



Strategy Document.

Group Technology

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FACILITIES**

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1. INTRODUCTION

This document provides the maintenance base required to ensure effective management of Substation Facilities in Eskom Substations and to provide an appropriate return on investment over the assets life. It is part of Eskom's commitment to ensure that the engineering of its power delivery networks is managed in such a manner that the requirements of customers, internal stakeholders, regulatory and legal authorities are fully met.

The Maintenance Engineering Strategy is developed as a result of the engineering performed during the design process or retrospectively, taking cognisance of the original design intent, to define the maintenance requirements of substation facilities. These will typically include the following strategies:

- The Maintenance Engineering Strategy,
- Condition, Criticality and Risk Assessment (CCRA), and
- The Maintenance Execution Strategy

2. SUPPORTING CLAUSES

2.1 SCOPE

This Maintenance Engineering Strategy is applicable to facilities in Eskom's substations. All minimum maintenance activities are described down to the lowest level at which Eskom performs maintenance along with the triggers for said maintenance activities and the associated logistics requirements.

The condition monitoring and maintenance activities are prescribed based on the outcome of FMECA and ageing analyses. Triggers for these maintenance activities are developed based on the criticality assessment and may be influenced by the plant functional location to execute maintenance more often whilst complying with the minimum requirements provided. Where training or task manuals are deemed necessary, these are indicated to be developed.

Aging analysis is performed to indicate the operational life of the plant and factors that contribute to the acceleration of the life of that plant. Asset health indicators are developed and the associated remnant life calculations given.

2.1.1 Purpose

The purpose of this Maintenance Engineering Strategy is to define the minimum maintenance requirements for substation facilities, the associated logistics, the plant life intent and factors influencing this life.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions dealing with Power Delivery Assets.

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

International document(s):

- [1] IEEE 80 – "IEEE Guide for Safety in AC Substation Grounding", 2000

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South African National document(s):

- [2] Act no 85 Occupational Health and Safety Act, 1993
- [3] SANS 1125:2004 Room Air Conditioners and Heat Pumps
- [4] SANS 54511:2010 Air Conditioners, Liquid Chilling Packages and Heat Pumps with Electrically Driven Compressors for Space Heating and Cooling.

Eskom National document(s):

- [5] 474-190 Design Base Standard
- [6] MN 240-44509543 Process Control Manual (PCM) for Design System
- [7] MN 240-45920887 Process Control Manual (PCM) for Maintenance of Design Base
- [8] MN 240-45921037 Process Control Manual (PCM) for Optimise Operational Asset Performance.
- [9] Guide to Integrated Risk Management, ©Eskom Ltd, 2009
- [10] Substation Layout Design Guide, 2010

Eskom Divisional documents(s):

- [11] 34-804 Substation Routine Inspection
- [12] TSG41-818 Substation Asset Health Assessment, Planning and Prioritisation Strategy
- [13] TCP41-245 Secondary Plant Security Systems Maintenance Procedure

2.2.2 Informative

- [14] 240-49230046 Failure Mode and Effects Analysis Guideline
- [15] 240-49230148 Maintenance and Logistics Support Design Guideline
- [16] 24-49230067 Life Data Analysis Guideline

2.3 DEFINITIONS

HVAC	.The heating ventilation and air conditioning is the technology of indoor and automotive environmental control
Substation	A site on which is situated any transforming, switching or linking apparatus forming part of the Power System and on which no generating equipment is situated, other than auxiliary generating sets. The term “substation” includes compressor stations, distribution stations, capacitor stations and switching stations.
HV Yard	Shall mean any outdoor area enclosed in a safety fence in which is situated any combination of transforming, switching and / or linking apparatus, together with any associated strung or solid busbar arrangement.
Failure Causes	The circumstances during design, manufacture or use which have led to failure (IEEE). Failure causes describes why, but not how equipment fails. Failure causes are rarely the root causes of failures, and are defined at the

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	level at which maintenance is performed.
Condition monitoring	The monitoring or diagnostic activity that is used to predict or foresee equipment failures (EPRI).
Design Change	A modification or redesign of an item or system (EPRI).
Discard Task	A time-directed replacement of an equipment item (EPRI).
Failure Mechanism	The physical, chemical or other process that results in failure. Note: The circumstance that induces or activates the process is termed the root cause of failure (IEEE).
Failure Mode	The effect by which a failure is observed to occur (IEEE). A failure mode describes how, but not why equipment fails.
Failure rate	The actual or expected number of failures in a specified time period or specified number of operations.
Hidden failure	A non-evident and non-apparent equipment failure mode that is not normally detectable without performing a failure finding task (EPRI).
Maintenance Template	A pre-engineered set of maintenance tasks for an equipment type, environment, application, etc., developed using a logic tree analysis. Maintenance template improves efficiency of task selection (EPRI).
Non-critical failure Modes	An equipment failure mode that has limited physical, operational, safety, maintenance, or financial effects such that the selection of maintenance tasks using a task selection logic is not warranted (EPRI).
Run-to-failure	A decision not to perform preventive maintenance (EPRI).
Task Selection logic	A structured decision process for selecting applicable and effective tasks to address the causes of critical equipment failure modes (EPRI).

2.3.1 Classification

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

2.3.2 Corrective Maintenance

The maintenance carried out after a failure has occurred and intended to restore an item to a state in which it can perform its required function.

2.3.3 Preventive Maintenance

The maintenance carried out at predetermined intervals or corresponding to prescribed criteria, and intended to reduce the probability of failure or the performance degradation of an item.

2.3.4 Functional Importance – Critical

Applicable to an asset which must operate, as designed, in order

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- to meet legal requirements, or
- to meet regulatory requirements, or
- to ensure safety of people, or
- to prevent irreversible environmental harm, or
- to prevent economic loss (net profit) of greater than R99 million
- 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.

2.3.5 Functional Importance – Significant

Applicable to an asset which must operate, as designed, in order

- to prevent impact on personnel and public, or
- to prevent measureable impact on environment, or
- to prevent damage to, or accelerated aging of plant resulting in economic loss,
- to ensure continued income through the provision of services and accurate billing, or
- to protect the Eskom brand and reputation, such that any economic losses (net profit) are limited to between R1 million – R99 million.

2.3.6 Functional Importance – Economic

Applicable to an asset which must operate, as designed, in order

- to ensure continued income through the provision of services and accurate billing, or
- to prevent damage to, or accelerated aging of plant resulting in economic loss, such that any economic losses (net profit) are limited to between R100 thousand - R1 million.

2.3.7 Functional Importance – Run to Failure

Applicable to an asset where the consequences of failure are acceptable, without preventative maintenance being performed, for a period of time until normal inspection and test activities will determine the failure and correction actions can be carried out. Economic losses are limited to less than R100 thousand.

2.3.8 Maintenance Engineering Strategy

Maintenance Engineering Strategy refers to the engineering performed during the design process (logistic support analysis) to define the maintenance requirements of the 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 strategy.

2.3.9 Critical Maintenance Spares

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.

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2.3.10 Plant

It is any infrastructure which has been established for the generation, transmission, distribution and sale of electricity.

2.4 ABBREVIATIONS

Abbreviation	Description
CoE	Centre of Excellence
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
RCM	Reliability Centred Maintenance
SSC	System, Structure or Component

2.5 ROLES AND RESPONSIBILITIES

The Manager - Design Base Maintenance is responsible for the consistency and process of compiling and implementation of the maintenance engineering strategy in the Asset Performance Management tool. The wires Operating Units are responsible for capturing asset operation, condition and performance information required in the Asset Performance Management tool to develop asset specific maintenance execution strategies.

2.6 PROCESS FOR MONITORING

The Manager - Design Base Maintenance will monitor the development and is accountable for the implementation of Maintenance Engineering Strategies as well as the development of maintenance Execution Strategies in the Asset Performance Management Tool. The Asset Management will monitor the effectiveness and consistency of maintenance execution strategies in the various wires Operating Units. The Design CoE Managers are accountable for the development of Maintenance Engineering Strategies.

2.7 RELATED/SUPPORTING DOCUMENTS

Refer to the Normative and Informative sections.

3. MAINTENANCE ENGINEERING STRATEGY

The objective of the maintenance strategy is to ensure that the health of substation facilities in Eskom substations is managed over their lifecycle. This will ensure optimal reliability, availability and life of the equipment.

The maintenance requirements for facilities in Eskom substations are derived based on the RCM principles. FMECA studies have been carried out for substation facilities in Eskom substations (refer to Annexure B). The results of the FMECA study have been used as the basis of the maintenance execution strategy template (refer to Annex E). The information and data collected during these maintenance activities shall be captured and processed in the relevant maintenance management system as stipulated by the "Maintenance of Design Base" PCM. The probability of failure for substation facilities shall be determined assuming best practises are applied over the entire life cycle of the electrical component in Eskom substations.

The maintenance categories include the following:

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- Routine inspection: This involves a visual inspection/investigation of the principle features of the substation facilities without requiring them to be taken out of service. Observations resulting from inspections may lead to the decision to carry out further maintenance activities.
- Minor maintenance: This involves the execution of scheduled or preventive maintenance work and may require the substation facilities to be taken out of service. Minor maintenance may be time based and/or operational based. Minor maintenance may also include the assessment of the condition of the substation facilities in Eskom substations.
- Major maintenance: This involves work performed with the objective of repairing, replacing or modifying parts/facilities as required. Major maintenance may involve the execution of specialised maintenance where specialised knowledge is required (live substation work).

In the event of a breakdown (unplanned shutdown), the substation facilities and surrounding areas shall be restored and reinstated in accordance with its original design base.

All associated data affected by changes to the substation facilities shall be collected and captured on the relevant systems in accordance with the design base requirements.

In order for the various maintenance activities to be effectively carried out, accurate substation facilities data (i.e. functional location, duty cycle, and environment) is a prerequisite. These maintenance requirements shall be customised to cover all substation facilities types as described in Annexure E.

3.1 PLANT IDENTIFICATION

Eskom transmission and distribution divisions own, operate and maintain electrical substations – supplying key, commercial, industrial, agricultural and residential customers. The current operating voltages range from 6.6kV – 765kV. The substation facilities form part of the substation and are common across all substation types and voltage range.

3.2 DESIGN INTENT

Maintenance requirements contribute to achieving the design intent, i.e. what the maintenance should sustain. In order to accurately specify the maintenance requirements it is necessary to understand the following design intent for substation facilities:

- For the purposes / functions of different substation facilities – see Annexure B
- The substation facilities shall be reliable and dependable. They shall be maintainable in order that the specified / required maintenance is implemented.
- Substation facilities shall be in the manner that its operation and maintenance will be carried out safely.
- The substation facilities shall physically and electrically operate in the environment that the plant is intended or located to operate.
- The substation facilities shall be operated within their design limits (load etc.)

The intended design life of the substation facilities shall be as per Eskom's specifications in collaboration with the OEMs.

3.3 CONDITION, CRITICALITY AND RISK ASSESSMENT FOR SUBSTATION FACILITIES

3.3.1 Demographics background

The wires business currently owns, operates and maintains all substations in transmission and distribution networks. The voltage range for transmission substations starts from 88kV up to 765kV and these substations are used to fulfil the following functions:

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- They play a key role in the process of transmitting electric power from power stations to load centers.
- They are used to interconnect the transmission network in order to improve the security of supply.
- They are used to supply the electric power to sub-transmission or distribution networks and in some cases to customers directly connected to the transmission network.

The voltage range for transmission substations starts from 6.6kV up to 132kV and these substations are used to fulfil the following functions:

- They play a key role in the process of transmitting electric power from transmission system to the distribution system.
- They are used to interconnect the distribution network in order to improve the security of supply.
- They are used to supply the electric power to customers directly connected to the distribution network.

The Eskom wires business operates and maintains over three thousand substations country wide and most of them belong to the Distribution business.

3.3.2 Demographic requirements

It is required for Eskom's wires business to capture and keep a record of information for existing or newly built substations. The information about Transmission substation assets is currently captured in SAP PM Database while that of Distribution substation assets is captured in Maximo Database.

3.3.3 Degradation review and health index

The substation facilities shall be analysed in order to understand the related failure modes of the units. The following facilities considered:

3.3.3.1 Buildings

Substation buildings comprise of the following:

- Control room
- Switch house
- Battery room
- Carrier room
- Office
- Stores
- Guardhouse
- Workshop

These are used to house secondary plant equipment (protection, metering, DC, tele-protection, etc), switchgear and consumables.

3.3.3.2 Heating ventilation and air conditioning

The main purpose of HVAC is to maintain good indoor air quality through adequate ventilation with filtration and provide thermal comfort. The objective of maintaining good air quality in substation buildings is achieved by using one or a combination of the following:

- Air conditioning systems
- Extractor Fans
- Whirlybirds or air vents

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3.3.3.3 Lights

Lights are used provide a specific level of illumination adequate for those working in the area. Lights in this case refer to the following lights:

- Buildings
- Security lights

The illumination in buildings shall be sufficient enough to enable personnel to identify any apparatus on which they are required to operate. Security lights shall illuminate the area outside the security fence to ensure ready observation of any one approaching the security area.

3.3.3.4 Fences

Fences are used to secure Eskom properties and to ensure the safety of personnel, public and stray animals. There are three types of fences used in Eskom:

- Boundary fence: is a low level fence that is used to demarcate Eskom's property.
- Security fence: is used to protect Eskom's assets (i.e to prevent unauthorized access into the substation). There are three levels of security fencing and this depends on the risk assessment done for the substation.
- Safety fence: is used to prevent accidental encroachment by persons or animals

These fences are used to achieve different purposes and their specifications are also different.

3.3.3.5 Roads

Roads are used to provide access for personnel and equipment into the substation. This includes heavy duty trucks which are used to transport transformers and reactors.

3.3.3.6 Oil Dam

Oil dams are used to achieve the following purposes:

- Prevent oil spillage from a unit of equipment spreading to adjacent units of equipment, buildings, other structures, etc.
- Minimize exposure to the main oil-filled equipment during a fire involving an oil spillage from the auxiliary equipment.
- Minimize the severity and duration of fire in an oil catchment area.
- Prevent oil conveyed by the oil drainage system from polluting the environment.
- Prevent the spread of fire from a unit of equipment to adjacent units, buildings, etc.

3.3.3.7 Drainage System

Drainage systems are designed for the following purposes:

- To retain liquids, within a bounded area for treatment or disposal as required.
- To remove liquids to a remote location such as oil for retention or treatment prior to discharge.

3.4 FAILURE MODES

In order to define asset health indices and a CCRA strategy for substation facilities, it is crucial to understand the related failure modes. These failure modes are listed in Annexure B (FMECA worksheet).

3.4.1 Designed life expectancy failure issues

Substation facilities shall be designed for a period of at least 30 years or the duration of the substation life. Failure modes are analysed in annexure B (FMECA).

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3.4.2 Condition assessment techniques

3.4.2.1 Buildings

Visual inspection is used to assess the condition of all buildings in Eskom.

3.4.2.2 Heating ventilation and air conditioning

Routine inspection (including visual) is the assessment technique used to assess the condition of HVAC systems. For an air conditioning system, visual inspection is used to verify the gas pressure and to assess the general condition of the unit (condenser and evaporator units). The noise emitted by the compressor (which is inside the condenser unit) gives an indication of the condenser unit condition. The extractor fan condition can also be picked up by the noise it makes.

3.4.2.3 Lights

Lights use luminaries whose lifespan is determined by their type (e.g. LEDs last longer than Halogens). Visual inspection and light output (light intensity) measurement are the only assessment techniques that are used to assess the condition of lighting. Visual inspection is used to check luminaries that have already failed.

For a given power input the light output (lumens) of a light source decreases with time and this can be used to predict failure. The technique is used to verify the decreasing light output and whether the light output is above the minimum required illumination (illumination requirement differs per area e.g. HV yard, security lights, control room, etc)

3.4.2.4 Fences (Electric and non-electric)

Non-electric fences refer to the safety fence, inner barrier and outer barrier fences. Electric fence consists of the following components:

- Conductors
- Insulators
- Energisers
- Surge Arresters

Visual inspection is used to assess the condition of the electric and non-electric fences. Voltage and energy measurements are the techniques that are used to assess the condition of the electric fence components.

3.4.2.5 Roads

Visual inspection is the technique used to assess the condition of all roads in and around substations in Eskom.

3.4.2.6 Oil dams

Visual inspection is the technique used to assess the condition (oil leaks, cracks etc) of the oil dams in substations.

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3.4.2.7 Drainage

Visual inspection and diagnostic tests are techniques used to assess the condition (flooding, drainage pipes blockage, etc) of the drainage systems in substations.

3.5 END OF LIFE CRITERIA AND CONDITION RATING

Computing the Health Index for the substation facilities will require developing end-of-life criteria for the various components of these assets as described in section 4.3 (Degradation review and health index) of this report. Each component criterion represents a factor critical in determining the component's condition relative to end-of-life.

The condition assessment and rating process must include visual inspections and detailed reviews of maintenance records and diagnostic test reports extracted from Eskom's asset management system databases. In addition to maintenance histories, these databases contain information about operating requirements and conditions, defects, failures, and spares. In assessing the information available against end-of-life criteria, condition states must be rated A through E. For this asset class, letter condition ratings have the following general meanings:

- "A" means the component is in "as new" condition;
- "B" means the component has some minor problems or evidence of aging;
- "C" means the component has many minor problems or a major problem that requires attention;
- "D" means the component has many problems and the potential for major failure; and
- "E" means the component has completely failed or is damaged or degraded beyond repair.

The specific definitions are used for each condition rating (i.e., A – E) in the assessment of each system component. An equivalent rating score is awarded for each assessment outcome based on the scoring guideline provided in table 1 below.

Table 1: Condition score rating guideline

Condition rating	Description
A	= 4
B	=3
C	=2
D	=1
E	=0

3.5.1 Buildings

This parameter is comprised of three categories, namely:

- General conditions (Visual inspection), accounting for 100% of the overall score

The condition scoring description can be found in Table 2 below. The final score for the buildings health index is then calculated using Equation 1 below:

$$Score(Buildings) = (General_Conditions) \quad (1)$$

Table 2: General condition visual inspection condition scoring description

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Condition rating	Description
A	No visible defects – new building
B	Minor defects but still in good condition
C	Minor defects that requires attention
D	Major defects and the potential for major failure
E	Major damage – Immediate action required

3.5.2 Heating ventilation and air-condition (HVAC)

This parameter is comprised of two categories, namely:

- Degradation of unit accounting for 60% of the overall score.
- General conditions (Visual inspection), accounting for 40% of the overall score

The condition scoring description for each parameter can be found in Table 3 and 4 below. The final score for the HVAC health index is then calculated using Equation 2 below:

$$Score(HVAC) = 0.6(Degradation) + 0.4(General_Conditions) \quad (2)$$

Table 3: Degradation condition scoring description

Condition rating	Description
A	No degradation of unit – New installation
B	Low level of degradation and within limits – Good operating condition
C	
D	
E	High level of degradation and major damage – Immediate action required

Table 4: General condition visual inspection condition scoring description

Condition Rating	Description
A	No damage or signs of deterioration – New installation
B	Low levels of deterioration and no damage - good operating condition
C	Low levels of deterioration and minor damage – fair operating condition
D	Medium levels of deterioration and minor damage - potential for failure
E	Major damage – Immediate action required

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3.5.3 Lights

This parameter is comprised of two categories, namely:

- Light intensity (measured) accounting for 20% of the overall score
- General conditions (Visual inspection), accounting for 80% of the overall score

The final score for the lights health index is then calculated using Equation 3 below:

$$Score(lighting) = 0.2(light_intensity) + 0.8(General_Conditions) \quad (3)$$

Table 5: Light intensity condition scoring description

Condition rating	Description
A	As per Eskom requirements – New installation
B	-
C	Light intensity below Eskom's requirements
D	-
E	No light available – Immediate action

Table 6: General (visual inspection) condition scoring description

Condition Rating	Description
A	Light in good condition - "as new" condition
B	-
C	-
D	-
E	Light not in working condition – Immediate action

3.5.4 Fences

The electric fences, energising unit and nonelectric fence health score is computed using equation 4 below.

$$Score(Fences) = 0.33(Electric\ fence) + 0.33(Energ\ unit) + 0.33(Non-electric\ fence) \quad (4)$$

3.5.4.1 Electric fence

This parameter is comprised of two categories, namely:

- Degradation (corrosion, pollution – visual inspection), accounting for 50% of the overall score.
- General conditions (vandalism, vegetation – visual inspection), accounting for 50% of the overall score

The condition scoring description for each parameter can be found in Table 5 & 6 below. The final score for the electrical fence health index is then calculated using Equation 5 below:

$$Score = 0.5(Degradation) + 0.5(General\ Conditions) \quad (5)$$

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Table 7: Degradation (Corrosion, pollution) condition scoring description

Condition rating	Description
A	No corrosion / pollution – New installation
B	-
C	Minor or a major corrosion / pollution that requires attention
D	-
E	High level of corrosion / pollution – Immediate action required

Table 8: General (vandalism and vegetation) condition scoring description

Condition rating	Description
A	No vandalism / vegetation – New installation
B	-
C	Minor or a major vandalism / vegetation that requires attention
D	-
E	There is major vegetation touching security fence or vandalism – Immediate action required

3.5.4.2 Electric fence - energiser units

This parameter is comprised of two categories, namely:

- Degradation of the energiser (impulse analyser test), accounting for 50% of the overall score.
- Circuitry failure (alarms and indications), accounting for 50% of the overall score.

The condition scoring description for each parameter can be found in Table 9 to Table 10 below. The final score for the energiser units' health index is then calculated using Equation 6 below:

$$Score = 0.50(\text{degradation}) + 0.5(\text{circuitry_failure}) \quad (6)$$

Table 9: Degradation (Non-lethal Voltage and Energy) condition scoring description

Condition rating	Description
A	As per Eskom requirements – New installation
B	-
C	Voltage and Energy intensity below Eskom's requirements
D	-
E	No Voltage and Energy – Immediate action

Table 10: Circuitry failure condition scoring description

Condition rating	Description
------------------	-------------

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A	Circuit in good condition – New installation
B	-
C	-
D	-
E	Energiser circuitry failure – Immediate action

3.5.4.3 Fences (non-electrical)

This parameter is comprised the following category:

- General conditions due corrosion vandalism (Visual inspection), accounting for 100% of the overall score

The condition scoring description for each parameter can be found in Table 11 below.

$$Score(non_electrical) = (General_Conditions)_{(7)}$$

Table 11: General condition visual inspection condition scoring description

Condition rating	Description
A	No visible corrosion – new Fence
B	minor corrosion but still in good condition
C	minor corrosion that requires attention
D	Major corrosion and the potential for major failure
E	major damage /vandalism – Immediate action required

3.5.5 Roads

This parameter is comprised the following category:

- General conditions (Visual inspection), accounting for 100% of the overall score

The condition scoring description for each parameter can be found in Table 12 below.

$$Score(Roads) = (General_Conditions)_{(8)}$$

Table 12: General condition visual inspection condition scoring description

Condition rating	Description
A	No visible defects – new road
B	minor defects but still in good condition
C	minor defects that requires attention
D	Major defects –reduced accessibility
E	major damage – Immediate action required

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3.5.6 Oil dams & drainage systems

The oil dams and drainage systems score is computed using formula 9 below.

$$Score(Oil_dams \& drainage\ systems) = 0.5(Oil\ dams) + 0.5(drainage\ systems) \quad (9)$$

3.5.6.1 Oil dams

This parameter is comprised the following category:

- General conditions (Visual inspection), accounting for 100% of the overall score

The condition scoring description for each parameter can be found in Table 12 below.

$$Score(Oil_dams) = (General_Conditions) \quad (10)$$

Table 13: General condition visual inspection condition scoring description

Condition rating	Description
A	No visible defects
B	minor defects but still in good condition
C	minor defects that requires attention
D	-
E	Blockage/leakage – Immediate action required

3.5.6.2 Drainage System

This parameter is comprised the following category:

- General conditions (Visual inspection), accounting for 100% of the overall score

The condition scoring description for each parameter can be found in Table 13 below.

$$Score(Drainage_system) = (General_Conditions) \quad (11)$$

Table 14: General condition visual inspection condition scoring description

Condition rating	Description
A	No visible defects
B	minor defects but still in good condition
C	minor defects that requires attention
D	-
E	Blockage – Immediate action required

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3.6 HEALTH INDEX SCALE OF SUBSTATION FACILITIES

The health index for substation facilities can then be calculated by applying the combined condition scoring weight distribution as indicated in Table 15:

Table 15: Substation Facilities health index scale

Item No.	Substation components health index criteria	Weight	Condition rating	Maximum score
1	Buildings Condition	3	A,B,C,D,E / (4,3,2,1,0)	12
2	Heating ventilation and air-condition	3	A,B,C,D,E / (4,3,2,1,0)	12
3	Lights Condition	3	A,B,C,D,E / (4,3,2,1,0)	12
4	Fences: Electric, non-electric & energiser unit Condition	3	A,B,C,D,E / (4,3,2,1,0)	12
5	Roads Condition	3	A,B,C,D,E / (4,3,2,1,0)	12
6	Drainage system and Oil dam Condition	3	A,B,C,D,E / (4,3,2,1,0)	12
Max. Score: 72 (Calculate percentage result)				

Totalled scores were used in calculating final Health Indices for each asset class component. For each component, the Health Index calculation involved dividing its total condition score by its maximum condition score, then multiplying by 100. This step normalizes scores by producing a number from 0-100 for each asset class member.

Table 16: Health index scale for Substation facilities

Health Index	Condition	Description	Requirements
85 – 100	Very Good	Some ageing or minor deterioration of a limited number of facilities	Normal maintenance
70 – 85	Good	Significant deterioration of some facilities	Normal maintenance
50 – 70	Fair	Widespread significant deterioration or serious deterioration of specific facilities	Increase diagnostic testing, possible remedial work or replacement needed depending on criticality
30 – 50	Poor	Widespread serious deterioration	Start planning process to replace or rebuild considering risk and consequences of failure
0 – 30	Very Poor	Extensive serious deterioration	At end-of-life, immediately assess risk; replace or rebuild based on assessment

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3.7 CONSEQUENCE OF FAILURE

Consequences of Failure are the full range of effects that occur when an asset fails. Possible effects include the direct cost to repair the asset, replacement of the asset (if appropriate), customer interruptions and customer minutes, as well as possible safety or environmental costs.

All consequences must be expressed in equivalent economic (Rand) and technical terms.

Consequences of failure should capture the following information:

- Direct cost of the failure, to repair or replace failed equipment.
- Emergency repair costs due to asset failure.
- Associated damages caused by the failure, such as damage to neighbouring equipment.
- Customer interruption costs and cost of un-served energy (COUE).

3.7.1 Buildings

- The direct cost to repair/re-build – R6k per square meter
- The emergency repair/re-build – R6k per square meter.
- Associated damages caused by the failure, such as damage to neighboring equipment – dependent on type of building – High risk
- Customer interruption costs and lost energy served – 2-3 days customer interruption time

3.7.2 Heating ventilation and air-condition (HVAC)

- The direct cost to repair/replace – R10k per unit
- The emergency repair/replace – R10k per unit.
- Associated damages caused by the failure, such as damage to neighboring equipment – Low risk
- Customer interruption costs and lost energy served – N/A (low risk to customer interruption)

3.7.3 Lights

- The direct cost to repair/replace – R5k per unit
- The emergency repair/replace – R5k per unit.
- Associated damages caused by the failure, such as damage to neighboring equipment – Low risk
- Customer interruption costs and lost energy served – N/A (low risk to customer interruption)

3.7.4 Electric fence

- The direct cost to repair/replace – R5k per meter
- The emergency repair/replace – R5k per meter
- Associated damages caused by the failure, such as damage to neighboring equipment – Low risk
- Customer interruption costs and lost energy served – N/A (low risk to customer interruption)

3.7.5 Electric fence - energiser units

- The direct cost to repair/replace – R20k per unit
- The emergency repair/replace – R20k per unit
- Associated damages caused by the failure, such as damage to neighboring equipment – Low risk
- Customer interruption costs and lost energy served – N/A (low risk to customer interruption)

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3.7.6 Non-Electric fence

- The direct cost to repair/replace – R5k per meter
- The emergency repair/replace – R5k per meter
- Associated damages caused by the failure, such as damage to neighboring equipment – Low risk
- Customer interruption costs and lost energy served – N/A (low risk to customer interruption)

3.7.7 Roads

- The direct cost to repair – R20k per square meter
- The emergency repair– R20k per square meter
- Associated damages caused by the failure, such as damage to neighboring equipment – Low risk
- Customer interruption costs and lost energy served – N/A (low risk to customer interruption)

3.7.8 Oil dam

- The direct cost to repair – R135k for 80kL and R150k for 120kL
- The emergency repair– R135k for 80kL and R150k for 120kL
- Associated damages caused by the failure, such as damage to neighboring equipment – Low risk
- Customer interruption costs and lost energy served – N/A (low risk to customer interruption)

3.7.9 Drainage system

- The direct cost to repair – R10k per square meter
- The emergency repair– R10k per square meter
- Associated damages caused by the failure, such as damage to neighboring equipment – Low risk
- Customer interruption costs and lost energy served – N/A (low risk to customer interruption)

3.8 REQUIRED TASK MANUALS

The specific maintenance tasks (i.e. what and how) shall be derived / developed from the maintenance categories mentioned in the Maintenance Engineering Strategy. For all maintenance task identified, maintenance documents in the form of a maintenance task manual and associated training modules are used.

The actual task manual will be compiled by the Operating, Maintenance and Outage Management function or the Design function in the case of new designs.

3.9 FACILITIES AND TRAINING MATERIAL

Training modules shall be developed for all maintenance tasks (i.e. what and how) derived from the task manuals. The training modules will ensure that the transformer/reactor maintenance is executed properly and safely by skilled and competent staff. Skills shall be continuously developed and maintained to adequately maintain substations.

The actual training material will be compiled by the Operating, Maintenance and Outage Management function or the Design function in the case of new designs.

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4. AUTHORISATION

This document has been seen and accepted by:

Name	Designation
Roger Cormack	HV Plant Manager
Colin Smith	Manager Design Base
Sebastian Pasquallie	Manager Maintenance CoE

5. REVISIONS

Date	Rev.	Compiler	Remarks
N/A			

6. DEVELOPMENT TEAM

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

- Sibongile Maphosa
- Refilwe Buthelezi
- Peter Busch

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ANNEX A – IMPACT ASSESSMENT

(Normative)

Impact assessment form to be completed for all documents.

A1 Guidelines

- All comments must be completed.
- Motivate why items are N/A (not applicable)
- Indicate actions to be taken, persons or organisations responsible for actions and deadline for action.
- Change control committees to discuss the impact assessment, and if necessary give feedback to the compiler of any omissions or errors.

A2 Critical points

A2.1 Importance of this document. E.g. is implementation required due to safety deficiencies, statutory requirements, technology changes, document revisions, improved service quality, improved service performance, optimised costs.

Comment: Document Revision, improved service performance document was previously only applicable in Transmission Division.

A2.2 If the document to be released impacts on statutory or legal compliance - this need to be very clearly stated and so highlighted.

Comment: No

A2.3 Impact on stock holding and depletion of existing stock prior to switch over.

Comment: No

A2.4 When will new stock be available?

Comment: N/A

A2.5 Has the interchangeability of the product or item been verified - i.e. when it fails is a straight swap possible with a competitor's product?

Comment: N/A

A2.6 Identify and provide details of other critical (items required for the successful implementation of this document) points to be considered in the implementation of this document.

Comment: No

A2.7 Provide details of any comments made by the Regions regarding the implementation of this document.

Comment: N/A

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Annex A

(continued)

A3 Implementation timeframe

A3.1 Time period for implementation of requirements.

Comment: This is based on existing document.

A3.2 Deadline for changeover to new item and personnel to be informed of DX wide change-over.

Comment: This is based on existing document.

A4 Buyers Guide and Power Office

A4.1 Does the Buyers Guide or Buyers List need updating?

Comment: No

A4.2 What Buyer's Guides or items have been created?

Comment: None

A4.3 List all assembly drawing changes that have been revised in conjunction with this document.

Comment: None

A4.4 If the implementation of this document requires assessment by CAP, provide details under 5

A4.5 Which Power Office packages have been created, modified or removed?

Comment: N/A

A5 CAP / LAP Pre-Qualification Process related impacts

A5.1 Is an ad-hoc re-evaluation of all currently accepted suppliers required as a result of implementation of this document?

Comment: No

A5.2 If NO, provide motivation for issuing this specification before Acceptance Cycle Expiry date.

Comment: N/A

A5.3 Are ALL suppliers (currently accepted per LAP), aware of the nature of changes contained in this document?

Comment: N/A

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Annex A

(continued)

A5.4 Is implementation of the provisions of this document required during the current supplier qualification period?

Comment: No

A5.5 If Yes to 5.4, what date has been set for all currently accepted suppliers to comply fully?

Comment: N/A

A5.6 If Yes to 5.4, have all currently accepted suppliers been sent a prior formal notification informing them of Eskom's expectations, including the implementation date deadline?

Comment: N/A

A5.7 Can the changes made, potentially impact upon the purchase price of the material/equipment?

Comment: No

A5.8 Material group(s) affected by specification: (Refer to Pre-Qualification invitation schedule for list of material groups)

Comment: None

A6 Training or communication

A6.1 Is training required?

Comment: No

A6.2 State the level of training required to implement this document. (E.g. awareness training, practical / on job, module, etc.)

Comment: N/A

A6.3 State designations of personnel that will require training.

Comment: N/A

A6.4 Is the training material available? Identify person responsible for the development of training material.

Comment: N/A

A6.5 If applicable, provide details of training that will take place. (E.G. sponsor, costs, trainer, schedule of training, course material availability, training in erection / use of new equipment, maintenance training, etc).

Comment: N/A

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Annex A

(continued)

A6.6 Was Technical Training Section consulted w.r.t module development process?

Comment: N/A

A6.7 State communications channels to be used to inform target audience.

Comment: Change Control

A7 Special tools, equipment, software

A7.1 What special tools, equipment, software, etc will need to be purchased by the Region to effectively implement?

Comment: None

A7.2 Are there stock numbers available for the new equipment?

Comment: No new equipment

A7.3 What will be the costs of these special tools, equipment, software?

A8 Finances

A8.1 What total costs would the Regions be required to incur in implementing this document? Identify all cost activities associated with implementation, e.g. labour, training, tooling, stock, obsolescence

Comment:

None.....
.....
.....

Impact assessment completed by:

Name: _____ Sibongile Maphosa_____

Designation: __Chief Engineer HV Plant_____

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ANNEX B: FMECA WORKSHEET

Table 2: Maintenance Activities, Triggers and Duration

FMEA						Criticality Assessment			Maintenance Determination / Recommendation
Ref	Function / item	Failure mode	Failure mechanism / cause	Failure effects	Detection Methods	Sev ¹	Prob ²	Risk ³	
1. Buildings	To house assets	1. Building burning	a. Fire	Indoor assets not protected	Visual	4	1	4	1. Visual inspection (monthly) 2. Testing
		2. Cracks	a. Unstable foundation	Indoor assets not protected	Visual	4	1	4	
		3. Collapse	a. Weather conditions	Indoor assets not protected	Visual	4	1	4	
2. HVAC	To control the flow of air within buildings to achieve a specific temperature, pressure and humidity level	1. No controlled environment in the control room	a. Clogged air filters b. Control circuitry c. Compressor d. Loss of pressure (gas)	Control plant equipment malfunction.	Detect & Visual inspection	2	3	6	

FMEA						Criticality Assessment			Maintenance Determination / Recommendation
Ref	Function / item	Failure mode	Failure mechanism / cause	Failure effects	Detection Methods	Sev ¹	Prob ²	Risk ³	
	necessary for equipment or personnel in those buildings to perform their designated functions								
3. Lights	To provide a specific level of illumination adequate for those working in the area	1. Lamp not burning	a. Loose connection b. Short circuit (burnt out) c. End of life	Partial or no illumination	Visual inspection & testing	1	4	4	
4. Fences (Non-electrical)	To demarcate Eskom boundary, to prevent unauthorised access and accidental encroachment by persons and animals	1. Vandalism	a. Physical failure (tearing, bending or deformation)	Alarm and visual inspection	Visual	1	2	2	
		2. Vegetation	a. Physical failure (tearing, bending or deformation)	Alarm and visual inspection	Visual	1	2	2	
		3. Rust	a. Corrosion	Alarm and visual inspection	Visual	1	2	2	

FMEA						Criticality Assessment			Maintenance Determination / Recommendation
Ref	Function / item	Failure mode	Failure mechanism / cause	Failure effects	Detection Methods	Sev ¹	Prob ²	Risk ³	
5. Electrical Fence	To prevent unauthorised access	1. Vandalism	a. Security Fence out of order	Alarm and visual inspection	Visual inspection & testing	1	3	3	
		2. Vegetation	a. Security Fence out of order	Alarm and visual inspection	Visual inspection & testing	1	3	3	
		3. Corrosion	a. Security Fence out of order	Alarm and visual inspection	Visual inspection & testing	1	3	3	
		4. Circuitry failure	a. Security Fence out of order	Alarm and visual inspection	Visual inspection & testing	1	3	3	
6. Roads	To provide access into the substation	1. Potholes	a. Poor drainage b. Heavy loads c. Soil stability	Substation not accessible	Visual	3	3	9	
		2. Cracks	a. Soil stability	Substation not accessible	Visual	3	3	9	

FMEA						Criticality Assessment			Maintenance Determination / Recommendation
Ref	Function / item	Failure mode	Failure mechanism / cause	Failure effects	Detection Methods	Sev ¹ ₃	Prob ² ₂	Risk ³ ₃	
		3. Washed away	a. Poor drainage	Substation not accessible	Visual	3	3	9	
7. Oil Dam	To minimise environmental damage due to spillage from transformers	1. Oil leaks into environment	a. Cracks b. Blocked drainage pipe	Oil discharged into environment	Visual and test (for drainage)	2	3	6	
8. Drainage	Provides for the collection, control and disposition of water from land surface as well as large quantities of runoffs from roads, parking lots, walkways, and other paved areas	1. Flooding in substation	a. Blocked drainage pipes	Water damage	Visual and test	2	3	6	
		2. Sewage presence	a. Blocked drainage pipe	Water damage	Visual	2	3	6	

1 See Table 1 – Consequence Criteria, in Eskom's Guide to Integrated Risk Management

2 See Table 2 – Likelihood Criteria, in Eskom's Guide to Integrated Risk Management

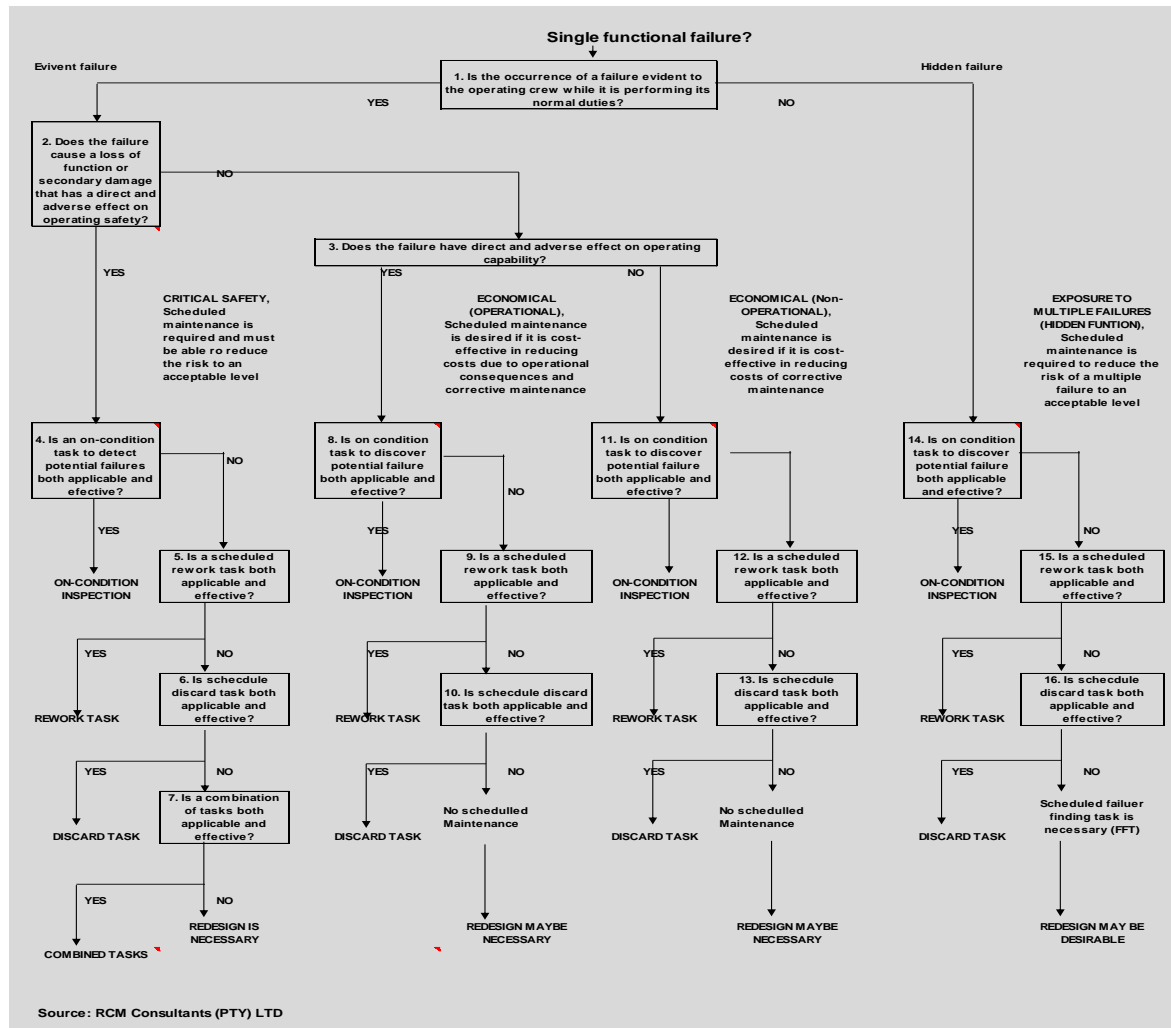
3 See Table 3 – Risk Matrix, in Eskom's Guide to Integrated Risk Management

ANNEX C: RCM WORKSHEET**Table 3: RCM Worksheet**

Reference from FMECA	Response to decision diagram questions																	
	Conseq.			Task selection														
Ref	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Proposed task	Frequency
1.1.a	Y	Y	N	N	N	N	N										Redesign	After occurrence
1.2.a	Y	Y	N	N	N	N	N										Redesign	After occurrence
1.3.a	Y	Y	N	N	N	N	N										Redesign	After occurrence
2.1.a	Y	N	Y					Y									On Condition task	Routine inspection
2.1.b	Y	N	Y					Y									On Condition task	Routine inspection
2.1.c	Y	N	Y					Y									On Condition task	Routine inspection
2.1.d	Y	N	Y					Y									On Condition task	Routine inspection
3.1.a	Y	Y		Y													On Condition task (Repair lamp / wiring)	Routine inspection
4.1.a	Y	Y		N	Y												Repair / Replace	After occurrence
4.2.a	Y	Y		Y													On Condition task	Routine inspection
4.3.a	Y	Y		Y													On Condition task	Routine inspection
5.1.a	Y	Y		N	Y												Repair / Replace	After occurrence
5.2.a	Y	Y		Y													On Condition task	Routine inspection
5.3.a	Y	Y		Y													On Condition task	Routine inspection
5.4.a	Y	Y		N	N	N	N										Replace	After occurrence
6.1.a	Y	Y		N	Y												Rework task	After occurrence
6.1.b	Y	Y		N	Y												Rework task	After occurrence
6.1.c	Y	Y		N	Y												Rework task	After occurrence

Reference from FMECA	Response to decision diagram questions																	
	Conseq.			Task selection														
6.2.a	Y	Y		N	Y												Rework task	After occurrence
6.3.a	Y	Y		N	Y												Rework task	After occurrence
7.1.a	Y	Y		Y													On Condition task	Routine inspection
7.1.b	N													Y			On Condition task (Test)	Routine inspection
8.1.a	Y	Y		Y													On Condition task (Test)	Routine inspection
8.2.a	Y	Y		Y													On Condition task (Test)	Routine inspection
6.2.a	Y	Y		N	Y												Rework task	After occurrence

ANNEX D – RCM DECISION FLOW DIAGRAM



ANNEX E: MAINTENANCE EXECUTION STRATEGY TEMPLATE

Maintenance Task Selection Template

Equipment Class:	Buildings and Lights										
Equipment Sub Class:											
Equipment Sub Class Family:											
		Combinations							Key		
Options		1	2	3	4				1Y	Once every year	
Functional Location	Significant	X	X						*	To be determined by OU based on harshness / significance	
	Economic			X	X						
Environment	Harsh	X		X							
	Mild		X		X						
Maintenance Tasks	FMECA Ref No	Trigger (Time and/or Condition)¹				Outage Required Y/N	Task Manual Required Y/N	Activities / Duration	Quality Criteria	Hold Point	Witness Point
Preventative maintenance (time based)											
On Condition task	3.1.a	*	*	*	*	N	Y	As per Task Manual	As per Task manual / Procedures	N/A	N/A
Corrective Maintenance:											
Redesign, rebuild and replace	1.1.a 1.2.a 1.3.a 3.1.b 3.1.c	N/A	N/A	N/A	N/A	N	N	As scope of work	As per QITP	Y	Y

[illegible]

Equipment Class:	Electrical and Non-Electrical Fences										
Equipment Sub Class:											
Equipment Sub Class Family:											
		Combinations							Key		
Options		1	2	3	4				1Y	Once every year	
Functional Location	Significant	X	X						*	To be determined by OU based on harshness / significance	
	Economic			X	X						
Environment	Harsh	X		X							
	Mild		X		X						
Maintenance Tasks	FMECA Ref No	Trigger (Time and/or Condition)¹				Outage Required Y/N	Task Manual Required Y/N	Activities / Duration	Quality Criteria	Hold Point	Witness Point
Preventative maintenance (time based)											
On Condition task	4.2.a							As per Task Manual	As per TM / Procedures	N/A	N/A
	4.2.b										
	5.2.a	*	*	*	5Y	N	Y				
	5.3.b										
Corrective Maintenance:											
Repair / Replace	4.1.a	N/A	N/A	N/A	N/A	Y	Y	As per Task Manual	As per TM / Procedures	N/A	N/A
	5.1.a										
	5.4.a										

Equipment Class:	Roads										
Equipment Sub Class:											
Equipment Sub Class Family:											
		Combinations							Key		
Options		1	2	3	4				1Y	Once every year	
Functional Location	Significant	X	X						*	To be determined by OU based on harshness / significance	
	Economic			X	X						
Environment	Harsh	X		X							
	Mild		X		X						
Maintenance Tasks	FMECA Ref No	Trigger (Time and/or Condition) ¹				Outage Required Y/N	Task Manual Required Y/N	Activities / Duration	Quality Criteria	Hol d Poi nt	Withn ess Point
Preventative maintenance (time based)											
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A
Corrective Maintenance:											
Repair / Replace	6.1.a 6.1.b 6.1.c 6.2.a 6.2.b	N/A	N/A	N/A	N/A	Y	Y	As per Task Manual	As per TM / Procedures	N/A	N/A

Equipment Class:		Oil Dam and Drainage										
Equipment Sub Class:												
Equipment Sub Class Family:												
			Combinations							Key		
Options			1	2	3	4				1Y	Once every year	
Functional Location	Significant	X	X			*				To be determined by OU based on harshness / significance		
	Economic			X	X							
Environment	Harsh	X		X								
	Mild		X		X							
Maintenance Tasks		FMECA Ref No	Trigger (Time and/or Condition) ¹				Outage Required Y/N	Task Manual Required Y/N	Activities / Duration	Quality Criteria	Hold Point	Witness Point
Preventative maintenance (time based)												
On Condition task (Test)		7.1.a 7.1.b 8.1.a 8.2.a	*	*	*	*	N	Y	As per Task Manual	As per TM / Procedures	N/A	N/A
Corrective Maintenance:												
N/A			N/A	N/A	N/A	N/A	Y	Y	As per Task Manual	As per TM / Procedures	N/A	N/A

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