

Title: **MAINTENANCE STANDARD FOR  
STANDBY GENERATORS IN  
DISTRIBUTION** Unique Identifier: **240-171000447**

Alternative Reference Number: **n/a**

Area of Applicability: **Engineering**

Documentation Type: **Standard**

Revision: **1**

Total Pages: **25**

Next Review Date: **October 2029**

Disclosure Classification: **Controlled  
Disclosure**

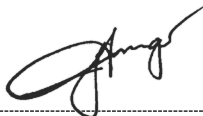
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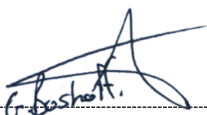
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## **1. Introduction**

While the requirement to document maintenance standards which define maintenance that is applicable to plant in the Eskom environment is not new, the initiatives to standardise the engineering design processes have formalised that a Maintenance Engineering Standard shall be compiled as part of the process to design and specify plant.

This Maintenance Engineering Standard has been developed retrospectively (i.e. substantially post design), documenting maintenance requirements to achieve the original design intent, for standby power systems and associated infrastructure.

Consideration has been given to:

- Maintenance tasks definition,
- In-service inspection and test requirements,
- Maintenance periodicities and triggers,
- Minimum critical spares requirements,
- Training requirements, and
- Facilities such as workshops, simulators and specialist test equipment.

Standby generators (mostly diesel fuelled standby generators are used in Eskom) in Eskom vary in size and functional complexity. The largest units are complex in design and may require that maintenance activities are conducted by distinct disciplines including:

- Mechanical maintenance
- Electrical maintenance
- Protection
- Control and Instrumentation and
- Power Electronics

The standard indicates how maintenance triggers may be affected, based on the specific plant functional location (the plant environment, criticality to the network and how the plant is used) and an aging analysis indicates intended design life, plant aging mechanisms, specific plant health indices and calculations to determine useful remnant life, which serve as primary input to the Maintenance Execution Strategy and Condition, Criticality and Risk Assessments.

## **2. Supporting Clauses**

### **2.1 Scope**

The document covers the Maintenance Engineering Standard (MES) and Maintenance Implementation Standard (MIS) requirements.

The document details the minimum maintenance activities for standby generators down to the lowest level at which Eskom should perform maintenance along with the triggers for said maintenance activities and the associated logistics requirement.

Preventative, corrective, test and inspection maintenance activities are included, based on the recommendations from OEM user manuals. The triggers for this maintenance based on potential plant functional location are indicated. The required list of training or task manuals deemed necessary are indicated but not developed.

Supporting facilities such as workshops, simulators, any other special equipment as well as spares, both critical and non-critical, is also indicated. Spares are deemed critical if they are necessary to sustain the plant's maintainability objectives, i.e. critical to return the plant to full operational status in the specified maintenance durations (maintainability intent).

In addition an aging analysis shall be performed to indicate the design life of the plant and factors that shall contribute to the acceleration of the life of that plant. Indicate specific parameters and the associated impact on the asset health and hence remaining life expectancy. It is intended that the implementation of this standard shall be phased in over a period of time. The Operating Units shall determine the most appropriate plan to achieve this, while maintaining appropriate levels of safety and network integrity as well as compliance with all applicable legislative and regulatory requirements. Full compliance with this standard is not compulsory at the time of publication.

### **2.1.1 Purpose**

The purpose of this document is to stipulate Engineering's requirements for maintenance of standby generators, as utilised in a specific functional location, and to indicate how the health of said plant is to be monitored such that the appropriate capital and operational investments can be made, at the appropriate times, to sustain the operational capability of the asset.

### **2.1.2 Applicability**

This document shall apply throughout Eskom Distribution.

## **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] Guide to Integrated Risk Management, ©Eskom Ltd, 2009
- [3] Act no 85 Occupational Health and Safety Act, 1993
- [4] 474-190 Design base Standard
- [5] MN 240-44509543 Process Control Manual (PCM) for Design System
- [6] MN 240-45920887 Process Control Manual (PCM) for Maintenance of Design Base
- [7] MN 240-45921037 Process Control Manual (PCM) for Optimise Operational Asset Performance.
- [8] 240-91177160 DC Technician Tools, Test Equipment and Accessories
- [9] 240-118870219 Standby Power Systems Topology and autonomy for Eskom sites
- [10] 240-118706834 Maintenance of Battery Chargers Task Manual
- [11] 240-118705836 Maintenance of Batteries Task Manual
- [12] 240-91177854 Certification of Secondary Plant Field Personnel

### **2.2.2 Informative**

- [13] 474-34 Engineering Change Procedure

## 2.3 Definitions

### 2.3.1 General

The table below explains all terms used, including documents, titles and departmental references.

Definition	Description
<b>Corrective Maintenance</b>	The process of restoring asset / plant and equipment which have failed or deteriorated to a state which renders it unable to meet the acceptance criteria required for its particular application.
<b>Condition Based Maintenance</b>	Predictive maintenance carried out because of findings from analysis of parameters measured under a condition-monitoring regime, or from recommendations from reliability analysis.
<b>Condition Monitoring</b>	Non-intrusive monitoring carried out to determine the physical condition of asset / plant and equipment.
<b>Critical Maintenance Spares</b>	Those spares that are needed to perform maintenance activities which must be completed before plant can be returned to service; i.e. the plant may not be returned to service, for safety or other compelling reasons, or cannot perform a key function unless the maintenance, requiring these spares, is carried out
<b>Functional Importance Generic</b>	<p>The functional importance of the standby generator in terms of the relative importance of the availability of the standby generator to ensure the continuity of supply.</p> <p>Applicable to an asset that must operate, as designed, in order:</p> <ul style="list-style-type: none"> <li>• to meet legal requirements; or</li> <li>• to meet regulatory requirements; or</li> <li>• to ensure safety of people; or</li> <li>• to prevent irreversible environmental harm; or</li> <li>• to prevent economic loss (net profit) of &gt; R99 million; or</li> <li>• to ensure continuity of supply, where not doing so would imply failure to meet one of the above points in the Eskom or public domain.</li> </ul>
<b>Functional Importance – Critical</b>	<p>Applicable to standby generators which are linked to:</p> <ul style="list-style-type: none"> <li>• A Power station (directly linked to Power Generating Units), Transmission Substation,</li> <li>• Important Distribution Substations (based on network impact and customer importance),</li> <li>• NMC, WMC, PIC, EDNO, Regional Control Centre, National Control Centre, ECC, RJCC</li> </ul>
<b>Functional Importance – Significant</b>	<p>Applicable to standby generators which are linked to:</p> <ul style="list-style-type: none"> <li>• Power station (outside plant), Smaller Distribution Substations, Data centres not directly linked to services to ensure continuity of supply</li> <li>• CNC's, WIC, Area Radio telecommunication sites not supporting any of the Critical or Significant installations.</li> </ul> <p><b>Note:</b> The functional importance of all telecommunications sites is based on the functional importance of the supported site.</p>
<b>Functional Importance – Run to Failure</b>	Not applicable to standby generators.

Definition	Description
<b>Maintenance Engineering Standard</b>	Maintenance Engineering Standard refers to the engineering performed during the design process (logistic support analysis) to define the maintenance requirements of the System, Structure or Component (SSC) (which typically include the following: minimum critical spares requirements; maintenance tasks definition; in-service inspection and test requirements; maintenance periodicities and triggers; training requirements; facilities; expected SSC life, etc.) that serves as primary input to the maintenance execution standard.
<b>Plant</b>	Any infrastructure that has been established to enable the generation, transmission, distribution and sale of electricity.
<b>Preventative Maintenance</b>	The maintenance carried out at predetermined intervals or corresponding to prescribed criteria (such as measured condition or number of operations), and intended to reduce the probability of failure or the performance degradation of an item. This is maintenance which is less frequent and involves specialised equipment to perform with a minimum craft (may use a higher level) of Technician level (T11)
<b>Routine Preventative Maintenance</b>	Is maintenance utilising a <u>minimum</u> craft level of T06 (may use a higher level) and covering the routine maintenance inspection and preventive maintenance at this level
<b>Maintenance</b>	A combination of all technical, administrative and managerial actions during the lifecycle of an item intended to retain it in, or restore it to, a condition in which it can perform its required function.
<b>Maintenance Philosophy</b>	The principle approach decided upon for performing maintenance, such as pro-active or re-active maintenance.
<b>Maintenance Strategy</b>	The type of maintenance selected for specific asset / plant and equipment, such as time or condition-based maintenance, corrective or preventative maintenance.
<b>Maintenance Plan</b>	A plan that details the maintenance that needs to be done on a specific asset / plant item or component and the frequency and quality requirements for that maintenance.
<b>Maintenance Schedule</b>	The timing of the Maintenance Plan information stipulating when in the calendar year, work needs to be done.
<b>Preventive Maintenance</b>	Planned time or schedule-based maintenance carried out with the explicit objective of preventing functional failures and is directed towards maintaining the physical condition of the asset / plant or equipment. It includes scheduled overhauls and scheduled replacement of worn-out parts or failure prone components.
<b>Reliability Centred Maintenance</b>	RCM represents a disciplined decision logic approach that focuses on the consequences of failure to develop the most cost-effective lifetime maintenance programme. The decision logic question is sequenced to those parts of the asset / plant that are maintenance significant. Significant components failure modes are evaluated to identify appropriate maintenance tasks and their costs.
<b>Inspection</b>	Activities, which by means of examination, observation or measurement, determine the conformance of material, parts, components etc., to predetermined specifications and quality requirements.
<b>In-service Inspection</b>	All inspection and testing conducted on plant and equipment at regular intervals and prescribed by regulatory and statutory codes or other types of specification throughout its service life.

Definition	Description
<b>Testing</b>	All activities required determining the actual performance or condition of an item.
<b>Technical Plan</b>	The technical plan will be the first five years of the Lifecycle Manage Plan (Life of Plant Plan).
<b>Lifecycle Management Plan</b>	This is the plan that details the financial and technical requirements with respect to all planned projects over the life of the plant. This plan covers Capital, and Routine Maintenance and Planned Maintenance costs.
<b>Competent Person</b>	a) Is qualified by virtue of his knowledge, training, skills and experience to organise the work and its performance, b) Is familiar with the provisions of the Act and Regulations which apply to the work to be performed, c) Has been trained to recognise any potential or actual danger to health or safety in the performance of the work, Is in possession of the appropriate certificate of competency where such certificate is required by these regulations

### 2.3.2 Disclosure classification

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

## 2.4 Abbreviations

Abbreviation	Description
<b>AC</b>	Alternating Current
<b>ATS</b>	Automatic Transfer Switch
<b>CB</b>	Condition Based
<b>CBM</b>	Condition Based Maintenance
<b>CM</b>	Corrective Maintenance
<b>DC</b>	Direct Current
<b>DCS</b>	Digital Control System
<b>ECC</b>	Emergency Control Centre
<b>EDNO</b>	Electricity Delivery Network Operations
<b>FMECA</b>	Failure Modes, Effects and Criticality Analysis
<b>HFO</b>	Heavy Fuel Oil
<b>I</b>	Inspection
<b>IT</b>	Inspections and Tests
<b>LFO</b>	Light Fuel Oil
<b>NMC</b>	Network Management Centre
<b>OEM</b>	Original Equipment Manufacturer
<b>OU</b>	Operating Unit
<b>PDE</b>	Power Delivery Engineering
<b>PIC</b>	Phone-in Centre

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Abbreviation	Description
PLC	Programmable Logic Controller
PM	Preventative Maintenance
PMG	Permanent Magnet Generator
RJCC	Regional Joint Command Centre
SCADA	Supervisory, Control and Data Acquisition
SCOT	Steering Committee of Technologies
WIC	Walk-in Centre
WMC	Works Management Centre

## **2.5 Roles and responsibilities**

The Maintenance Centre of Excellence (MCOE) is responsible for the consistency and process of compiling and implementation of the maintenance standard.

The Distribution Operating Units are responsible for implementing the maintenance standard.

The Standards Implementation section is responsible to ensure that the correct change control and awareness takes place, within the relevant structure in each Operating Unit environment to ensure that the document is dispersed and understood. The SCOT Maintenance Study Committees will be required to ensure that any task manuals and job plans required from this standard are developed and implemented.

## **2.6 Process for monitoring**

The Maintenance Centre of Excellence (MCOE) will monitor the development and is accountable for the implementation of Maintenance Engineering Standards (MES) as well as the development of Maintenance Implementation Standard (MIS) in the future Asset Performance Management (APM) Tool. The same Manager will also monitor the effectiveness and consistency of maintenance execution strategies in the various Operating Units.

Standards Implementation will have some oversight in terms of the application of the document, but it is ultimately the responsibility of each of the Maintenance and Operations departments to ensure that there is adequate adherence to the maintenance standard provided in this document.

## **2.7 Related/supporting documents**

All relevant forms and checklists will be maintained in the relevant task manual.

# **3. Maintenance Standard requirements for Standby Generators**

## **3.1 Plant identification**

The plant under consideration is standby generators which are required to provide secondary standby power for extended normal power supply outages at substations, power stations, telecommunications sites, offices etc.; essentially all sites where essential activities or processes are required or as a last resort the safe shutdown of the system or site.

The status of the standby generator is constantly monitored by built-in monitoring circuits to detect any failures or abnormalities and provide local alarms (audible and visual). Remote alarms are also provided via potential free contacts, but only add value at sites with a SCADA / DCS system which is connected to the Network Management and Monitoring Centre.

The operating philosophies and applications differ in complexity and functionality. The level of complexity governs the maintenance strategy. The different application categories indicated in below provide a short description of the design complexity, functionality and application.

Each division's application is unique, and the Auxiliary Power Supply system design philosophy must be properly documented, and drawings kept up to date.

**Table 1: Standby generator application categories**

<b>Category A</b>	<b>Category B</b>	<b>Category C</b>	<b>Category D (Mobile)</b>
Gx, Complex Tx	Gx, Tx, Dx	Gx, Tx, Dx	Gx, Tx, Dx
<ul style="list-style-type: none"> <li>Station- or Unit DG Large units that could require multiple units in parallel or single units that need to supply load into the network for routine maintenance operation</li> </ul>	<ul style="list-style-type: none"> <li>Sub-station DG as second source of supply (Tx)</li> <li>Large units that could supply load into the network for routine maintenance operation or supply current to dummy loads provided with the installation.</li> <li>Alternatively it must periodically supply the standing load of the designed system</li> </ul>	<ul style="list-style-type: none"> <li>Gx - outside plant installations, Building back-up supply Tx, Dx - sub-station or building back-up supplies</li> </ul>	<ul style="list-style-type: none"> <li>Gx - emergency temporary measures only as back-up to installations not designed with permanent generator support Dx, Tx - back-up supply to installations that have permanent reticulation designed to periodically be supplied by generator in case of prolonged power outage</li> </ul>
<ul style="list-style-type: none"> <li>Synchronised or non-synchronised units</li> </ul>	<ul style="list-style-type: none"> <li>Non-synchronised units</li> </ul>	<ul style="list-style-type: none"> <li>Non-synchronised units</li> </ul>	<ul style="list-style-type: none"> <li>Non-synchronised units</li> </ul>
<ul style="list-style-type: none"> <li>Complex control systems often using external system PLC controllers Transfer load via external switchgear (plant reticulation) Extremely high level of reliability and availability due to criticality in generating plant Could be sacrificial component considering the importance of the load supplied Extensive maintenance philosophy due to complexity Total System by-pass is possible via external switchgear High nr of analogue+digital I/Os</li> </ul>	<ul style="list-style-type: none"> <li>Complex control systems often using external system PLC controllers Transfer load via external switchgear (plant reticulation) or Internal ATS or External ATS High level of reliability and availability due to criticality in generating plant Extensive maintenance philosophy due to complexity Total System by-pass is possible via internal/external switchgear Limited nr of I/Os</li> </ul>	<ul style="list-style-type: none"> <li>Simple on-board control systems Transfer load via Internal/external ATS Non-sacrificial component, designed to achieve maximum life expectancy Simple maintenance philosophy because it is not complex unit, yet is essential in its design in the plant No system bypass is required Limited nr of I/Os</li> </ul>	<ul style="list-style-type: none"> <li>Simple on-board control systems Transfer load via Internal ATS if it is designed with an auxiliary AC supply to be used when parked in a storage facility to maintain battery charge and operating temperature. This is for improved starting. Designed to achieve maximum life expectancy Simple maintenance philosophy because it is not complex unit, yet is essential to be available when required No system bypass is required Very simple hard-wired alarm outputs available for remote monitoring/alarming or alarming via wireless GSM module</li> </ul>

## **3.2 Standby generators system overview**

### **3.2.1 General**

Large standby generator sets can consist of the following sub-systems that are individual in essence but collectively form one system function and that is to supply emergency or standby power to the plant:

- Diesel engine (prime mover)
- Alternator
- Control system
- Electrical switchgear
- Fuel supply and filtration
- Coolant system
- Lubricating system
- Starting system (electrical or air-start)
- Exhaust and charge air system
- Internal ATS or external switchgear
- Fire detection and suppression
- Container or building

### **3.2.2 Diesel engine (Prime mover)**

Eskom specifies diesel engines to be used and range from small 4-cylinder engines with a single starter to very large V20 engines with dual starters.

### **3.2.3 Alternator (Generator)**

The Permanent Magnet Generator (PMG) is a brushless generator separately excited by a Permanent Magnet Generator (PMG). The PMG is a shaft mounted, high frequency, pilot exciter which provides a constant supply of clean power via the Automatic Voltage Regulator (AVR) to the main exciter. The main exciter output is fed to the main rotor, through a full wave bridge rectifier, protected by surge suppression. The independent PMG assures the performance of the AVR against non-linear loads and reduces the radio frequency interference on the generator terminals. The PMG supply enables the generator to maintain current into a short circuit. The AVR senses the voltage on the main generator winding. This signal is used to control the power fed to the exciter stator (and hence the main rotor) to maintain the generator output voltage within the specified limits, compensating for load, speed, temperature and power factor.

### **3.2.4 Control system**

The control system can vary between a single on-board engine controller for small generator sets to externally mounted system controllers, PLCs and DCS to not just control the generator set but also the auxiliary systems such as fuel replenishing, water treatment, ventilation, fire monitoring, etc.

### **3.2.5 Electrical switchgear**

The switchgear can range between internal on-board ATS to external ATS to external system reticulation switchgear to achieve load transfer from normal supply to generator supply.

### 3.2.6 Fuel supply and filtration

Fuel systems range between simple sub-frame base tank or day tank with suction from pick-up to the fuel pump and a single return line, to day tank and bulk fuel tank arrangement with level monitoring and automated fuel transfer and filtration systems. See example in the following.

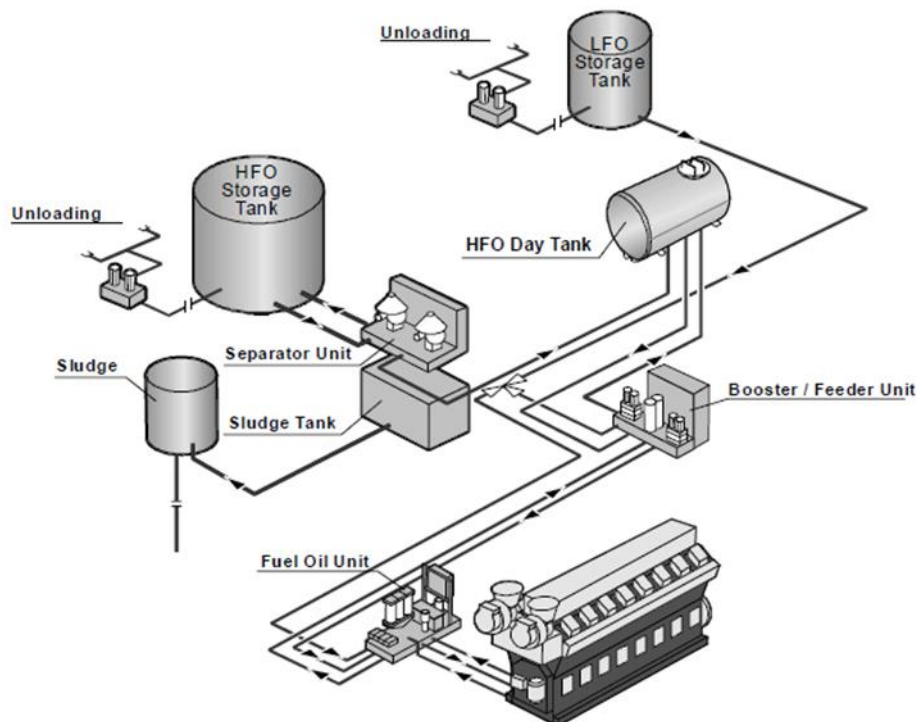


Figure 1: Fuel supply and filtration system

### 3.2.7 Coolant system

Coolant systems have subtle differences between different size systems but fundamentally work the same. The coolant additive is a very important aspect for some manufacturers and specifications and procedures must be followed strictly.

#### 3.2.7.1 Jacket water heating system

The jacket water heating system is very important, the heating of the water helps to protect the engine against cold corrosion attacks on the cylinder liners during starting. The rapid start and fast loading of a cold engine, typical of nuclear application diesels under emergency conditions, causes high stress and increased wear until the engine reaches its normal operating temperature. Since diesel engines rely on the heat of compression for ignition, keeping the engine warm substantially decreases the start time and reduces the chances of a failure to start because of low intake air temperature. It is recommended that, under normal circumstances, the engine jacket water be heated to a minimum of 50 °C before the engine is started and gradually run up to 90% of rated speed.

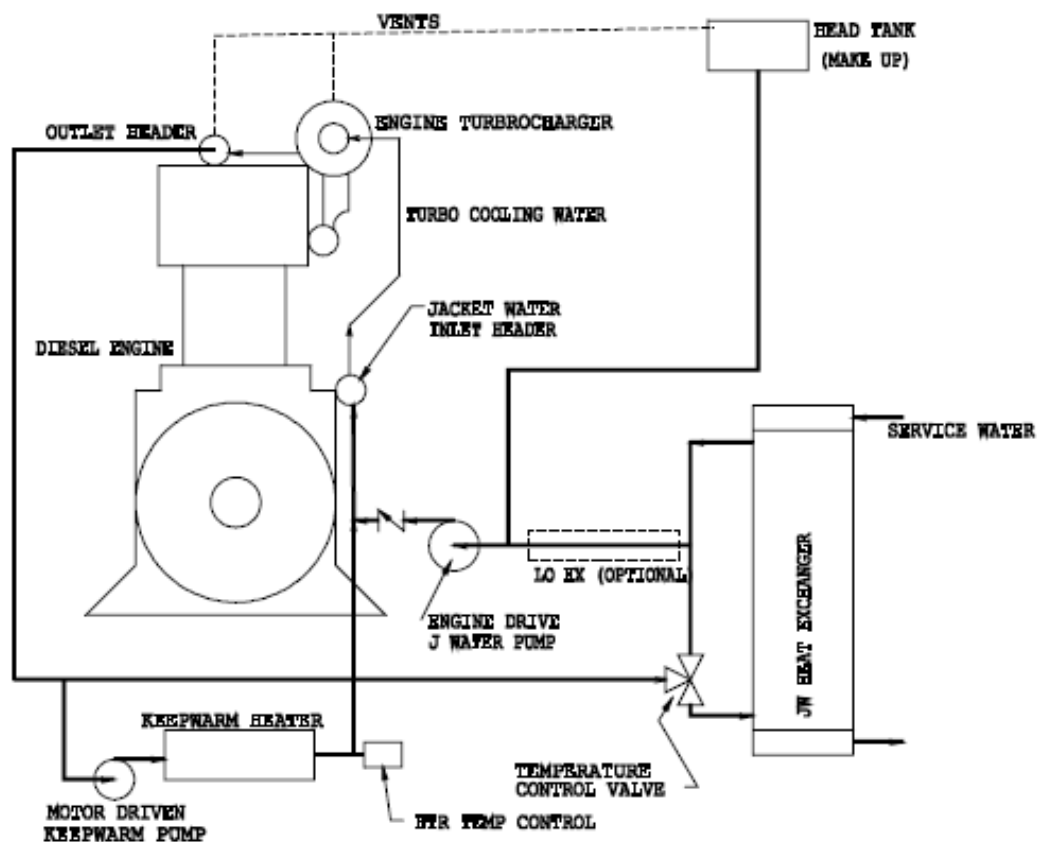
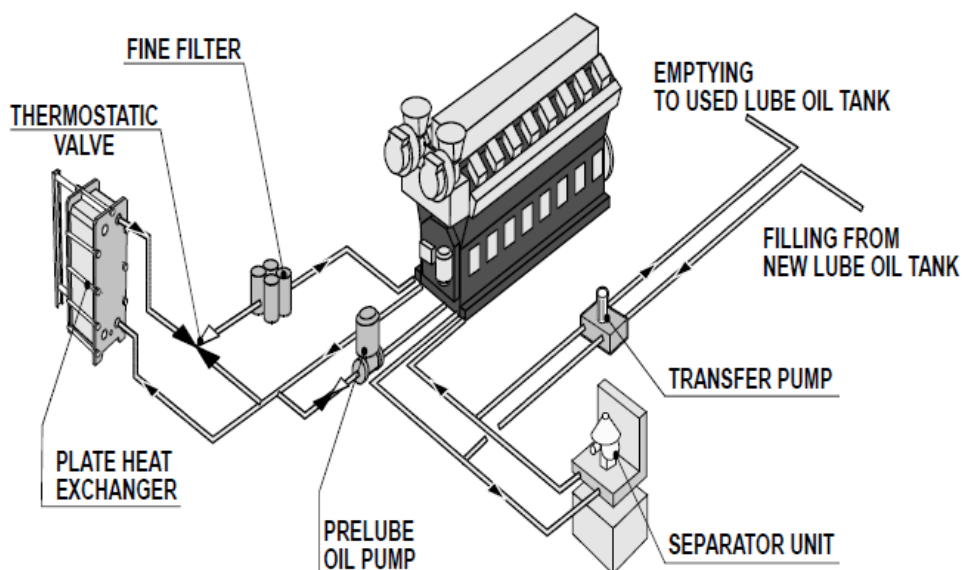


Figure 2: Water jacket heating system

### 3.2.8 Lubricating system

Lubricating differs from simple systems in small engines to complex systems on large machines involving pre-lube pumps allowing the lubrication of all parts of the system before start-up.

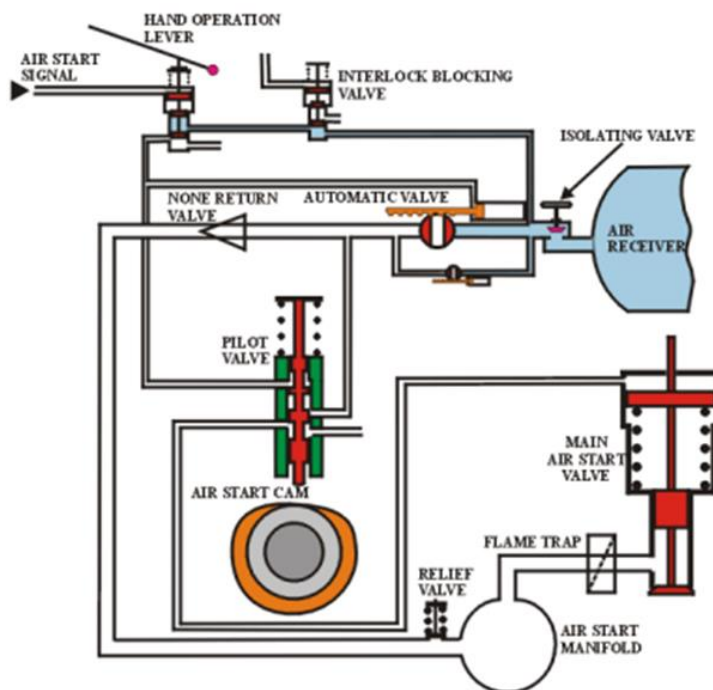
The system supplies lubricating oil to the engine and is used as a coolant in the addition to the lubricity provided. The system is designed to ultimately carry the heat of the engine transferred to the oil on to the cooling water system. It is required to use lubricating oil of the SAE class 40 with a maximum operating temperature of about 70°C behind the engine and a working pressure of about 4.5 bar before the engine. The lubricating oil pressure and temperature are normally monitored.

**Figure 3: Lubricating system**

The analysis of the lubricating oil can reveal a lot of information about the mechanical condition of the engine.

### 3.2.9 Starting system (electrical or air-start)

Starting systems range from single electric starter to dual electric starters to air starters. The following figures illustrate.

**Figure 4: Air-starter system**

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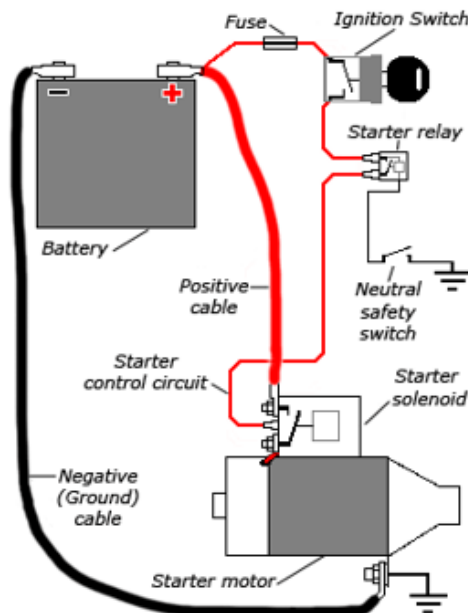


Figure 5: Electrical starter system

### 3.2.10 Exhaust and charge air system

Ventilation and filtration designs to allow for the ample supply of fresh air to the intakes of the engine come in many forms and require careful maintenance to maintain clean air supply which is essential for performance and durability.

Larger machines could incorporate intercoolers which all add to the maintenance requirements.

### 3.2.11 Internal ATS or external switchgear

ATSs range from a single device with internal motorised transfer between two sources to individual contactor type arrangements with electronic and mechanical interlocks. Some machines only have output breakers that are controlled by system controllers or DCS for external transfer of the load to the generator.

### 3.2.12 Container or building

Generators can be mounted under a carport type roof design which results in “harsh” environment or inside soundproof/weatherproof cubicles or a generator room which allows for a “milder” environment.

The air ventilation and filtration system will require maintenance.

**Note:** Because of all the sub-components varying in size and complexity it can be expected that maintenance checks and activities will vary to a certain degree.

## 3.3 Design intent for standby generators

### 3.3.1 Plant purpose

The system functional block diagram for a single standby generator is shown in Figure 6. The system is defined as the complete standby generator System consisting of the different sub-systems.

The functional requirements or mission of the system and sub-systems are as follow:

**Standby generator system:** Provision of safe and reliable standby power to the load equipment

**Battery:** Provision of safe DC Power to start the standby generator

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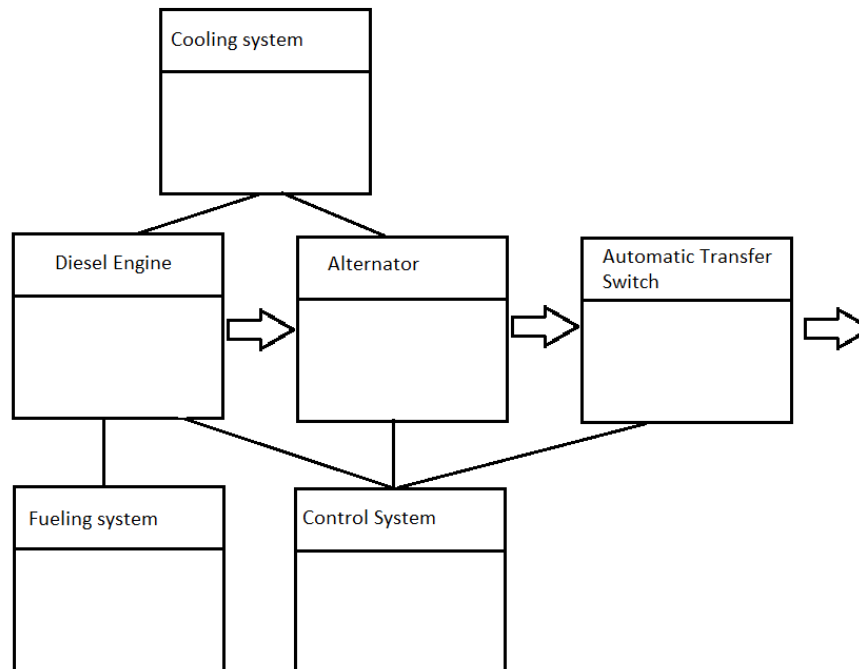
**3.3.1.1 Standby generator system functional block diagrams****Figure 6: System functional block diagram for a single standby generator system**

Figure 6 shows the functional block diagram for a Diesel Generator. There exist various maintainable and replaceable items.

**3.3.2 Operating environment**

The physical operating environment includes indoor and outdoor locations across South Africa.

- a) Generic:
  - 1) Altitude: 2 000 m maximum
  - 2) Relative humidity: 10% to 85%, non-condensing
  - 3) Lightning: Standard design for high lightning area
- b) Mild:
  - 1) Air quality: Controlled / no – low pollution levels
  - 2) Generator room air temperatures:
    - maximum: 27 °C
    - average: 25 °C
    - minimum: 20 °C
- c) Harsh:
  - 1) Air quality: Uncontrolled / medium – high pollution levels
  - 2) Generator room air temperatures:
    - maximum: 45 °C

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- average: 30 °C
- minimum: -5 °C

### 3.3.2.1 Operating limits

The operating limits are specified in the standby generators OEM manual and applicable model datasheet.

### 3.3.3 Intended design life of plant

The intended design life of the plant is minimum 35 years as per the standard.

## 3.4 Maintenance engineering standard

Maintenance requirements are defined based on the activities identified from the FMECA and taking criteria, associated with the actual functional location, into consideration. This results in several possible maintenance requirement permutations, one of which will be selected by the maintenance function for any item of plant, and from which a consolidated maintenance execution strategy can then be developed.

When applying the maintenance requirement, the environmental conditions should be assessed and determined as per the definition for “Mild” and “Harsh”. The functional importance should further be determined in terms of whether the location is Critical or Significant site.

The duty cycle of the relevant plant will also need to be assessed to determine the applicable maintenance interval and strategy.

Once this is established the appropriate column can be selected from the maintenance requirement table for each of the respective technology types (categories) of standby generators.

### 3.4.1 Maintenance activities definition

The maintenance requirements include routine maintenance and preventative maintenance.

### 3.4.2 Asset classification questionnaire

Questions to be answered below are designed to lead to the most appropriate maintenance strategy for the standby generator and associated equipment.

**Table 2: Functional Importance of standby generators**

Question	Functional Importance	Critical	Significant	Run to Failure
1	Is the standby generator supplying: a Power station (directly linked to Power Generating Units)?	Yes		
2	Is the standby generator supplying: a Transmission Substation?	Yes		
3	Is the standby generator supplying: an important Distribution Substation (based on network impact and customer importance)?	Yes		
4	All sites categorised as Priority 1 & 2 as per document 240-118870219.	Yes		
5	All sites categorised as Priority 3 as per document 240-118870219.		Yes	

Table 3: Operating environment classification

Operating Environment	Harsh	Mild
1) Is the temperature controlled through air-conditioning?	No	Yes

### 3.4.3 Maintenance spares

Each division is responsible to develop spares holding strategies and maintain spares levels.

### 3.4.4 Required task manuals

The 240-171000445, Task manual for Diesel generators in Distribution must be used to perform the maintenance activities.

### 3.4.5 Facilities and training material

The first line maintenance is conducted on site and no portion thereof is removeable to be maintained in any workshop facility.

For first line generator maintenance all measurements, values and conditions are monitored directly from the Controller or visually from the generator. Occasionally a multi-meter and current probe will be necessary.

First line generator maintenance training is provided by the OEM at installation and commissioning.

## 3.5 Maintenance task grouping

Maintenance activities are the individual activities as identified in the FMECA and Maintenance activity table. These activities then need to be grouped for the sake of efficiency and effectiveness during execution.

Maintenance Activities are grouped into Maintenance Task groupings dependant on the craft, trigger and outage requirements.

These task groupings will be used to develop Job Plans, Task lists, Scopes of Work, PM's and Task Manuals.

### 3.5.1 Diesel Generator task grouping

Where "CB" (Condition Based) is noted, the following factors and test results that will impact on standby generator health will trigger a CB activity or prolong the period.

		CHS	CLS	CHM	CLM
Functional Importance	Critical	X	X	X	X
	Significant				
Duty Cycle	High	X		X	
	Low		X		X
Environment	Severe	X	X		
	Mild			X	X
PM Task		Frequency			
Inspection inclusive of Functional Testing - Start and Run (15 min)		2W	2W	2W	2W
Inspection inclusive of Functional Testing - Full Load (30-60mins)		1M	1M	1M	1M
Preventative Maintenance (inclusive of Full Load test and Protective devices test)		1Y / 250hrs	1Y	1Y	1Y

		NHS	NLS	NHM	NLM
Functional Importance	Critical				
	Significant	X	X	X	X
Duty Cycle	High	X		X	
	Low		X		X
Environment	Severe	X	X		
	Mild			X	X
PM Task		Frequency			
Inspection inclusive of Functional Testing - Start and Run (15 min)		1M	1M	1M	1M
Inspection inclusive of Functional Testing - Full Load (30-60mins)		3M	3M	3M	3M
Preventative Maintenance (inclusive of Full Load test and Protective devices test)		1Y / 250hrs	1Y	1Y	1Y

### 3.6 Statutory Maintenance (based statutory requirements / regulations)

The Electrical Machinery Regulations (2011) of the Occupational Health and Safety Act 85 of 1993 requires that the electrical installation of any hazardous area shall be visually inspected and tested at intervals not exceeding two years by a person who is competent to express an opinion on the safety thereof.

### 3.7 Plant, maintenance and test data to be recorded

#### 3.7.1 Standby Generator plant data

Table 4: Standby generator plant data

Data	System Tx : Dx	Source
Functional Location	SAP PM:MAXIMO	Substation Design/Smart Plant
<b>Plant Data</b>		
Manufacturer	SAP PM:MAXIMO	Name Plate
Manufacturer Type Number	SAP PM:MAXIMO	Name Plate
Manufacturing Year	SAP PM:MAXIMO	Name Plate
Year Commissioned	SAP PM:MAXIMO	Commissioning Sheets
Alternator rating	SAP PM:MAXIMO	Name Plate
AC Voltage	SAP PM:MAXIMO	Name Plate
Fuel type	SAP PM:MAXIMO	Name Plate
Current Rating (Output)	SAP PM:MAXIMO	Name Plate

**3.7.2 Inspections and Tests (IT), Preventative Maintenance (PM), Corrective Maintenance (CM) and Investigation (I) Data****3.7.2.1 Inspections and tests data****Table 5: Inspections and test data**

Maintenance Task / data	Data type	Source	Source Activity
Routine Maintenance Check list	As per the relevant Check sheet in the Task Manual	TBA	Routine Maintenance Inspections
Preventative Maintenance Check list	As per the relevant Check sheet in the Task Manual / OEM maintenance manual and corrective maintenance and Investigation data as determined by the OEM	TBA	Preventative Maintenance Inspections

**3.7.2.2 Standby generator health data**

During OEM Preventative maintenance activities, the relevant OEM/agent shall determine the generator Asset Health as determined by OEM procedures. The maintenance report shall be suitable detailed with recommendations for Eskom to decide on any further actions.

**3.8 Failure causes to be recorded in performance management systems**

To enable the trending of failure causes and to monitor the effectiveness of the Maintenance Engineering and Execution Strategies in preventing failures, it is required that incidents be investigated, and the root cause/s of the failures be determined and captured in the appropriate systems.

**3.8.1 Generator performance data requirements**

The reason for the failures to be determined by the first responder or the OEM/agent if failure is escalated to the OEM/agent.

**Table 6: Generator performance data**

Event	Data	System Tx:Dx	Source	Primary Data
Number of failed start attempts per year	No. per Year	SAP PM:MAXIMO	Inspection Reports (Routine first line maintenance or Work Order)	Maintenance
Reason for start failures	Failure Mode	SAP PM:MAXIMO	Maintenance Reports	Maintenance
Number of failed attempts to continue running per year (trip events)	No. per Year	SAP PM:MAXIMO	Inspection Reports (Routine first line maintenance or Work Order)	Maintenance
Reason for trip/failures	Failure Mode	SAP PM:MAXIMO	Maintenance Reports	Maintenance

**3.9 Functional equipment grouping**

The functional Grouping is listed as Standby Generators.

### 3.10 Maximo location and asset requirements

Diesel Generator locations are identified by the class structure shown below in Table 7.

**Table 7: Maximo Class Structures**

Grand Parent Class structure ID	Class structure description	Parent Class structure ID	Class structure description	Child Class structure ID	Class structure description
		10005109	ERF"organisation_id"	10002020	Building
				10002030	Control Building
				10000167	TSC Office
10002020	Building	10003024	AC/DC System 240V	10002207	Diesel Generators
10002030	Control Building				
10000167	TSC Office				

#### 3.10.1 Asset ownership

Regarding Asset ownership and work execution the following shall apply:

- When Standby Generator Assets belong to Eskom DX and work is done by either Eskom DX Resources or External resources: the Assets, associated PM's and Work orders needs to be managed in Maximo.
- When Standby Generator Assets belong to Eskom but located on the Customer premises and work is done by Eskom DX Resources: the Assets associated PM's and Work orders needs to be managed in Maximo.
- When Standby Generator Assets does not belong to Eskom and work is done by Eskom DX Resources: the Assets associated PM's and Work orders needs to be managed by the Asset Owner. (Smallworld location supplying Asset owner should be used to create the work order)

#### 3.10.2 Standby Generators at Buildings

- A "ERF" Location with classification 10005109 should be created starting with the Smallworld "organisation\_id" as an example: The organisation\_id from Smallworld for Mkondeni Regional Office is 254396805, thus create a location ERF254396805 below the Zone/Sector hierarchy.
- A Location with classification 10002020 (Building), 10002030 (Control Building) or 10000167 (TSC Office) should be linked below the ERF"organisation\_id" location (Class structure 10005109), depending at which building location the generator is located.
- A CP Location (EDL) with classification 10003024 (AC/DC System) should be created below the Building (class structure 10002020), Control Building (class structure 10002030) or TSC Office (class structure 10000167).
- A CP Location (EDL) with classification 10002207 (Diesel Generators) should be created below the AC/DC System (class structure 10003024),
- Diesel generators should be captured in the respective CP (EDL) location. National item numbers should be used. Serial numbers and year of manufacture should be included for generator assets.
- The CP location should be associated with the TSCRESP and CPRESP System.

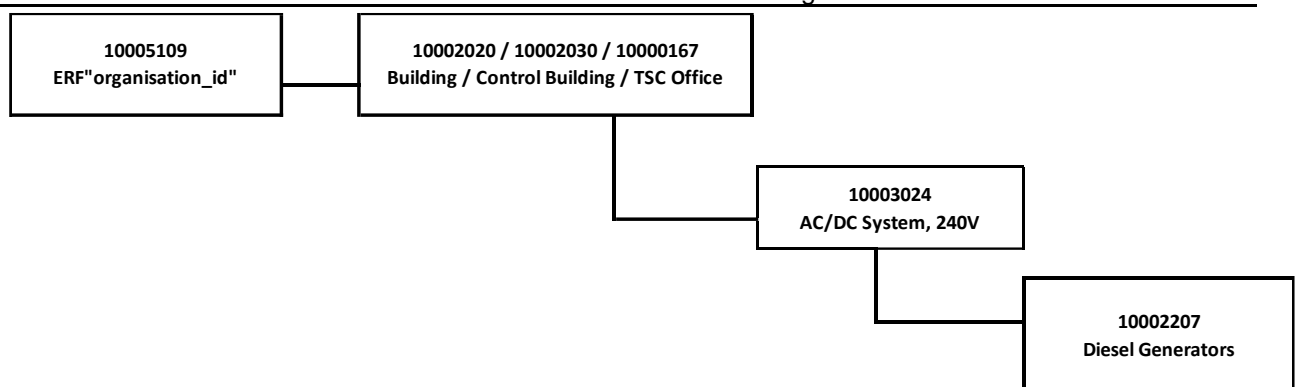


Figure 7: Maximo structural hierarchy for a single standby generator system

### 3.10.3 PMs and work orders

- Maintenance tasks to be implemented as per the time phasing in Table 8.
- Feedback capturing must be in line with the operational step requirements as prescribed in the job plan. OUs wanting to include additional details in the work order can include the details after the last operational step.
- Slip periods are prescribed in the job plans. Slip periods in the work orders can be reduced but not increased.
- Work order target start, and completion dates must fall within the same financial year. If work is to commence before the new financial year, the target start date should be adjusted as per the actual start date, however, the target completion date must be such that it falls in the desired financial year.
- Work orders for emergent (defects) work to be created as follow up work orders to the initial maintenance activity.
- All inspection/test/check sheets must be attached to the relevant work order. When attaching documents ensure that the document is flagged to be visual in the public domain.

- Capturing of Labour hours should be split between travel and work according to Maximo training (Module 5 – Capturing Labour Actuals : Maximo 7.1 for Senior Clerks Learner guide)

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- h) Any urgent emergent work needs to be reported and addressed immediately.
- i) Technical Instructions (TIs) / Technical Bulletins (TBs) should be addressed as required by Technical Change Implementation Forum (TCIF), either as an ad hoc work order (Safety or Urgent) or as part of Maintenance.
- j) Maintenance should be done by trained and accredited resources. The relevant TASK manuals should be used.
- k) Inspection/Test/Check lists should comply with contents requirement of national templates.

#### **3.10.4 Routine Diesel Generator Inspection Maintenance: PM**

- a) PM's will be created against the Diesel Generator location as per the frequency specified in Table 8.
- b) 2 Different PM's will be created for inspections on Diesel Generators, inspection with Start and run (15min) as well as an inspection with full load testing (30-60min).
- c) Job plans to be used as specified in Table 8.
- d) Routine Diesel Generator Inspection Maintenance will be done by the PPM (Power Plant Maintenance) Section as indicated in Table 8.
- e) Routine inspections will be done according to the Maintenance Inspection Check sheet as indicated in the relevant Task Manual.
- f) The Diesel generator check sheet should be attached to the relevant work order as a separate attachment.
- g) Emergent work orders shall be created by the works coordinator as required.

#### **3.10.5 Diesel Generator Preventative Maintenance: PM**

- a) PM's will be created against the Diesel Generator location as per the frequency specified in Table 8.
- b) Job plans to be used as specified in Table 8.
- c) Preventative Maintenance shall be executed by the OEM according to the contract that is established by the owner of the building. As the owner of the building, ERE (Eskom Real Estate) will be responsible for creating a contract with the relevant OEM of the diesel generator.
- d) PPM (Power Plant Maintenance) Section will the owner of the work order to ensure that records is kept for an Asset where the responsibility to maintain a diesel generator is ERE and provided feedback as per work order requirements.
- e) The Maintenance feedback sheet as prescribed by the relevant Task Manual standard must be attached to the work order.
- f) Plant department is responsible for processing the work order feedback.
- g) Plant (or as per agreement in OU) to ensure that emergent work be created as follow-up work orders against the original work orders. The emergent work order needs to be against the Diesel Generator location.



**3.11 Maintenance Tasks for Standby Generators and corresponding job plans****Table 8: Maintenance Tasks and job plans.**

Maintenance Task	PM/ Adhoc	PM/Work order against location or asset	Strategy Frequency	Job plan Number	Job plan Slip Period
Diesel Generators at Critical Locations					
Inspection inclusive of Functional Testing - Start and Run (15 min)	PM	Diesel Generator Location	2 Weekly	312200053	7 days
Inspection inclusive of Functional Testing - Full Load (30-60mins)	PM		Monthly	503-1029	15 days
Preventative Maintenance (inclusive of Full Load test and Protective devices test)	PM		250hrs/1Y	503-1030	90 days
Diesel Generators at Significant locations					
Inspection inclusive of Functional Testing - Start and Run (15 min)	PM	Diesel Generator Location	1M	312200053	7 days
Inspection inclusive of Functional Testing - Full Load (30-60mins)	PM		3M	503-1029	15 days
Preventative Maintenance (inclusive of Full Load test and Protective devices test)	PM		250hrs/1Y	503-1030	90 days

**3.12 Ageing analysis****3.12.1 Degradation Review and Health Index****3.12.1.1 Review of Life Expectancy and Failure Issues**

Two techniques exist to determine the potential for failures in this asset class. The first technique relies on generic and qualitative degradation indicators readily assessed through visual inspections and testing. The second technique relies on converting recent quantitative asset performance and failure data into in-service performance ratings.

Visual inspections, calibrations and test results serve as key indicators of the health and condition of DC Systems.

**3.12.1.2 End-of-Life criteria and condition rating**

Age, runtime, preventative maintenance results and obsolescence (spares availability and technical support) will serve as decision criteria for the major overhaul or end-of-life of the generator or components thereof substantiated by the relevant OEM/Agent asset health report.



## **4. Authorisation**

This document has been seen and accepted by:

<b>Name and Surname</b>	<b>Designation</b>
Mfundi Songo	Senior Manager: Technology and Engineering
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## **5. Revisions**

<b>Date</b>	<b>Rev</b>	<b>Compiler</b>	<b>Remarks</b>
Oct 2024	1	Thomas Jacobs, Welman van Niekerk	Original issue

## **6. Development team**

The following people were involved in the development and revision of this document:

- Thomas Jacobs
- Frikkie Knoetze
- Welman van Niekerk
- Philip Groenewald
- Ajith Persadh

## **7. Acknowledgements**

Thanks to the DC & Auxiliary Supplies Study Committee and the Maintenance WG that assisted with the document.