

**JOHANNESBURG WATER (SOC) Ltd.**  
**BULK WASTEWATER**

**PARTICULAR SPECIFICATION**  
**E14 : ELECTRICAL SUPPLY AND**  
**INSTALLATION OF A STANDBY**  
**GENERATOR**



Johannesburg Water (SOC) Ltd.  
PO Box 61542  
Marshalltown  
2107

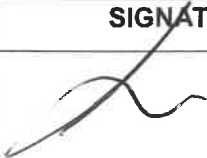


## DOCUMENT CONTROL SHEET

**Document Title:** Particular Specification – E14 : Electrical Supply and Installation of a Standby Generator

**JW Reference:** BWW523C

**Document Ref. No:** E14

### DOCUMENT APPROVAL

ACTION	FUNCTION	NAME	DATE	SIGNATURE
Prepared	Senior Electrical Engineer	B Pieterse	August 2019	
Reviewed	Director	R Baard	August 2019	
Approved	Regional Maintenance Manager	T Thabeng	August 2019	

### RECORD OF REVISIONS

Date	Revision	Author	Comments
4	2019-08-20	B Pieterse	Review of Electrical Standards, plus New Design Guidance
3	2014-06-03		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance
2	2012-05-30		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance
1	2009-05-12		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance

**PARTICULAR SPECIFICATION: VOLUME E14: ELECTRICAL SUPPLY AND INSTALLATION OF A  
STANDBY GENERATOR**

**CONTENTS**

<b>E14.1</b>	<b>SCOPE .....</b>	<b>4</b>
<b>E14.2</b>	<b>STANDARDS AND STATUTORY DOCUMENTS .....</b>	<b>4</b>
<b>E14.2.1</b>	<b>Standards .....</b>	<b>4</b>
<b>E14.2.2</b>	<b>Particular Specifications to be read in conjunction with this specification .....</b>	<b>4</b>
<b>E14.3</b>	<b>ENVIRONMENTAL CONDITIONS .....</b>	<b>5</b>
<b>E14.4</b>	<b>GENERAL REQUIREMENTS .....</b>	<b>5</b>
<b>E14.4.1</b>	<b>Operation .....</b>	<b>5</b>
<b>E14.4.2</b>	<b>Rating .....</b>	<b>6</b>
<b>E14.5</b>	<b>ENGINES .....</b>	<b>6</b>
<b>E14.5.1</b>	<b>General .....</b>	<b>6</b>
<b>E14.5.2</b>	<b>Flexible Connections .....</b>	<b>7</b>
<b>E14.5.3</b>	<b>Lubrication .....</b>	<b>7</b>
<b>E14.5.4</b>	<b>Cooling .....</b>	<b>8</b>
<b>E14.5.5</b>	<b>Engine Fuelling .....</b>	<b>8</b>
<b>E14.5.6</b>	<b>Combustion Air .....</b>	<b>8</b>
<b>E14.5.7</b>	<b>Instrumentation .....</b>	<b>8</b>
<b>E14.5.8</b>	<b>Engine Speed Governing .....</b>	<b>9</b>
<b>E14.5.9</b>	<b>Automatic Voltage Regulator (AVR) .....</b>	<b>9</b>
<b>E14.5.10</b>	<b>Exhaust Gas .....</b>	<b>9</b>
<b>E14.5.11</b>	<b>Starting (Electrical) .....</b>	<b>10</b>
<b>E14.5.12</b>	<b>Battery .....</b>	<b>10</b>
<b>E14.5.13</b>	<b>Battery Charging Systems .....</b>	<b>11</b>
<b>E14.5.14</b>	<b>Engine Protection .....</b>	<b>11</b>
<b>E14.5.15</b>	<b>Fuel Tank .....</b>	<b>12</b>
<b>E14.5.16</b>	<b>Engine/alternator Coupling .....</b>	<b>12</b>
<b>E14.6</b>	<b>ALTERNATORS .....</b>	<b>13</b>
<b>E14.6.1</b>	<b>Standards .....</b>	<b>13</b>
<b>E14.6.2</b>	<b>Rating .....</b>	<b>13</b>
<b>E14.6.3</b>	<b>Insulation .....</b>	<b>13</b>
<b>E14.6.4</b>	<b>Enclosure .....</b>	<b>13</b>
<b>E14.6.5</b>	<b>Shaft .....</b>	<b>13</b>
<b>E14.6.6</b>	<b>Main Windings .....</b>	<b>13</b>
<b>E14.6.7</b>	<b>Damper Windings .....</b>	<b>13</b>
<b>E14.6.8</b>	<b>Winding Terminations .....</b>	<b>13</b>
<b>E14.6.9</b>	<b>Excitation .....</b>	<b>13</b>
<b>E14.6.10</b>	<b>Steady State Voltage Performance .....</b>	<b>14</b>
<b>E14.6.11</b>	<b>Transient Voltage Performance .....</b>	<b>14</b>
<b>E14.6.12</b>	<b>Voltage Adjustment .....</b>	<b>14</b>
<b>E14.6.13</b>	<b>Wave Form .....</b>	<b>14</b>
<b>E14.6.14</b>	<b>Overload Factor .....</b>	<b>14</b>
<b>E14.6.15</b>	<b>Radio Interference Suppression .....</b>	<b>14</b>
<b>E14.7</b>	<b>SET MOUNTING .....</b>	<b>14</b>
<b>E14.7.1</b>	<b>Main and Sub Frames .....</b>	<b>14</b>
<b>E14.7.2</b>	<b>Lifting and Transportation .....</b>	<b>15</b>
<b>E14.8</b>	<b>CONTROL SYSTEM .....</b>	<b>15</b>
<b>E14.8.1</b>	<b>General .....</b>	<b>15</b>
<b>E14.8.2</b>	<b>Control Panel Equipment .....</b>	<b>15</b>
<b>E14.8.3</b>	<b>Sequence of operation .....</b>	<b>16</b>
<b>E14.8.4</b>	<b>Auto/test/manual/off selector switch .....</b>	<b>16</b>
<b>E14.8.5</b>	<b>Mains voltage sensing module .....</b>	<b>17</b>

E14.8.6	Alternator Voltage Sensing Module .....	17
E14.8.7	Timing Module .....	17
E14.8.8	Start Control Module.....	17
E14.8.9	Protection and Alarm Module .....	18
E14.8.10	Battery charging module .....	18
E14.9	POWER SYSTEM .....	19
E14.9.1	General .....	19
E14.9.2	Control system .....	19
E14.9.3	Changeover Distribution Board.....	19
E14.10	TESTING.....	19
E14.10.1	General .....	19
E14.10.2	Testing at works .....	19
E14.10.3	Procedures (Works testing) .....	20
E14.10.4	Testing at site .....	20
E14.10.5	Test Reports .....	21
E14.11	INSTALLATION .....	21
E14.11.1	Handling, Hoisting and Crane Usage .....	21
E14.11.2	Erection .....	21
E14.11.3	Cabling .....	21
E14.11.4	Notices .....	22
E14.11.5	Tools and Loose Equipment .....	22
E14.12	DRAWINGS AND MANUALS .....	22
E14.12.1	Drawings Submitted for Approval .....	22
E14.12.2	"As-built" Drawings .....	22
E14.12.3	Manuals .....	23
E14.13	OPERATING INSTRUCTIONS AND MAINTENANCE .....	23
E14.13.1	Training for Owner's Representative .....	23
E14.13.2	Maintenance Period .....	23
E14.13.3	Maintenance Contract.....	23
E14.14	MEASUREMENT AND PAYMENT.....	24

## **E14.1 SCOPE**

This section covers the design, manufacture works testing, delivery to site, site erection, site testing, commissioning and handover of 50 Hz 380V standby diesel generator sets.

## **E14.2 STANDARDS AND STATUTORY DOCUMENTS**

All materials and apparatus shall be new and of the best quality and shall comply with the relevant current specifications of the SANS, BS or IEC and as stated in this document.

The equipment offered and work performed, shall comply with the requirements of the governing occupational Health and Safety act, at time of tender.

The standby generator shall be produced in a factory with ISO9000 rating and the applicable quality assurance standards.

### **E14.2.1 Standards**

- |                    |   |   |
|--------------------|---|---|
| (a) SANS 60439     | : | Low-voltage switchgear and controlgear assemblies   |
| (b) SANS 60529     | : | Degrees of Protection Provided by Enclosures (IP Code)  |
| (c) SANS 60947     | : | Low-voltage switchgear and controlgear  |
| (d) SANS 10142-1   | : | The wiring of premises Part 1: Low-voltage installations  |
| (e) SANS 60439     | : | Low-voltage switchgear and controlgear assemblies   |
| (f) SANS 1195      | : | Busbars   |
| (g) SANS 61238     | : | Compression and mechanical connectors for power cables for rated voltages up to 30 kV (Um = 36 kV) Part 1: Test methods and requirements  |
| (h) SANS 342       | : | Automotive fuel - Requirements and test methods for diesel  |
| (i) SANS 62271-206 | : | High-voltage switchgear and controlgear Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV   |
| (j) SANS 8528      | : | Reciprocating internal combustion engine driven alternating current generating sets   |
| (k) BS 5000-3      | : | Rotating electrical machines of particular types or for particular applications - Part 3: Generators to be driven by reciprocating internal combustion engines - Requirements for resistance to vibration |
| (l) BS 2869        | : | Fuel oils for agricultural, domestic and industrial engines and boilers   |
| (m) SANS 10219     | : | The determination of performance (at net power) of industrial internal combustion engines   |
| (n) BS 800         | : | Limits of radio interference.   |

### **E14.2.2 Particular Specifications to be read in conjunction with this specification**

The following particular specifications shall be read in conjunction with the Project Specification:

E06	:	ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION
E05	:	LOW VOLTAGE POWER AND CONTROL CABLES
E08	:	WIRING
E11	:	GENERAL EARTHING AND LIGHTNING PROTECTION

### **E14.3 ENVIRONMENTAL CONDITIONS**

The engine shall be amply rated for the site electrical demand, load characteristics and power factor as specified in the detail specification. The engine shall be derated for the specific site conditions as stated in the detailed specification. The engine shall be capable of delivering the specified real power (kW) output continuously at the stated site conditions without overheating.

### **E14.4 GENERAL REQUIREMENTS**

The standby power installation shall automatically take over the load in the event of a mains failure, under voltage or any abnormal voltage condition on any one or more phases after this condition has persisted for a pre-set (but adjustable) period. The transition shall be done automatically via an automatic mains transfer equipment with sufficient intelligence and logic.

#### **E14.4.1 Operation**

The most common form of backup generator to the mains supply is a single generator in “standby” mode. When the mains supply fails, the load is left without power until the generator is started. Once the set is “available”, the transfer switch changes over so that the load is supplied by the generator. Typically, the “down time” will be around 15 seconds, but may be longer depending upon the time taken to run the engine to nominal speed and other application dependent factors. When the mains supply returns, the load-switching device (contactors/breakers) will momentarily remove power from the load (typically 1 second) before transferring the load back to mains supply power.

The break in supply when transferring back to the mains can be eradicated by synchronising the generator supply to the returned mains supply, and closing the supplies in parallel with each other for a short period. Then, the generator load switch is opened, returning the mains to supply power to the load. There has been no break in supply to the load during this return transfer process. Terms often used for this procedure are “bumpless transfer”, “no break return” and “no break transfer”. Additionally, the same procedure can be used to transfer from mains supply to generator supply enabling, for instance, “on load” testing of the generator set with no break in supply to the load. This can also be performed if the supply authority informs customers of a scheduled break in supply.

An Automatic Load Transfer system shall be provided which shall:

- (a) Monitor the mains power supply continuously to ensure it is within limits.
- (b) In the event of any mains abnormality (parameters pre-set but generally adjustable) initiate the disconnection of the load from the mains supply.
  - i. Start the diesel alternator set;
  - ii. Monitor the generator output (voltage and frequency);
  - iii. Automatically transfer the load to the standby power installation as soon as the alternator output is within specified limits and stable.
- (c) In the event of any mains return (parameters pre-set but generally adjustable) initiate the transfer of the load from the generator to the mains supply.

Two modes of operation are possible as specified in the detail specification:

- i. Break Transfer

The Automatic Load Transfer system will momentarily remove power from the load (typically 1 second) before transferring the load back to mains supply power

ii. No-break transfer

Reconnect the load to the mains after the stable re-establishment of the mains by synchronising the generator to the mains and transferring the load to the mains before disconnecting the generator.

- (d) Transfer the load from mains supply to generator supply when a scheduled break in mains supply is scheduled by the supply authority.

A detailed description of the sequence of operation, time delays, adjustment parameters, set points, etc., may be found under clauses dealing with the generator control system.

E14.4.2

Rating

The rating of the standby power installation shall be such that the prime mover and the alternator with all deductions for auxiliaries are amply rated for the site electrical output, load characteristic and power factor as specified in the detail specification.

- (a) The engine should be Prime Rated

A Prime rated generator is capable of providing power to a varying load for an unlimited number of hours per year (maximum 8760 hour/year less service), if:

- i. The maximum average load factor over a 24-hour period does not exceed 70% of Prime Rated Power (PRP), including the following;
- Full Prime Rated Power (PRP) for a period of time;
  - Ten percent (10%) overload of Prime Rated Power (PRP) during emergencies. Operating at 110% is restricted to a period of 1 hour within a 12-hour period of operation and the total operating time at the 10% overload power cannot exceed 25 hours per year;

- (b) Should the load fall below 30% of the engine maximum power (kWe), a dummy load (resistive load bank) must be automatically connected to the generator to add load to above the 30% margin.

(The diesel engine should be run at loads greater than 30% of its maximum power (kWe) for optimum engine life. This ensures that the exhaust temperature will be high enough to burn up the majority of particulate in the exhaust gas. Incomplete combustion at low loads can cause increased valve wear and degradation in the turbochargers, both of which increase maintenance needs and decrease reliability.)

**E14.5**

**ENGINES**

E14.5.1

General

The prime mover shall be a diesel fuelled, compression ignition, direct injection, four-stroke industrial engine designed for stationary duty.

The output of the engine under the specified site conditions shall be the net available output power after allowance for all auxiliary equipment including air filter, radiator and fan, oil pump, water pump, battery charging alternator, governor, etc., has been made. The engine shall be rated for diesel fuel complying with BS 2869 as amended, Class A1 or SANS 342, as amended, for diesel fuel with a minimum octane number of 40 and a minimum nett calorific value of 10 000 kcal/kg.

The starting period from either automatic or manual switching until the taking over by the generating set of a load equal to the specified site electrical demand shall not exceed 25 seconds or the time as in the detail specification. The load acceptance shall comply with the requirements stated in the detail specification.

The engine speed shall be 1500 rpm.

The engine and installation shall be of neat appearance and all water, lubricating and diesel oil

lines, filters and stopcocks shall be leak free.

All service connections to the engine shall be flexible to allow the free movement of the set and to prevent the transmission of vibration to the building or other structural elements.

All engine flexible or rigid piping not heat resistant shall be adequately protected against damage by radiant heat.

Engine wiring shall be of the heat-resisting type.

The crankcase vent pipe shall terminate inside the plant room above the drip tray to collect condensate.

All moving parts shall be adequately protected mechanically against accidental contact.

It shall be the responsibility of the Contractor to design the dynamic system comprising engine, flywheel and alternator rotor. The Contractor shall ensure that the vibration stresses in the crank and rotor shafts shall not exceed allowable tolerances.

Tenderers shall state in the technical data sheets the specified fuel consumption of the complete set with auxiliary equipment in kg/kWh of alternator output at 100%, 75% and 50% load to an accuracy of  $\pm 10\%$ . These figures shall be guaranteed.

Modern electronic engine control units (ECU) that monitor and manage engine status and operating conditions of the generator set and can be interfaced to an external computer for monitoring diagnostic purposes and setting of operation limits are preferred. A digital interface for remote status and alarm monitoring based on a common industrial communication protocol is also preferred.

#### E14.5.2 Flexible Connections

Any supply line or hose connected to the generator set, including exhaust coupling and exhaust pipe hangers, jacket water connections, heat recovery systems and fuel lines must be fitted with a flexible section that can withstand vibrations incurred by the operating generator set. These flexible connections should be installed as close to the generator set as possible and be designed to prevent line leaks or breaks.

#### E14.5.3 Lubrication

The engine shall have a forced feed pressure lubrication system adequately rated to supply circulating lubrication oil to all bearings, gear trains and important moving parts.

The filter(s) shall be suitable for use with detergent type lubricating oils and shall be fitted between the lubricating oil pump and the engine circuit. It shall be equipped with replaceable elements capable of 500 hours working time without attention and shall be placed for easy access and maintenance.

An engine oil heater (250Vac) must be installed to maintain the engine oil in the sump between 40 and 50°C to ensure coming online at the engine's rated speed and full load rating within a short period without engine damage.

An oil temperature gauge shall be fitted in the case of air-cooled engines and if required as per the Detailed Specification.

A semi-rotary hand operated sump drain pump shall be fitted if draining the sump is difficult. The drainpipe and shut-off valve shall be placed in a convenient position outside the bedplate frame to facilitate drainage. The successful Tenderer must advise the Engineer whether additional concrete plinths are required for the generator set, in order to drain the sump properly.

A stainless steel or galvanised mild steel, removable, drip tray shall be placed under the engine. The tray must be large enough to catch a drip from any part of the engine and must be at least 25 mm deep.

The tender price shall include

- (a) Supply and fill all lubricating oils (first fill)
- (b) Supply and install all filter elements



E14.5.4 Cooling

Water-cooled or air-cooled engines may be offered.

Careful attention shall be paid at the time of tendering to the cooling system and the building requirements to accommodate the cooling system. Any special building requirements shall be stated by the Tenderer in his submission.

Where radiators are used, they shall be heavy duty, air blast tropical type pressurised radiators, adequately sized for rated load operation of the set. The radiator fan may be either engine or motor driven and shall be complete in all respects including fan, drive, guards, filling and drain connections. The fan shall be arranged to draw cooling air from the plant room and exhaust the air to atmosphere. The capacity of the fan shall be sufficient to provide the required engine cooling and plant room ventilation.

Engine jacket water shall be circulated by an engine mounted centrifugal pump that is driven by the engine.

A water jacket heater (250Vac) must be installed to maintain the cooling water between 40 and 50 °C to ensure coming online at the engine's rated speed and full load rating within a short period without engine damage.

E14.5.5 Engine Fuelling

An engine-mounted fuel pump shall be fitted.

The governor-controlled fuel injection pump(s) shall be fitted between the lift and injection pumps and shall be arranged for easy access and easy maintenance.

A micro filter with replaceable elements suitable for the full flow rate of the injection pump(s) shall be fitted between the lift and injection pumps and shall be arranged for easy access and easy maintenance.

The filter element shall be capable of filtering out particles down to 5 microns in size.

An additional heavy-duty primary filter (sludge filter), suitable for the full flow rate of the fuel pump, shall be fitted in the fuel line between the fuel tank and the lift pump. The filter shall be rated for 500 hours service without attention. The filter shall be arranged for easy access and maintenance.

Interconnection fuel piping shall be neatly run in copper tubing from the sludge filter to the other component parts of the fuel system.

The overflow from the engine fuel and injection pumps shall be returned to the fuel tank via a steel return pipe.

All piping shall be securely fixed by means of saddles and clamps.

Connections between static and vibrating components shall be flexible.

Should the engine require a particular grade of fuel, this shall be clearly stated in the tender.

E14.5.6 Combustion Air

The engine shall be fitted with a high efficiency air filter adequately sized for 500 hours running without attention.

Dry type, cartridge air filters are preferred and, if offered, shall be complete with a service indicator.

E14.5.7 Instrumentation

The Engine Control Unit (ECU) must give digital indication for:

- (a) Engine speed (RPM)
- (b) Battery volts (DC volts)
- (c) Generator operating hours
- (d) Engine oil pressure (kPa)
- (e) Engine coolant temperature (°C)

City of Johannesburg  
Johannesburg Water (SOC) Ltd

- (f) Output volts (L-L and L-N)
- (g) Output frequency (Hz)
- (h) Current (Amps - per phase and average)
- (i) ekW, kVA, kVAR, kW-hr, %kW, PF

Alarm/Trip (shutdown) with indication for:

- (a) Low lubrication oil pressure
- (b) High coolant temperature
- (c) Low coolant temperature
- (d) Low coolant level
- (e) Overspeed
- (f) Emergency stop
- (g) Failure to start (overcrank)

E14.5.8

Engine Speed Governing

- (a) Break transfer

A solid-state isochronous electronic speed governor to SANS 8528-2, as amended, or better is required unless stated in the detail specification. Approved governors shall be provided with

- i. Steady state speed bank, 0.25% isochronous control
- ii. Speed regulation (droop), externally adjustable 0% to 15%.

- (b) No-break transfer

An electronic governor with remote speed control capability must be supplied:

- i. Digital signals (raise/lower inputs) to control engine speed (droop control must be configured in the governor);
- ii. An analogue signal is used to control engine speed;
- iii. An electronic engine with an Electronic Control Unit (ECU) with CANbus that supports speed control over the engine data link (CAN).

- (c) Operating voltage

24Vdc unless starting battery bank nominal voltage is different in which case the operating voltage is to be the same as the nominal starter motor voltage.

When commissioning the set, the normal nominal speed shall be accurately set with the aid of a frequency meter.

E14.5.9

Automatic Voltage Regulator (AVR)

An electronic AVR must be supplied. The AVR must be sourced from a reputable manufacturer and must be from a known brand. The AVR must match the type of alternator supplied. The AVR must be installed, commissioned and tested in the generator supplier's facility.

E14.5.10

Exhaust Gas

The exhaust gases shall be ducted into the atmosphere through insulated piping and an exhaust silencer.

A baffle or absorption type silencer shall be installed in the plant room.

The silencer shall be of such a size and construction that sound level measurements taken within two meters of the exhaust opening shall not exceed 70 dB absolute.

The silencer shall be of stainless steel construction.

The silencer shall be fixed independently of the exhaust pipe and engine. All material including brackets, hanger/s clamps, etc., to support the entire exhaust system form part of this contract.

The exhaust pipe shall be of stainless steel construction.

The exhaust pipe diameter shall be sufficiently sized to ensure that the back-pressure limits of the engine are not exceeded. It shall be taken overhead and protrude through the wall at a height of not less than 2 meters. Exhaust gases shall be expelled into the open air. If exhaust angle is vertical, the exhaust pipe end should be fitted with a flap lid to avoid ingress of rain into the pipe.

A stainless steel, concertina type, flanged, flexible section shall be installed between the exhaust manifold and the exhaust line to allow relative movement between the engine and exhaust pipe as well as thermal expansion and contraction without placing any strain on the exhaust manifolds and silencer. Except for the length of flexible exhaust pipe mentioned above the exhaust pipe shall be of rigid construction. All bends shall have a radius of at least two and a half times the pipe diameter.

The exhaust system shall be sufficiently offset from the centre-line of the engine to allow for the installation of a crawl beam above the centre of the engine for maintenance on the engine without fouling the exhaust system.

Where the exhaust pipe arrangement specified above passes through the engine room wall a weatherproof anti-vibration seal complete with insulation and/or expansion gaskets shall be provided.

The exhaust pipe outlet will be protected with a stainless steel mesh wire (horizontal pipe) to prevent access of birds or other foreign objects. If the exhaust pipe is vertically installed, a stainless steel counterbalanced flapper type rain cap will be installed on the pipe opening to prevent water and debris from entering the pipe. The flapper should be installed at a point that allows clearance for counterweight rotation.

The exhaust system shall be lagged with 25 mm thick asbestos rope, cloth wrapped and thereafter clad in bright polished stainless steel sheeting. On bends, the cladding shall be segmented to provide a semi-smooth neatly curved appearance.

#### E14.5.11

##### Starting (Electrical)

The engine shall be easily started from cold under summer as well as winter conditions without the use of special starting equipment.

Water-cooled engines shall be fitted with thermostatically controlled immersion heaters capable of maintaining jacket water temperature to ensure successful starting in the lowest ambient temperature stated. The rated heater voltage shall be the same as the mains voltage and shall be wired to the control panel and the circuit protected by suitably rated circuit breakers or fuses.

A 24 Volt DC starter motor, fitted with an approved positive engagement device, shall be used. The motor will be controlled by the panel mounted starter control circuitry and will be supplied from a 24V battery set.

Arrangement shall be made to ensure that the starter motor cannot be engaged unless the engine is at rest, i.e. the starting system shall be blocked while the engine is running or running down.

The contractor shall provide all necessary auxiliary equipment, i.e. solenoids, bendix drives etc. for the full automatic operation of the system.

#### E14.5.12

##### Battery

The set shall be supplied with a fully charged lead-acid battery rated for the voltage and current requirements of the starting motor(s) and control equipment, but shall not be rated for less than 150 ampere hour.

The battery discharge capacity at 5°C shall be such that the full cranking current can be drawn for 60 seconds with cell voltage falling to not less than 1,5 Volt, taking into account locked motor current and minimum motor cranking voltage. Where the control equipment is operated from the engine starting battery, the battery voltage, after six starting attempts at 5°C (i.e. six starting cycles of 10 seconds each shall be sufficient to provide satisfactory operation of the control equipment and five rest periods of 10 seconds in between starts).

Should the required battery ampere/hour rating be specified in the detail specification, for the purpose of obtaining comparable tenders, the Contractor would be relieved of the responsibility

for meeting the requirements of the above clause.

The cells shall be of 2 Volts per cell, and shall be mounted on an angle iron frame of sufficient size to allow 50 mm clearance between units for ventilation and mounted as close as possible to the starter motor.

#### E14.5.13 Battery Charging Systems

The battery shall be charged from an engine driven brushless alternator/rectified with automatic rate control during engine operation.

A battery charging system must be supplied to maintain batteries while the generator unit is on standby. The charging system must be mounted in the control panel

The charging system must:

- (a) Recharge batteries quickly in the constant current mode, then automatically switches to maintain charge in a constant voltage mode
- (b) Recharge completely dead batteries or those with no open circuit voltage
- (c) Float and equalize batteries, which maintains charge with minimal water loss in cells
- (d) Match charger capacity to the battery's ampere-hour (AH) capacity. Charger output should be between C/5 and C/20, where C equals the battery AH capacity. For example, a 10 amp unit can charge batteries between 50 and 200 AH.
- (e) Offer short circuit protection to prevent damage to any DC powered controls, and allows engine cranking without disconnecting the charger
- (f) Diagnostic functions or alarms complete with an output voltage sensor to detect power loss as well as overcharging problems. The voltage sensor must be time delayed to prevent false alarms caused by power drains from engine cranking

#### E14.5.14 Engine Protection

The necessary sensors for low oil pressure protection and engine over-temperature protection shall be fitted. Over speed and/or under speed protection shall be derived from the frequency sensor.

A continuously rated fail-safe engine-stop solenoid (energised to run), shall be provided. If a separate short time rated pull-in winding is employed, the linkage must ensure transfer to the full-time rated hold-in winding. The engine protective devices shall cut off the solenoid hold-in current and shut the engine down.

A fail-safe series circuit for the engine-mounted protection devices shall actuate the fuel cut-off solenoid in the event of the operation of a sensor, failure of a sensor, breaks in wiring or failure of the associated timing or control circuits.

A fail-safe device shall bypass the protection circuits during engine cranking and the protection circuits shall become operative with the start-discontinue signal. This device and the associated protection control circuitry shall be incorporated in the control section of the generator panel.

The sensors shall also operate the parallel protection circuits as stated.

All protection devices shall cut off the engine-run solenoid hold-in current to shut the engine down. Provision must be made in the control circuitry of each engine to disconnect the load immediately should the engine shut down for any reason whatsoever. The alternator must not be connected to load during the "run down" period.

Water-cooled engines shall be fitted with a water temperature gauge and an engine over-temperature cut-out system. A high engine water temperature cut-out system on its own is not acceptable. In the case of an air-cooled engine, the over-temperature protection shall be derived from the oil-temperature. For both water and air-cooled engines the over temperature protection shall de-energise the engine stop solenoid on the engine and give the required alarms.

An oil pressure gauge shall be fitted in the main lubrication oil circuit after the oil filter(s).

Digital engine protection with status monitoring provide via an engine control unit is preferable. All engine protection parameters must be accessible at the set mounted control panel as either

indicator lamps or a scrollable LCD display. In the event of a fault, the screen mode should be in alarm display mode for the faults to be displayed. A reset button must be provided for clearing faults after correction.

E14.5.15

Fuel Tank

A properly constructed diesel fuel tank shall be supplied complete with all pipework and shall be installed in the plant room.

- a) The fuel tank shall be sized to supply fuel to the generator for 24h operation without refilling the tank
- b) The fuel tank shall preferably be mounted in such a position that fuel is gravity fed to the engine.
- c) The tank shall be designed and positioned such that access to the set and the movement of maintenance personnel will not be impeded.
- d) The tank shall be fitted with a full height transparent gauge glass.
- e) A flange will be fitted on the tank for the future installation of an ultrasonic fuel level transmitter. The flange will comply to EN-1092-1, with
  - Type 1 Plate flange for welding
  - Nominal diameter DN 300mm
  - Nominal pressure PN2.5
  - Sealed with a matching blind flange
  - Mounted 300mm above the top of the fuel tank (offset on a matching pipe DN300mm)
- f) The tank shall be designed to collect water and sludge at the lowest point to be drained off.
- g) A manual outlet shut-off valve in the fuel line to the engine shall be fitted.
- h) A manual outlet shut-off valve in the fuel return line from the engine shall be fitted.
- i) The fuel pipe to the primary sludge filter and the return pipe shall be steel.
- j) The fuel shall be supplied directly from and returned to the tank. The fuel return pipe shall be connected directly to the fuel tank and shall terminate at the same depth as the fuel feed pipe.
- k) The fuel feed pipe shall be connected to the tank in such a manner that any sludge or sediment formed in the tank will not enter the fuel line.
- l) A semi-rotary, hand-operated, wing-pattern pump with hose shall be provided to facilitate filling the service tank from 200 litre drums.
- m) It is the responsibility of the Contractor to supply and install fuel pipes of adequate diameter. Galvanised materials or materials containing zinc shall not be used in the fuel lines.
- n) The engine fuel pumps shall be amply rated to overcome any height difference that may exist between the suction point and engine.

Base mounted fuel tanks are also acceptable, provided the above requirements are met.

E14.5.16

Engine/alternator Coupling

The engine shall be directly or closely coupled to the alternator without a reduction gearbox and the engine power shall be correctly matched to the alternator output at 1 500 rpm.

The coupling shall be by means of a flange adaptor ring or bell housing within which a shock absorbing flexible coupling shall be fitted.

## **E14.6 ALTERNATORS**

### **E14.6.1 Standards**

The alternator shall be a 4 pole, self-excited, brushless, 3 phase, 4 wire, 50 Hz unit alternator complying with SANS 60034, as amended.

### **E14.6.2 Rating**

The site rating of the alternator shall be no less than the site rating of the prime mover.

The alternator shall be capable of delivering the output specified in the detail specification continuously as well as on overload of 10% for one (1) hour in any period of twelve (12) hours consecutive running under the site conditions as stated without exceeding the temperature limits of SANS 60034, as amended.

The kVA rating shall be derated strictly in accordance with SANS 60034, as amended, for the worst engine room conditions specified in the detail specification. (installation at an altitude above 1000m).

### **E14.6.3 Insulation**

The alternator shall be tropically insulated, i.e. special precautions shall be taken against the attack by harmful fungi on the insulation.

Both stator and rotor windings shall be fully impregnated for tropical climate and shall have an oil resisting anti-tracking finishing varnish.

The insulation provided shall be Class H or better throughout.

### **E14.6.4 Enclosure**

The alternator shall be self-ventilated, screen protected and of IP23 construction.

### **E14.6.5 Shaft**

The shaft shall be horizontal for direct coupling to the prime mover.

The shaft shall be either a single bearing or a two-bearing version designed to be suitable for commercially available heat engines. The bearings shall be of the "permanently greased" type.

A second shaft extension is not a requirement but would be an advantage for unforeseen additions such as tachogenerators, etc.

### **E14.6.6 Main Windings**

The main field shall be of the rotating salient pole type and shall employ laminated poles in order to reduce eddy current losses to a minimum.

The rotor shall be dynamically balanced and the windings, excitation and regulating equipment shall be suitably braced to allow an over speed of 20%.

### **E14.6.7 Damper Windings**

Brazed copper damper windings shall be provided on the main field poles.

The alternator damper windings shall allow an unbalanced load of 25% under steady state conditions.

### **E14.6.8 Winding Terminations**

All alternator windings shall terminate in a suitable terminal box with removable cover plate. The terminal box shall be large enough to accommodate the cables and cable glands.

### **E14.6.9 Excitation**

The alternator shall be provided with brushless, solid state excitation and automatic voltage regulation.

Excitation shall be provided by a rotating-armature AC exciter, flange-mounted on the alternator shaft on the non-drive side.

The rotor-mounted 3 phase AC exciter and full-wave rotating rectifier bridge shall supply a DC

field current controlled by a solid state Automatic Voltage Regulator (AVR). The inherent damping of the exciter shall limit overshoot and hunting.

The rotating silicon diodes shall be protected from voltage spikes by means of a selenium diode which shall rotate with them. Alternative surge suppression means may be submitted for consideration.

In cases where a compounding circuit is provided, it shall be possible to remove the AVR when it fails and by a simple adjustment run the machine on compound regulation only.

**E14.6.10**      Steady State Voltage Performance

The voltage regulation shall be better than  $\pm 1\%$  of the nominal voltage specified at all loads with a power factor between unity and 0,8 and within the engine speed variations of 4,5% between 0% and 100% of full load.

The steady state voltage regulation may deteriorate under the unbalanced conditions as specified under Damper Windings above but shall not be worse than  $\pm 3\%$  under steady state conditions with phase power factors individually varying between 0,8 to unity power factor and engine speed variations of 4,5%.

**E14.6.11**      Transient Voltage Performance

The excitation system shall be designed to promote rapid voltage recovery following the sudden application of full load.

With instantaneous application of full load (70% in the case of turbocharged engines) from the no-load condition the voltage drop must not exceed 10% and recovery to rated voltage must be within 300 milliseconds.

The voltage recovery and voltage dip specified shall apply on site for the engine offered and do not refer to laboratory test conditions where large prime movers may be used.

**E14.6.12**      Voltage Adjustment

Alternator voltage adjustment over a range of  $\pm 5\%$  of nominal rated voltage shall be provided.

**E14.6.13**      Wave Form

The output waveform shall be sinusoidal and the deviation from a true sine wave shall not exceed 5% when measured in accordance with BS or VDE standards.

The line-to-line harmonic content or distortion (Distortion Factor) when measured between any of the phases at any linear load capacity of the alternator shall not exceed 4%.

**E14.6.14**      Overload Factor

The overload capacity of the alternator shall be such as to allow overloads of 10% for one hour or 50% for two minutes or any straight line interpolated intermediate overloading condition in between once every twelve hours.

Unless exactly equally rated, the site rating of the alternator shall always exceed the net site rating of the prime mover (as specified under clause - "Engines (General)") taking due cognisance of the overload factors applying in both cases. For power factors of 0,8 or higher it shall therefore not be possible for the alternator to be damaged by overloading.

**E14.6.15**      Radio Interference Suppression

The alternator output shall comply with the RF suppression requirements of EN 55011 group 1 class B standard, and the requirements of the Supply Authority, the Department of Posts and Telecommunications and any other statutory body having authority.

**E14.7**            **SET MOUNTING**

**E14.7.1**        Main and Sub Frames

The engine and alternator shall be built together and bolted onto a common painted mild steel frame.

The base frame shall be placed on adequate anti-vibration mounting blocks, fit for the specific

installation, on a concrete floor.

The frame must be high enough off the floor to facilitate easy installation and removal of the drip tray specified and for the draining of engine oil.

The outer casing of the alternator, the engine and all parts of the base frame shall be earthed to the plant room main earth busbar.

**E14.7.2**      Lifting and Transportation

The frame shall be of rigid construction enabling the complete set to be transported without dismantling.

The frame shall have lifting hooks or holes to facilitate handling during transportation and when positioned on site.

**E14.8**      **CONTROL SYSTEM**

**E14.8.1**      General

The control panel shall be freestanding, all metal construction with a rated level of protection of IP55 according to SANS 60529.

The control panel shall be divided into two compartments to separate the instrument and control circuits from the power circuits.

**E14.8.2**      Control Panel Equipment

All meters shall be either 96 mm 240° circular scale instruments or alternatively rectangular linear scale 64 mm x 192 mm (approximately).

The following flush mounted equipment shall be incorporated in the control panel, together with the associated apparatus:

- Three maximum demand ammeters, 96 mm x 96 mm with a red line at the full load amperes, conforming to SANS 61958.
- Frequency meter 45-55 Hz with prominent mark on 50Hz
- Protection and alarm devices as specified
- Battery charger: Automatic trickle and boost and shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC indication ammeter and voltmeter plus ON/OFF switch with automatic switching from normal mains supply to alternator.
- One flush voltmeter scaled 0 - 400 volt, indicating alternator voltage with a multi-position voltmeter selector switch with one off position, connecting the voltmeter between the various phases and phases and neutral.
- One flush maximum demand indicating kW meter scaled to suit alternator output. At 100% and 110% of engine output the scale is to be crosshatched with red lines. Above 110% of rated engine output the scale is to be coloured solid red.
- One flush power factor meter.
- "running hours" meter with cyclometer counter.
- Adequately rated main MCB with overload and short circuit protection
- Automatic start stop cranking module with a four position mode selector OFF, MANUAL, AUTO and TEST with START and STOP pushbuttons operating on the manual mode.
- Voltage failure relay monitoring the voltage and phase rotation of the main supply working in conjunction with the AUTO mode of the automatic start/stop cranking.
- Over and under voltage relay, phase unbalance relay, phase reversal relay and earth fault relay.
- One set of potential fuses.

All instruments shall match and shall be clearly scaled for maximum legibility.

LCD display capable of providing multiple-parameter-viewing with critical parameter recording,



networkable via common industrial protocol is preferable (Ethernet).

E14.8.3 Sequence of operation

In the event of a mains failure (for description of mains failure refer to the clause - "MAINS VOLTAGE SENSING"), the sequence of events shall be generally as described in the clause - "OPERATION". The timing of the detailed sequence shall be as follows:

E14.8.3.1 Mains Disconnection

As a mains failure may also include single phasing, incorrect phase sequence, phase angle deviations or under/over voltage, a positive disconnecting of the mains is required immediately after detection of a fault. This shall be effected by operation of the Mains/Standby transfer switch.

E14.8.3.2 Engine Start Command

Following a mains fault a start command shall be given to the engine after an adjustable delay of 0 to 60 seconds (pre-set at 10 seconds).

If the mains fault is cleared before the expiry of the adjustable start delay period the start command shall not be given.

Instead, a command shall immediately be given for the immediate changeover by the Mains/Standby transfer switch back to the healthy mains.

E14.8.3.3 Start Attempts

Three start attempts by the starting system of 10 seconds each with a 15 second interval between each attempt shall be provided.

Restoration of the mains after the first engine start command has been given shall not interrupt the complete starting and power transfer sequence.

E14.8.3.4 Alternator Output CB Closure

Assuming the engine has started correctly the alternator output circuit breaker, or contactor as specified, shall be closed approximately two seconds after the output has reached voltage and frequency to specification, or, alternatively, immediately after the output is stable and within specification.

Restoration of the mains or clearance of the mains fault shall not inhibit the transfer from Mains to Standby, the sequence shall however advance to a "mains restored" situation.

E14.8.3.5 Mains to Standby Changeover

A changeover command shall be given to the mains/standby transfer switch immediately after the alternator output ACB closure if the mains fault has not been cleared.

E14.8.3.6 Mains Restored, Standby to Mains Changeover

A changeover command shall be given to the mains/standby transfer switch after a period adjustable from 10 to 60 minutes (pre-set at 10 minutes) after restoration of the main supply. Transfer from standby power to mains will be break or no-break transfer as specified in the detailed specification.

E14.8.3.7 Engine No-load Rundown

An engine stop command shall be given after an engine cooling period of no load adjustable from 5 to 15 minutes (pre-set at 5 minutes).

E14.8.4 Auto/test/manual/off selector switch

A key operated, four-position selector switch shall be provided.

(a) Auto

In this position, the generator and control circuit shall operate automatically under control of one or more of the logic modules detailed hereunder.

(b) Test

The generator shall start automatically but the alternator circuit breaker shall not close. The

mains control shall not be affected.

It shall be possible to prove the operation of the automatic synchronising unit (if provided) without closing the alternator circuit breaker.

The operation of the engine/alternator protective devices shall be provided by simulating a fault by means of test buttons.

(c) Manual

In this position, all automatic control circuits shall be inoperative. The set shall be started from a pushbutton or switch on the control board. The alternator circuit breaker, voltage and engine speed shall also be controlled by pushbuttons or potentiometers.

(d) Off

In this position, the set shall be completely disconnected from the automatic control for cleaning and maintenance purposes. The mains control selection shall, however, still operate normally.

A digital interface for selecting any of the above may be provided, in which case a by-pass switch should be provided to allow for test mode.

E14.8.5 Mains voltage sensing module

A mains voltage sensing module shall be provided. This shall monitor all three phases and the neutral both individually and jointly and shall initiate the starting sequence upon failure or malfunction of any one or all three phases and the neutral.

The over-voltage drop-out shall be adjustable between 110% and 120% of the normal supply voltage (400 V) and adjusted to 110%.

The under-voltage dropout shall be adjustable between 80% and 90% of the normal supply voltage (400 V) and adjusted at 90%.

Phase unbalance sensing shall be provided in the form of a phase unbalance monitor. A phase angle unbalance shall be adjustable between 5 to 20% and pre-set at 5%.

E14.8.6 Alternator Voltage Sensing Module

An alternator voltage/frequency sensing module shall be supplied.

The module shall provide voltage monitoring features as detailed above.

The unit shall incorporate a frequency monitor, adjustable to within limits of  $\pm 10\%$  of 50 Hz.

Three separate outputs from the module shall be provided: one for voltage and two for frequency. These outputs shall initiate operation of the over speed, under speed, as well as abnormal voltage trip and alarms but shall be sufficiently delayed to overcome short time voltage or frequency variations.

Visual monitoring facilities in the form of LEDS or LCD display shall be provided for voltage and frequency.

E14.8.7 Timing Module

A time delay unit which upon mains failure, initiates start delay of 0 - 60 seconds (set at 15 seconds) shall be provided. If the mains should return during the start delay, the start-up cycle shall not proceed.

E14.8.8 Start Control Module

A control module incorporating the start command circuits shall be provided which shall, in the event of a power failure as sensed by the mains voltage sensing module and the mains having been restored by the time the start delay timer has elapsed, initiate the automatic starting sequence and thereafter prevent interruption of the starting sequence even if power is restored before starting is achieved.

The control panel, after the delay start timer has timed out, shall initiate three 10 second attempts

with a 15 second delay between each attempt.

E14.8.9

Protection and Alarm Module

A protection and alarm circuit module offering engine protection and alarm circuits shall be provided which shall include:

ALARMS NON-URGENT (Visual only)	ALARMS URGENT (Visual + audible + engine shutdown)
Selector switch not in auto Starter battery charger failed Low fuel Low cooling water	Low oil pressure (engine) High temperature (engine) Under speed (engine) Over speed (engine) Start failure (engine) Abnormal output voltage (alternator) Reversed power (alternator) CB O/C trip (alternator)

Operation of each of the protection circuits shall interrupt the fuel cut-off solenoid supply and give a separate visual indication on the module.

The protection circuits shall be reset by a push-button and a further push-button shall be provided for lamp testing of the visual indicators.

The protection and alarm indication circuits shall be operated from the starter battery.

A spare voltage-free single pole changeover contact rated at 5 amps 220 AC shall be provided for each alarm indication. Each contact shall be wired to terminals to enable a remote alarm panel to be installed by others.

The protection and alarm module may be digital, separate or integral to the main control module or engine control unit.

E14.8.10

Battery charging module

One mains-operated battery charger module, complete with ammeter, voltmeter and protection, which shall charge the engine starter battery shall be provided.

The charger shall operate in parallel with the engine-driven generator and shall have self-adjusting, stepless control characteristics (constant voltage, current limiting).

A loss-of-charge current alarm shall be provided to indicate failure of the mains charger. This may be a current or voltage monitor. The alarm signals (contacts or voltage) shall be brought to terminals for connection to an external monitoring system.

The module shall be suitable for connection to the 230 Vac mains with a maximum voltage variation of  $\pm 15\%$  and a maximum frequency deviation of  $\pm 3$  Hz.

Output voltage shall be kept within 1% of the float charge voltage designed for maximum water conservation and maximum life of the battery.

The ripple content in the output of the charger shall be less than 2%.

The battery charger shall be equipped with the following additional equipment:

- (a) Overload protection
- (b) One 48 mm x 48 mm dial shielded voltmeter and associated push-button for the indication of battery volts
- (c) One 48mm x 48 mm dial shielded type ammeter for the indication of battery charging current.

## **E14.9 POWER SYSTEM**

### **E14.9.1 General**

Unless detailed otherwise in the detail specification to suit a particular installation, an integral, free floor-standing switchboard/control unit shall be provided which shall house the control system covered under the clause - "CONTROL SYSTEM" as well as a switchboard as describe below.

For installations where the changeover equipment forms part of the set requirements, the section "400 V switchboards" shall apply, in addition to any additional requirements as set out in the detail specification.

### **E14.9.2 Control system**

The control system shall comply with the requirements as set out under the clause "CONTROL SYSTEM".

### **E14.9.3 Changeover Distribution Board**

The Changeover Distribution Board must comply with all requirements as stipulated in the specification E04: ELECTRICAL LOW VOLTAGE DISTRIBUTION BOARDS AND MOTOR CONTROL CENTRES

The following shall be provided:

- (a) 25 mm x 6 mm earth bar and terminal stud.
- (b) Terminal blocks as necessary (approved).
- (c) One fully automatic supply change over assembly, which will function as the automatic closing and opening device to connect or disconnect the alternator supply from the main LV switchboard.
- (d) Copper busbars (3 phases and neutral). The busbars shall be drilled to accept suitably sized copper lugs.
- (e) A removable gland plate which shall be located a minimum of 800 mm above floor level and shall be large enough to mount the glands of all the power cables plus 50% spare capacity for sensing, control and LT supply cables.
- (f) The copper busbar shall be connected by means of secondary busbars to the outgoing terminal stubs of the CB and are to be spaced well apart and firmly braced.

The star-point (neutral) of the alternator shall be earthed to the earth bar in the switchboard. The size of the earth wire shall be at least 50% of the cross-sectional area of the supply cable connected to the generator and switchboard with a maximum size of 70 mm<sup>2</sup>.

## **E14.10 TESTING**

### **E14.10.1 General**

The complete testing including the provision of test facilities, instruments, dummy loads and switchgear at both the manufacturer's premises and on site, as well as fuel at both sites shall form part of this Contract.

For both tests at the manufacturer's premises and on site, the Engineer shall be notified two weeks in advance in order that a representative can be sent to witness these tests.

The test instruments provided shall in all cases be of high quality and suitable to adequately assess the quantities being measured or the equipment being tested. The test equipment remains the property of the Contractor.

### **E14.10.2 Testing at works**

The necessary tests to prove compliance with this Specification shall be carried out at the manufacturer's premises.

These tests shall include, but not necessarily be limited to, the tests detailed below:

- (a) Full load and overload output with all auxiliary equipment attached.

- (b) Cold starting and load acceptance
- (c) Governing for steady and step-loads.
- (d) Fuel consumption
- (e) All relevant pressures, flows, speeds, etc.
- (f) Alternator characteristics including rated full load and overload output, harmonic distortion, regulation under steady and step-loads, voltage transients, recovery times and overshoot, etc.
- (g) Systems operation and fault protection circuits
- (h) Switchgear and instrumentation
- (i) Insulation of alternator, cables and switchboard
- (j) Battery capacity
- (k) All relevant operating temperatures including cooling medium, alternator windings, bearings, exhaust gas, etc.

E14.10.3 Procedures (Works testing)

The set shall be run long enough to satisfactorily determine all the relevant quantities under stabilised conditions.

A varying load test shall be carried out at the manufacturer's premises where the set must be run at various loads from no-load to 10% overload and back to no-load, the following readings being taken at 20% load steps:

- (a) Voltage
- (b) Current
- (c) Power factor (alternatively wattage)
- (d) Frequency
- (e) The test sequence is to be carried out at unity power factor and a second test sequence at 0,85.
- (f) It has to be ensured that the machine was stationary for a minimum period of six (6) hours before the test is performed.
- (g) The engine water heaters may be supplied from the mains for the purpose of the test.

E14.10.4 Testing at site

- (a) The final acceptance tests at site shall include, but not necessarily be limited to, the tests listed below:
- (b) Insulation and continuity of wiring
- (c) Cold starting and load acceptance
- (d) System operation, fault protection circuits and alarm
- (e) Switchgear and instrumentation
- (f) Battery capacity and battery charger
- (g) A six (6) hour test. The set shall be subjected to prime rated load for five (5) hours followed by 10% overload for one (1) hour. The following readings shall be taken at 30 minute intervals during the five hour period and at 10 minute intervals under overload:
  - temperature (oil, water and exhaust gas)
  - oil pressure
  - alternator voltage, frequency, power factor or wattage
  - battery voltage and charging current

- ambient temperature

(h) The alternator and engine shall be inspected after the test.

E14.10.5

Test Reports

At the completion of all tests, a comprehensive test report shall be compiled and submitted to the Engineer in duplicate.

The tests at the manufacturer's premises and the on-site tests shall be shown separately. In addition, the test reports shall be included in the manuals as specified.

A thermal image of the generator running under normal operating conditions shall be taken and presented as part of the Operation and Maintenance Manuals.

**E14.11**

**INSTALLATION**

E14.11.1

Handling, Hoisting and Crane Usage

The Contractor shall provide and carry out everything necessary to complete the whole installation and put it into service.

The set is to be located as indicated on the drawings and the subcontractor is to allow for all handling, hoisting, crane usage and other equipment necessary for installing the set in position.

The time of arrival on site and method of handling and installation is to be fully discussed with the Building Contractor in order that this may be co-ordinated with the construction programme.

E14.11.2

Erection

Before erection commences the equipment shall be inspected and properly cleaned to remove the protective coverings and coatings applied before dispatch.

All coils, instrument windings and relays shall be tested by means of a 500 Volt Megger to ascertain whether any breakdown of insulation has taken place.

All components shall be examined for visible signs of damage and all damage shall be reported in writing to the Engineer.

The Contractor shall carry out the erection, including cutting holes for holding down bolts, positioning and grouting holding down bolts in accordance with jigs or drawings supplied, observing all erection instructions and precautions for erection that may be issued by the manufacturers of the equipment.

The Contractor is to make sure that the complete set has been properly aligned and that all bolts and connections and mating parts have been properly assembled.

All bolts and any other fastenings are to be tightened up and all electrical connections checked for tightness.

All wedges and packings installed at manufacturer's works to prevent damage to moving or delicate components during transport are to be removed.

The paintwork is to be touched up with matching paint.

E14.11.3

Cabling

The Contractor must include for the complete installation and wiring of the set, including the termination and connection of those cables as shown on the drawings.

The installation is to comply with the requirements of the relevant Machinery and Occupational Safety Act and the relevant regulations of the Factories, Machinery and Building Works Act of 1941, as amended, and with the Code of Practice for the Wiring of Premises, as amended.

For the alternator circuit PVC insulated steel wire armoured and PVC sheathed cables are to be used and for control circuits multi-core PVC cable or PVC insulated wires in buried conduit may be used.

E14.11.4 Notices

In the plant room a clearly legible and indelible warning notice must be mounted in a conspicuous position. The notice shall be made of a non-corrodible and non-deteriorating material, preferably plastic, and must read as follows, in red letters on a white background:

<p style="text-align: center;"><b>DANGER</b></p> <p style="text-align: center;">The engine will start without notice</p> <p style="text-align: center;">Turn selector switch on control board to "OFF" before working on the plant</p>
--

A metal danger plate of 250 mm x 150 mm complete with skull and crossed bones with the following words engraved on the plate shall be supplied and installed on the door leading into the plant room:

**DANGER**

All other notices as required by the Machinery and Occupational Safety Act, and the relevant regulations of the Factories, Machinery and Building Works Act, as amended, shall be supplied and installed both inside the plant room and outside on the entrance doors.

An additional notice or engraved metal plate shall be fitted to the engine to indicate the type, grade and manufacture of the lubricating oils for the engine.

An "Operator's Check List" shall be mounted in a suitable position below one of the emergency lights. The Check List shall contain a step-by-step procedure to be carried out should the set fail to start. The Check List shall be printed in bold, black letters and shall either be made of plastic or metal or shall be printed on stiff paper and mounted behind Perspex or glass.

The drawings as mentioned under the clause - "DRAWINGS AND MANUALS" are required.

E14.11.5 Tools and Loose Equipment

A wall-mounted sheet steel cabinet is to be provided containing a recommended set of tools for the service, maintenance and small repairs of the complete installation. All equipment shall be neatly hung in the cabinet for easy identification. The cabinet shall be padlockable.

A list of the proposed items shall be submitted with the Tender.

**E14.12 DRAWINGS AND MANUALS**

E14.12.1 Drawings Submitted for Approval

As soon as possible after the award of the Contract, the successful Tenderer shall, at his expense, submit to the Engineer for approval three prints of the drawings scheduled below:

- (a) All general arrangement drawings, including a dimensioned plant room layout.
- (b) Installation drawings for the cooling and exhaust systems.
- (c) Detailed dimensioned drawings of all plant and equipment.
- (d) Complete wiring diagrams and block schematic diagrams.
- (e) Dimensioned general arrangement drawing of all equipment on the switchboard.

E14.12.2 "As-built" Drawings

On completion of the Contract, all drawings required for the manuals shall be prepared and included in the manuals as specified. In addition a set of transparencies shall be handed to the Engineer to form the "as-built" records. These final drawings shall include the drawings schedules below:

- (a) A proper and accurate as-made wiring diagram of the complete installation showing circuit numbers, terminal strip numbers and conductor colours.
- (b) A schematic diagram clearly showing functions and components of the control equipment and switchgear is to be included.
- (c) Fully dimensioned as-made physical layout drawings of the generating set, substation, cooling and exhaust system.

- (d) Fully dimensioned as-made physical layout of the switchboard.
- (e) A detailed schedule of all wiring.
- (f) The Contract shall be deemed incomplete until all drawings have been received by the Engineer.
- (g) A print of the drawings under the second and third clauses of this section shall be mounted on the wall of the plant room behind a Perspex or glass cover.
- (h) The drawings must be professionally drawn on plastic transparencies with annotations.
- (i) A copy of each wiring- and circuit-diagram shall be supplied mounted in a single glass-fronted timber frame adjacent to the switchboard.

#### E14.12.3 Manuals

- (a) Upon completion of the Contract, three complete sets of manuals shall be handed to the Engineer.
- (b) Each handbook shall contain complete information on the following aspects of all units comprising a working installation:
  - (c) Technical descriptions and specifications of equipment
  - (d) Engine workshop manual
  - (e) Erection and commissioning instructions
  - (f) Operating instructions
  - (g) Description of functioning, adjustment and maintenance of equipment
  - (h) Parts lists, with illustrations where necessary, for correct identification of components for ordering of replacements.
- (i) The Contract shall be considered incomplete until all drawings and manuals have been received and approved by the Engineer.
- (j) An additional notice or engraved metal plate shall be fitted to the engine to indicate the type, grade and manufacture of the lubricating oils for the engine.
- (k) An "Operator's Check List" shall be mounted in a suitable position below one of the emergency lights. The Check List shall contain a step-by-step procedure to be carried out should the set fail to start. The Check List shall be printed in bold, black letters and shall either be made of plastic or metal or shall be printed on stiff paper and mounted behind Perspex or glass.
- (l) The drawings as mentioned under the clause - "DRAWINGS AND MANUALS" are required.

### **E14.13 OPERATING INSTRUCTIONS AND MAINTENANCE**

#### E14.13.1 Training for Owner's Representative

After completion of the installation and when the plant is in running order, the Contractor will be required to train the Owner's (user) Engineer and/or attendant in the operation of the plant until he is fully conversant with the equipment and the handling thereof.

#### E14.13.2 Maintenance Period

The Contractor will be required to maintain the plant in good running order after the plant has been taken over by the Client for a period of twelve (12) months. The Contractor shall carry out the maintenance as described in the clause - "MAINTENANCE CONTRACT". The cost of this maintenance must be included in the tender price.

#### E14.13.3 Maintenance Contract

After the lapse of the maintenance period, the Contractor may be required to enter into a maintenance agreement with the Owner. This agreement will initially be for one calendar year and may subsequently be renewed for yearly periods.

Tenderers shall prepare and submit a pro forma maintenance and service contract. This



City of Johannesburg  
Johannesburg Water (SOC) Ltd

maintenance and service contract shall be a formal service agreement of the suppliers of the standby set signed by an authorised employee and shall include the monthly cost of the services to be provided. Tenderers must state to what extent the price quoted will be subject to variation.

The entering into of a Maintenance and Service Contract shall in no way invalidate the Guarantee.

Under this agreement the Contractor will undertake to arrange monthly visits to the plant by a qualified member of his staff, who shall effect the following:

- (a) Report to the Officer-in-Charge, keeping the maintenance records and enter into a log book the date of the visit, the test carried out, the adjustments made, any further details that may be required.
- (b) When necessary, clean the plant and its components.
- (c) Grease and oil moving parts where necessary.
- (d) Check the air filter and when necessary, clean the filter and replace filter oil.
- (e) Check the lubricating oil and top-up when necessary.
- (f) After the plant has run on one oil change for the number of hours stipulated by the makers, drain the sump and refill with fresh lubricating oil. The reading of the hour meter on the switchboard will be taken to establish the numbers of hours run by the plant.
- (g) Clean the lubricating oil filter and/or replace the filter element at intervals recommended by the engine manufacturer.
- (h) Check and when necessary adjust the valve setting and the fuel injection equipment.
- (i) Check the battery and top-up the electrolyte when necessary.
- (j) Test-run the plant for two hours and check the proper working of all parts, including the electrical gear, the protective devices and fault indicators, the change-over equipment and the battery charger. Make the necessary adjustments.
- (k) Advise the Owner when it has become necessary to decarbonise the engine and submit a quotation for this service.
- (l) Report to the Owner on any parts that have become unserviceable, through fair wear and tear, or damaged by causes beyond the control of the Contractor and submit a detailed quotation for the repair or replacement of such parts.

**E14.14 MEASUREMENT AND PAYMENT**

<u>Item</u>	<u>Unit</u>
Supply and deliver standby diesel generator .....	No
The tendered rate shall include full compensation for the manufacture, supply, testing and delivery of the standby diesel generator incorporating all options/extras as detailed in the detail specification. The tender price shall also include the supply and fill of all lubricating oils (first fill) and the supply and install of all filter elements	
<u>Item</u>	<u>Unit</u>
Install standby diesel generator .....	No
The tendered rate shall include full compensation for the installation, site testing and commissioning plus the 12 months maintenance of the standby diesel generator incorporating all options/extras as detailed in the detail specification.	
<u>Item</u>	<u>Unit</u>
Yearly maintenance contract .....	Sum
The tendered rate shall include full compensation for the work detailed under paragraph "maintenance contract" above.	