0931P YANMAR GAS POWERED MICRO COGENERATION

Branded worksection

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Worksection abstract

This branded worksection *Template* is applicable to YANMAR gas engine driven, micro-cogeneration system generating electrical power and reclaiming heat from the engine to provide a heat source for hot water usage in a wide range of commercial and domestic applications. The units comprise high efficiency, packaged, outdoor plant, with nominal generator output capacity of 25.0 kW, with nominal heat recovery of 38.4 kW. Units are able to operate using natural gas, LPG and biogas.

***Guidance* text**

All text within these boxes is provided as guidance for developing this worksection and should not form part of the final specification. This *Guidance* text may be hidden or deleted from the document using the NATSPEC Toolbar or the hidden text *Hide* and *Delete* functions of your word processing system. For additional information visit FAQs at www.natspec.com.au.

***Optional* style text**

Text in this font (blue with a grey background) covers items specified less frequently. It is provided for incorporation into *Normal* style text where it is applicable to a project.

Related material located elsewhere in NATSPEC

Related material may be found in other worksections. See for example:

- *0943 Switchboard components.*

Documenting this and related work

You may document this and related work as follows:

- This worksection contains text, including *Optional* style text, which may be adapted for use in Design and Construct projects. See NATSPEC TECHreport TR 03 for information on specifying Design and Construct.

The following areas of responsibility may need to be ascertained by the designer before the preparation of the contract documents (for package documentation) and coordinated with other worksections:

- Specify the application of the generator set for standby, stand alone, hybrid or grid connection in *0921 Low voltage power systems*, which will be determined by the design of the complete low voltage power system.
- Interconnection with the main building electrical services: e.g. are transfer switches to be located in the main switchgear and controlgear assemblies or the generating set control and distribution board?
- Supply and installation of the generating set control and distribution board.
- For gas engine driven: The normal gas supply and, if required, backup supply. This often forms part of the hydraulic services trade package. See *0824 Fuel gas*.
- Provision of exhaust system, particularly in high rise or multiple generating set installations.
- The type of cooling system required i.e. self-contained radiators.
- For internal building installations provide plantroom supply and exhaust air systems.
- Provision of heat recovery to hot water for domestic space heating and other heating applications.
- The provision of silencers for generating set room cooling air.

The *Normal* style text of this worksection may refer to items as being documented elsewhere in the contract documentation. Make sure they are documented.

Specifying ESD

The following may be specified by retaining default text:

- Heat recovery to hot water for domestic space heating and other heating applications..

- NCC provisions and published Minimum Energy Performance Standard (MEPS).
- Durable components.
- Provisions to reduce transmitted noise and vibration.

Refer to the NATSPEC TECHreport TR 01 on specifying ESD.

1 GENERAL

YANMAR's Energy Systems division began operation in 1984, and today has installed more than 375,000 air conditioning, chiller and cogeneration systems worldwide. Using a YANMAR-designed, lean-burn Gas Engine, which was developed from the company's world-class diesel engine technology, these environmentally friendly systems are designed for reliability, efficiency, energy conservation, comfort and long-term savings.

1.1 RESPONSIBILITIES

General

Requirement: Provide YANMAR gas powered micro cogeneration plant, as documented, to incorporate the following:

- Engine cooling system.
- Combustion air system.
- Exhaust system.
- Gas fuel system.
- Acoustic enclosure.
- Control and inverter systems.
- Connection to low voltage power system.
- Heat recovery system
- Hot water circulation system

Delete components as necessary.

Documented is defined in *0171 General requirements* as meaning contained in the contract documents.

DESIGN

Each electrical network has specific connection requirements, they may require a grid protection relay.

The *Optional* text in this clause may be used when the contractor is to design and select the gas engine micro cogeneration plant and use with *0901 Electrical systems* to describe design parameters for electrical systems, as a whole.

General

Requirement: Design the gas engine driven micro cogeneration plant, as documented.

Gas engine driven micro cogeneration plant selection.

Selection parameters included in the **SELECTIONS** schedules should not be repeated here**.** The **SELECTIONS** schedules' *Guidance* text includes suggestions for modification to suit Design and Construct projects.

General: Select gas engine driven micro cogeneration plant for the electrical and heating loads calculated.

System design and installation

Requirement: Conform to the recommendations of YANMAR GHP engineering data manual.

1.2 COMPANY CONTACTS

YANMAR technical contacts

Website: www.yanmarenergy.com.au/contact.html

1.3 CROSS REFERENCES

General

Requirement: Conform to the following:

- *0171 General requirements*.

0171 General requirements contains umbrella requirements for all building and services worksections.

List the worksections cross referenced by this worksection. *0171 General requirements* references the *018 Common requirements* subgroup of worksections. It is not necessary to repeat them here. However, you may also wish to direct the contractor to other worksections where there may be work that is closely associated with this work.

NATSPEC uses generic worksection titles, whether or not there are branded equivalents. If you use a branded worksection, change the cross reference here.

- *0752 Mechanical piping insulation*.
- *0824 Fuel gas.*
- *0901 Electrical systems.*

0901 Electrical systems deals with matters common to more than one electrical worksection.

1.4 STANDARDS

General

Requirement: For the purpose of this worksection, conformance to the following standards relating to stand-alone systems is also applicable to those systems which are to be connected to the network supply:

- Electrical system: To AS/NZS 3000 Part 2.
- Selection of cables: To AS/NZS 3008.1.1.
- Electrical equipment: To AS/NZS 3100.
- Electrical installation of generating sets: To AS/NZS 3010.

AS/NZS 3010 covers minimum safety standards for generating sets. It does not set out performance or construction requirements.

Refer to NATSPEC TECHnote DES 021 for information on site electricity supply.

- Grid connection: To AS/NZS 4777.1, AS/NZS 4777.2, IEC 62109.1 and IEC 62109.2.

1.5 SUBMISSIONS

Operation and maintenance manuals

Standard: To AS/NZS 4509.1.

Requirement: Provide all operational and maintenance documentation necessary to operate and maintain the systems installed.

Products and materials

General: Submit technical data including the following:

- Technical description and specifications of each generating set, including output curves for base load and stand-by conditions, alternator and engine data, automatic voltage regulator, synchronising and load sharing modules and auxiliaries.
- JAS_ANZ Certificate of Suitability for inverters to AS/NZS 4777.2, IEC 62109.1 and IEC 62109.2
- Net continuous rated output.
- Net short-time rated output.
- Transient and subtransient reactance of the alternators.
- Voltage regulation grade.
- Generating set efficiency at 50%, 75% and 100% load.
- Calculations for performance of acoustic enclosures and silencers.

- Evidence that the engine type has previously passed cold starting tests at the minimum ambient site temperature.

Shop drawings

General: Submit shop drawings indicating the following:

- General arrangement of equipment, generating sets, exhaust silencers, control panels, batteries.
- Single line schematic showing the interconnection with the building electrical system.
- Inverters
- Operating sequence in test and emergency modes as well as restoration of normal supply.
- Location and size of gas supplies.
- Physical size of cogeneration units including clearances from other system, building and structural elements.
- Physical size of generating set base and clearances for maintenance.
- Location and estimated size of control and distribution boards.
- Location of control and starting batteries.
- Acoustic performance criteria (engine, exhaust, air flow), to determine the level of sound proofing required.
- Maximum mass and overall dimensions of each separable assembly.
- Access clearances for operational maintenance and dismantling.
- Electrical single line diagram, and general arrangement for the complete system.
- Control diagrams.
- Alarms and shutdown annunciator text engraving schedule.
- Details of foundations and anti-vibration mountings.
- Exhaust system
- Heat exchangers and water circulation pump system

INSPECTION

If inspections are required, include them here by changing this *Optional* text, to *Normal* style text.

Notice

Complete tests: Give notice so that factory inspection may be made of each complete cogeneration set and associated systems at YANMAR's factory or the supplier, before delivery to the site.

Amend to suit the project adding critical stage inspections required. **Hold points**, if required, should be inserted here.

2 PRODUCTS

2.1 EQUIPMENT

General

Components: The gas powered micro cogeneration unit is an integrated unit comprising gas engine, alternator, alternator control equipment, engine cooling system, output control inverter, system protection equipment, engine radiator and heat recovery, heat exchangers and water circulation pump.

YANMAR micro cogeneration unit table

Model	**CP25WE**
Output: Rated power output (kW)	25.0
Output: Frequency (Hz)	50
Output: Voltage (V)	400 AC
Output: Load current (A)	35.4 AC
Output: Phases / Wires	3 Phase / 4 Wire

Model	CP25WE
Output: Power factor (%)	≥ 97
Heat recovery: Natural gas (kW)	38.4
Heat recovery: LPG (kW)	39.2
Heat recovery: Biogas (kW)	38.7 / 40.6
Heat recovery: Inlet hot water temp. (°C)	80
Heat recovery: Outlet hot water temp. (°C)	85
Heat recovery: Hot water flow rate (L/min)	110.0
Input: Power supply voltage (V)	230 AC
Input: Average start current (A)	46.0 AC
Grid connection method	Inverter
Engine type	Gas engine

The micro cogeneration unit is available with a 25kw generator capacity. Units can be connected in parallel to provide a maximum output of 200kW, i.e. a maximum of 8 units.

The micro cogeneration gas engines are able to operate on natural gas, LPG and biogas.

Nominate the gas fuel supply in the **YANMAR micro cogeneration plant selection schedule**.

Multiple cogeneration units

General: For multiple cogeneration units where the power generation sets operate in parallel provide generating sets of the same make, size and type.

Delete if single generating set required.

Document the number of cogeneration units in the **YANMAR micro cogeneration plant selection schedule**.

Consider circulating currents.

Detail the project specific performance requirements for the sequencing, control and interworking of the sets to function as a single emergency power supply. Include the sequence of events to occur when normal power is restored.

Mounting

General: Mount the engine and alternator units on a common structural steel frame within the integral enclosure to support the generating set assembly and the engine local control board.

Vibration suppression and seismic restraints

General: Conform to *0171 General requirements*.

Vertical and horizontal restraint: Support the mounting frame on vibration isolating mountings complete with seismic snubbers or captive type vibration isolation mounts.

Coupling

General: Directly couple the engine and generator.

Vary if engine local control board is excluded.

2.2 ALTERNATORS

General

Standards: To AS 60034.1, AS 60034.5, AS 60034.7, AS 60034.8, AS 60034.9 and AS 60034.11.

Voltage waveform: Sinusoidal, with total wave form deviation not exceeding 10%.

May need to be varied for generating sets below 300 kVA – discuss with YANMAR.

Excitation: Provide self-regulated brushless type exciters.

Alternatively, directly-driven excited.

Overspeed: Withstand a speed of 1.2 times unit rated speed for both alternator and engine.

Alternator underspeed withstand: Normal operation at net continuous rated output at a speed of 0.95 times unit rated speed, without overheating.

Sustained short-circuit withstand: At least 2.5 times full load steady state short-circuit current, for at least 5 s.

Output: 320 V, 253 Hz, three phase, three wire.

Number of poles: 16.

Power factor: Unity.

Efficiency: >96%.

Output power and current: As documented.

YANMAR cogeneration units are rated at 25kW.

Insulation classification: F type to IEC 60085.

Cooling method classification: Natural air-cooled.

IP classification: IP00.

Winding thermistors

General: Provide thermistors to alternator stator windings.

Standard: To AS/NZS IEC 60947.8 and AS 60034.11.

Thermistor type: Positive temperature coefficient.

Thermistor temperatures:

- Engine shutdown: 160°C.
- Winding temperature high pre-alarm: 140°C.

Terminal boxes

Construction: Provide metal terminal boxes sized to allow the neat installation and termination of the power and control cables and cable lugs with necessary clearances between live parts and the box, and without placing undue strain on termination points.

Supply cable terminal box: Provide removable lid and side covers.

Terminals: Provide terminals to manufacturer’s requirements.. Establish a neutral terminal if required.

Sealing: Provide neoprene or bonded cork gaskets between terminal boxes and their frames and covers.

Marking: To AS 60034.8.

2.3 ENGINES

General

Standards: The AS 4594 series covers internal combustion engines, but is primarily intended for the land, rail and marine transportation sector.

YANMAR gas powered micro cogeneration plant utilises gas driven engines fuelled by one of the following:

- Natural gas.
- Liquefied petroleum gas (LPG).
- Biogas.

Nominate which of the above gases are to utilised in the **YANMAR micro cogeneration plant selection schedule**.

Requirement: Provide gas engine type, as documented.

Engine: Vertical-type, serial water cooled 4 stroke cycle.

Number of cylinders: 4.

Rotational speed: 1900 rpm.

Started motor: Electric 12V DC.

Radiator: Water type, fan cooled.

Cooling water pump: Internal coolant water pump.

Engine protection

Requirement: Provide the following engine protection:

- Engine start malfunction.
- Engine overspeed.
- Engine stall.
- Low oil pressure.
- Coolant temperature malfunction.
- Oil temperature malfunction.
- Low coolant level.
- Engine misfire.
- Throttle system malfunction.
- Emergency stop press buttons.

Governing

The micro cogeneration units use a zero governor, utilising the throttle valve and fuel control valve in the fuel gas mixer to regulate gas flow to the engine via the control panel, to control the output of the engine and its speed.

General: Provide electronic controlled fuel gas mixer, to control engine load and speed.

2.4 GAS SUPPLY

General

Consider control devices for the safe supply of fuel gas to the engine. YANMAR include basic gas control devices integral to the unit required for the safe operation of the unit. Additional control devices may include:

- Pressure regulators.
- Emergency shut off valves.
- Pressure monitoring gauges.

Nominate in the documents devices required to control gas supply to the engine.

The YANMAR gas powered micro cogeneration plant is inclusive of an external gas train with a filter, solenoid valve, regulator and low pressure switch to satisfy Type B requirements. Internally there is a double block solenoid, LP switch, zero governor and mixer controlled by the system control panel.

Standard: To AS/NZS 5601.1.

Requirement: Provide gas installation, as documented.

Gas supply protection

Requirement: Provide the following gas supply protection:

- Gas valve malfunction.
- Low gas pressure.

2.5 INVERTER

General

Standard: To AS/NZS 4777.2.

Selection: To meet the documented performance.

Multiple unit operation: Up to 8 inverters / systems can be controlled in a multi arrangement to stage a sequence, as required.

Waveform: True sine wave.

Waveform quality: To AS/NZS 61000 series.

Input voltage: DC 380 to 450V.

Output voltage: 220/400V AC, 50 Hz.

Voltage regulation: ± 8%.

Harmonic distortion of output current: < 4%.

Frequency regulation: ± 1%.

Efficiency: ≥ 90% at 10% load.

Inverter malfunction protection: Provide the following inverter protection:

- DC overvoltage.
- DC earth fault.
- DC component detection.
- AC overcurrent.
- Abnormal equipment temperature.
- Earth fault circuit disconnection.
- Abnormal phase rotation.
- Faulty connection relay.

Grid connection malfunction protection: Provide the following grid connection protection:

- AC overvoltage and undervoltage.
- High and low frequency.
- Isolation operation detection.
- AC instantaneous over and under voltage.
- Reverse power flow.

Automatic no-load shutdown: Required.

Display:

- Output power.
- Grid stability.

Synchronisation

Requirement: Self commutation modules which automatically synchronise the inverter supply frequency and phase angle to the low voltage network or other embedded generator system.

Delete if not applicable.

If appropriate for larger systems include RS232 or RS485 for a digital output facility and software for remote monitoring. Refer as necessary to *0773 Building management systems*.

2.6 ELECTRICAL CONTROL AND PROTECTION EQUIPMENT

General

The YANMAR gas powered micro cogeneration plant includes fully integrated electrical control and protection equipment for the:

- Alternator.
- Gas engine.
- Gas supply.
- Inverter.
- Power distribution from the plant.
- Heat recovery system.
- Enclosure environment.

Requirements: Provide control and protection equipment to YANMAR's requirements and as documented.

Touch panel system controller: Provide integral YANMAR touch panel controller for the control of individual cogeneration plant and the control of multiple units.

Interconnection switch: Inverter output to building load and power grid switched by internal electromagnetic power contactor controlled from the inverter. Contactor to meet YANMAR's requirements.

Moulded case circuit breakers: Miniature circuit breakers: Interrupting capacity classification to AS/NZS 60898.1 or AS/NZS 3111.

- For general building services: Type C.
- For motor protection: Type D.

Surge protection devices: To IEC 61643-11 and IEC 61643-12.

Contactors: To AS/NZS IEC 60947.4.1.

- Type: Enclosed, block type, air break, electromagnetic.

Control devices and switching elements: To AS/NZS IEC 60947.1 and AS/NZS IEC 60947.5.1.

Control relays: To AS/NZS IEC 60947.5.1.

2.7 BUILDING MANAGEMENT SYSTEM INTERFACE

The YANMAR control unit has a number of Digital Input / DigitalOutput / Ai LLI (Low Level Interface) points that can be connected to the BMS. There are no HLI (high Level Interface) to BACnet.

On large projects Building Management Systems (BMS) are often utilised for the control and management of building systems. Start up and micro cogeneration plant selection and control may be required for the plant.

Management of operational information, plant fault management may be required.

Designers are to nominate in the documents BMS interface requirements.

The digital system interface is based on the BACnet standard. If non-BACnet systems are acceptable, modify or replace it with suitable material. If the systems are non-BACnet, it may be necessary to also specify a suitable gateway to connect them.

Designers are to detail the measuring and control systems required to be monitored and to detail the interfacing equipment necessary for connection to the BMCS.

Refer to *0773 Building management systems*, optional clause **Digital System Controller Interface**.

Standard

Building automation system protocol: To ANSI/ASHRAE 135.

Interface

General: Provide suitable BACnet interface equipment for connection to the BMS to achieve the documented performance and functionality.

Analogue measuring equipment: Provide signal transducers to convert sensed signal to the required system signal standard for input to the BMS. Provide transducers with integral, accessible zero and span adjustments, open and short circuit protection and reverse polarity protection.

AC current transducer input: Provide current sensing input devices, i.e. current transformers or Hall Effect Sensors, to input the current into the transducer.

Analogue BMS transducer output: Provide both 0 – 10 V dc and 4 – 20 mA output signals for input to the BMS system.

BMS points: Provide the alarm and monitoring points to interface with the BMS, as documented.

BMS connection: Provide voltage-free contacts wired to a dedicated terminal strip in the respective medical gases switchboard.

Coordinate with *0773 Building management systems*.

Independent operation: Arrange the interface so that failure or fault in the BMS does not render the micro cogeneration system inoperative in any way.

2.8 HEAT RECOVERY SYSTEM

Plate heat exchangers

Requirement: Provide single pass, counterflow, brazed plate heat exchangers, constructed from type 316 stainless steel to ASTM A240/A240M and including water drain and vent connections, insulation, and necessary valves and fittings.

Accessories

The YANMAR gas powered micro cogeneration plant includes a fully integrated heat recovery system, comprising:

- Exhaust gas cooler.
- Water coolant pump.
- Water filter.
- Water plate heat exchanger.
- Hot water manifold.
- Control valves.

Water flow and return connections: RC1 tapered thread. Provide matching flexible connections.

Shipping protection: Fit blank companion flanges, bolts and gaskets or removable plugs or caps.

Drain connections: Minimum DN 20 screwed connection with valve at the lowest point. Arrange to permit complete drainage of water from the liquid cooler.

Vent connections: Minimum DN 10 screwed connection with valve. Extend valve clear of insulation.

Thermometer pockets: Provide at water inlet and outlet.

Water side pressure drop test sockets: Factory test and stamp heat exchanger, or provide metal tag, stating pressure drop at design water flow. Provide pressure drop test sockets at inlet and outlet, located to measure the same pressure drop as measured at the factory.

Heat exchanger insulation
Requirement: Insulate the heat exchanger and other surfaces that operate above ambient temperature to *0752 Mechanical piping insulation*.

Material: Glass wool, rock wool or polyester blanket.

See NATSPEC TECHnote DES 003 for information on the fire hazard properties of insulation and pliable membranes.

Insulation R-Value: To BCA J5.8.

See NATSPEC TECHnote DES 031 for information on specifying R-Values.

Excess heat rejection radiator: Provide inbuilt excess heat rejection radiator to reject heat energy not required by the heat recovery system.

2.9 EQUIPMENT ENCLOSURES

General
Requirement: Provide ventilated, enclosure, materials and finishes that are weatherproof and corrosion-resistant, assembled and reinforced to prevent flexing and drumming.

Material and finishes
Materials: Conform to the following:

- Metallic-coated steel:
  - Base and legs: ≥ 1.6 mm.
  - Panels: ≥ 1.0 mm.

Outdoor equipment enclosure finishes: Powder coat all metallic-coated steel interior and exterior surfaces to AS 4506.

Powder coating is the default as it is more durable than an enamel finish, but is also more expensive.

Indoor equipment finish: YANMAR's standard finish.

Outdoor IP rating: IP44.

Moisture retention: Design and install so that all parts are free draining with no pockets for condensation and/or rainwater retention.

Installations near the sea: Provide anti-salt treatment to key parts of the equipment and enclosure to YANMAR's recommendations.

Access
General: Provide access to the interior of the unit for routine inspection and maintenance and for removal of major components. Provide doors and panels with handles and captive fasteners. Provide

weatherproof doors and panels on outdoor enclosures. Do not use self-tapping screws on removable panels.

Access: As a minimum, provide access to the following:

- Gas engine and alternator.
- Starter battery.
- Water coolant pump.
- Plate heat exchanger and pipe connections.
- Gas supply valves and regulators.
- Radiator and cooling fan.
- Electrical control panel.

Handles: Provide handles to permit easy and safe removal and replacement of panels, as follows:

- < 450 mm diagonal panel dimension: 1 handle.
- ≥ 450 mm diagonal panel dimension: 2 handles.

3 EXECUTION

3.1 GENERAL

Plinths

General: Provide reinforced concrete plinths for floor mounted equipment, sized to suit equipment footprints.

Resilient mounts

General: Provide at least 6 resilient mounting blocks between the frame and the plinth.

Show on the drawings the location of the generating set and the natural frequency of the floor system. Alternatively, make provision in Tendering for requesting contractors to advise maximum static and dynamic loads, and the vibration frequencies and amplitudes of the generator set during normal operational conditions (check out the effect of the generating set operation on the building structure before approving the generating set).

3.2 INTERNAL PLANTROOM VENTILATION AND ENGINE EXHAUST

Internal ventilation

General: Where cogeneration plant is installed within buildings, provide air supply and air exhaust systems suitable to allow satisfactory cogeneration plant operation.

Engine exhaust systems

Requirement: Connect individual plant exhaust systems to a central exhaust system allowing engine exhaust external to the building.

Material: Type 321 Stainless steel.

Diameter: Match engine exhaust manifold connection.

Connections: Provide flanged connections to silencers and pipe interconnections.

Vibration isolation: Provide a stainless steel flexible connection to the engine.

Weatherproofing

External: Provide weatherproof flashing, sleeves and acoustic seals where the exhaust system penetrates the roof or external walls.

Exhaust drainage
General: Grade the exhaust line away from the engine to drainage pockets, or connect to a suitable drainage outlet.

Exhaust pipe insulation
Requirement: Insulate the full length of exhausts within buildings.

Insulation Material: Mineral wool, suitable for temperatures up to 260°C.

Maximum thermal conductivity: 0.036 W/m.K at 20°C.

Minimum thickness: 50 mm.

Application: Wrap insulation around exhaust pipes. Hold in place with 12 mm x 0.55 mm zinc-coated steel straps at 600 mm maximum centres.

Sheathing: Sheath insulation as follows:

- Sheathing not exposed to weather: 0.55 mm metallic-coated steel sheet.
- Sheathing exposed to weather: 0.55 mm metallic-coated steel sheet or 0.8 mm minimum aluminium sheet.
- Joints: Lap joints in sheathing at least 30 mm and rivet or screw at 150 mm maximum centres.
- Edges: Neatly cut around nozzles and cone down to flanges.
- Terminations: At terminations, return edges of sheathing to protect edges of insulation.

3.3 GAS SUPPLY SYSTEM

Designers to modify to following requirements relative to the type of gas supply to be utilized..

General
Requirement: Conform to *0824 Fuel gas*.

Reticulated gas systems
General: To AS/NZS 5601.1.

This standard covers gas provided from a reticulation system to the consumer's site (e.g. natural gas & biogas) and from bulk storage onsite (e.g. LP gas).

3.4 COMPLETION

Completion tests

Testing and commissioning is an important part of the generating set installation and, in particular, the way in which the generating set interacts with the building electrical services. YANMAR gas powered micro cogeneration plant cannot run during a power outage. Therefore testing and demonstration of the controls and sequencing are probably more important than individual tests applied to each unit.

Schedule the specific tests required for the project, including additional site tests e.g. noise measurements, high voltage tests.

General: For each generating set carry out the following:

- Check tightness of connections and securing devices.
- Verify correctness of operation of protection devices and systems including sensor settings. Simulate actual conditions as far as possible, in order to test responses to faults imposed.
- Before connecting the generator to mains supply or project loads, verify that the correct electricity supply phase sequence is provided at switchboards and control panels, and that circuit protective devices are correctly sized and adjusted.
- Functional checks to AS 4594.1 Table 7, List C, items C1 to C5 inclusive.

- Cold start with the engine having been at rest for the previous 24 hours, timed from receipt of mains failure signal to acceptance of full rated load in 3 load steps to within the limits of output voltage and frequency.
- Continuous operational trial consisting of:
  . 4 hours at 100% rated power.
  . 1 hour at 110% rated power.
  . 30 min at 75% rated power.
  . 30 min at 50% rated power.
- Record fuel consumption for each step of the continuous trial.
- Sample engine oil from engine sump before and after tests. Perform laboratory analysis and submit a report on each oil sample.
- Continuous operational trial: During the trial, measure the following at maximum intervals of 30 minutes:
  . Generator kW and kVAR output.
  . Generator output voltage.
  . Generator output current.
  . Generator output frequency.
  . Power factor.
  . Oil pressure and water temperature.
  . Electrical power requirements of continuously running electric motor driven ancillaries.
  . Each battery charger current and voltage readings.
  . Noise level.

Synchronisation and load sharing tests: For generating sets running in parallel perform tests to verify automatic synchronisation and load sharing including the following:

- Sequence start and shutdown of each generating set.
- Parallel operation of generating sets.
- Synchronising of generating sets.
- Equal load sharing of kW and kVAR over 5 equal load steps.
- Neutral switching sequence and operation, where provided.
- Operation of controls, switchgear and auxiliaries.

Temporary test loads

General: Provide test loads including power and control wiring, ancillary equipment and test instruments to achieve the kW, kVAR and necessary load steps.

Reports

General: Submit reports from manufacturers or suppliers verifying the performance of safety and control functions of each system.

3.5 MAINTENANCE

General

Requirement: Provide YANMAR approved maintenance at intervals recommended by YANMAR.

Schedule the specific items to be carried out during the maintenance period. Refer to YANMAR's recommendations.

Do not specify maintenance work to be performed by the principal, if any. Specify tools and spares required.

Call out: Respond to call outs for breakdowns or other faults requiring corrective maintenance. Attend site within 24 hours of notification. Rectify faults and replace faulty materials and equipment.

4 SELECTIONS

Schedules are a way of documenting a selection of proprietary or generic products or systems by their properties. Indicate their locations here and/or on the drawings. Refer to NATSPEC TECHnote GEN 024 for guidance on using and editing schedules.

4.1 PERFORMANCE

Performance schedule

Property	A	B	C
Net continuous rated output (kVA)			
Overload kVA output			
Overload time duration			
Rated voltage (V)			
Number of phases			
Neutral connection			
Earthing			
Frequency (Hz)			
Duty-type to AS 60034.1			
Voltage regulation grade to AS 60034.1			
Compensation			
Machine location			
Altitude (m)			
Available cooling water temperature (C)			
Degree of protection (IP rating)			
Other relevant site conditions			

A, B, C: These designate each instance or type or location of the item scheduled.

Edit codes in the Schedule to match those on drawings.

Net continuous rated output (kVA) (i.e. the net continuous output of the generating set after allowing for independent auxiliaries essential for the operation of the machine): Temperature-rise is proportional to output. See AS 1359.30 Table 1 for preferred rated kVA outputs for a.c. generators.

Overload kVA output and overload time duration: The overload kVA output of the generating set must be capable of at least matching the required engine performance.

Note in this connection that AS 4594.1 clause 8.3 permits an engine overload power of 110% for 1 hour in 12 hours.

Rated voltage (V): e.g. 230/400.

Neutral connection: e.g. Star connected.

Frequency (Hz): e.g. 50 Hz.

Duty-type: e.g. SI continuous running duty-type. See AS 60034.1 for other designations.

Voltage regulation grade: e.g. VR1, VR2-11. See AS 60034.1 for guidance on the choice of grades. When stability is important, the required speed/load/time characteristics must be specified; these will be affected by the prime mover governor. If parallel operation is involved, voltage regulation and power factor compensation may need to be specified.

Degree of protection (IP rating): e.g. IP40.

Other relevant site conditions: Specify operating conditions including the following:

- Machine location e.g. indoor or outdoor. Not required if location is apparent from the drawings.
- Barometric pressure (kPa) - minimum, maximum. Alternatively, if the range is unknown, state the altitude in metres.
- Air temperatures (C) (monthly mean) - minimum and maximum, for hottest month and coldest month; plus ambient around engine, exhaust temperature, temperature drop across the plant room.
- Maximum air flow through the plant room e.g. 6 m/s.
- Relative humidity at maximum ambient air temperature (%). Especially important for turbochargers.
- Available cooling water (if any) temperature (C) – maximum, minimum.
- Other relevant site conditions e.g. environmental hazards such as weather extremes, air pollution, dust, limitations on transmitted noise levels.

5 YANMAR UNITS

5.1 YANMAR MICRO COGENERATION PLANT SELECTION SCHEDULE

Generator power output	Model	Number of units	Gas supply
25.0 kW	CP25WE		
25.0 kW	CP25WE		
25.0 kW	CP25WE		
25.0 kW	CP25WE		

Designers to nominate number of units and gas fuel supply type.

REFERENCED DOCUMENTS

The following documents are incorporated into this worksection by reference:

AS/NZS 3000	2018	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3008		Electrical installations - Selection of cables
AS/NZS 3008.1.1	2017	Cables for alternating voltages up to and including 0.6/1 kV - Typical Australian installation conditions
AS/NZS 3010	2017	Electrical installations - Generating sets
AS/NZS 3100	2017	Approval and test specification - General requirements for electrical equipment
AS/NZS 3111	2009	Approval and test specification - Miniature overcurrent circuit-breakers
AS 4506	2005	Metal finishing - Thermoset powder coatings
AS 4509		Stand-alone power systems
AS/NZS 4509.1	2009	Safety and installation
AS 4594		Internal combustion engines - Performance
AS 4594.1	1999	Standard reference conditions, declarations of power, fuel and lubricating oil consumption and test methods
AS/NZS 4777		Grid connection of energy systems via inverters
AS/NZS 4777.1	2016	Installation requirements
AS/NZS 4777.2	2015	Inverter requirements
AS/NZS 5601		Gas installations
AS/NZS 5601.1	2013	General installations
AS 60034		Rotating electrical machines
AS 60034.1	2009	Rating and performance (IEC 60034-1, Ed 11(2004) MOD)
AS 60034.5	2009	Degrees of protection provided by the integral design of rotating electrical machines (IP Code) - Classification
AS 60034.7	2009	Classification of types of construction, mounting arrangements and terminal box position (IM Code)
AS 60034.8	2009	Terminal markings and direction of rotation (IEC 60034-8, Ed. 3 (2007) MOD)
AS 60034.9	2009	Noise limits
AS 60034.11	2009	Thermal protection
AS/NZS 60898		Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations
AS/NZS 60898.1	2004	Circuit-breakers for a.c. operation
AS/NZS IEC 60947		Low voltage switchgear and controlgear
AS/NZS IEC 60947.1	2015	General rules
AS/NZS IEC 60947.4.1	2015	Contactors and motor-starters - Electromechanical contactors and motor-starters
AS/NZS IEC 60947.5.1	2015	Control circuit devices and switching elements - Electromechanical control circuit devices
AS/NZS IEC 60947.8	2015	Control units for built-in thermal protection (PTC) for rotating electrical machines

AS/NZS 61000		Electromagnetic compatibility (EMC)
BCA J5.8	2019	Energy efficiency - Air-conditioning and ventilation systems - Pipework insulation
ANSI/ASHRAE 135	2016	BACnet: A data communication protocol for building automation and control networks
ASTM A240/A240M	2018	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
IEC 60085	2007	Electrical insulation - Thermal evaluation and designation
IEC 61643		Low voltage surge protective devices
IEC 61643-11	2011	Surge protective devices connected to low voltage power distribution systems – requirements and test methods
IEC 61643-12	2008	Surge protective devices connected to low voltage power distribution systems – selection and application principles
IEC 62109		Safety of power converters for use in photovoltaic powers systems
IEC 62109.1	2010	General requirements
IEC 62109.2	2011	Particular requirements for inverters
The following documents are mentioned only in the *Guidance* text:		
AS 1359		Rotating electrical machines - General requirements
AS 1359.30	1997	Preferred outputs and frame sizes
AS 4594		Internal combustion engines - Performance
NATSPEC DES 003	2006	Fire hazard properties of insulation and pliable membranes
NATSPEC DES 021	2013	Site electricity supply
NATSPEC DES 031	2014	Specifying R-Values
NATSPEC GEN 024	2015	Using NATSPEC selections schedules
NATSPEC TR 01	2018	Specifying ESD
NATSPEC TR 03	2018	Specifying Design and Construct for Mechanical services
YANMAR	2016	GHP engineering data manual