



TECHNICAL SPECIFICATIONS

CATERPILLAR 16CM32C DIESEL ENGINE WITH GE GENERATOR PACKAGING

MAIN DIESEL GENERATOR SET PRIME POWER OPERATION 7370 kW @ 720 RPM

(GE ALTERNATOR 7370 kW, 11 kV – 60 Hz – 0.8 P.F.)

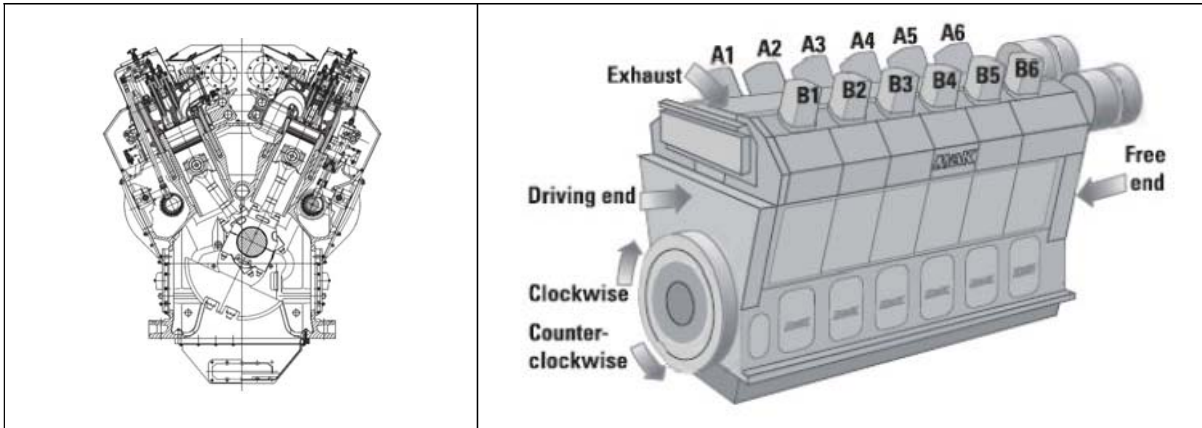


(*Image just for illustration, do not represent the real generator and/or accessories



1. GENERAL ENGINE DESCRIPTION:

The engine is a four stroke, direct injected, turbocharged and intercooled design, with reduced number of components, requiring simpler maintenance, assembly and dismantling. The long stroke CM engines provide complete combustion with lower emissions and lower fuel consumption. The improved combustion provides market leading efficiency and heat rate with less heat need to be transferred and cooled by the cooling system.



- Type: 16CM32C CAT four-stroke marine main diesel engine as generator prime mover (diesel-electric propulsion)
- Design: 16 cylinders in Vee-form
Counter-clockwise rotation
Compressed-air starting,
Suitable for operation with MDO,
Max. viscosity: 14 cSt/40 °C
- 1-piece dry engine block made of nodular cast iron. It incorporates the crankshaft bearings, camshaft bearings, charge air receiver, vibration damper housing and gear drive housing.
- Under slung crankshaft with corrosion resistant main and big end bearing shells.
- Natural hardened liners, centrifugally casted, with calibration insert.
- Composite type pistons with steel crown and nodular cast iron skirt.
- Piston ring set consisting of 2 chromium plated compression rings, first ring with chromium ceramic plated running surfaces and 1 chromium plated oil scraper ring. All ring grooves are located in the steel crown. The first ring groove is chromium plated. The other ring grooves are hardened.
- 3-piece connecting rod with the possibility to dismount the piston without opening the big end bearing.
- Cylinder head made of nodular cast iron with 2 inlet and 2 exhaust valves with valve rotators. Directly cooled exhaust valve seats.
- Camshaft made of sections per cylinder allowing a removal of the pieces sideways.



- Turbocharger supplied with inboard plain bearings lubricated by engine lubricating oil.
- 2-stage fresh water cooling system with 2-stage charge air cooler.

1.1. **TECHNICAL DATA:**

- Cylinder configuration: **“V”**
- Number of Cylinders: **16**
- Bore: **320 mm**
- Stroke: **420 mm**
- Stroke/Bore-Ratio: **1.3**
- Swept volume: **33.8 l/Cyl.**
- Output/cyl.: **480 kW**
- BMEP: **23.7 bar**
- Revolutions: **720 rpm**
- Mean piston speed: **10.1 m/s**
- Turbocharging: **Single pipe**
- Direction of rotation: **Counter clockwise**

1.2. **RATED OUTPUT:**

- 7680 kW at 720 rpm;
- Reference conditions to ISO 3046/1:
 - 45 °C (318 K) air temperature;
 - 38 °C (311 K) charge-air cooling water temperature;
 - 60 % humidity;
 - 1 bar (100kPa) air pressure;

The engine will be run at 110% continuous rating on the test bed. The fuel rack position will then be limited to 110%. The engine features an intermittent overload capacity to ISO 3046/1.

1.3. **LOW LOAD OPERATION:**

- An unrestricted low load operation is permitted with diesel oil.
Below 25 % rated output diesel oil operation is neither efficient nor economical.



Low load below 25 % rated output over prolonged periods usually occurs only during lay time operation in the harbor. These duties are best carried out by means of harbor gen sets or the emergency diesel genset.

1.4. **LOAD INCREMENT:**

The admissible load increment as per ISO 8528/5 and the IACS recommendations must be carried out in 4 or 3 steps. The customer promises to keep this admissible load increment in the design of the ship's network and to obtain the approval of the responsible classification society early enough before classification acceptance of the engine.

- 4 Loads Steps Increments:

1 st . Maximum load from:	0 % to 34 % MCR
2 nd . Maximum load from:	34 % to 56 % MCR
3 rd . Maximum load from:	56 % to 77 % MCR
4 th . Maximum load from:	77 % to 100 % MCR

The 16CM32C diesel engine genset is also capable to achieve the following load steps in order to fulfill the requirements of the customer

- Loads Steps Increments:

1 st . Maximum load from:	0 % to 33 % MCR
2 nd . Maximum load from:	34 % to 66 % MCR
3 rd . Maximum load from:	67 % to 100 % MCR

Reference values for load steps, depending on BMEP at continuous rating.
Please see the load step graphic attached [1].



1.5. PERFORMANCE DATA:

PERFORMANCE DATA SUMMARY	UNIT	16CM32C IMO321605
Maximum continuous rating acc. ISO 3046/1	kW	7680
Speed	1/min	720
Brake mean effective pressure	bar	23.7
Charge air pressure	bar	3.3
Firing pressure	bar	198
Combustion air demand (ta = 20 °C)	m ³ /h	46700
Specific fuel oil consumption 100 %	g/kWh	182
Lubricating oil consumption ³⁾	g/kWh	0.6
Nox-emission ⁷⁾	g/kWh	9,69
Turbocharger type		ABB TPL65

3) Standard value, tolerance + 0.3 g/kWh, related on full load.

7) Marpol 73/78, annex VI, cycle E2,D2

Please see the performance data attached [2].

1.6. EXHAUST GAS EMISSION:

Exhaust gas from each cylinder is connected to a common exhaust manifold (one per bank for Vee engines) and piped through the turbocharger to provided compressed combustion air. The engine mounted turbocharger(s) are mounted at the non-driven end to provide free crane access to the heads for maintenance. Metal expansion joints are fitted in the pipe system as well as between the turbocharger and the exhaust discharge pipe system.

The turbocharger(s) (for liquid fuels) are lubricated by engine lube oil and equipped with controlled water wash systems. The exhaust gas pipe is fastened to the cylinder head by a clamp connection with a single bolt which provides quick release for service.

NOx emission evidence for the engine about compliance with IMO-Marpol effective as of January 2011 through EIAPP Certificate or EAPP Documents of Compliance or EAPP Statement of Compliance according to the authorization by the flag state and related technical file.



For constant speed/generator operation visible smoke (FSN > 1,0) in the load range < 40% and for combinatory operation visible smoke (FSN > 0,5) in the load range < 35% in quasi-stationary engine operation and if the ramp-up times according to the Project Guide are complied with.

1.7. VIBRATION LEVEL:

Engine movement due to vibration referred to the global vibration characteristics of the engine:

The basis for assessing vibration severity are the guidelines ISO 10816-6. According to these guideline the CAT engine will be assigned to vibration severity grade 28, class 5. On the engine block the following values will not be exceeded:

Displacement $S_{eff} < 0.448 \text{ mm } f > 2 \text{ Hz} < 10 \text{ Hz}$
Vibration velocity $V_{eff} < 28.2 \text{ mm/s } f > 10 \text{ Hz} < 250 \text{ Hz}$
Vibration acceleration $a_{eff} < 44.2 \text{ m/s}^2 f > 250 \text{ Hz} < 1000 \text{ Hz}$

1.8. CONSUMPTION:

Fuel: 182* g/kWh @ 100 % rated output;
181* g/kWh @t 85 % rated output;
Tolerance: +5 %;
Additional fuel consumption per engine driven pump: 1 %;

Reference conditions to ISO 3046/1:
Calorific value LCV = 42,700 kJ/kg;
Air pressure 1 bar (100 kPa);;
Intake-air temperature 25 °C (298 K);;
Charge-air temperature after cooler 45 °C (318 K);
Charge-air refrigerant temperature 25 °C (298 K);

In case of different reference conditions conversion of fuel consumption according to ISO 3046/1 Paragraph 10.4 and 13.2 shall be effected.

Lube oil:

- 0.6 g/kWh over the entire load range (related to 100 % engine output). The tolerance is $\pm 0.3 \text{ g/kWh}$;



1.9. IMO SOLAS:

Additional equipment on engine as pre-requisite for IMO SOLAS, Chapter II-2, Part A15 (new B4), Regulation 2.9 to 2.11 and 3:

- Jacketed high pressure fuel pipes;;
- Leak fuel collecting system with collecting tank and sensor for alarm;
- Exhaust lagging;
- Covers for indicator valve and safety valve;
- Covers for connections in the fuel system;
- Covers for connections in the lube oil system;

Provided that other flammable media (i.e. hydraulic oil) could be concerned IMO SOLAS Chapter II-2, Part A15 (new B4), Regulation 4 has to be followed.

1.10. ENGINE CONTROL, MONITORING AND DIAGNOSTIC SYSTEM:

1.10.1. SPEED CONTROL:

- Six(6) electronic speed setting equipment, fitted on engine, consisting of:
Actuator (without mechanical back-up) and speed pick-up
- Six(6) emergency shut-down equipment, fitted on engine, with pushbutton, separate, for manual emergency stop

Electronic governor system make by Regulateurs Europa (RE) or Woodward.

- Type: Actuator UG40. Please see folder WOODWARD UG40[5] attached.
- Governor WW 723+. Please see folder WOODWARD 723+[6] attached.

On request the governor can be delivered as a separate part for installation by the shipyard at a suitable place. The governor comprises the following functions:

- Speed setting range to be entered via parameters;
- Adjustable acceleration and deceleration times;
- Adjustable synchronizing ramp rates;
- Starting fuel limiter;
- Input for stop (not emergency stop);
- 18 - 32 V DC voltage supply;
- Alarm output;
- Isochronous load sharing by master / slave principal;
- Droop operation selectable;



1.10.2. **INDICATORS – ENGINE:**

- Six(6) gauge board (please see the engine indicators attached [7]), fitted on engine, with 1 set liquid damped pressure gauges each for fuel, lubricating oil, fresh water, starting air and charge air;
- One set thermometers on the engine for lubricating oil, fresh water and charge air;

Electric remote speed indicator, consisting of:

- Six(6) rpm pick-up, fitted on engine 96x96 mm, fitted in gauge board;
- Six(6) indicator, separate, 144x144 mm, without interior illumination;

Twelve(12) turbocharger speed indicator, consisting of:

- Pulse generator, fitted on engine;
- Indicator, 96x96 mm, fitted in gauge board;
- Indicator, separate, 96x96 mm;
- Six(6) exhaust gas temperature indicator, with selector switch, fitted in gauge board;

The analogue signals required for the following remote indicator in ECR must be provided by an alarm system not supplied by Caterpillar:

- Six(6) fresh water (HT) temperature indicator, separate, 96x96 mm, input signal 4-20 mA
- Six(6) lube oil pressure indicator, separate, 96x96 mm, input signal 4-20 mA
- Six(6) fresh water (HT) pressure indicator, separate, 96x96 mm, input signal 4-20 mA
- Six(6) fuel pressure indicator, separate, 96x96 mm, input signal 4-20 mA

1.10.3. **CONTROL DEVICES:**

- Six(6) manual control on engine, consisting of:

Control panel with start/stop key;
Fixed minimum speed in local control;
Mechanical shut-down device;
Change-over of control functions from engine to remote control;

- Six(6) starting solenoid valve, 24 V DC, on engine;
- Six(6) electronic speed governor, loose supply (see item 2.10.1. above);



The electronic speed setting includes the isochronous load distribution of the engines. The required output signal (4-20 mA) - proportional to the generator output - is not included in our scope of supply.

1.10.4. **MONITORING FOR UNATTENDED OPERATION:**

The monitoring is carried out with analogue and binary sensors. Analogue sensors are specifically indicated.

- Six(6) set of **pressure switches**, fitted on engine, for:

Lube oil pressure at full load below danger level	alarm/reduction
Low lube oil pressure	alarm/analogue sensor
Lube oil pressure below danger level	alarm/engine stop
Lube oil pressure of prelubrication failed	Alarm
Low fresh water pressure at engine inlet	alarm/analogue sensor
Fresh water pressure at engine inlet below danger level	alarm/engine stop
Low fresh water pressure in LT circuit	alarm/analogue sensor
Low starting air pressure	alarm/analogue sensor
Low control air press/shutdown air pressure	Alarm
Low fuel pressure at engine inlet	alarm/analogue sensor

- Six(6) set of **temperature switches**, fitted on engine, for:

High lube oil temperature at engine inlet	alarm/analogue sensor
Lube oil temperature at engine inlet above danger level	alarm/engine stop
High fresh water temperature at engine outlet	alarm/analogue sensor
Fresh water temperature at engine outlet above danger level	alarm/engine stop
High charge air temperature at engine inlet	alarm/analogue sensor
Detection of water in charge air duct	alarm
Leak fuel level	alarm
Alarm contact for high differential pressure at fuel filter	alarm
Alarm contact for high differential pressure at lube oil filter	alarm
Alarm contact for high differential pressure at lube oil back flushing filter	alarm

- Six(6) set of thermocouples (Ni/CrNi, signals in mV) after each cylinder, before and after turbocharger.
- Six (6) exhaust gas mean value monitoring equipment, integrated in the N3000 data converter including monitoring before and after turbocharger (alarm/reduction).



- Six(6) crankcase oil mist detector, fitted on engine (high smoke development – alarm/engine stop)

An equipment for oil detection in the cooling water is not included.

- Six(6) fresh water (HT) temperature indicator, separate, 96x96 mm, input signal 4-20 mA
- Six(6) lube oil pressure indicator, separate, 96x96 mm, input signal 4-20 mA
- Six(6) fresh water (HT) pressure indicator, separate, 96x96 mm, input signal 4-20 mA
- Six(6) fuel pressure indicator, separate, 96x96 mm, input signal 4-20 mA

1.10.5. LESS – LARGE ENGINE SAFETY SYSTEM:

LESS is a compact engine control, monitoring and protection system. Included functions are control of the engine (start, stop), monitoring of the actual status of sensors and the protection system (emergency stops, interlocks, i.e.).

- Six(6) LESS (Large Engine Safety System) installed in a terminal cabinet, separate, consisting of:

Protection system with display unit with automatic and manual stop input signals. All of the signal input units and the emergency shutdown solenoid are monitored for wire break. The equipment works according to the open circuit system.

Protection device with input and output signals for:

- Optional automatic stops
- Automatic load reduction
- Starting interlock

Start/stop system with following signal outputs:

- RPM contacts for alarm suppression
- RPM contacts for pump controls
- Fuel rack position signals 4 - 20 mA and 0 - 10 V contacts for overload
- Six(6) set N3000 data converter built into the engine terminal box, for binary and analogue monitoring signals for data transfer via a serial interface RS485/Modbus RTU to the alarm system.

The Remote Alarm system, not delivered by CATERPILLAR.



The alarm system has to be equipped for analogue and binary inputs and an interface for RS485/Modbus RTU.

The temperature and pressure remote indicators analogue outputs are to be provided according to the requirements of the classification societies.

Diesel start automatic and synchronizing unit, not delivered by CATERPILLAR
Please see the large engine safety system attached [8].

1.10.6. DIAGNOSTIC SYSTEM DICARE:

DICARE is the diagnostic & preventive maintenance tool used for CM engines. It monitors engine intake air pressure and temperature to identify drops in performance due to turbocharger wear, early identification of thermal overload through permanent monitoring of all available temperature sensors, charge air cooler with regard to pressure loss, charge air temperature, check fuel oil temperature and viscosity to identify any malfunction of the viscosity measuring and control unit, check fuel rack position and power output to identify injection pump wear, listing of possible causes of deviation of exhaust gas temperatures from the nominal value, lube oil consumption to identify any possible wear at an early stage, cooling water pressure and temperature to avoid and identify any possible wear.

By means of accurate information on the current condition and operating mode of the diesel engine DICARE provides for condition based, adjusted maintenance intervals. Progress of contamination and wear can be identified at an early stage through trend charts.

For the evaluation DICARE essentially uses installation specific measuring values. Current measuring values are compared to the basic protocol with high accuracy. This takes place by evaluating all measuring data at a consistent level according to complex thermodynamic formulas.

By means of different comparison charts and condition based maintenance recommendations DICARE supports optimum operating conditions. This allows enhancing service life and provides savings in terms of maintenance and operating costs.

State-of-the-Art PC for DICARE diagnostic program, not supplied by CAT



- Twelve(12) set of transmitters for data logging with instruments (DICARE ONLINE).
- DICARE diagnostics program with data logging with instruments (ONLINE) via a suitable alarm system.

The alarm system is not included in the MaK scope of supply.

The exhaust gas monitoring equipment must be integrated in the alarm and monitoring system.

Please see the DICARE schematic attached [9].

1.11. BARRING GEAR:

- Six(6) motor-driven barring gear, fitted on engine, incl. reversing contactor and pushbutton switch with cable, with starting interlock when barring gear is engaged.

1.12. AIR INTAKE SYSTEM:

- Twelve (12) Air Intake Filter (two for each engine), fitted on turbocharger;

1.13. FRESH COOLING WATER SYSTEM:

Designed for two-circuit cooling.

- Six(6) HT pump, fitted on engine.
- Six(6) LT pump, separate, vertical design, electric motor driven
- Six(6) HT thermostat, not powered, separate
- Six(6) LT thermostat, not powered, separate
- Six(6) central cooler, plate type, titanium, separate
- Six(6) electronic charge-air temperature control (to be installed in a console) with control valve, separate, without part load heating
- Six(6) engine preheating equipment, fitted on baseframe, consisting of:
 - electric preheater
 - switch box
 - pump

Fresh water cooling	Unit	Value
Engine content	m ³	1,9
Pressure at engine inlet min / max	bar	2,5 / 6,0
Header tank capacity	m ³	1
Temperature at engine outlet	°C	80 - 90
Two circuit system		
Engine driven pump HT	m ³ /h / bar	130 / 4,5
Independent pump HT	m ³ /h / bar	130 / 4,0
HT-Controller NB	mm	150
Water demand LT-charge air cooler	m ³ /h	100
Temperature at LT-charge air cooler inlet	°C	38

- Six(6) Cooling Water Expansion Tanks

(please see heat balance attached [10]);

(please see cooling system accessories attached [11]);

(please see optional expansion tank data sheet attached [14]);

(please see expansion tank p&id attached [15]);

1.14. **EXHAUST SYSTEM**

- Twelve(12) Turbochargers at free end, with transition nozzle, Nozzle position: 0 degrees from the vertical and away from the engine, with compressor cleaning device;
- Six(6) Carbon Steel Silencer and spark arrestor (one for each engine), separate, unlagged, 35 dB(A) (please see exhaust system silencer attached [16]);
- Twelve(12) Expansion joint (two for each engine), separated;

Exhaust gas	Unit	Value
Silencer/spark arrester NB	mm	1000
Pipe diameter NB after turbine	mm	2 x 700
Maximum exhaust gas pressure drop	bar	0,03
Exhaust gas temp. after Turbine (intake air 25°C) ⁶⁾	°C	311
Exhaust gas mass flow (intake air 25°C) ⁶⁾	kg/h	57020

6) Tolerance 10%, rel. humidity 60%



Note: The Customer will supply all the exhaust interconnection piping works from the Gen Set equipment skid to the platform facilities.

1.15. DIESEL OIL SYSTEM:

- Six(6) circulating pump, separate, horizontal or vertical installation are possible, driven by electric motor;
- Six(6) duplex primary filter, separate;
- Six(6) duplex filter, fitted on engine, with differential pressure indication;
- Optional Three(3) preheater, separate, heated by means of cooling water, with thermostat;

Fuel	Unit	Value
Engine driven booster pump	m ³ /h	-
Stand-by booster pump	m ³ /h	5,2/10
Mesh size MDO fine filter	mm	0,025

- Three(3) Diesel Oil Booster Modules

(please see fuel oil p&i;d attached [17]);

Two fuel product groups are permitted for the engines:

- Pure distillates: Gas oil, marine gas oils, diesel fuel
- Distillate/mixed fuels: Marine gas oil (MGO), marine diesel oil (MDO). The difference between distillate/mixed fuels and pure distillates are higher density, sulphur content and viscosity.

	MGO		MDO	
	Designation	Max. viscosity [cSt/40 °C]	Designation	Max. viscosity [cSt/40 °C]
ISO 8217: 1996	ISO-F-DMA	1.5 - 6.0	ISO-F-DMB	11
			ISO-F-DMC	14
ASTM D 975-78	No. 1 D	2.4	No. 2 D	4.1
	No. 2 D	4.1	No. 4 D	24.0
DIN	DIN EN 590	8		

Note: The Customer will supply all the fuel interconnection piping works from the Gen Set equipment skid to the platform facilities.

1.16. LUBRICATION SYSTEM:

- Six(6) plate cooler, separate (material: stainless steel);
- Six(6) force pump, fitted on engine;
- Six(6) prelubrication pump, electric motor driven, fitted on baseframe;
- Six(6) automatic back flushing filter, maker Boll & Kirch, separate, with differential pressure indication;
- Six(6) duplex filter, separate, with differential pressure indication
- Six(6) pressure control valve, fitted
- Six(6) thermostat, not powered, separate
- Six(6) dry sump pump, fitted on engine

Engine driven pumps	Unit	Value
Independent pump	m ³ /h / bar	161,3 / 10
Working pressure on engine inlet	m ³ /h / bar	160 / 10
Engine driven suction pump	bar	4 - 5
Sump tank content/dry sump content	m ³ /h / bar	16 / 5
Temperature controller NB	°C	60 - 65
Double filter NB	mm	150
Mesh size double filter	mm	125
Mesh size automatic filter	mm	0,03

Please see lube oil system attached [21];

1.17. AIR STARTING SYSTEM:

- Six(6) air bottle (NR 13 Compliance), separate, 1000 litres, with pressure gauge, filling valve, relief valve with pipe connection and drain valve. (Two per engine room).
- Six(6) automatic drain valve for starting air bottle, separate.
- Six(6) non-return valve, separate, for the starting air pipe to the engine.
- Air compressor shall be provided by shipyard.

Note: (please see air starting system schematic attached [24]);

Starting air	Unit	Value
Starting air pressure max.	bar	30
Minimum starting air pressure	bar	10
Air consumption per Start ⁵⁾	Nm ³	1,2
Maximum allowed crank case pressure, ND Ventilations pipe	mmWs / mm	15 / 125

5) Preheated engine

1.18. **CONNECTING PARTS - ENGINE:**

- Six(6) set of connecting parts between flange coupling and flywheel;
- Six(6) flexible flange coupling between engine and generator;
- Six(6) set of conical elements for direct resilient mounting of the engine;
- Six(6) set of flexible pipe connections;
- Six(6) base frame, with flywheel guard and incorporated lube oil sump tank;

1.19. **AUXILIARY COMPONENTS:**

- Six(6) optional Front End Combined Auxiliary Modules (Lubrication Oil, Cooling water and Fuel Booster Systems), one for each engine.

Please see optional front end combine module p&id attached [53]);

Please see optional front end combine module heat balance attached [54]);

Please see optional front end combined module data sheet attached [55]);

1.20. **GENERAL INFORMATION:**

2.20.1 **PAINTING**

Engine/Genset painted to RAL according to Caterpillar - Standard N 576-4.3

Accessories as to maker standard.

Engine/Genset with VCI packaging according to Caterpillar - Standard N 576-5.2

1.20.2 **INSIDE PRESERVATION**

According to Caterpillar - Standard N 576-3.3



1.20.3 REQUIRED KINDS OF CURRENT

- Three phase current : 440 Volt/ 60 Hz
- Alternating current : 230 V
- Direct current : 24 V DC

The electric power supply and the pump controls are not included in the MaK scope of supply.

1.20.4 ENGINE INTERFACES

Engine interfaces with screwed union, counter flange and gaskets as well as electric terminal box.

All connections (incl. material) between engine interfaces and plant components are not included in the CAT scope of supply.

1.20.5 SCALE

Pressure in bar, temperature in °C, speed in rpm

2. GE GENERATOR DESCRIPTION:

GE synchronous generator 9213 KVA; 7370 KW; 10 poles; 720 rpm; 11000 volts; 0.8 PF; 60 Hz, 1.00 S.F., IP54 IC81W; estimated frame: 8800 for Installation in NON-Hazardous location.

Please see generator data sheet attached [45];

2.1. ACCESSORIES AND SPECIAL FEATURES:

- (1) PMG
- (1) Set of space heater –220V - 1 phase
- (6) Stator winding temperature detector, type RTD Pt 100 Ohm (0 °C), 2 per phase
- (2) Bearing temperature detector, type duplex RTD Pt 100 Ohm (0 °C), 1 per bearing
- (3) RTDs for cooling air



(1) Rotor earth fault slip ring & brush

(1) VT

(3) CT (loose)

(1) Water leakage detector

SS 304 junction boxes for accessories

Standard Painting

Generator lube system will be performed by diesel engine lube system

Marine Classification Society Certification for Marine Application (considering 6 generators package).

2.2. ACCESSORIES AND SPECIAL FEATURES:

The tests will be executed with the equipment completely mounted.

- . Visual and dimensional inspection
- . External dimensions
- . Position of the components in relation to the drawings.
- . Conformity of the material of the wiring and component

a) Routine Test (all units)

- . Resistance of armature and field windings
- . Exciter field current at no load
- . Insulation resistance test
- . High potential test
- . Mechanical balance
- . Bearing temperature rise test
- . Phase Sequence

b) Witnessed Complete Test (1 unit per vessel)

- . Measurement of losses
- . Efficiency calculation at $\frac{3}{4}$ and full load
- . Determination of reactances and time constants
- . Check of wave form and voltage distortion
- . Heat run test per IEEE 115 method 4



2.3. COMMENTS AND EXCEPTIONS

IEC tolerances applies on the values presented on datasheet.

This quotation does not include any installation, start-up or field-testing. Please refer to GE Engineering Services if required.

We are offering our standard Warranty Terms: 18 months from shipment/12 months operational.

We are offering our standard Painting Procedure.
Offered generators will have IC81W cooling method (TEWAC enclosure) supplied with a top-mounted, integral, heat exchanger. The heat exchanger radiators will be double tubes and made of 90 percent copper, 10 percent nickel for fresh water. We are not considering redundant heat exchangers.

We are considering Pitch and Roll according to ABS Publication 2, Part 4, Chapter 1, Section 1, Table 7, like shown below:

	Static	Dynamic
Pitch (For-and-Aft)	5°	7.5°
Roll (Athwart ship)	15°	22.5°

2.4. TECHNICAL INFORMATION

STANDARD PAINTING PROCEDURE

1 - SURFACE PREPARATION: ACCORDING TO SIS Sa 2 ½ NEAR WHITE METAL BLAST

2 - PRIMER: ONE COAT OF "PRIMER EPOXY POLYAMID SHERWIN WILLIAMS – SHER TILE HS PRIMER BR

STANDARD COLOR: GRAY

SUBTOTAL DRY THICKNESS = 5.5 MILS (140 *um*)

2 - FINISH: ONE COAT OF ACRYLIC ALIPHATIC POLYURETHANE

SHERWIN WILLIAMS – POLANE 234

FINISH COLOR: DARK GRAY – MUNSELL N3.5



DRY THICKNESS = 2.4 MILS (60 μm)

3 - TOTAL DRY THICKNESS: 7.9 MILS (200 μm)

3. GENERATOR SET PACKAGING DESCRIPTION:

- Genset bases have to be **resiliently mounted**.

This provides an active insulation against forces generated by the engine as well as protection against vibration from rigidly mounted main engines.

The platform's foundation does not require machining. Unevenness is to be compensated by welding plates and shims (to be provided by the shipyard).

Major components:

- Resilient mounting between engine and baseframe.
- Conical mountings.
- Torsional Coupling. Provides torsional coupling and drive adapter with split ring to facilitate servicing components on the rear of the engine. Coupling intended for two-bearing generator applications.
- Systems Connections (please see system connections plan attached [26]).
- Inside preservation up to 1 year, engine protected from moisture. Main running gear and internal mechanics;
- VCI packaging - Storage in the open, protected from moisture, up to 1 year.
- Maintenance Platform based on manufacturer standard design.
- Lifting of Gen sets - For the purpose of transport the genset is equipped with a lifting device which shall remain the property of Caterpillar. It has to be returned in a useable condition free of charge.

(please see lifting device attached [27]).

Please see preliminary genset drawing 16CM32C [28].



4. SPARE PARTS FOR TWO YEARS OPERATION AND CONSUMABLES LIST:

- One set of recommended engine two years operation spares list will be provided for customer analysis. Spares are not included in our scope of supply.

Please see two years operation spare parts list attached[29].

- One consumables list will be provided for customer analysis. Consumables are not included in our scope of supply.

Please see consumables start-up list attached[30].

5. SPECIALIZED TOOLS LIST:

- One Specialized Tools List will be provided for customer analysis. Special Tools are not included in our scope of supply.

Please see special tools list attached[31].

6. CERTIFICATION AND QUALITY:

6.1. MARINE POLLUTION CERTIFICATE:

- Includes statement of compliance or Engine International Air Pollution Prevention (EIAPP) certificate, supplied by the Recognized Organization (RO) where available and technical file to be kept on board per IMO Tier II regulations.

6.2. MARINE CLASSIFICATION SOCIETY CERTIFICATE:

- ABS certification for Heat Exchangers;
- ABS certification for Flexible Couplings;
- ABS certification for Diesel Engine;
- ABS certification for Generator;
- ABS Design Review (as required by ABS);
- ABS Factory Survey (as required by ABS);



6.3. **QUALITY PLAN**

- Factory ISO 9001 Certification.
Please see ISO 9001 certificate attached[32].
- Quality Plan for genset 16CM32C.
Please see quality plan attached[33].

7. **FACTORY TESTING:**

7.1. **STANDARD ACCEPTANCE TEST RUN:**

Standard acceptance test run of the engine at the water brake on the test bed at the discretion of the contractor with MDO or gas oil.

Inspection of parts on the test bed, consisting of:

- visual inspection of gear and camshaft drive
- bore scoping of the combustion chamber of one cylinder
- removal of one main bearing

7.2. **TEST:**

Acceptance of the engine and the accessories subject to testing with certificate issued by ABS.

Compliance with the safety requirements of flag states can only be realized by the overall ship/engine room system and is, therefore, within the responsibility of the shipyard.

These will only have a concrete effect on the engine equipment if any requirements are individually mentioned in this specification.

NOTE:

It must be specified what representatives will be present at the factory during any dynamometer or package witness test four (4) weeks prior to the actual witness test date.

Representative information to include, but not limited to: name, title, and company of each person attending, phone number and complete name of dealership, and whether you need any special arrangements.



A complete Visit Request Form is available through the Caterpillar facility project services group. Also note that an end customer, dealer, or third party representative may not attend a witness test without subsidiary representation.

8. TECHNICAL ASSISTANCE, COMMISSIONING AND PRODUCT SUPPORT:

The commissioning, training and day rates for services for the offered scope of supply are described on the attached Commissioning Plan. The services are offered under a separate service proposal.

9. DOCUMENTATION AND LITERATURE:

Documents to be supplied:

- 5 set of installation documents English
- 4 set (2x as CD-ROM) of documents, consisting of:
 - operating instructions [book A] in English
 - tool and spare parts list and spare parts catalogue [book B] in German/English
 - supplement folder [book C] in English

Please see master document list attached[34].

10. WARRANTY:

The minimum scope of supply is warranted according to Caterpillar Limited Warranty Policy. The standard warranty period is twelve (12) Months after date of delivery to the first user.

Please see caterpillar limited warranty attached[44]

11. RELEVANT INFORMATION:

11.1. NOISE LEVEL

Please see noise level attached[35].

11.2. MAINTENANCE SPACE

Please see maintenance space attached[36].



11.3. UTILITY CONSUMPTION LIST

Please see utility consumption list attached[37].

11.4. REFERENCE LIST

Please see reference list attached[38].

11.5. SUPPLIER LIST FOR MAIN ITEMS

Please see supplier list for main items attached[39].

12. DEVIATION AND CLARIFICATION LIST:

Please see deviation and clarification list attached[43].

13. QUICK LINK INFORMATION:

a description of the scope of supply;	Technical Proposal
a list of deviations from technical specifications and standards, including reasons for those deviations. This list shall be presented in a table with the following columns: technical specification/standard; item description; deviation; and performance impact;	Please see: list attached
a complete data sheet for scope item;	Please see: CENTRAL COOLING UNIT DATA SHEET. EXPANSION TANK DATA SHEET (OPTIONAL). DIESEL OIL BOOSTER DATA SHEET (OPTIONAL). GE GENERATOR DATA SHEET.
performance curves, whenever applicable;	Please see: PERFORMANCE DATA.
an outline drawing showing the key dimensions and maintenance area, details of interface with other systems and/or utility supplies in accordance to the specification requirements;	Please see: GENSET OUTLINE DRAWING_WEIGHT.CG
Electrical Inter-connection / Single Line Diagrams	Please see: ELECTRICAL INTER-CONNECTION-SINGLE LINE DIAGRAM



Piping diagrams of internal and external for each system	Please see: CENTRAL COOLING UNIT P&ID (OPTIONAL) EXPANSION TANK P&ID (OPTIONAL) DIESEL OIL BOOSTER P&ID LUBE OIL COOLING UNIT P&ID
List of point of Termination or End-Connections	Please see: SYSTEM CONNECTIONS DIESEL GENSET INSTALLATION DRAWING
the weight and the center of gravity;	Please see: GENSET OUTLINE DRAWING_WEIGHT.CG attached
information on level of noise and vibration, whenever applicable;	Please see: NOISE LEVEL VIBRATION: Displacement $S_{eff} < 0.448 \text{ mm } f > 2 \text{ Hz } < 10 \text{ Hz}$ Vibration velocity $V_{eff} < 28.2 \text{ mm/s } f > 10 \text{ Hz } < 250 \text{ Hz}$ Vibration acceleration $a_{eff} < 44.2 \text{ m/s}^2 f > 250 \text{ Hz } < 1000 \text{ Hz}$
Heat Dissipation Data	Please see: PERFORMANCE DATA.
Utilities Requirements	Please see: UTILITIES CONSUMPTION LIST.
Comissioning Outline, supporting system	Please see: COMISSIONING PLAN.
Surface Preparation and Protection, Painting Data	Please see: Technical Proposal
detailed production and delivery schedule;	Please see: MILESTONES PLAN.
list of all recommended spare parts (unpriced) for two years operation for information, in agreed Excel format.	Please see: TWO YEARS OPERATION SPARE PARTS LIST.
list of all spare parts and consumables (unpriced) for commissioning and start-up (included in bidder's offer, in agreed Excel format;	Please see: CONSUMABLES FOR START-UP LIST.
list of all special tools (if applicable) - unpriced;	Please see: SPECIAL TOOLS LIST.
Control Philosofy including performance data for all operation cases	Please see: CONTROL PHILOSOPHY



list of lube/hydraulic oils, whenever applicable;	Please see: LUBE & HYDRAULIC OILS LIST.
List of Consumable Materials	Please see: CONSUMABLES FOR START-UP LIST.
storage, preservation and maintenance requirements;	Please see: STORAGE, PRESERVATION AND MAINTENANCE PROCEDURES.
master list of drawings to be provided;	Please see: MASTER DOCUMENT LIST.
Manufacturing Schedule	Please see for reference: MILESTONES PLAN.
quality/inspection levels;	Please see: QUALITY PLAN.
quality plan;	Please see: QUALITY PLAN.
HSE Management System	Please see: HSPP PROGRAM
Inspection and Test Plan	Please see: REQUIRED INSPECTIONS AND/OR TESTS
Classification and Certification (sample)	Please see: Type Approval 10-HG593718_1_PDA ISO 9001 CERTIFICATE
Description of Warranties	Please see: Caterpillar Limited Warranty
Technical Assistance, Commissioning and Training	Please see: Service Proposal
reference list of similar installations performed by the bidder;	Please see: REFERENCE LIST.
a list of sub-suppliers;	Please see: SUPPLIER LIST.
List of Representatives and Local Technical Assistance Services	Please see: Technical Proposal item 9
Brazilian Local Content (%)	Please see: Commercial Proposal
construction & assembly minimum requirements, where applicable;	It will be available after receipt order.
Recommended capacity of auxiliary machinery such as pumps, heat exchangers, filters and etc	Please see: CENTRAL COOLING UNIT DATA SHEET



	EXPANSION TANK DATA SHEET (OPTIONAL) DIESEL OIL BOOSTER DATA SHEET (OPTIONAL)
Air consumption (starting, control and combustion)	Please see: UTILITIES CONSUMPTION LIST.
Heat balance for cooling water system	Please see: COOLING SYSTEM SCHEMATIC.
General lay-out drawing with dimensions including the location of junction boxes and maintenance spaces of accessories attached on the engine	Please see: MAINTENANCE SPACE. GENSET OUTLINE DRAWING_WEIGHT.CG.
General lay-out drawing for loose supply units	Will be available after receipt order.
Capacity and installation height of expansion tank	Please see: EXPANSION TANK DATA SHEET. EXPANSION TANK P&ID.
Weight of engine, foundation and spare parts	Please see: GENSET OUTLINE DRAWING_WEIGHT.CG TWO YEARS OPERATION SPARE PARTS LIST CONSUMABLES START-UP LIST GENSET FOUNDATION PLAN
Specification for engine-driven pumps including performance curve and speed	Please see: CENTRAL COOLING UNIT DATA SHEET DIESEL OIL BOOSTER DATA SHEET (OPTIONAL)
Specification for all electric motors including actual power consumption	Please see: UTILITIES CONSUMPTION LIST.
Specific fuel oil consumption	178 g/bkW.h @ 100% load
Exhaust gas amount and temperature	57.139 kg/h - 294 ^o C @ 100% load – 25 ^o C Charge air temperature
Permissible exhaust gas back pressure	30 mBar
Pressure loss at silencer in case it is provided by Maker	10 mBar
Alarm set points	Please see: ALARM POINTS
Permissible vibration level (mm/s, RMS)	Displacement Seff < 0.448 mm f > 2 Hz < 10 Hz Vibration velocity Veff < 28.2 mm/s f > 10 Hz < 250 Hz Vibration acceleration aeff < 44.2 m/s ² f > 250 Hz < 1000 Hz



Natural frequency	Will be provided after Torsional Vibration Analysis (TVA)
Noise data	Please see: NOISE LEVEL.
Confirmation of compliance with NR-13 (Brazilian legislation for pressure vessels) – whenever applicable.	Please see: CONFIRMATION OF COMPLIANCE WITH NR-13

14. PROPOSAL ANNEXES :

- [1]LOAD STEPS GRAPHIC
- [2]PERFORMANCE DATA
- [5]WOODWARD UG40
- [6]WOODWARD 723+
- [7]ENGINE INDICATORS
- [8] LARGE ENGINE SAFETY SYSTEM
- [9]DICARE
- [10]HEAT BALANCE
- [11]COOLING SYSTEM ACCESSORIES
- [14]EXPANSION TANK DATA SHEET (OPTIONAL)
- [15]EXPANSION TANK P&ID (OPTIONAL)
- [16]EXHAUST SYSTEM SILENCER
- [17]FUEL OIL SYSTEM
- [20]LUBE SYSTEM THERMOSTAT
- [21]LUBE OIL SYSTEM
- [24]AIR STARTING SYSTEM SCHEMATIC
- [25]GENSET FOUNDATION PLAN
- [26]SYSTEM CONNECTIONS
- [27]LIFTING DEVICES
- [28]DIESEL GENSET INSTALLATION DRAWING [REV. 1]
- [29]TWO YEARS OPERATION SPARE PARTS LIST
- [30]CONSUMABLES START-UP LIST
- [31]SPECIAL TOOLS LIST



- [32]ISO 9001 CERTIFICATE
- [33]QUALITY PLAN
- [34]MASTER DOCUMENT LIST [REV. 1]
- [35]NOISE LEVEL
- [36]MAINTENANCE SPACE
- [37]UTILITIES CONSUMPTION LIST
- [38]REFERENCE LIST
- [39]SUPPLIER LIST FOR MAIN ITEMS
- [40]REQUIRED INSPECTIONS AND/OR TESTS
- [41]ALARM POINTS
- [42]CONFIRMATION OF COMPLIANCE WITH NR-13
- [43]DEVIATION AND CLARIFICATION LIST
- [44]CATERPILLAR LIMITED WARRANTY
- [45]GENERATOR DATA SHEET
- [46]TYPE APPROVAL CERTIFICATE
- [48]CONTROL PHILOSOPHY
- [49]HSPP PROGRAM
- [51]COMMISSIONING PLAN
- [53]FRONT END COMBINED MODULE P&ID
- [54]FRONT END COMBINED MODULE HEAT BALANCE
- [55]FRONT END COMBINED MODULE DATA SHEET

END OF TECHNICAL PROPOSAL