

 Eskom	Standard	Technology
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Title: **STANDARD FOR STATIONARY DIESEL GENERATOR SYSTEMS** Unique Identifier: **240-62772907**

Alternative Reference Number: **<n/a>**

Area of Applicability: **Engineering**


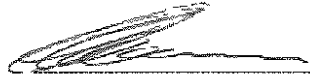
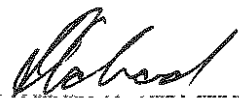
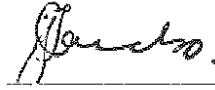
Documentation Type: **Standard**

Revision: **2**

Total Pages: **62**

Next Review Date: **November 2021**

Disclosure Classification: **Controlled Disclosure**

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1. Introduction

The document is required to provide the baseline requirements for new AC Diesel Generator systems with or without synchronising requirements. It also provides a standardised approach when defining the user or site-specific requirements for Diesel Generator systems.

2. Supporting clauses

2.1 Scope

This standard covers the design, testing, supply, delivery to site, erection and commissioning requirements for stationary AC Diesel Generator (DG) Systems.

2.1.1 Purpose

To provide the minimum technical requirements for DG systems used in Eskom.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] ISO 9001 Quality Management Systems.
- [2] BS 5514-5, Reciprocating internal combustion engines: performance -Part 5: Torsional vibrations
- [3] ISO 3046, Reciprocating internal combustion engines
- [4] NFPA 850, Recommended practice for fire protection for electric generating plants and high voltage direct current converter stations
- [5] Act No. 85 of 1993, Occupational Health and Safety Act
- [6] SANS 342, Automotive diesel fuel
- [7] SANS 1186, Symbolic safety signs
- [8] SANS 1507, Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
- [9] SANS 1632, Batteries
- [10] SANS 1652, Battery chargers – industrial type
- [11] SANS 8528, Reciprocating internal combustion engine driven alternating current generating sets (all parts)
- [12] SANS 10089, The Petroleum Industry: Storage and distribution of petroleum products in above-ground bulk installation
- [13] SANS 10140, Identification colour marking
- [14] SANS 60034, Rotating electrical machines
- [15] SANS 60529, Degrees of protection provided by enclosures
- [16] SANS 60947, Low-voltage switchgear and control gear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors

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- [17] SANS 10142, Wiring of Premises
- [18] 240-54937450, Include Eskom Fire Protection and Life Safety Design Standard
- [19] 240-56227516, Specification for LV switchgear and control assemblies and associates equipment for voltages up to and Including 1 000 V AC and 1 500 V DC
- [20] 240-56737448, Eskom Fire Detection and Life Safety Design Standard
- [21] 240-75655504, Corrosion protection standard for new indoor and outdoor Eskom equipment, components, materials and structures manufactured from steel standard.
- [22] 32-333, Standard for Electronic Protection and Fault Monitoring Equipment for Power Stations

2.2.2 Informative

- [23] 32-9, Definition of Eskom documents
- [24] 32-644, Eskom documentation management standard
- [25] 474-65, Operating manual of the Steering Committee of Technologies (SCOT)

2.3 Definitions

2.3.1 General

Refer to [11] SANS 8528-1 and [14] SANS 60034-1 for definitions relevant to this document.

Definition	Description
Bulk Tank	A fuel tank (usually of larger capacity than a day tank) that is positioned externally to the diesel generator and may supply one or more diesel generators
Cold Start	The DG shall start immediately under the prevailing environmental conditions as specified to accept load as fast as possible.
Day Tank	A fuel tank that is either underneath (base tank) or in close proximity to a dedicated diesel generator
Duty Type	A continuous, short-time or periodic duty, comprising one or more loads remaining constant for the duration specified, or a non-periodic duty in which generally load and speed vary within the permissible operating range.
Duty Type S1 – Continuous running duty	Operation at a constant load maintained for sufficient time to allow the machine to reach thermal equilibrium.
Duty Type S2 – Short-time duty	Operation at a constant load for a given time, less than that required to reach thermal equilibrium, followed by a time de-energised and a rest of sufficient duration to re-establish machine temperatures within 2K of the coolant temperature.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
AC	Alternating Current

Abbreviation	Description
AVR	Automatic Voltage Regulator
BIL	Basic Insulation Level
CAP	Committee for Accepted Products
CCA	Cold Cranking Amps
COP	Continuous Power
DC	Direct Current
DCS	Distributed Control System
DG	Diesel Generator
ESP	Emergency Standby Power
FAT	Factory Acceptance Test
HMI	Human–Machine Interface
HV	High Voltage
IP	International (Ingress) Protection
ISO	International Organization for Standardization
LAP	List of Accepted Products
LCD	Liquid Crystal Display
LED	Light-emitting Diode
LTP	Limited-time running power
MCCB	Moulded Case Circuit-breaker
n/a	not applicable
NFPA	National Fire Protection Association
OEM	Original Equipment Manufacturer
OHSA	Occupational Health and Safety Act
P	Proportional
PI	Proportional Integral
PID	Proportional Integral Differential
PRP	Prime Power
rpm	revolutions per minute
SAE	Society of Automotive Engineers
SANS	South African National Standards
SAT	Site Acceptance Test
SC	Steering Committee
THD	Total Harmonic Distortion
VAR	Volt-Ampere Reactive

2.5 Roles and responsibilities

This document shall be used whenever diesel generators are procured for Eskom purposes.

2.6 Process for monitoring

The Standby Generators Care Group operating under the DC & Auxiliary Supplies Study Committee shall ensure that this document is maintained.

2.7 Related/supporting documents

This document is to be used in conjunction with the following:

- a) Application-specific Design Guide (where available)
- b) Employer's Specification for Works which will contain the plant-specific Operating and Control philosophy
- c) Supporting AB Schedules

This document supersedes 240-56227929, Power Station Standby Diesel Generators Specification.

3. Requirements

3.1 General

- a) The DG shall be built in accordance with the latest revisions of [11] SANS 8528, except where deviations are specified in this document and its accompanying Schedule A and Schedule B.
- b) Where deviations exist between this document; its accompanying Schedule A, Schedule B and [11] SANS 8528, the order of precedence is as follows: accompanying Schedule A and Schedule B; followed by this document; and then [11] SANS 8528.
- c) The system shall be designed to run free of excessive vibration and noise under all conditions of load and speed, and shall comply with the requirements of [14] SANS 60034 and [2] BS 5514-5.
- d) All moving and rotating parts shall comply with the requirements of the Occupational Health and Safety Act (OHSA) [5] Act No. 85 of 1993.

3.2 Application and operating philosophy

- a) DGs will be generally used at the following sites:
 - Power stations
 - Substations
 - Telecommunication sites
 - Office buildings
- b) The generator configuration shall be for fixed (stationary) applications. This requirement shall be specified in Schedule A.
- c) The DG will generally be used for extended backup unless specified differently in Schedule A. The DG shall not be used to back-feed in to the Eskom National Grid.
- d) The Standard is only applicable to AC generating sets.

3.3 Site conditions

- a) The DG shall be designed for use inland or coastal as specified in Schedule A.

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- b) Some areas, e.g. telecommunications stations, are mainly found in isolated areas, e.g. rural and mountainous areas.
 - c) The customer shall specify the location of the DG in Schedule A (inside installation, outside installation with protection from weather or open-air installation).
 - d) The DG System shall be designed for a maximum ambient temperature of 50 °C unless otherwise stated in Schedule A.
 - e) The prevailing site conditions shall be clearly specified by the customer and any particular hazardous conditions (e.g. explosive atmospheres, flammable gases, coal dust, etc.) shall be described. The DG System must be designed to operate in these conditions.
 - f) The following conditions shall be specified in Schedule A:
 - 1) Minimum ambient temperature
 - 2) Altitude
 - 3) Humidity
 - 4) Air quality (dust or sand)
 - 5) Marine environment
 - 6) Shock and imposed vibration
 - 7) Chemical pollution
 - 8) Radiation
 - 9) Externally provided Cooling water/liquid

3.4 Reliability

- a) The DG System shall be designed for an operating life of 35 years under the specified operating conditions stated in Schedule A.
- b) Any deviation from this shall be clearly indicated.

3.5 Maintainability

- a) The DG System shall be designed to minimize the need for maintenance.
- b) Whether preventative or predictive, where maintenance is required, the design shall provide for good ergonomics in order to make it as easy as possible, with due consideration given to personnel safety.
- c) The design shall allow for modular replacement of assemblies and components to a level as low as possible.
- d) Component conditions that may lead to a failure shall be monitored, and an alarm condition generated.
- e) Spares and parts availability shall be guaranteed for the designed life of the DG.
- f) Warranty on any part of the system shall be at least two years unless specified differently in Schedule A.

3.6 System definition

Eskom prefers that the entire Diesel Generator set (engine and alternator) is supplied from a single OEM, in order to minimise spares holding and for standardisation purposes.

Table 1 provides an overview of a typical DG system, which is defined in more detail in the clauses following the table.

Table 1: System definition – overview

Diesel Engine (prime mover)	Alternator	Control and switchgear	Auxiliaries	Mechanical build
<ul style="list-style-type: none"> Engine rating Speed Governor Emissions 	<ul style="list-style-type: none"> Type Excitation Power Output Voltage and Frequency 	Equipment for the control, switching, operation, monitoring and alarming of the generating set shall be part of the associated controlgear and switchgear systems	<ul style="list-style-type: none"> Starting system Air intake and exhaust gas systems Cooling systems Lubricating oil system Fuel system (including fuel treatment where applicable) Auxiliary electrical power supply Earthing 	<ul style="list-style-type: none"> Base frame Coupling Enclosure Fire detection

3.6.1 Diesel engine (prime mover)

3.6.1.1 General

- a) The diesel engine shall be of the diesel fuelled, cold starting, water-cooled or air-cooled, speed-governed type. Tenderer to offer alternative cooling methodologies with the benefits and cost implications.
- b) Preheating and pre-lubrication of the engine are requirements.
- c) The supplier shall state in Schedule A, the guaranteed specific fuel consumption of the complete set with all auxiliary equipment at full load, three-quarter load and half load to accuracy within 5%.
- d) The fuel consumption shall be determined in accordance with [3] ISO 3046-1, and given in litres per kilowatt hour (l/kWh). The supplier shall also make reference to lubricating oil consumption.

3.6.1.2 Rating

- a) The engine shall be suitably rated to provide the required power output from the generator, even under impact loading when all pre-impact loads are connected.
- b) The generator start-up time (as specified in [11] SANS 8528-1) shall be specified in Schedule A.
- c) The engine shall deliver full load in accordance with [3] ISO 3046-1, within the starting period, and under the specified environmental conditions.
- d) De-rating shall be in accordance with [3] ISO 3046-1.
- e) The DG performance classification shall be Continuous Power (COP), Prime Power (PRP), Limited-time running power (LTP) or Emergency Standby Power (ESP) as defined in [11] SANS 8528-1 and as specified in Schedule A.
- f) The required mounting type and Generating set configuration shall be in accordance with [11] SANS 8528-1 and specified in Schedule A.
- g) The required Performance Class as defined in [11] SANS 8528-1 and load type are also given in Schedule A. If no performance class is specified, a G3 class shall be assumed.
- h) Where the customer does not declare a duty type, the supplier shall assume that duty type S1 (continuous running duty) applies.
- i) The power rating shall be expressed in kilowatts at rated frequency and a power factor of 0,8 lagging unless otherwise stated in Schedule A.

- j) The output of the engine under the specified site conditions shall be the net available output power after allowance has been made for all auxiliary equipment (i.e. parasitic losses) including air filter, radiator fan, oil pump, water pump, battery charger alternator, governor, etc.
- k) It shall be possible to operate the DG with a lagging Power Factor from 0,8 up until Unity, depending on the active power demand, unless otherwise stated in Schedule A.
- l) The DG shall be capable of performing a single load step equal $\geq 50\%$ of the continuous kilowatt (kW) rating of the machine while remaining within operating limits.
- m) The DG shall be capable of performing a single load step equal to 110% of the most severe single step load in the plant design profile.
- n) The DG shall accept the load without voltage collapse or engine stalling and recover to normal operating speed.
- o) The supplier shall document the voltage and frequency deviation observed.
- p) The supplier shall supply with the tender all technical data with de-rating graphs on altitude of all engines. This shall form part of the engine sizing.

3.6.1.3 Governor

- a) The engine shall be fitted with a mechanical or electronic governor to provide speed control in accordance with the required performance class requirements and requirements of [3] ISO 3046-4 and [11] SANS 8528-1.
- b) If an electronic governor is used the governor shall be of the Proportional Integral (PI) or Proportional Integral Derivative (PID) type as specified in Schedule A.
- c) Table 2 indicates the required governor type with regards to the performance class.

Table 2: Acceptable Governor Types

Performance Class	Governor type
Class G1	Mechanical or Electronic
Class G2	Mechanical or Electronic
Class G3	Electronic
Class G4	Electronic

3.6.1.4 Speed

An engine operating nominal speed of 1 500 rpm is preferred, except where it is otherwise stated in Schedule A.

3.6.1.5 Emissions

Any emission (noise, vibration, heat, gas and electromagnetic disturbance) limits as specified by applicable legislation relating to the protection of the environment and to the health and safety of personnel operating or maintaining the generating set shall be specified in Schedule A.

3.6.2 Alternator (generator)

3.6.2.1 Type

- a) The alternator shall be of the brushless type and comply with the relevant requirements of [14] SANS 60034-1, [14] SANS 60034-8, [14] SANS 60034-9 and [11] SANS 8528-3, and with the additional requirements specified.
- b) Where the customer does not declare a duty type, the supplier shall assume that duty type S1 (continuous running duty) applies.

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3.6.2.2 Excitation

- a) The tenderer shall quote for an option with permanent magnet excitation and without unless otherwise specified in Schedule A.
- b) Series current boost (consisting of controls and current transformers) shall be provided, if required, to meet transient voltage response performance.

3.6.2.3 Heaters

- a) The alternator shall be fitted with one or more anti-condensation heater elements to protect those components that can be adversely affected by moisture.
- b) The heater shall be approved by the alternator supplier.
- c) The heater's power requirement shall be stated.

3.6.2.4 Power output

- a) The customer shall specify the required output power requirements in kilovolt-ampere (kVA) and the power factor at the output terminals of the alternator.
- b) The supplier shall specify the short-circuit rating of the alternator. The alternator shall comply with the requirements of section 9.8 of [14] SANS 60034-1 which states that the short-circuit current shall not exceed 15 times the peak value or 21 times the r.m.s. value of the rated current.
- c) The alternator's efficiency at full load, 3/4 load, 1/2 load and 1/4 load at unity and at 0.8 lagging power factor shall be stated in Schedule B. This shall be confirmed during FAT.

3.6.2.5 Loading

- a) Linear and non-linear loads shall be stated as per the Starting Sequence detailed in Schedule A and the load schedules.
- b) The alternator shall be suitable for supplying the following types of loads:
 - 1) Linear loads, such as incandescent lighting circuits and/or
 - 2) Non-linear loads, such as saturable-reactor controlled rectifiers, six-pulse or twelve-pulse controlled thyristors, Variable speed drives or stop/start control systems and motors (inductive loads).

3.6.2.6 Voltage and frequency

- a) The nominal voltage and frequency, including tolerances, shall be as stated in Schedule A. The terminal voltage shall be adjustable over the specified range.
- b) The generator voltage shall remain within the limits specified from no-load to full-load at unity, and at 0.8 lagging power factor, inclusive of diesel engine speed drop of 4% and temperature drift.
- c) The maximum permissible voltage drop and frequency variation for the maximum load step should be maintained within the specified limits as stated in Schedule A. For more detail refer to section 3.6.1.2. l) and m).

3.6.2.7 Type of construction

- a) The alternator shall be air-cooled.
- b) The alternator insulation class for its different parts shall be Class H with a Class B temperature rise.

3.6.3 Control, monitoring, alarms, indications and switchgear

3.6.3.1 General

The customer shall provide the Employer's Specification for Works which will contain the Operating and Control philosophy for the electrical plant system. This will include operating scenarios (test functionality, test load, shut down, breaker status, etc) in a Matrix table.

- a) The control system shall comply with the requirements of [11] SANS 8528-4, and shall be electrically fail-safe.
- b) The control system shall be powered from Direct Current (DC) available from the engine cranking batteries.
- c) The control system shall be capable of operating on an alarm-only basis or alarm and shut down, if so required.
- d) All data (events) shall be date and time stamped.

3.6.3.2 Control panel controls (for Gen sets with synchronising capabilities)

- a) The DG control panel shall provide local control of DG functions.
- b) As a minimum, the local control panel shall include the following. Any or all of the functions can be available from a local Human-Machine Interface (HMI).
 - 1) Local Start
 - 2) Local Stop
 - 3) Emergency Stop
 - 4) Raise/Lower Load (when synchronized)
 - 5) Raise/Lower Volt-Ampere Reactive (VAR)
 - 6) Breaker Selection (Generator or Paralleling)
 - 7) Initiate Sync Command
 - 8) DG Breaker Trip and Close Functions
 - 9) Auto/Manual Start
 - 10) Raise/Lower Voltage
 - 11) Raise/Lower Speed
 - 12) Alarm Accept/Test/Reset
 - 13) Lamp Test
 - 14) Local/Remote Control/Maintenance
 - 15) Generator Bus Breaker (if parallel units)
- c) The sync function shall utilize the supplier's standard auto-synchronizer.
- d) Manual sync capability (including sync scope and sync lights) shall not be provided unless specifically requested in Schedule A.

3.6.3.3 Control panel controls (for Gen sets without synchronising capabilities)

- a) The DG control panel shall provide local control of DG functions.
- b) As a minimum, the local control panel shall include the following. Any or all of the functions can be available from a local Human Machine Interface (HMI).
 - 1) Local Start

- 2) Local Stop
- 3) Emergency Stop
- 4) DG Breaker Trip and Close Functions
- 5) Auto/Manual Start
- 6) Alarm Accept/Test/Reset
- 7) Lamp Test
- 8) Local/Remote Control/Maintenance

3.6.3.4 Control panel features

- a) The following features shall be included in the control panel. Any or all of the functions can be available from a local HMI:
 - 1) If the HMI does not have a digital display then an Analogue Metering panel is needed. This should provide a colour-coded display of generator set output voltage (phase-phase and phase-neutral), - current, - frequency, power factor and kilowatt (kW). In the case where an analogue metering panel is provided, individual phase current meters with maximum current indicators shall be provided.
 - 2) The operator shall have the ability to view system parameters and to make adjustments from the control panel.
 - 3) In addition to the requirements above a digital HMI needs to comply with the following: All DG system events shall be date and time stamped and a minimum of 100 events shall be recorded.
 - 4) Light-emitting Diode (LED) Status Lamps: Indicate remote start command, not in auto, warning and shutdown.
 - 5) Exercise switch: Automated exercise function in the DG controller allows the operator to initiate an exercise period and have it automatically completed by the controller. The controller shall start the engine; perform the testing method as specified in the AB Schedules (synch with main supply where applicable, dummy resistor load or unloaded); run for a pre-set period; then run down, open the generator breaker, and shut down.
 - 6) Fault Reset switch: Allows the operator to reset the control after a warning or shutdown condition.
- b) The following features shall be included in the control panel and not from a local HMI:
 - 1) Emergency stop push-button: Provides positive and immediate shutdown of the generator set.
 - 2) Key-type mode selector switch (local/remote/maintenance).

3.6.3.5 Remote Control System interface (If required in the AB Schedules for Gen sets with synchronising capabilities)

- a) The control system shall cater for all the input/output signals required for a complete system. Remote inputs to the DG from the remote control system may include, but are not limited to the following:
 - 1) Remote Start Command Control
 - 2) Remote Stop Command Control
 - 3) Initiate Sync Command Control
 - 4) Select Generator Breaker for Sync Control
 - 5) Select Paralleling Breaker for Sync Control

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- 6) Generator Breaker Close Command
 - 7) Paralleling Breaker Close Command
 - 8) Generator Breaker Open Command
 - 9) Paralleling Breaker Open Command
 - 10) Emergency Mode (disabled engine trips) Control
- b) The control system shall cater for all the input/output signals required for a complete system. Remote outputs from the DG to the remote control system (indications) may include, but are not limited to the following:
- 1) Control Mode (local/remote/maintenance)
 - 2) Engine Running
 - 3) Load kW (analogue)
 - 4) VARs (analogue)
 - 5) Ready to Load
 - 6) Ready to Start
 - 7) Common Alarm
 - 8) Shutdown Alarm
 - 9) Generator Breaker Status Indication (Closed / Open)
 - 10) Paralleling Breaker Status Indication (Closed / Open)
 - 11) Generator Voltage/s (analogue)
 - 12) Bus Voltage (reference for testing)
 - 13) Paralleling Source Voltage (reference for return after power outage)
 - 14) Air filter differential pressure alarm
- c) If the required input/output signals are not specified by the customer, the control system shall cater for the following:
- 1) 8 × Digital inputs.
 - 2) 2 × Analogue inputs.
 - 3) 16 × Digital outputs.
 - 4) 4 × Analogue outputs.

3.6.3.6 Remote Control System interface (If required in the AB Schedules for Gen sets without synchronising capabilities)

- a) The control system shall cater for all the input/output signals required for a complete system. Remote inputs to the DG from the remote control system may include, but are not limited to the following:
- 1) Remote Start Command Control
 - 2) Remote Stop Command Control
 - 3) Generator Breaker Close Command
 - 4) Generator Breaker Open Command
 - 5) Emergency Mode (disabled engine trips) Control

- b) The control system shall cater for all the input/output signals required for a complete system. Remote outputs from the DG to the remote control system (Indications) may include, but are not limited to the following:
- 1) Control Mode (local/remote/maintenance)
 - 2) Engine Running
 - 3) Load kW (analogue)
 - 4) VARs (analogue)
 - 5) Ready to Load
 - 6) Ready to Start
 - 7) Common Alarm
 - 8) Shutdown Alarm
 - 9) Generator Breaker Status Indication (Closed / Open)
 - 10) Generator Voltage/s (analogue)
- c) If the required input/output signals are not specified by the customer, the control system shall cater for the following:
- 1) 8 × Digital inputs.
 - 2) 2 × Analogue inputs.
 - 3) 16 × Digital outputs.
 - 4) 4 × Analogue outputs.

3.6.3.7 Diesel generator local control panel indications

- a) As a minimum, the following indications are available locally on the DG control panel HMI:
- 1) Control system in remote mode.
 - 2) Control system in local.
 - 3) DG control system healthy.
 - 4) Diesel engine ready to accept load.
 - 5) Main DC supply healthy.
 - 6) Backup DC supply healthy (if required).
 - 7) Generating kVAr (kilovolts-ampere reactive), kW (kilowatt), Volts, Frequency and Amps are displayed on digital instruments.
 - 8) Starter battery charger voltage and current.
 - 9) Engine running hours.
 - 10) Fuel level.
 - 11) Engine temperature.
 - 12) Oil pressure.

3.6.3.8 Diesel generator annunciator alarms (if required in the AB Schedules)

- a) The following alarms are available on the local DG annunciator:
- 1) Diesel engine start failure
 - 2) Low engine oil pressure
 - 3) Low radiator water level

- 4) Engine over speed
- 5) Engine air flaps closed
- 6) Emergency stop activated
- 7) Generator field breaker tripped
- 8) Fuel tank < 5%
- 9) Fuel tank < 20%
- 10) Fuel tank < 50%
- 11) Fuel tank leak alarm
- 12) Fire alarm
- 13) Protection trip
- 14) High engine temperature
- 15) Low engine temperature
- 16) High bearing temperature
- 17) Stator temperature
- 18) Under frequency
- 19) Abnormal voltage
- 20) Low starter battery voltage
- 21) Charger fail
- 22) Auxiliary supply fail
- 23) Fuel transfer scheme failure
- 24) Water in fuel alarm
- 25) Synch. failure
- 26) DC failure
- 27) Generator Breaker Tripped

b) The following alarms will be repeated for input into the Remote Control System (i.e DCS):

- 1) Engine protection tripped alarm
- 2) Engine protection delayed time before trip will occur alarm
- 3) Engine protection alarm

3.6.3.9 Safety features

a) The following safety features shall be available:

- 1) A continuously rated, fail-safe engine stop solenoid used to control the fuel injection system.
- 2) An emergency stop push-button on the diesel engine.
- 3) An emergency stop push-button on the control panel.
- 4) Remote emergency shutdown capability.
- 5) Over speed protection.
- 6) Full automatic mode with very little human interaction during power restoration after a blackout.

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- 7) The DG controller will ensure that an engine will only shut down after running at no load for the engine manufacturer's recommended time period. This no load run is necessary to cool down the turbo chargers properly. However, using the emergency shutdown function will stop the machine immediately. Using the manual key switch function will also override the no load run function.

3.6.3.10 Control system functionality

- a) Emergency stop: Emergency stop push-buttons shall be provided as indicated in Schedule A (3.6.3.9 item 2) and item 3). These push-buttons shall be of the self-latching, twist-to-release type, red in colour, and at least 25 mm in diameter. Directly above each push-button, there shall be a red label indicating the function of the push-button. The button shall open the DG main breaker and shut the diesel engine down by cutting the fuel.
- b) If an automatic Voltage Regulator (AVR) is used: The AVR shall control the generator output voltage by three-phase sensing. When operating in either the asynchronous or in the synchronous mode, the AVR shall operate accordingly.
- c) Control functions: Refer to the Employer's Specification for Works for the required control philosophy.

3.6.3.11 Alarms and indications

- a) Each alarm shall register and maintain the alarm indication until manually cancelled, even if the signal that initiated the alarm has ceased.
- b) Each alarm shall be displayed in the front of the alarm panel by an indicating lamp, LED or Liquid Crystal Display (LCD).
- c) A common 'Alarm Reset' push-button shall be provided to restore the control circuit to its original state, once the alarm conditions have been noted and rectified.
- d) All alarm lamps or LEDs shall have a Lamp Test facility to test whether they are operational; this facility shall be operated by a single push-button.
- e) Each alarm shall be duplicated at a potential-free changeover contact. Both positions (three wires) shall be wired to outgoing terminals. Archiving/logging of alarms shall be kept.

3.6.3.12 Assemblies, Terminals, wiring and cabling

- a) LV Switchgear and control gear assemblies and associated equipment shall be in accordance with [18] 240-56227516 and [22] 32-333.
- b) [17] SANS 10142 shall be used as a minimum for Distribution boards.
- c) External wiring for low voltage control, interlocking, alarm, measuring, and DC circuits shall terminate on numbered wiring terminals that comply with the requirements of [16] SANS 60947-7-1.
- d) Unless otherwise agreed upon, all terminals shall be marked in accordance with [14] SANS 60034-8. The position of the supply terminal boxes, if of importance, shall be as specified.
- e) Where heat-generating equipment is present and the internal temperature is likely to exceed 50 °C, heat-resistant insulation (silicon wire) shall be used on stranded conductors. The supplier shall state where such insulation is used.

3.6.4 Auxiliaries

3.6.4.1 Cooling

- a) If water-cooled, the engine shall be cooled by a pressurized radiator and shall be entirely self-contained. The radiator shall be filled with anti-freeze.

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- b) Unless otherwise specified, fans of engines that are installed in an engine room shall draw air through the room and exhaust it externally. The method of driving the radiator fan (i.e. whether it is driven by electric motor or mechanical coupling to the engine) is listed in Schedule A. Electric motors will only be used for remote radiators and should be avoided where possible.
 - c) A heating element operating at either U_{AC} 230 V single-phase or U_{AC} 400 V three-phase shall be fitted in the engine water jacket to maintain the engine at a temperature suitable for cold starting. It is a requirement that these jacket water heaters can be isolated individually for heating element change out without draining the complete engine coolant capacity.
 - d) The element terminals shall be brought out separately, such that both terminals of each heater element are available externally. The element wiring shall be terminated on a separate external terminal strip. The circuit shall be wired independently to ensure that a heater element failure will not affect the DG control system. The power to the heater element shall be thermostatically controlled to adequately regulate the engine temperature. An alarm shall be issued if the engine temperature drops below the minimum temperature specified by the supplier.

3.6.4.2 Starting

- a) The preferred starting method shall be via electric motor unless otherwise specified in Schedule A.
- b) For electric motor starter/ air starting, on initiation of the start command, the engine starter shall make five consecutive start attempts. Depending on the application, the required start philosophy will be as follows and indicated by the customer in Schedule A:
 - 1) Start Initiation option 1: maximum duration of 10 s each, with rest periods of not more than 10 s between attempts (minimum requirement for Generation applications).
 - 2) Start Initiation option 2: maximum duration of 8 s each, with rest periods of not less than 10 s between attempts.
- c) If the fifth start attempt is unsuccessful, the indication 'Start Failure' (red) shall be activated on the control panel.

3.6.4.3 Batteries

- a) The type of batteries to be used shall be specified in Schedule A. For generation applications the specified battery type will be Ultra High Performance Nickel Cadmium. The sizing of the batteries will comply with the starting philosophy specified in terms of section 3.6.4.2.
- b) Batteries shall be rated for the voltage and currents of the starting motors and the control equipment, and for the time requirements of the alarm system specified. Details of the batteries offered shall be provided.
- c) The rated battery capacity shall be selected to ensure that a successful start attempt as stated in section 3.6.4.2. is possible at the minimum expected operating temperature specified in schedule A. The final discharge voltage shall not fall below the value as specified in [9] SANS 1632 or the minimum voltage required by the controller, whichever is the maximum of the two.
- d) During engine operation, the starter battery shall be charged from a charging alternator. The battery charger shall take over battery charging when the charging alternator fails or if the engine is shutdown.
- e) The battery shall be mounted separately from the vibrating part of the set, preferably in a clean and cool environment.
- f) The battery mounting shall be protected against corrosion, and shall include a spill tray and a transparent cover over the battery.
- g) A removable link system between battery and starters, whereby it is safe to isolate the engine for maintenance, yet have the charger and controller still energized shall be installed. The starter battery mounting shall be as close as possible to the starter motor, and shall be arranged in a position permitting easy access for maintenance.

3.6.4.4 Battery charger

- a) Equipment shall be provided in the control panel for charging the starter battery from the customer's U_{AC} 230 V or U_{AC} 400 V system.
- b) Battery chargers shall comply with the requirements of [10] SANS 1652, and shall be of the constant voltage, current limited type.
- c) The performance characteristics of battery chargers shall comply with the recommendations of the battery manufacturer.
- d) There shall be a separate charger for each battery/starter system if specified in Schedule A.

3.6.5 Fuel system

3.6.5.1 General

- a) Each Generator Set shall be equipped with either a day tank or bulk tank or both as specified in Schedule A and the required accessories such as pumps, valves and piping in order to supply the DG Set with fuel, when running at full load for duration as specified in Schedule A.
- b) The minimum run-time at full load shall be specified in Schedule A.
- c) The fuel system design and installation shall comply with the requirements of the local authority, e.g. fire department, department of environmental affairs, and of the latest OHSAS standards.
- d) Galvanized materials or materials that contain zinc, copper, brass shall not be used in the fuel system for piping, valves, etc.
- e) In order to filter the input fuel to the DG, a water and fuel separator shall be fitted before the engine supply pump.
- f) The water and fuel separator device shall be installed between the fire shut-off valve and the engine fuel pump.
- g) The water and fuel separator drain shall be connected to an external outlet.
- h) A water level alarm system shall be provided to monitor the water level in the water and fuel separator.
- i) The alarm system shall have a 'water in fuel' alarm.

3.6.5.2 Fuel injection

- a) A common rail fuel system is preferred.
- b) The engine shall be equipped with a means of priming the fuel system to the injectors following long engine shutdown times if it is not a common rail system.
- c) If the fuel serves as 'injector cooling', the supplier shall provide adequate cooling to the fuel supply system to avoid increases in day tank temperature.
- d) A continuously-rated fail-safe engine-stop solenoid shall be provided on the fuel pump supply line.
- e) The main fuel line shall be equipped with a fire-resistant shutdown valve, operated by a fusible link or similar type fire detector that closes off the main fuel supply line and 'spill' return line between the tank and diesel in the event of a fire.

3.6.5.3 Day fuel tank (if applicable)

- a) Each engine shall be equipped with its own day fuel tank installed next to the generator.
- b) The supplier shall construct and install the day tank in accordance with [12] SANS 10089 parts 1 to 3.
- c) The capacity of the day fuel tank shall be a minimum of 4 h continuous operation at full load unless specified differently in Schedule A.

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- d) The day tank shall be of single wall construction and a leak detection feature will be incorporated in the controller.
- e) Alarm sensors shall be furnished for 50% fuel level, low fuel (20%) and critical low fuel (5%) at which point the generator set shall automatically shutdown.
- f) Alarm contacts from these fuel sensors shall be connected to the engine control system for local alarm indication. In addition, single-pole double-throw contacts from each alarm sensor shall be connected to terminal blocks in the engine control panel for the customer's use.
- g) The top of the day tank shall be such as to allow for gravity feed from the bulk storage tank, if applicable.
- h) The day fuel tank shall have a sloping bottom with a drain valve at the lowest point of the tank. The slope shall be 1:20 towards the drain valve.
- i) The intake to the fuel delivery pipe to the engine shall be located at a level that is equal to a position representing at least 2% of the total tank capacity. A manual shut-off valve shall be fitted in this pipe.
- j) The overflow pipe shall be twice the diameter of the filler pipe, and shall be so positioned that the overflow can occur only when the tank is 98% full. The overflow pipe shall be connected to the bulk storage tank.
- k) A filler pipe shall be provided and shall preferably pass through the tank top.
- l) A removable hand hole with an inspection cover shall be provided in the top of the day tank, for maintenance purposes. The cover shall have a gasket and be provided with a locking facility.
- m) No farm tank shall be used for fuel storage.

3.6.5.4 Bulk fuel tank

Alarm sensors shall be furnished for 50% fuel level, low fuel, and critical low fuel.

3.6.5.5 Diesel fuel

The fuel injection equipment offered shall use diesel fuel that complies with the requirements of [6] SANS 342.

3.6.6 Lubrication system

- a) An oil pressure gauge and an oil pressure sensor and switch shall be so mounted downstream of the oil filter that the engine lubricating oil pressure is readily indicated on the engine or on the control panel (or on both), as specified. The safety range and the danger zones shall be indicated on the gauge.
- b) The oil pressure sensor shall be connected to the control system, to give an alarm and to stop the engine if low oil pressure occurs.
- c) The oil filter shall have adequate capacity of at least 250 h continuous operation.
- d) Oil filters shall be readily accessible.
- e) All bearings and continuously rotating moving parts that are not pressure lubricated shall be fitted with sealed ball, roller or needle bearings.
- f) A semi-rotary hand-operated sump drain pump shall be fitted, and so positioned as to facilitate oil drainage during oil change servicing.
- g) If a motor-driven lubricating oil priming pump is provided, this shall be stated in Schedule B. The supplier shall also indicate if this is a prerequisite for engine pre-lubing, and should no oil gallery pressure be successfully achieved, any engines starting shall be aborted.

- h) A label indicating the grade of oil to use, the frequency of oil changes and the volume of oil shall be affixed to the engine. The use of multigrade oils is preferred against monograde oils.
- i) Any need for separate oil cooler or auxiliary oil heater or both for cold starting shall be stated in Schedule B together with the power requirements for any auxiliary oil heater.
- j) The crank case breather shall be extended/ routed beyond the radiator system where vapours can be discharged within the hot airflow.

3.6.7 Aspiration and cooling air intake

- a) The engine air filter shall be dry type as appropriate for the site conditions.
- b) The air intake shall be so mounted that the intake of dust or other particles is minimized.
- c) The air intake shall be screened to prevent vermin or birds from entering the intake.
- d) If water has entered the intake, it shall be possible to drain the water from a low-lying collection point.
- e) The air filter construction shall be such that the filter element can be readily cleaned or replaced.
- f) A 'differential pressure high' switch shall be provided to indicate a dirty filter element condition.
- g) The air intake shall be positioned such that the intake of exhaust gasses or radiated heat is avoided.

3.6.8 Earthing

3.6.8.1 General

- a) Earthing shall be provided to meet the system protection and safety requirements for the DG Set power circuits. The minimum earth fault current dictates the generator protection settings for correct operation.
- b) The maximum earth fault current and its duration determine the cross-sectional area of the earth conductors to be used.
- c) Independent earthing is required in order to eliminate electromagnetic disturbances in control circuitry, and also to prevent mechanical damage to the shaft and bearings in the set, caused by induced and stray currents.
- d) The Employer shall design the main earth mat under the civil contract. Provision shall be made by the supplier to enable the earthing of the plant to the earth mat in the DG building.
- e) The supplier shall provide details of its specific earthing system requirements, philosophy, etc. clearly indicating the interface points to the DG building earth mat.

3.6.8.2 Generator neutral earthing

- a) Neutral earthing implies interconnection of the generator's neutral and the customer's power system's neutral, which is generally earthed.
- b) Multiple earth connections can cause neutral circulating currents between parallel systems. Care shall be taken to avoid this phenomenon and the consequent unnecessary operation of the protection.
- c) The neutral earthing method employed shall be in accordance with [11] SANS 8528 and will depend on the existing site earthing philosophy, DG mode of operation and level of protection required. The customer shall specify the neutral earthing method in Schedule A.
- d) The supplier shall provide protection of the generator against internal earth faults, and details of such protection shall also be supplied.

3.6.8.3 Earthing and bonding of components

- a) Each main component of equipment shall be earthed directly to a solid copper earth bar, which shall be connected to the Employer's earth system at a point as specified.
- b) As a general rule, the earth continuity conductor shall be of a nominal cross-sectional area at least half that of the largest phase conductor, but not more than 70 mm².
- c) Earth conductors may be bare copper, insulated copper, aluminium or an anti-theft copper/steel compound unless specifically stated in Schedule A. Where aluminium is used as an earth conductor, bimetal connections shall be used between different materials and these cannot be installed underground.
- d) On batteries and battery chargers, the negative pole shall be earthed to the frame of the set unless specified differently.
- e) The frame of the DG Set shall be flexibly earthed to the earth continuity conductor with due regard to the magnitude and duration of possible local earth faults.
- f) Electrolytic corrosion shall be avoided. A suitable earthing facility shall be provided on the frame. If so recommended, bypass earthing of insulated bearings shall be carried out by means of an earthed brush, to prevent damage caused by induced shaft currents.
- g) Tanks shall have an earthing facility provided on the tank, for connection of an earth conductor between the tank and the frame of the set.
- h) Junction boxes shall be fitted with an earth terminal. The earthing conductor shall be of suitable cross-sectional area to withstand any earth fault currents.
- i) Junction boxes enclosures shall be rated IP54 as per [15] SANS 60529, unless specified otherwise in Schedule A.

3.6.8.4 Enclosures

- a) Enclosures shall be rated IP54 as per [15] SANS 60529, unless specified otherwise in [15] SANS 60529. Colour shall be as specified in [15] SANS 60529.
- b) Enclosure doors shall be positively drawn and closed onto seals by means of pad-lockable lever-operated catches. Cable entry shall be from the bottom using removable gland plates.
- c) Enclosures containing a rectifier and/or inverter shall be fitted with removable filters that prevent the ingress of dust. The airflow to air-cooled components shall be arranged to promote cross ventilation, and such that it cannot be impeded accidentally in any way.
- d) A stud shall be provided for earth connections from inside and outside the enclosure. Where studs are not welded to the plate, flat washers shall be used as the final mating surface in the case of a conductive gland plate. A bolt and nut arrangement may also be used.
- e) Where the plate is coated with non-conductive covering, studs shall be welded to the plate after the coating is removed.
- f) An earth bar shall be provided. The earth bar shall be connected to the earth stud inside the enclosure by the shortest possible path. All earth connections shall follow the shortest path, and no 'pigtails' (wire coils for neatening purposes) are permissible.
- g) The connection between the earth stud and the earth bar shall be made using a suitability sized conductor, and shall be appropriately lugged for the purpose.
- h) Gland plates shall be fabricated from a conductive material, and shall be protectively coated against corrosion using a conductive coating, such as cadmium.
- i) The gland plate shall be bolted to the enclosure in at least four places, in such a manner as to ensure galvanic continuity between the plate and the enclosure is ensured.
- j) Doors shall be bonded to the enclosure using earth studs.

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- k) Doors > 0,5 m in length shall be bonded in at least two different locations, with 0,5 m spacing between each bond.
 - l) Bonds shall be made using braided copper strapping ≥ 10 mm wide and having a width to thickness ratio > 5:1. (larger machines).

3.6.9 Mechanical build

3.6.9.1 Coupling

- a) The generator and engine may be coupled directly with a flange adapter ring or a bell housing within which a shock absorbing flexible coupling is fitted. The method shall be fully described by the supplier.
- b) If the generator is offered with double bearings, it shall be coupled to the engine with a flexible coupling designed to take up any angular misalignment, and to transmit the drive torque smoothly.

3.6.9.2 Base frames

- a) DG Sets shall be mounted on a simplex frame.
- b) The overall dimensions of the frame shall be provided.
- c) Lifting provisions on the base shall be provided to lift the complete set, including any canopy or enclosure, if fitted. Lifting provisions are to be clearly marked. Lifting eyes not suitable for complete lifting shall be indicated as such.
- d) The maximum overall mass of the DG Set (including oil) and its frame shall be provided. This is required to ensure suitable rated equipment to lift the complete set, without decoupling.
- e) The base shall be so constructed as to allow for an oil drip tray, and to allow space for draining the engine oil from the sump.

3.6.9.3 Vibration damping

- a) The system shall comply with the requirements of [11] SANS 8528.
- b) Vibration damping mounting details shall be provided.

3.6.9.4 Exhaust system

- a) The exhaust line diameter shall be adequate for the length of the exhaust line.
- b) The exhaust shall have an effective silencer that reduces the noise level to not more than that allowed by local noise regulations.
- c) The exhaust system shall have a low-lying collection point provided with a drain plug, to enable any condensation to be removed.
- d) Exhaust gases shall be released at a location that complies with the local and national regulations, and shall not be drawn into the engine or ventilation intake again.
- e) The position of the exhaust shall not hinder operation and maintenance.
- f) The exhaust pipe shall be so arranged as to prevent the ingress of rain and also bird nesting.
- g) Emission levels and noise levels shall be as defined in Schedule A. The maximum noise level shall be 90 dBA at 1 meter away from the DG set.
- h) The exhaust system, with the exception of expansion bellows and flexible joints, shall be constructed from aluminized steel.
- i) The external (from the building) exhaust system shall be manufactured from stainless steel.
- j) Exhaust cowl/cladding shall be manufactured from stainless steel sheet.

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- k) Expansion bellows shall be fabricated from stainless steel and shall be of the type, length and diameter recommended by the supplier.
 - l) Leak-tight flexible joints shall allow for expansion and contraction without straining the system.
 - m) No welding shall be done on the exhaust system.
 - n) Adequate lagging, of non-asbestos material, shall be provided. The type of lagging and the thermal capabilities of the lagging offered shall be provided in Schedule B. As a minimum, the lagging shall be rated 400 °C fibreglass material or other suitable material.
 - o) Expansion bellows shall not be lagged. Flexible joints shall be lagged.
 - p) The piping outside the Plant room shall not be lagged. Non-lagged piping shall be corrosion protected with a heat-resistant paint.
 - q) Suitable flexibility shall be built into the system to isolate the exhaust system from the structure, and to prevent any stresses on the engine flanges. Relative movement of the engine and surrounding structure shall be considered.
 - r) Hangers, supports and guides shall be designed to allow for expansion and contraction, and to allow necessary access to the set.
 - s) Exhaust lagging shall be protected by means of metal cladding/cowling if specified in Schedule A.
 - t) Safety guards to prevent accidental contact shall be provided over all exposed exhaust pipes and bellows.
 - u) All metal and surface preparation, painting and coating processes shall comply with the requirements of 36-1126 [20].
 - v) Before lagging, all silencers, fittings, etc. shall be painted with heat-resistant, aluminium/zinc-based, high-temperature paints.
 - w) Rubber hoses and belts shall not be painted.
 - x) Exhaust outlets shall either be fitted with a weight-operated rain flap; or, if exiting in a horizontal direction, fitted with a 'bird screen' and appropriately cut at an angle that does not allow rain water to enter the opening.

3.6.9.5 Building fire detection and protection

- a) A fire risk analysis shall be performed to determine suitable fire protection in the building.
- b) Fire protection and detection shall be provided by others if required.
- c) These activities shall comply with 240-54937450, Include Eskom Fire Protection and Life Safety Design Standard and 240-56737448, Eskom Fire Detection and Life Safety Design Standard.

3.6.9.6 Outdoor canopy (if required)

- a) Refer to Schedule A for whether an outdoor canopy is required. If required, the canopy will comply with the following:
 - 1) The canopy shall be sized for the required generator.
 - 2) The canopy shall be constructed of mild steel and epoxy coated or powder coated for a high corrosive environment.
 - 3) The canopy shall be constructed from 3CR12 for a coastal environment.

3.6.9.7 Acoustic canopy (if required)

- a) Under special conditions, an indoor acoustic canopy may be required to reduce the acoustic noise level. The requirement will be specified in Schedule B by the supplier.

- b) If additional damping material is required in addition to the canopy, to curtail the noise, such damping material shall be fire resistant.

3.6.9.8 Control panel

- a) The control panel shall:
- 1) be vermin-proof;
 - 2) have 20% of component mounting space and wire ways available for future additions;
 - 3) include 'closed-cell' neoprene seals throughout to ensure that foreign objects, such as dust and moisture, do not ingress into the enclosure;
 - 4) have an easy means of access to the underside of the gland plates from above floor level;
 - 5) have removable, cadmium-plated, hot-dip galvanized or white painted, steel equipment-mounting panels or chassis, of thickness at least 2 mm;
 - 6) include suitable rigging facilities (eyebolts, lifting brackets, etc.) if required. There shall be no protrusions beyond the bounds of the cubicles;
 - 7) have sufficiently large doors, stiffened if necessary, to permit easy and complete access to the interior.
- b) In addition, the doors shall have:
- 1) one pad-lockable locking mechanism on doors of height < 600 mm;
 - 2) two pad-lockable locking mechanisms on doors of height in the range 600 mm to 1 200 mm;
 - 3) three lockable mechanisms in doors of height > 1 200 mm, one of which is pad-lockable;
 - 4) keepers, if necessary, to keep the door open;
 - 5) corrosion-resistant hinges and handles; and
 - 6) removable, undrilled, cadmium-plated or hot-dip galvanized steel gland plates of thickness at least 2 mm.
- c) Individual component labelling shall be placed on the backing plate.
- d) Fuse bases shall be labelled with the rating of the fuse link that should be fitted into them.
- e) The engine control panel can be mounted to the base frame if additional anti-vibration bolts are used, all components are securely fixed and suitably rated for the vibrations.
- f) Alternatively, the control panel can be mounted separately using 'anti-vibration' fix on the concrete floor to ensure that engine vibrations do not cause unnecessary vibration of the components mounted within the engine.
- g) All relays shall be adequately secured to prevent the relay base from falling out during vibrations.
- h) The wiring between the control panel and the engine-mounted devices shall be resistant to temperature.
- i) Components shall be mounted in the compartments on the equipment mounting plates or chassis, using bolts screwed into tapped holes, or hank nuts that engage at least three full threads.
- j) A DIN mounting rail shall be fixed to the mounting plate or chassis in a similar manner.
- k) Self-tapping screws or bolts with loose nuts shall not be used.
- l) Components shall be spaced at least 10 mm apart when components are dissimilar or intended for flush mounting on front doors and covers.
- m) Equipment manufactured for surface mounting shall not be modified for flush mounting, and shall be labelled exactly in accordance with the drawing or the wiring diagram.

- n) Control transformers shall:
 - 1) Be double-wound isolating transformers with an earth screen between the primary and secondary windings; rated Class 1SANS 61588-1.
 - 2) Have one leg of the secondary winding earthed.
 - 3) Include at least 25% spare output capacity.
- o) Wiring in the assemblies shall be:
 - 1) Run in covered wire duct that is filled to not more than 80% of its capacity.
 - 2) Protected against chafing, with grommets, where it passes through the panel work.
 - 3) Loomed with spiral wrap or alternative protection, and arranged for minimal twisting rather than a bending action where it crosses door hinges and other areas that can move relative to one another.
 - 4) Thermoplastic-insulated or thermosetting-insulated, stranded copper wire. Solid conductors shall not be used.
 - 5) Of cross-sectional area at least 1,5 mm², except for current transformer circuits, where it shall be at least 2,5 mm² and shall be 600 V/1 000 V grade in accordance with [8] SANS 1507.
 - 6) Identified at each end with an indelibly marked, interlocking, slip-on identification ferrule. The number on the ferrule shall be shown on the wiring diagram; adhesive wrap-on type ferrule numbering shall not be used.
 - 7) Terminated at each end with pre-insulated crimp lugs. Lugs shall be crimped on with ratchet type crimping tools that do not release until the crimp is complete.
 - 8) Colour-coded in accordance with [18] 240-56227516.
 - 9) Free from joints or splices.
- p) All terminals shall, as far as possible, be at the front of the control panel, and shall be accessible without it being necessary to disturb wiring or remove components.
- q) All metalwork, including the cabinet, shall be electrically bonded to the earth connection with a conductor of suitable cross-section.

3.7 Marking, labelling and packaging

3.7.1 General

A metal file holder or box shall be provided and attached at a suitable location for the purpose of holding relevant documentation and drawings.

3.7.2 Marking

- a) All water pipes for external cooling circuits shall be clearly and permanently marked at all connection points to indicate the direction of flow.
- b) All drain plugs shall be clearly marked with an identifying colour in accordance with [13] SANS 10140 parts 1 to 3.
- c) Fuel pipes and taps to be clearly marked and labelled.
- d) Battery and DC circuit terminals shall be clearly marked to indicate their polarity.
- e) All timers shall be marked or labelled to indicate their time control range.
- f) Earth connections shall be labelled with a standard earth symbol in black on a yellow background.

3.7.3 Labelling

3.7.3.1 Labels

- a) Labels shall be in English.
- b) Labels shall be indelibly and permanently marked, and shall be securely attached to the equipment.
- c) A label indicating the grade of oil shall be attached to the diesel engine.
- d) All printed-circuit cards shall be clearly identified.
- e) All instruments shall be clearly labelled to indicate their function, and all alarm indicators shall be clearly labelled to indicate the alarm they represent.
- f) Statutory labels required to be attached to building doors, etc. shall be provided and fitted when applicable.
- g) Labels that have red letters on a white background, the lettering being of height at least 10 mm, shall be affixed to all places where danger can exist owing to automatic start-up. The text on these labels shall be in accordance with Table 3:

Table 3: Danger label

<p style="text-align: center;">DANGER</p> <p>THIS MACHINE COULD START WITHOUT NOTICE. BEFORE WORKING ON THE MACHINE, LOCK THE CONTROL SWITCH ON THE CONTROL PANEL IN THE OFF POSITION</p>

- h) A label shall be attached adjacent to each terminal to indicate its function and designation in accordance with the relevant circuit diagram.
- i) A graphic diagram with an electric flash in accordance with type designation WW7 of [7] SANS 1186, and a label indicating the voltage shall be placed near all mains terminals.
- j) Labels may be engraved on sandwich plastic material that is suitable for tropical outdoor use.
- k) Warning and danger labels shall be in red on a white background.
- l) Information and instruction labels shall be in black on a white background.
- m) Devices fitted to the set shall be labelled in accordance with the relevant circuit diagram.
- n) Components shall not be labelled on the component, but on the chassis or printed circuit board adjacent to the component.
- o) Electronic modules shall be labelled to identify them, and the rear connectors shall be keyed to prevent incorrect positioning.

3.7.3.2 Rating plates

- a) All major items of plant shall be provided with corrosion-resistant rating plates.
- b) The following details (where applicable) shall be clearly, legibly and indelibly marked on the plates:
 - 1) manufacturer's name;
 - 2) manufacturer's type number;
 - 3) manufacturer's serial number;
 - 4) year of manufacture;
 - 5) rated engine speed, power, operating altitude;
 - 6) voltage, power factor, frequency, etc.;
 - 7) short-time withstand current, in kilo-amperes (kA), for the maximum time, in seconds;

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- 8) performance class;
 - 9) load acceptance;
 - 10) type of fuel used.
- c) Rating plates shall be permanently fixed in a prominent position on the equipment.

3.7.4 Packaging and shipping

- a) The system shall be suitable packed to prevent damage to the system or any components during transportation to site, and to allow for outdoor storage on site before installation.
- b) The DG System may be shipped as a unit or dismantled (shipped as a unit as far as practically possible).

4. Tests

The customer reserves the right to witness any of the tests set out in this section of the standard. The tests specified in this section of this standard are a minimum requirement and serves to highlight some of the tests to be performed. For a complete list of tests to be done, please see the Annex C for complete checklists.

4.1 Responsibility for testing

- a) The supplier shall be responsible for all tests.
- b) Test shall be performed and certified in accordance with [11] SANS 8528-6 and this section of the standard.
- c) As a minimum, the International Organization for Standardization (ISO) standard functional tests (as specified in [11] SANS 8528-6). Additional acceptance tests to be performed shall be specified in Schedule A.

4.2 Type tests

- a) Type tests shall either be performed after the first unit has been completed, or type test certificates for the offered equipment shall be submitted with the tender documents for evaluation.
- b) If type test certificates are not available it is the responsibility of the *Contractor* to perform these tests at their own cost and supply the relevant type test certificates.
- c) It is the responsibility of the *Contractor* to prove compliance with the required specifications in cases where type tests have previously been performed.

4.3 Insulation resistance testing

- a) An insulation resistance test shall be applied to all circuits that do not contain components such as semiconductor devices, electronic modules and printed-circuit cards.
- b) Printed-circuit cards shall be removed from the connectors prior to testing of circuits.
- c) This test shall be performed in an atmosphere where the relative humidity is not higher than 85%, and shall consist of the following:
 - 1) a test voltage of 2 kV (rms) applied for 1 min for all AC circuits below 1 000 V, between the conductors and any earthed components;
 - 2) a DC test voltage of 500 V applied for 2 min between two separate circuits, using a 500 V resistance tester. The resistance recorded shall exceed 50 MΩ;
 - 3) a test voltage as in 2) above, but between all circuits connected together and the frame;
 - 4) a test voltage of 1 kV (rms) applied for 1 min to all DC circuits.

4.4 Factory acceptance tests

- a) As a minimum, the following Factory Acceptance Tests (FATs) shall be performed:
 - 1) A full functional test of all control and operating systems.
 - 2) A full load test, at the rated kilovolt-ampere (kVA) of the generator, for a period of at least 4 h.
- b) The full load test should be followed immediately by any overload capacity test as specified. During this test, the following shall be recorded at 10 min intervals:
 - 1) engine temperature;
 - 2) engine oil pressure;
 - 3) generator voltage;
 - 4) generator frequency; and
 - 5) generator current.
- c) The DG shall be capable of performing a single load step equal $\geq 50\%$ of the continuous kilowatt (kW) rating of the machine while remaining within operating limits.
- d) The DG shall be capable of performing a single load step equal to 110% of the most severe single step load in the plant design profile. The DG shall accept the load without voltage collapse or engine stalling, and recover to normal operating speed. The supplier shall document the voltage and frequency deviation observed.
- e) The supplier shall provide the customer with copies of the following:
 - 1) The engine manufacturer's test results, clearly indicating the specified performance.
 - 2) The generator manufacturer's test results, clearly indicating the specified performance.
 - 3) A pressure test of the air receiver of the compressed-air starter system, if a compressed air starter is used.
 - 4) A pressure and functional test of the air valves included in the compressed-air starter system, if a compressed air starter is used.
- f) The supplier shall perform a simulated function test of the control panel.
- g) Test results shall indicate that the performance at the specified site altitude meets the requirements of [3] ISO 3046.

4.5 Site acceptance tests

- a) On completion of the installation, the following Site Acceptance Tests (SATs) shall be performed:
 - 1) A full Functional test and Acceptance test of all control and operating conditions.
 - 2) A load test utilizing the available site load and under the load parameters given will be done until it is established that the engine temperature is stable for at least 20 min and all parameters are within the specified limits.
- b) During the load test, the following shall be recorded at 10 min intervals:
 - 1) engine temperature;
 - 2) engine oil pressure;
 - 3) generator voltage;
 - 4) generator frequency; and
 - 5) generator current.

- c) The equipment shall perform in accordance with the requirements as specified; and the noise produced by the engine/generator set shall comply with the noise levels as specified.
- d) The following tests shall then be performed:
- 1) Battery discharge test.
 - 2) Battery charger test.

5. Spares holding and availability

Spares availability shall be guaranteed to be locally available for a period of at least 10 years after delivery within a turn-around time of 48 hours.

6. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Danie Odendaal	Engineering SGM (Acting)
Prince Moyo	Power Delivery Engineering GM
Richard McCurrach	Senior Manager – PTM&C CoE
Amelia Mtshali	Metering, DC & Security Technologies Manager (Acting) – PTM&C CoE
Prudence Madiba	Senior Manager Electrical and C&I Engineering
Phera Rakeketsi	Middle Manager – Electrical Plant COE
Thomas Jacobs	DC & Auxiliary Supplies SC Chairperson

7. Revisions

Date	Rev	Compiler	Remarks
Nov 2016	2	D J Oosthuizen	<p>Some numbering changes</p> <p>In section 2.2.1 standard numbers updated</p> <p>In section 2.3.1 Additional definitions added</p> <p>In section 3.3 cooling specified in more detail</p> <p>In section 3.4 expected design life increased</p> <p>In section 3.5 removed some requirements</p> <p>In section 3.6.1.1 Added option for tenderer on alternative cooling methodologies</p> <p>In section 3.6.1.3 Added the option of mechanical governor and added a table for guidance on governor type selection</p> <p>In section 3.6.2.2 additions were made with respect to permanent magnet excitation</p> <p>In section 3.6.2.4 reference was made to SANS 60034-1 and added requirements</p> <p>In section 3.6.2.5 some wording was changed</p> <p>In section 3.6.2.6 reference was made to section 3.6.1.2</p> <p>In section 3.6.2.7 bearing requirement removed and the insulation class was specified</p> <p>Section 3.6.3.2 was made applicable only to generator sets with synchronising capabilities</p> <p>Section 3.6.3.3 for generator sets without synchronising capabilities was added</p> <p>In section 3.6.3.4 (previously 3.6.3.3) additional requirements given for analogue metering panels and generally</p> <p>Section 3.6.3.5 (previously 3.6.3.4) was made applicable only to generator sets with synchronising capabilities and diff pressure alarm added</p> <p>Section 3.6.3.6 for generator sets without synchronising capabilities was added</p> <p>Section 3.6.3.7 was previously section 3.6.3.5</p> <p>Section 3.6.3.8 was previously section 3.6.3.6 and some alarm description/s changed</p> <p>In section 3.6.4.2 some wording changed</p> <p>Section 3.6.4.3 changed to accommodate Gx specific requirements and elaboration</p> <p>In section 3.6.6 (Previously 3.6.5.1) some wording changes</p> <p>In section 3.6.6.2 (previously 3.6.5.3) some wording changes and removals</p> <p>In section 3.6.7 (previously 3.6.6.4) some removals</p> <p>Technical Schedules updated to be in line with clauses of the standard</p> <p>Added Annex B: DG Test Check Sheet</p> <p>Section on spares holding and availability added</p>

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Date	Rev	Compiler	Remarks
Dec 2014	1	L E Spies	First issue

8. Development team

This standard is a revised edition of the original standard compiled by Leon Spies and his development team. The following people were involved in compiling the new document:

- Daniel Oosthuizen
- Thomas Jacobs
- Christine van Schalkwyk
- Fred Claassens
- David Kunene
- Welman van Niekerk

9. Acknowledgements

Not applicable.

Annex A – Scope of Works

ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
AB.0	Qualification				
AB.0.1	Local Agent Representation required	Yes (Provide Details)	Yes / No		
AB.0.2	Number of Years local representative exists in South Africa	Yes	Years		
AB.0.3	Supply Reference list with installations (Projects), designs and MVA size duration, location, contract persons	Yes	Yes / No		
AB.0.4	Compliance with SANS (ISO) 9001:2008 required	Yes	Yes/No		
AB.0.5	The Diesel Generators are to built in accordance with SANS 8528-All Parts	Yes	Yes/No		
AB.1	Supplier / Agent Details				
AB.2	OEM Details	Specify			
AB.3	The Works				
AB.3.1	Number of Diesel Generator Sets required				
AB.3.2	Name of Diesel Generator Set Manufacturer (Also indicate if Local / Foreign)	Specify			
AB.3.2.1	Engine brand	Specify			
AB.3.2.2	Alternator brand	Specify			
AB.3.3	Factory Test	Yes	Yes / No		
AB.3.4	Install and Erect	Yes	Yes / No		
AB.3.5	Site test and Commission	Yes	Yes / No		
AB.3.6	Install Fire Protection System	No	Yes / No		
AB.3.7	Perform Fire Risk Analysis	Yes	Yes / No		

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Annex B – A/B Technical Schedules

NB:	This Technical schedule shall be completed in conjunction with reading the applicable detailed corresponding clause/s in the abovementioned standard. It is critical that references to supporting documentation (document title, page number and clause / paragraph no.) that confirm compliance shall be clearly indicated on the Technical Schedules in the "Reference" column.				
	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
3	REQUIREMENTS				
3.1	General				
a)	Comply with requirements of SANS 8528	SANS 8528			
b)	Order of precedence for deviations	As specified			
c)	Vibrations and noise	SANS 60034 and BS 5514-5			
d)	Compliance to OHSAct	Yes - as specified			
3.2	Application and operating philosophy				
a)	Application - sites				
b)	Installation configuration	Fixed			
c)	Primary application	Extended backup			
d)	AC Generating sets	Yes - as specified			
3.3	Site Conditions				
a)	Site location - Drop down list	Other			
	Site location - Other				
b)	Information	As specified			
c)	Location of generator	Outside Installation with Protection			
d)	Maximum ambient temperature	50	°C		
e)	Information				
f)	1) Minimum ambient temperature	-10	°C		
	2) Altitude	1753	m		

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ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
	3) Humidity	30 - 80	%		
	4) Air quality (dust or sand)	Dust			
	5) Marine environment	No			
	6) Shock and imposed vibration	No			
	7) Chemical pollution	No			
	8) Radiation	No			
	9) Cooling water/liquid	N/A			
3.4	Reliability				
a)	Expected operating life	35	yrs		
b)	Deviations	Specify			
3.5	Maintainability				
a)	Low maintenance	Yes	Yes/No		
b)	Ergonomics	Yes - as specified			
c)	Modular assemblies	Yes - as specified			
d)	Component condition monitoring and alarming	Yes - as specified			
e)	Spares and parts availability	Yes - as specified			
f)	Warranty	2			
3.6	System definition				
	Single OEM Diesel Generator Set	Yes - as specified			
3.6.1	Diesel Engine (prime mover)				
3.6.1.1	General				
a)	Diesel Engine Type	Diesel fuelled			
		Cold start			

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
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ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
		Water / Air cooled			
	Alternative cooling methodology - benefits and cost	Specify			
b), c), d)	Specific Fuel / Oil consumption - ISO 3046-1	Yes - as specified			
		-			
3.6.1.2	Rating				
a)	Engine rating suitable for alternator of this size		kVA		
b)	Start-up time	Specify	s		
c)	Ability to deliver full load	As specified			
d)	De-rating in accordance with ISO 3046-1	As specified			
e)	DG performance classification - SANS 8528-1	Emergency Standby Power (ESP)			
f)	Mounting type	Fully Resilient			
g)	Performance Class	Class G3			
h)	Duty type (S1 if not specified)	S1			
i)	Power rating at rated frequency and pf = 0.8 (lag).		kW		
j)	Engine output power	As specified			
k)	Diesel Generator (DG) operating under varying pf's (0.8 lag - 1)	Yes - as specified			
l)	DG single step load handling ability (≥ 50%)	Yes - as specified			
m) - n)	DG single step load handling ability (110%)	Yes - as specified			
o)	Voltage and frequency deviation observed for m) - n)	Specify			
p)	Supply altitude related de-rating graphs	Yes - as specified			
3.6.1.3	Governor				

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
a)	Governor type	Electronic			
b)	PI / PID governor	Proportional Integral Differential (PID)			
3.6.1.4	Speed - 1500 rpm preferred	Specify	rpm		
3.6.1.5	Emissions				
	Noise at 1 m	90	dbA		
	Other emissions	As specified			
3.6.2	Alternator				
3.6.2.1	Type				
a)	Brushless type	As specified			
b)	Duty type (S1 if not specified)	S1			
3.6.2.2	Excitation				
a)	Permanent magnet / AVR	Both are acceptable			
b)	Series current boost	As specified			
3.6.2.3	Heaters				
a)	Anti-condensation heater elements	Yes - As specified			
b)	Approved heater	As specified			
c)	Heater's power requirement	Specify	W		
3.6.2.4	Power output				
a)	Required output power		kVA		
	Power factor	0.8			

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
b)	Short circuit rating	Specify	kA		
c)	Alternator efficiencies	Yes - as specified			
		-			
3.6.2.5	Loading				
a)	Starting sequence and load schedules	Not available			
b)	1) Linear loads	Yes	Yes/No		
	2) Non-linear loads	Yes	Yes/No		
3.6.2.6	Voltage and frequency				
a)	Base Frequency	50	Hz		
	Continuous frequency operating range	48.5 to 51.5	Hz		
	Frequency deviation not more than 10 minute per incident	48 to 52	Hz	XXXXXXXXXXXXXX	
	Frequency deviation not more than 1 minute per incident	47.5 to 52.5	Hz		
	Total Harmonic Distortion (THD) of HV side Voltage and % even harmonics	XXXXXXX	% / %		
	Adjustment Range on terminal voltage	±2.5	%		
	Adjustment range of terminal frequency	±1.5	%		
	Waveform deviation factor limit	<10	%		
	Total Harmonic Distortion relative to the fundamental	<5	%		
	Percentage of any one harmonic relative to the fundamental	<3	%		
b) - c)	Output performance	As specified			
3.6.2.7	Type of construction				
a)	Alternator cooling	Air-cooled			

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
b)	Alternator insulation class	Class H with Class B temperature rise			
3.6.3	Control, monitoring, alarms, indications and switchgear				
3.6.3.1	General				
a)	Electrically fail-safe	Comply			
b)	Powered from DC	Comply			
c)	Operate on Alarm-only and Alarm-Shut down	Alarm and shutdown			
d)	Date and time-stamped data	Comply			
3.6.3.2	Control panel controls: Synchronising Generators	List			
a)	Local control functions	As specified			
b)	Control panel functions:	As specified			
1)	Local Start	Yes	Yes/No		
2)	Local Stop	Yes	Yes/No		
3)	Emergency Stop	Yes	Yes/No		
4)	Raise/Lower Load (when synchronized)	Yes	Yes/No		
5)	Raise/Lower Volt-Ampere Reactive (VAR)	Yes	Yes/No		
6)	Breaker Selection (Generator or Paralleling)	Yes	Yes/No		
7)	Initiate Sync Command	Yes	Yes/No		
8)	DG Breaker Trip and Close Functions	Yes	Yes/No		
9)	Auto/Manual Start	Yes	Yes/No		
10)	Raise/Lower Voltage	Yes	Yes/No		
11)	Raise/Lower Speed	Yes	Yes/No		
12)	Alarm Accept/Test/Reset	Yes	Yes/No		

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
13)	Lamp Test	Yes	Yes/No		
14)	Local/Remote Control/Maintenance	Yes	Yes/No		
15)	Generator Bus Breaker (if parallel units)	Yes	Yes/No		
c)	Sync function	As specified			
d)	Manual sync capability	N/A		XXXXXXXXXX	XXXXXXXXXX
3.6.3.3	Control panel controls: Non - Synchronising Generators	List			
a)	Local control functions	As specified			
b)	Control panel functions:	As specified			
1)	Local Start	Yes	Yes/No		
2)	Local Stop	Yes	Yes/No		
3)	Emergency Stop	Yes	Yes/No		
4)	DG Breaker Trip and Close Functions	Yes	Yes/No		
5)	Auto/Manual Start	Yes	Yes/No		
6)	Alarm Accept/Test/Reset	Yes	Yes/No		
7)	Lamp Test	Yes	Yes/No		
8)	Local/Remote Control/Maintenance	Yes	Yes/No		
3.6.3.4	Control panel features				
a) 1)	Alternating Current (AC) Metering panel	Digital HMI			
	Output voltage / phase	Yes	Yes/No		
	Output current / phase	Yes	Yes/No		
	Output frequency	Yes	Yes/No		
	Power factor	Yes	Yes/No		
	Delivered output power	Yes	Yes/No		
a) 2)	System parameters view and adjust	Yes - as specified			

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
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ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
a) 3)	Date-time stamped events (min. of 100)	Yes - as specified			
a) 4)	LED Status Lamps:	Yes - as specified			
	Remote start command	Yes	Yes/No		
	Not in Auto	Yes	Yes/No		
	Warning	Yes	Yes/No		
	Shutdown	Yes	Yes/No		
a) 5)	Exercise switch	Yes - as specified			
a) 6)	Fault reset switch	Yes - as specified			
b) 1)	Emergency stop push-button	Yes - as specified			
b) 2)	Key-type mode selector switch	Yes - as specified			
3.6.3.5	Remote Control System interface: Synchronising Generators				
a)	Remote input (control) signals:				
1)	Remote Start Command Control	Yes	Yes/No		
2)	Remote Stop Command Control	Yes	Yes/No		
3)	Initiate Sync Command Control	Yes	Yes/No		
4)	Select Generator Breaker for Sync Control	Yes	Yes/No		
5)	Select Paralleling Breaker for Sync Control	Yes	Yes/No		
6)	Generator Breaker Close Command	Yes	Yes/No		
7)	Paralleling Breaker Close Command	Yes	Yes/No		
8)	Generator Breaker Open Command	Yes	Yes/No		
9)	Paralleling Breaker Open Command	Yes	Yes/No		
10)	Emergency Mode (disabled engine trips) Control	Yes	Yes/No		
b)	Remote output signals (indications):				
1)	Control Mode (local/remote/maintenance)	Yes	Yes/No		
2)	Engine Running	Yes	Yes/No		
3)	Load kW (analogue)	Yes	Yes/No		

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
4)	VARs (analogue)	Yes	Yes/No		
5)	Ready to Load	Yes	Yes/No		
6)	Ready to Start	Yes	Yes/No		
7)	Common Alarm	Yes	Yes/No		
8)	Shutdown Alarm	Yes	Yes/No		
9)	Generator Breaker Status Indication (Closed / Open)	Yes	Yes/No		
10)	Paralleling Breaker Status Indication (Closed / Open)	Yes	Yes/No		
11)	Generator Voltage/s (analogue)	Yes	Yes/No		
12)	Bus Voltage (reference for testing)	Yes	Yes/No		
13)	Paralleling Source Voltage (reference for return after power outage)	Yes	Yes/No		
14)	Air filter differential pressure alarm	Yes	Yes/No		
c)	I/O requirements - if not specified above				
1)	8 × Digital inputs.	Yes	Yes/No		
2)	2 × Analogue inputs.	Yes	Yes/No		
3)	16 × Digital outputs.	Yes	Yes/No		
4)	4 × Analogue outputs.	Yes	Yes/No		
3.6.3.6	Remote Control System interface: Non-synchronising Generators				
a)	Remote input (control) signals:				
1)	Remote Start Command Control	Yes	Yes/No		
2)	Remote Stop Command Control	Yes	Yes/No		
3)	Generator Breaker Close Command	Yes	Yes/No		
4)	Generator Breaker Open Command	Yes	Yes/No		
5)	Emergency Mode (disabled engine trips) Control	Yes	Yes/No		
b)	Remote output signals (indications):				
1)	Control Mode (local/remote/maintenance)	Yes	Yes/No		
2)	Engine Running	Yes	Yes/No		
3)	Load kW (analogue)	Yes	Yes/No		

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
4)	VARs (analogue)	Yes	Yes/No		
5)	Ready to Load	Yes	Yes/No		
6)	Ready to Start	Yes	Yes/No		
7)	Common Alarm	Yes	Yes/No		
8)	Shutdown Alarm	Yes	Yes/No		
9)	Generator Breaker Status Indication (Closed / Open)	Yes	Yes/No		
10)	Generator Voltage/s (analogue)	Yes	Yes/No		
c)	I/O requirements - if not specified above				
1)	8 × Digital inputs.	Yes	Yes/No		
2)	2 × Analogue inputs.	Yes	Yes/No		
3)	16 × Digital outputs.	Yes	Yes/No		
4)	4 × Analogue outputs.	Yes	Yes/No		
3.6.3.7	Diesel generator control panel indications				
a)	Local indications:				
1)	Control system in remote mode.	Yes	Yes/No		
2)	Control system in local.	Yes	Yes/No		
3)	DG control system healthy.	Yes	Yes/No		
4)	Diesel engine ready to accept load.	Yes	Yes/No		
5)	Main DC supply healthy.	Yes	Yes/No		
6)	Backup DC supply healthy (if required).	Yes	Yes/No		
7)	Generating kVAr (kilovolts-ampere reactive), kW (kilowatt), Volts, Frequency and Amps are displayed on digital instruments.	Yes	Yes/No		
8)	Starter battery charger voltage and current.	Yes	Yes/No		
9)	Engine running hours.	Yes	Yes/No		
10)	Fuel level.	Yes	Yes/No		
11)	Engine temperature.	Yes	Yes/No		
12)	Oil pressure.	Yes	Yes/No		

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
3.6.3.8	Diesel generator annunciator alarms				
a)	Local alarms:				
1)	Diesel engine start failure	Yes	Yes/No		
2)	Low engine oil pressure	Yes	Yes/No		
3)	Low radiator water level	Yes	Yes/No		
4)	Engine over speed	Yes	Yes/No		
5)	Engine air flaps closed	Yes	Yes/No		
6)	Emergency stop activated	Yes	Yes/No		
7)	Generator field breaker tripped	Yes	Yes/No		
8)	Fuel tank < 5%	Yes	Yes/No		
9)	Fuel tank < 20%	Yes	Yes/No		
10)	Fuel tank < 50%	Yes	Yes/No		
11)	Fuel tank leak alarm	Yes	Yes/No		
12)	Fire alarm	Yes	Yes/No		
13)	Protection trip	Yes	Yes/No		
14)	High engine temperature	Yes	Yes/No		
15)	Low engine temperature	Yes	Yes/No		
16)	High bearing temperature	Yes	Yes/No		
17)	Stator temperature	Yes	Yes/No		
18)	Under frequency	Yes	Yes/No		
19)	Abnormal voltage	Yes	Yes/No		
20)	Low starter battery voltage	Yes	Yes/No		
21)	Charger fail	Yes	Yes/No		
22)	Auxiliary supply fail	Yes	Yes/No		
23)	Fuel transfer scheme failure	Yes	Yes/No		
24)	Water in fuel alarm	Yes	Yes/No		
25)	Synch. failure	Yes	Yes/No		
26)	DC failure	Yes	Yes/No		

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
27)	Generator breaker tripped	Yes	Yes/No		
b)	Remote Control System - Repeated alarms				
1)	Engine protection tripped alarm	Yes	Yes/No		
2)	Engine protection delayed time before trip will occur alarm	Yes	Yes/No		
3)	Engine protection alarm	Yes	Yes/No		
3.6.3.9	Safety features				
a) 1)	Fail-safe engine stop solenoid	Yes - as specified			
a) 2)	Emergency stop push-button on engine	Yes	Yes/No		
a) 3)	Emergency stop push-button on the control panel	Yes	Yes/No		
a) 4)	Remote emergency shutdown capability	Yes	Yes/No		
a) 5)	Over speed protection	Yes	Yes/No		
a) 6)	Full automatic mode	Yes	Yes/No		
a) 7)	DG No load rundown functionality	Yes - as specified			
3.6.3.1 0	Control system functionality				
a)	Emergency stop	Yes - as specified			
b)	Automatic Voltage Regulator (AVR)	Yes - as specified			
c)	Operation as per URS functionality	Yes - as specified in Employer's Specification for Works			
3.6.3.1 1	Alarms and Indications				
a)	Manually cancelled alarms	Yes - as specified			
b)	Alarm display	Yes - as specified			
c)	Common 'Alarm Reset' push-	Yes - as specified			

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
d)	Lamp Test facility	Yes - as specified			
e)	Potential-free changeover contact.	Yes - as specified			
3.6.3.1 2	Assemblies, Terminals, wiring and cabling	As specified			
a)	LV switchgear and control gear	Yes - as specified			
b)	Distribution Boards compliance	Yes - as specified			
c)	Terminals	Yes - as specified			
d)	Terminal markings	Yes - as specified			
e)	Heat-resistant insulation (silicon wire)	Specify if applicable			
3.6.4	Auxiliaries				
3.6.4.1	Cooling				
a)	Radiator	Yes - as specified			
b)	Engine mounted fan or electric fan	Specify			
c)	Water jacket heaters	Yes - as specified			
d)	Heater element controls and alarm	Yes - as specified			
3.6.4.2	Starting				
a)	Starting method	Electric			
b)	Electric motor start philosophy	Yes - as specified.			
b) 1)	Start Initiation option 1	Yes	Yes/No		
b) 2)	Start Initiation option 2	No	Yes/No		
c)	Start failure alarm / indication	Yes - as specified.			
3.6.4.3	Batteries				
a)	Battery type	UHP Nickel Cadmium			

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
b) - c)	Battery performance	Yes - as specified			
d) - g)	Battery charging and system	Yes - as specified			
3.6.4.4	Battery charger				
a)	230Vac or 400V ac	Yes - as specified			
b) - c)	Charger performance	Yes - as specified			
d)	Battery charging and system	Yes - as specified			
3.6.5	Fuel system				
3.6.5.1	General				
a)	Tanks	Specify based on application			
b)	Tank capacity - runtime at full load	12	hrs		
c)	OHSA compliance	Yes - as specified			
d)	Fuel line materials	Yes - as specified			
e) - i)	Water separation and alarm	Yes - as specified			
3.6.5.2	Fuel injection				
a)	Fuel system	Common rail			
b)	Fuel system priming	Yes - as specified			
c)	Injector cooling	Yes - as specified			
d)	Engine-stop solenoid	Yes - as specified			
e)	Fire detection and protection	Yes - as specified			
3.6.5.3	Day fuel tank				
a)	Day fuel tank required	Yes - as specified			
b)	Construction	Yes - as specified			

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
c)	Capacity	4	hrs		
d)	Wall construction and leak detection	Yes - as specified			
e)	Alarm - fuel level sensors	Yes - as specified			
f)	Alarm contacts from fuel level sensors	Yes - as specified			
g)	Gravity feed from bulk storage tank	Yes - if applicable			
h)	Drain valve	Yes - as specified			
i)	Intake and shut-off	Yes - as specified			
j)	Overflow	Yes - as specified			
k)	Filler pipe	Yes - as specified			
l)	Inspection facilities	Yes - as specified			
m)	No farm tank allowed for fuel storage	Comply			
3.6.5.4	Bulk fuel tank	Yes - as specified (if applicable)			
3.6.5.5	Diesel fuel	Yes - as specified			
3.6.6	Lubrication				
a)	Oil pressure gauge, oil pressure sensor and switch positioning	Yes - as specified			
b)	Oil pressure sensor integration	Yes - as specified			
c)	Oil filter running hours	250	hrs		
d)	Oil filter accessibility	Yes - as specified			
e)	Bearings and other moving parts	Yes - as specified			
f)	Semi-rotary hand-operated sump drain pump	Yes - as specified			
g)	Motor driven oil pump	Specify			
h)	Oil label	Yes - as specified			

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	Legend:	Dropdown: User to select		Tenderer to state level of compliance	Tenderer to insert reference material
		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
i)	Separate oil cooler	Specify			
j)	Crank case breather	As specified			
3.6.7	Aspiration and cooling air intake				
a)	Dry type air filter	Yes - as specified			
b) - c)	Minimize intake of dust, vermin, etc.	Yes - as specified			
d)	Water drainage possible	Yes - as specified			
e)	Easy maintenance	Yes - as specified			
f)	'Differential pressure high' switch	Yes - as specified			
g)	Minimise intake of exhaust gasses and hot air	Yes - as specified			
3.6.8	Earthing				
3.6.8.1	General				
a) - c)	Reason for earthing	Information			
d)	Earth connection point in building	Yes - as specified			
e)	Generator set earthing requirements	Specify			
3.6.8.2	Generator neutral earthing				
a) - b)	Information	XXXXXX			
c)	Neutral earthing method	Solid earthing			
d)	Generator earth fault protection	Specify			
3.6.8.3	Earth and bonding of components				
a) - b)	Earth cable size	As specified			
c)	Conductor material	Specify			
d)	Battery negative earthing	Yes - as specified			
e) - f)	DG frame earthed	Yes - as specified			

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
g)	Tank earthing facility	Yes - as specified			
h)	Junction boxes	Yes - as specified			
i)	Junction boxes - IP rating	IP54			
3.6.8.4	Enclosures				
a)	Enclosure IP rating	IP54			
b)	Doors and cable entry	Yes - as specified			
c) - g)	Earth connections	Yes - as specified			
h) - i)	Gland plates	Yes - as specified			
j) - l)	Bonding	Yes - as specified			
3.6.9	Mechanical build				
3.6.9.1	Coupling				
a)	Direct coupling	Specify			
b)	Double bearings	As specified			
3.6.9.2	Base frames				
a)	Simplex frame	Yes - as specified			
b)	Overall frame dimensions	Specify	m		
c)	Lifting provisions	Yes - as specified			
d)	Maximum overall mass	Specify	kg		
e)	Oil drip tray	Yes - as specified			
3.6.9.3	Vibration damping				
a)	SANS 8528	Yes - as specified			
b)	Mounting details	Specify			

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
3.6.9.4	Exhaust system				
a) - f)	Design and positioning	Yes - as specified			
g)	Max noise level (at 1 m)	90	dBA		
h)	Internal exhaust system material	Aluminized steel			
i) - k)	External exhaust system, cowling, expansion bellows material	Stainless steel			
l) - r)	Joints, welding, lagging, construction	Yes - as specified			
s)	Protected lagging	Yes - as specified			
t)	Safety guards	Yes - as specified			
u) - w)	Painting	Yes - as specified			
v)	Exhaust outlet cover	Yes - as specified			
3.6.9.5	Building fire detection and protection				
a)	Fire risk analysis included	No	Yes/No		
b)	Fire protection and detection included	No	Yes/No		
c)	Fire protection and detection standards	As specified			
3.6.9.6	Outdoor canopy				
a) 1)	Size	Yes - as specified			
a) 2)	Material and protective coating - Mild steel	Yes - as specified			
a) 3)	Material and protective coating - 3CR12	No	Yes/No		
3.6.6.7	Acoustic canopy	If required			
3.6.6.8	Control panel				
a) 1) - 7)	Construction, layout and material	As specified			

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
b)	Doors	As specified			
c) - d)	Component labelling	Yes - as specified			
e) - f)	Mounting	As specified			
g)	Relay mountings	As specified			
h)	Heat resistant wiring	Yes - as specified			
i) - m)	Mounting of components	As specified			
n)	Control transformers	As specified			
o)	Wiring in assemblies	As specified			
p)	Terminals	As specified			
q)	Bonding	As specified			
3.7	Marking, labelling and packaging				
3.7.1	General - metal box with documentation	Yes - as specified			
3.7.2	Marking				
a)	Water pipes	Yes - as specified			
b)	Drain plugs	Yes - as specified			
c)	Fuel pipes and taps	Yes - as specified			
d)	Battery and DC circuit terminals	Yes - as specified			
e)	Timers - time control range	Yes - as specified			
f)	Earth connections	Yes - as specified			
3.7.3	Labelling				
3.7.3.1	Labels				
a)	English	Yes - as specified			
b)	Indelibly and permanently marked	Yes - as specified			
c)	Oil label	Yes - as specified			

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
d)	Printed-circuit cards	Yes - as specified			
e)	Instruments	Yes - as specified			
f)	Statutory labels	Yes - as specified			
g)	Danger labels	Yes - as specified			
h)	Terminals	Yes - as specified			
i)	Electric flash graphic	Yes - as specified			
j)	Engraving	Yes - as specified			
k)	Warning and danger labels	Yes - as specified			
l)	Information and instruction labels	Yes - as specified			
m)	Labelling correspond to circuit diagram	Yes - as specified			
n)	Components	Yes - as specified			
o)	Electronic modules	Yes - as specified			
3.7.3.2	Rating plates				
a)	Corrosion resistant	Yes - as specified			
b)	Details	Yes - as specified			
c)	Permanently fixed	Yes - as specified			
3.7.4	Packaging and shipping				
a)	Protective packaging	Yes - as specified			
b)	Shipped as a unit	Yes - as specified			
4	Tests				
4.1	Responsibility for testing				
a)	Supplier responsible for all tests	Yes - as specified			
b)	Tests in accordance to SANS 8528-6 and tests included in this standard	Yes - as specified			

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
c)	ISO functional tests	Yes - as specified			
4.2	Type tests				
a)	Type test certificates	Submit with tender			
b)	Type testing where certificates are not available	Yes - as specified			
c)	Proof of compliance	Yes - as specified			
4.3	Insulation resistance testing				
a) - b)	Precautionary measures	As specified			
c) 1)	2 kV (rms) applied for 1 min - AC circuits	Yes - as specified			
c) 2)	DC test voltage of 500 V applied for 2 min - Test 1	Yes - as specified			
c) 3)	DC test voltage of 500 V applied for 2 min - Test 2	Yes - as specified			
c) 4)	1 kV (rms) applied for 1 min - DC circuits	Yes - as specified			
4.4	Factory acceptance tests				
a) 1)	Full functional test of all control and operating systems	Yes - as specified			
a) 2)	Full load test - 4 hours	Yes - as specified			
b)	Readings to be taken during load test	Yes - as specified			
c)	Single load step - continuous kW rating	≥ 50	%		
d)	Single load step - most severe single step load	≥ 110	%		
e)	Documentation to be provided	Yes - as specified			
f)	Simulated control panel functional test	Yes - as specified			
g)	Test results at specified altitude	Yes - as specified			
4.5	Site acceptance tests				

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		User to insert requirement			
ITEM	DESCRIPTION	SCHEDULE A	Unit	Stationary Diesel Generator	
				SCHEDULE B	Reference
a) 1)	Full functional test of all control and operating systems	Yes - as specified			
a) 2), c)	Site load test - 20 min	Yes - as specified			
b)	Readings to be taken during load test	Yes - as specified			
d) 1)	Battery discharge test	Yes	Yes/No		
d) 2)	Battery charger test	Yes	Yes/No		
5	Spares holding and availability	Yes - as specified			

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Annex C – DG Test Check Sheet

Factory Checklist

Project Number:	
Contracts Engineer:	
Site:	

	Checklist	Signature	Date
1	Engine - check if correct		
2	Alternator - check if correct		
3	Coupling / Flex plate bolts		
4	Crank Shaft End Float		
5	Engine Mounting Bolts		
6	Alternator Mounting Bolts		
7	AVM Bolts		
8	Mount Heater		
9	Mount Fuel Tank		
10	Mount Water Trap		
11	Mount Electric Fuel Pump		
12	Mount Wing Pump		
13	Mount Sump Drain Pump		
14	Sump Drain Valve		
15	Electronic Governor		
16	Control Panel		
17	Exhaust System		
18	Exhaust System Stand		
19	Fuel Lines		
20	Fire Fuse		
21	Check Water Hose Clamps		
22	Check Fuel Hose Clamps		
23	Check Oil Hose Clamps		
24	Check Air Hose Clamps		
25	Lagging		
26	Battery Stand		
27	Drip Tray		

	Checklist	Signature	Date
28	Radiator Stub Duct		
29	Nalcool and Water		
30	Oil		

The above test checked and verified by:

Full Name	Signature	Date



Generator Test Sheet

(Factory Altitude 1750m.A.S.L.)

Site:		Project No.:
Represented By:		

Set Size	kVA	kW	V	P.F.	Set No:
Engine Make		Model No.		Serial No.	
Alternator Make		Model No.		Serial No.	
Control Unit Type				Serial No.	

Recorded Load Test Data

Time In Minutes	Recorded Readings					Rad. Air Temp.		Charge Alt. (Amp)	Water Temp	Engine Oil	
	Volt	Amp	Hz	kW	PF	In	Out			Pressure	Temp
0											
10											
20											
30											
40											
50											
60											
70											

Protection Circuits Tested

No.	Description	Sign	No.	Description	Sign
1	High Engine Coolant Temperature		11	Faulty Switch Position	
2	Low Oil Pressure		12	Low Water Level	
3	Underspeed		13	Emergency Stop	
4	Overspeed		14		
5	Alternator Abnormal Voltage		15		
6	Overload		16		
7	Overspeed Governor Locked		17		
8	Battery Charger Failure		18		
9	Low Fuel Level		19		
10	Engine Start Failure		20		

Important Data

Governor Type:			Serial No.:		Voltage:					
Engine Water Heater Rating:					kW	Thermostat Setting:	°C			
Alt. Circuit Breaker O/L Trip Setting:			Magnetic:		%	Therm.	%			
Mains Volt Monitor Trip Settings:			Over:		%	Under:	%			
Alt. Volt Monitor Trip Settings:			Over:		%	Under:	%			
Battery Charger:			Voltage Limit:		V	Current Limit:	A			
Start Delay:		SEC.	Supply C/O Delay:	SEC.	Stop Delay:		SEC.			
Dummy Load Rating:		Kw	Operating Stages:		Manual	Automatic				
Stage One:		On.	A	Off:	A	Stage Two:	On:	A	Off:	A

Notes:

	Full Name	Signature	Date
Q C Inspector			
Contracts Engineer			
Consultant			
Customer			

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Quality Control Snag List

Site:	
Project No.	
Contracts Engineer	

Item	Description	Rectified	
		Y	N
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

	Full Name	Signature	Date
List Compiled By:			
List Issued To:			
Date Issued:			
List Received By:			
Date Received:			
Photographs Attached		Y	N

Additional Comments

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Test Bay Checklist

Project No.: _____

Site: _____

Date: _____

1	Confirm that the correct product drawings are used		
2	Check quality manufactured		
3	Confirm ratings to be tested		
4	Check water level		
5	Add inhibitor to cooling system where applicable (10% anti-freeze by volume)		
6	Check oil level (on maximum mark)		
7	Adjust oil make-up tank		
8	Check all gate valves		
9	Tighten all hose clamps		
10	Check "V" belt tension		
11	Check magnetic pickup locknut and plugs		
12	Check heater connections		
13	Adjust heater thermostat to 55° C		
14	Check terminal connections on engine control panel and governor.		
15	Check cable connections on battery and starter motor		
16	Check if correct lugs (HD 70) and boots are fitted		
17	Check cable connections on alternator		
18	Check cable connections in control panel		
19	Check terminal connections in control panel		
20	Check dummy load connections		
21	Check auxiliary supply	R/N	Volt
		Y/N	Volt
		B/N	Volt
22	Check mains sensing supply	R/N	Volt
		Y/N	Volt
		B/N	Volt
24	Check mains phase rotation (Cross out appropriate block)	Clockwise	
		Anti-clockwise	
25	Zero all indicating meters		
26	Switch on auxiliary supply circuit breaker		
27	Check operation of engine heater		
28	Check operation of battery charger		
29	Check adjustments of fuel solenoid		
30	Check adjustments (mechanical) of electronic governor		
31	Start engine in override		
32	Check correct functioning of all gauges		
33	Measure and adjust alternator Voltage to nominal value	R/N	Volt
		Y/N	Volt
		B/N	Volt

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Test Bay Checklist

34	Adjust alternator frequency		
	Mechanical governor (no load)	51,5 HZ	
	Electronic governor	50,0 HZ	
35	Check alternator phase rotation and correct if necessary	Clockwise	
	(Cross out appropriate block)	Anti-clockwise	
36	Program controller to requirement of drawings (To be signed off by Programmer)		
37	Test functioning of all alarms		
38	Test system with duty selector in "Manual" position		
39	Check correct functioning of all meters on switchboard		
40	Mains failure in "Auto" position		
41	Test dummy load operation		
42	Check for fuel / oil / water leaks and correct if necessary		
43	Check operation and rotation of fuel pump, correct if necessary		
44	Check water pump/s and cooling tower operation		
45	Check cooling fan/s and thermostat settings		
46	Test complete system with customer / consultant present		
47	Post test items		
	A) Genset - General quality inspection		
	B) Control panel - General quality inspection		
	C) Set CB overloads		
	D) Bypass tested		
	E) Maximum load tested		kW
	F) Update and store program changes		
	G) Heater box cover plate fitted		
	H) Cover exhaust manifold after testing		
	I) Handed drawing in for updating		
	J) Panel key and override key in panel		
	K) Final paint inspection		
	L) Switch all circuits off in panel		
48	Record running hours	:	Hours

Remarks:

	Full Name	Signature	Date
Contracts Engineer			
Responsible Tester			
Eskom Representative			
Consultant			

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