol content engine jacket water / intercooler:	[% Vol.]	33 / 33
Water volume engine jacket / intercooler:	[dm³]	570 / 51
KVS / Cv value engine jacket water / intercooler:	[m³/h]	90 / 62
Jacket water coolant temperature in / out:	[°C]	78 / 90
Intercooler coolant temperature in / out:	[°C]	42 / 46
Engine jacket water flow rate from / to:	[m³/h]	105 / 125
Water flow rate engine jacket water / intercooler:	[m³/h]	123 / 65
Water pressure loss engine jacket water / intercooler:	[bar]	1,9 / 1,1
Engine jacket water pressure outlet min / max:	[bar rel.]	2 / 2,5
Lube oil temp. engine inlet max. / lube oil flow rate:	[°C] / [m³/h]	80 / 125

Notes:

1) See also Techn. Circular 0199-99-3017
2) See also "Layout of power plants"
3) Minimum pressure may be higher, depending on project conditions.
4) DIN EN ISO 3746 (σ_{tot}±4 dB)
5) Measured in exhaust pipe (f ≤ 250Hz: ±5dB f > 250Hz: ±3dB)
6) DIN 45635-11, Appendix A

Minimum loads 7)

Minimum electrical load for short-term operation:	[kW]	1060
Recommended minimum electrical load for continuous operation:	[kW]	2150