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# **South East Water Standby Diesel Generator Specification**

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# 1. General Requirements

## 1.1 General

Details included in this specification outline South East Waters minimum requirements to achieve, manufacture, testing, delivery, installation and commissioning of standby diesel generating sets and ancillary equipment. The document does not outline work practices associated with the management of risks during construction, installation and operational works.

## 1.2 Standards

All works implemented shall be in accordance or compliance to;

- Victorian Government, Occupational Health and Safety Act 2004
- Victorian Government, Occupational Health and Safety Regulations 2017 (OHS Regulations)
- Worksafe Victoria, 2005 'Guide for Assessing and Fixing Noise Problems at Work'
- Victorian Government, 'State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1'.
- Australian Standards or its IEC equivalent
- Electricity Safety (Installations) Regulations
- Victorian Service & Installation Rules
- Essential Services Commission Electricity Distribution Code
- Requirements of the Electricity Distribution Company
- Electricity Safety Act
- Manufactures guidelines
- South East Water Electrical Performance Specification AM2714

## 1.3 Interpretations

### 1.3.1 Definitions

Net continuous rated output (or prime rating): Net continuous electrical output available at alternator terminals, not including the electrical power consumed by the generating set's dependent and essential auxiliaries.

Net short-time rated output (or stand-by rating): Net electrical output available from the generating set for 1 hour in every 12 hours at net continuous rated output, not including electrical power consumed by the generating set's dependent and essential auxiliaries.

Start response time: Total elapsed time from receipt of start signal to final connection to load.

## 1.4 Quality

### 1.4.1 Inspection

#### Notice

Give sufficient notice so that inspections may be made of each complete generating set and associated systems at the manufacturer's or supplier's factory before delivery to the site.

### 1.4.2 Pre-Completion Tests

#### Production tests

Generating sets: Carry out acceptance tests to AS 2789.2.

Alternators: Carry out performance tests to AS 1359.101.

## 1.5 Preferred Manufacturer

Combination of diesel engine / AC alternator shall be selected from the following.

#### Diesel Engine

Caterpillar, Cummins, Deutz, John Deere, MTU, Perkins, Scania, Volvo, Yanmar

#### Alternator

Caterpillar, Leroy Somer, Mecc Alte, Stamford

## 1.6 Submissions

### 1.6.1 Product Data

Submit product data for test, manual and auto modes, including the following:

- Technical description and specifications, including output curves for base load and stand-by conditions, alternator and engine data, automatic voltage regulator, synchronizing and load sharing modules, generator controller and auxiliaries.
- Type test reports as follows:
  - Generating sets: To AS 2789.2.
  - Alternators: To AS 1359.60.
- Net continuous rated output.
- Net short-time rated output.
- Generating set efficiency at 50%, 75% and 100% load.
- Calculations for performance of acoustic enclosures and silencers
- Fuel consumption characteristics.

### 1.6.2 Shop Drawings

Submit shop drawings indicating the following:

- Maximum mass and overall dimensions of each separable assembly.
- Access clearances for operational maintenance and dismantling.
- Details of weatherproof and acoustic enclosure.

## 2. Technical Requirements

### 2.1 Components

#### 2.1.1 General

##### **Standards**

Alternators: To AS 1359

Engines: To AS 2789

Electrical Installation: To AS 3010

#### 2.1.2 Electrical Output

415 V, 3 phase, 4 wire, 50 Hz, star connected with neutral terminal.

#### 2.1.3 Vibration

The generator shall be statically and dynamically balanced such that when operating, the vibration of the generator set shall not exceed the limits of vibration amplitude given in AS1359.114.

### 2.2 Alternator

#### 2.2.1 Alternator Rating

The output power from the alternator shall be sufficient to supply the load specified in the Technical Data Sheets at a power factor of 0.8 for standby service in accordance with ISO3046.1.

#### 2.2.2 Alternator IP Rating

The alternator casing shall be dust, moisture and vermin proof. Housings shall provide minimum degree of protection IP53 to AS1939. Required protection, if different, shall be detailed in the Technical Data Sheets.

#### 2.2.3 Alternator Tolerance

Tolerance to alternator parameters shall be in accordance with AS1359, Table 69.1.

#### 2.2.4 Alternator Voltage Variations

The alternator shall be capable of supplying its rated output at rated speed and power factor at any voltage in the range 95% to 105% of its rated voltage continuously, in accordance with AS1359, Clause 31.5.

#### 2.2.5 Alternator Short Circuit

The alternator shall be capable of withstanding without damage a 30-second, 3 phase, short circuit at its terminals when operating at rated kVA and power factor, at 105% rated voltage with fixed excitation.

### **2.2.6 Alternator Overload Current**

The alternator shall be capable of supplying an overload current of 50% of rated current for one minute with the field set at rated excitation, and shall be capable of supplying an overload current of 10% for periods of one hour in any twelve hour period.

### **2.2.7 Alternator Excitation**

The alternator shall be provided with an air-cooled brushless exciter direct coupled to the generator shaft, excitation voltage being selected by the manufacturer. The stator winding of the exciter shall be brought onto a terminal box mounted on the side of the exciter.

The exciter enclosure shall be of a degree of protection equal to that of the alternator.

The exciter insulation class shall be to AS2768, Class B as a minimum.

### **2.2.8 Alternator Voltage Response**

The alternator shall be equipped with a Class A1 (1 % tolerance) automatic voltage regulator suitable for auto/manual operation.

Alternator reactance and voltage regulator performance shall be in accordance with AS1359.101. On application of loads under stand-by power the initial voltage drop shall not exceed 15% of rated voltage. Voltage regulation grade shall be VR 1 or better.

The alternator shall be capable of carrying a continuous unbalanced load of 15% without damage provided the rated current is not exceeded in any phase.

### **2.2.9 Over Speed Withstand**

A speed of 1.2 x unit rated speed for both alternator and engine.

### **2.2.10 Alternator under speed withstand**

Normal operation at net continuous rated output at a speed of 0.95 x unit rated speed, without overheating.

### **2.2.11 Coupling**

Directly couple the engine and alternator shafts using a self-aligning type coupling, capable of transmitting the engine maximum output torque under operating conditions, including starting and overload.

### **2.2.12 Insulation Classification**

Winding insulation temperature rating shall not be less than Class H to AS2768. Temperature rise shall be in accordance with AS1359.101, for the insulation class used.

All insulation, bushings and terminal supports shall be made of non-hygroscopic, anti-tracking, flame retardant materials.

### **2.2.13 Anti-condensation Heaters**

General: Provide at least 2 anti-condensation heaters within the winding enclosure.

Rating: Rate heaters to maintain the windings and insulation at least 6°C above ambient temperature when the alternator is at rest and one heater is in service.



Location: Locate a heater at each end of alternator windings in a position which allows heat transfer to the winding insulation by convection, without exceeding maximum allowable insulation temperature. Do not fix heaters to windings.

Terminations: Connect heaters to separate identified terminals within a separate accessories terminal box which is connected to a permanent supply.

Control cubicles shall be provided with anti-condensation heaters located at the base of the cubicle. Heaters shall be thermostatically controlled, and shall be shrouded.

Connection diagram: Provide a connection diagram for the heaters. Locate within the terminal box.

#### **2.2.14 Cooling**

The method of cooling shall be IC01 to AS1359.106. Subject to SE Water approval other categories of cooling may be accepted.

#### **2.2.15 Winding Thermistors**

Provide separate thermistors to alternator stator windings for alarms and engine shutdown functions.

Standard: To AS 1023.1.

Thermistor type: Positive temperature coefficient.

Thermistor temperatures:

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

#### **2.2.16 Terminal Boxes**

Construction: Provide metal terminal boxes. Size to allow the current transformers, power and control cables and cable lugs to be neatly installed and terminated with necessary clearances between live parts and the box, and without placing undue strain on termination points.

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

Terminals: Provide star connected windings. Bring both ends of each winding out to separate terminals. Establish a neutral terminal.

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

#### **2.2.17 Overload Protection**

The alternator shall be provided with circuit breaker sized according to the full load rating of the alternator. The circuit breaker shall be fitted with trip or off status dry contact for alarming purposes.

## 2.3 Engine

### 2.3.1 Mounting

Mount the engine and alternator units on a common structural steel frame to support the generating set assembly and the engine local control board. The assembly shall include lifting eyes at each corner.

### 2.3.2 Governing

Provide electronic or mechanically controlled governors which enable engines to operate continuously at 1480 r/min from no-load to the maximum rated electrical load connected to the alternator. Provide filters which ensure that harmonics or switching spikes generated by the load do not interfere with the operation of the governor, over speed or under speed cut out devices.

Governing accuracy: Class A<sub>1</sub>, to AS 2789.4.

Governor adjustments: Provide adjustment settings for

- speed droop;
- stability;
- maximum speed;
- acceleration rate; and
- load gain

### 2.3.3 Engine Speed Control

The engine shall be fitted with an electronic speed governor so that alternator frequency does not drop more than 3% on application of load.

### 2.3.4 Engine Over Speed

The generator set shall be so constructed such that in an emergency it can withstand an over speed of 25% without mechanical damage.

### 2.3.5 Engine Heater

The engine shall be fitted with a cooling jacket heater. A tank style heater shall consist of.

- Temperature high limit thermostat to prevent coolant overheating.
- Flow-through control thermostat.
- Inlet bi-directional ball check valve to maintain a jacket heater level to protect heater element for overheating when the engine is running.

All type heaters shall use an oil pressure switch or other automatic shut-off device to switch off the heater when the engine is running.

### 2.3.6 Crankcase Breather Filtration

A closed circuit crankcase ventilation filter shall be fitted to ensure crankcase blow-by gas / contaminated oil mist be removed and returned to the engine air intake system.

### **2.3.7 Engine Air Intake**

A dry type air cleaner (cyclopac or equivalent) with restriction indicator shall be fitted.

Provide dry type air intake filters of sufficient capacity to permit continuous engine operation for 200 hours before filter servicing becomes necessary.

### **2.3.8 Manual Lube Oil Drain Pump**

For maintenance purposes provide a manual lube oil drain pump.

## **2.4 Control Devices**

### **2.4.1 Control System**

The generator control management system shall be a Deep Sea 7320 Mark II housed within a control panel, minimum degree of protection IP51 to AS1939, located in a lockable steel cabinet, mounted on the generator and shall include the following ancillary equipment as a minimum;

- 3 phase voltage indication,
- generator current indication for each phase,
- engine/generator system diagnostics including;
  - ❖ coolant temperature,
  - ❖ engine speed,
  - ❖ engine oil pressure and
  - ❖ DC system volts,
- generator kW indication,
- generator frequency indication,
- hours run indication,
- automatic/manual stop start controls,
- engine start and stop buttons,
- automatic shutdown for engine/generator faults,
- engine available to start indication and
- emergency generator stop button
- analog fuel level sender
- low fuel switch - to operate 1 hour prior to fuel level low engine shutdown
- circuit breaker status

All control devices including indicating lamps, push buttons and selector switches shall comply with AS 3947.5.1 and the following requirements;

- all control devices shall be oil-tight and dust tight
- all indicating lamps shall have a minimum rated life of 3,000 hours at the rated voltage
- all indicating lamps shall include a press-to-test function

Volt free contacts shall be supplied via interposing relays for telemetry alarm purposes, to indicate;

- generator set available (also to incorporated emergency push button and generator isolator operation)

- generator set running
- generator set fault (including circuit breaker trip or off status)
- generator battery voltage low
- low fuel level - to operate 1 hour prior to fuel level low engine shutdown

The outputs shall be wired directly from the DSE7320 controller without the need of an output expansion module.

Hour run meters shall be similar in appearance to the ammeters/voltmeters used and shall register operating hours with five (5) digit cyclometer dial, the lowest digit showing 1/10 hours.

The engine shall automatically shut-down in the case of;

- engine oil pressure low,
- engine fuel level low,
- engine coolant temperature high or
- engine over speed

Protection for the generator shall include but not be limited to the following;

- alternator over current,
- alternator over/under voltage,
- alternator earth fault or
- alternator over temperature

#### **2.4.2 Current Transformers**

Current transformers shall be fully encapsulated and shall comply with AS 1675.

## **2.5 Operation**

### **2.5.1 Manual Sequence Control**

Provide controls to manually start and shut-down generating set. Include emergency stop, meters, selector switches and status indicating lights.

### **2.5.2 Automatic Start / Shutdown Control**

Upon receipt of a "remote start" signal, generator set to start automatically, warmup period and provide alternator output.

Removal of "remote start" signal, cease alternator output and provide a cooling period prior to shut down.

### **2.5.3 Engine Shutdown**

Provide a shutdown control system which electrically disconnects the alternator, and shuts down engine upon the occurrence of fault conditions, such that

- engines cannot be restarted before safety devices have been manually reset and system alarm sensors have returned to the normal state;

- the over speed shutdown acts directly to disconnect the fuel supply independent of the governor; and
- the shutdown control system may be reset by the operation of one reset switch, after safety devices have been manually reset

#### **2.5.4 Emergency and Fault Shutdown**

Provide for the following conditions to register as visible alarms and to trip the generating set main circuit breaker to open immediately and the generating set to immediately shutdown:

- Emergency stop push-button: Pressed.
- Generating set: Over voltage.
- Generating set protection: Activated.
- Generating set: Over current.
- Engine: Over speed.
- Engine oil pressure: Low.
- Engine oil temperature: High
- Coolant Level: Low
- Jacket water temperature: High.
- Day fuel tank: Critical low.

## **2.6 Batteries and Charger**

### **2.6.1 General**

Provide a maintainable 24VDC lead acid battery / charger system to supply engine start; engine management, control and alarm functions.

### **2.6.2 Standards**

Engine start batteries: To AS 2149.

Battery chargers: To AS 4044.

### **2.6.3 Battery Capacity**

Provide sufficient battery load capacity to supply full generating set control, monitoring and alarm functions for a period of 48 hours.

Provide sufficient cranking capacity for at least ten (10) cranking cycles. The cranking cycle shall consist of ten (10) seconds cranking then ten (10) seconds rest and shall preferably be adjustable.

Provide a starting lock out system which prevents further starting attempts after 6 successive unsuccessful attempts.

### **2.6.4 Battery Location**

Locate batteries in proprietary battery holders attached to the generating set, or on purpose-built stands above ground level. Isolate batteries from vibration.

Provide a high-impact resistant transparent cover for each battery.

Provide a lockable isolator.

### **2.6.5 Battery Charger**

Provide a 3 stage electronic lead acid battery charger comprising constant current (boost), constant voltage (absorption) and float charge.

The charge rate shall be limited to 10% of the battery's 20 hour (Ah) rating. E.g. 100AH @ 20Hr battery = 10A max charge rate.

Provide the following local visual alarms.

- Battery boost 'ON' status indicator
- Battery absorption 'ON' status indicator
- Battery float 'ON' status indicator
- Mains 'ON' status indicator
- Faulty battery status indicator

### **2.6.6 Battery Discharge Test**

Provide a din rail mounted 7 day electronic time clock to switch the AC supply input to the battery charger. The time clock shall be programmed to switch the battery charger between 8:00 to 12:00 every Monday.

## **2.7 Marking**

### **2.7.1 Rating Plates**

The generator shall be fitted with permanently affixed rating plate containing all the information specified in AS 1359.

Temperature-rise limits: If temperature-rise limits are achieved by de-rating an oversized generator, state the de-rated value.

Alternator mass: State alternator mass.

### **2.7.2 Thermistor Detector Identification and Warning Plates**

Thermistors: Provide details of thermistor type classification and reference temperature.

Warning: Provide a warning engraved in 4 mm high lettering as follows:

- "WARNING - Do not apply more than 2.5 V across the protection thermistor devices".

Anti-condensation heater identification and warning: Locate next to heater terminals. State the number, voltage and power rating of the heaters, and the following separate warning engraved in red letters on a white background:

- "WARNING - Anti-condensation heater. Circuit is live when the set is off".

### **2.7.3 Engine Direction of Rotation**

General: If driving shafts or associated rotating parts are accessible, clearly and permanently mark the direction of rotation on an adjacent fixed surface.

Rotation identification: Provide a label within the supply cable terminal box identifying the relationship between the direction of rotation and the marking of terminals.

## **2.8 Weatherproof Sound Attenuated Enclosure**

The generator enclosure shall be constructed internally and externally of marine grade aluminium or stainless steel, grade 316 sheeting not less than 3-mm thickness.

The sound insulating material shall be Stratocell Whisper® offering non corrosive, resilience to water and humidity and flame proof properties.

The enclosure shall be constructed to be securely mounted to the site concrete slab and be entirely removable in one part by means of lift –off anchor points to allow a major overhaul of the unit.

The enclosure must be of an adequate size to allow a 0.8m internal clearance between the generator and the enclosure to perform unrestricted maintenance works.

Access doors shall be fitted with latches to hold them in the fully open position. No less than 2 door openings shall be provided for generator set exceeding 100 kVA as per AS 3010. Door height minimum 2 metres.

Door hinges shall be heavy duty.

Door locks must be keyed to SEW Abloy Key system and must be vandal proof.

A reed switch shall be fitted to each access door indicating door open/close status ('1'= closed). The switches shall be wired back to generator control panel for connection with other alarms.

The enclosure shall be powder coated to AS2700 to colour G62, Rivergum.

The enclosure shall be fitting with LED lighting in accordance with AS 1680 - Interior and workplace lighting. A plug or a suitably located terminal box shall be installed to allow ease of disconnection in the event of removing the enclosure.

## **2.9 Ancillary Supply**

Battery chargers, water jacket heaters, enclosure lighting and other 230 Vac circuits are required to be powered externally whilst the generator is non-operational. Provide a common load centre and circuit breakers for each circuit fitted within the generator.

## 3. Installation

### 3.1 General

#### 3.1.1 Signs

Warning: Provide the following on each side of each generating set:

- "WARNING: This set may start at any time without notice."

Lettering: 50 mm high, red on white background.

#### 3.1.2 Drip Trays

General: Provide removable metal drip trays under those parts of the assembly where fuel or lubricant leakage may occur. Provide overflow outlet pipes taken to a point where a receptacle can be fitted under the pipe outlet.

Capacity: At least 1.5 times the oil capacity of the engine sump.

#### 3.1.3 Emergency Stop Push-Buttons

Generating sets < 2 m long: Provide one push-button per generating set.

Other generating sets: Provide 1 emergency-stop push-button on the generator set. Also add one emergency push-button on the main switchboard to be wired in series with the emergency-stop pushbutton on the generator set.

Type: 40 mm diameter red, palm operated latched mechanical type mounted in a metal wall box fixed. Stop to disconnect the generator and immediately shut down the engine when the controls are in the automatic or manual mode.

#### 3.1.4 Safety Guards

Provide safety guards to prevent contact with any rotating or high temperature parts, at least complying with the AS4024 (set) - Safeguarding of Machinery.

#### 3.1.5 Engine Cooling

General: Provide a cooling system consisting of radiators, fans and pumps.

Cooling air ductwork: If applicable connect the cooling air outlet to generator room cooling air outlet.

The engine cooling system shall be sized to allow continuous operation with ambient temperatures of 45°C in the shade.

#### 3.1.6 Exhaust System

The engine shall be installed complete with exhaust system including muffler and in the case of non-turbocharged engines, a spark arrester conforming to AS1019.



General: Provide exhaust piping from the engine complete with residential grade silencers, piping, ductwork, supports and expansion devices.

Exhaust piping: Grade 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.

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

Lag internal exhaust piping and ductwork using calcium silicate insulation sheathed using zinc-coated steel sheet. Lagging thickness: Minimum 55 mm.

### **3.1.7 Weatherproofing**

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

## **3.2 Fuel Supply**

The generator set shall incorporate a fabricated double banded steel fuel tank of sufficient capacity for at least eight (8) hours continuous operation at 75% load. The fuel tank shall be fitted with a sight gauge or calibrated dipstick.

The fuel system shall incorporate primary and secondary filters plus a water and sedimentation trap.

A check valve shall be installed between the fuel pump and the fuel tank to prevent loss of prime after each shutdown.

The fuel tank shall be supplied full of fuel and topped up after commissioning is complete.

A low level fuel switch shall be installed to shut the engine down when less than ½ an hour fuel supply remains.

An analog fuel sensor shall be installed to indicate the fuel level. A sensor or signal conversion shall provide a 4-20mA @ 24VDC signal for the purpose of connection to the site telemetry.

### **3.2.1 Fuel Connections**

Fuel piping and associated auxiliary equipment: To AS 1940.

Stop valves: Provide stop valves on the inlet to, and outlets from, the daily service tank.

### **3.3 Generator Foundation**

A concrete foundation shall be installed and designed to support the total weight of the generator, meet flotation, alignment and vibration parameters. Consideration for conduits shall be given for electrical and fuel connections.

The foundation footprint shall be sized to equal the generator enclosure to limit the ingress of rain. A 0.6m apron shall be installed along the length of the generator where access doors are fitted. The apron shall be lower than the generator foundation.

Rated deflection spring mounts c/w non-skid neoprene pads shall be installed between the generator base and the foundation located directly under the engine and generator mounting feet to limit vibration.

### **3.4 Noise**

The maximum noise output from the generator and motor must comply with both EPA and WorkSafe Victoria requirements (refer Section 1.2).

Both requirements shall be met and are generally interpreted as:

- 85 dB (A) outside the generator enclosure at a nominal distance of 1m.
- 42 dB (A) maximum at the nearest window of the nearest residence.

Meeting these standards will generally require the generator and motor to be housed within a custom-built sound attenuated enclosure. Refer Section 2.8 for further details on enclosure requirements.

### **3.5 Site Ancillary Supply**

Install a dedicated circuit within the site switchboard to provide single phase power for battery chargers, water jacket heaters, enclosure lighting and other ac circuits that are required to be powered externally whilst the generator is non-operational.

## 4. INSPECTION AND TESTING

### 1.1 Workshop Performance Tests

In the witness of a SE Water representative the generator shall be submitted to routine tests at the supplier's works in accordance with AS 1359.60 prior to delivery to site. Routine tests shall include but not limited to the following.

- At unity power factor load test shall be performed with a resistive load bank. A load shall be applied for 2-hour at unit steps to full load. Full load equates to 100 percent of the nameplate kW rating less applicable de-rating factors. Time, current, voltage, frequency, kilowatts, oil pressure, water temperature and battery volts shall be measure during the test steps.
- Record fuel consumption for each step of the continuous trial.
- Sample engine oil from engine sump after tests and have the oil sample analysed and submit a report on the sample.
- Measurement of cold resistance of generator windings
- Temperature rise test
- Generator insulation test
- Noise level test at load intervals up to 100%.
- Vibration Test
- Functional checks to AS 2789.2 List C, items C1 to C5 inclusive.

### 1.2 Site Commissioning & Performance Tests

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 site conditions as far as possible, in order to test responses to faults imposed.
- Cold start with the engine having been at rest for the previous 24 hours.
- Measure battery charger current and voltage readings.
- Measure noise level.

### 1.3 Maintenance

Supplier shall to respond to call outs for breakdowns or other faults requiring corrective maintenance during the \*defects and liability period. Attend on site within 24 hours of notification. Rectify faults and replace faulty materials and equipment.

### 1.4 Spare Parts and Tools

The Contractor shall supply and deliver one (1) complete set of any special tools required for the dismantling, service and re-assembly of the generator assembly.

## 5. DOCUMENTATION

The manuals and technical data sheets shall fully describe all specified equipment and clearly show its mode of operation as follows.

- a concise description of each engine type and ancillary equipment, together with a complete performance specification
- a concise description of the mode of operation of each part or sub-system
- procedures for installation and commissioning of each part or sub-system
- procedures to be followed for testing, maintenance and fault finding The fault finding table shall list fault indication, possible causes and remedies
- special precautions to be taken in replacement and/or adjustment of each item
- a comprehensive routine maintenance and testing program based on that recommended by the manufacturer
- a spare parts list for all items plus component assembly drawings of the motor and ancillary equipment
- a list of supplier's names and addresses to enable any parts to be ordered correctly and
- any other information or instructions necessary to fully operate and maintain the equipment in a complete and satisfactory manner