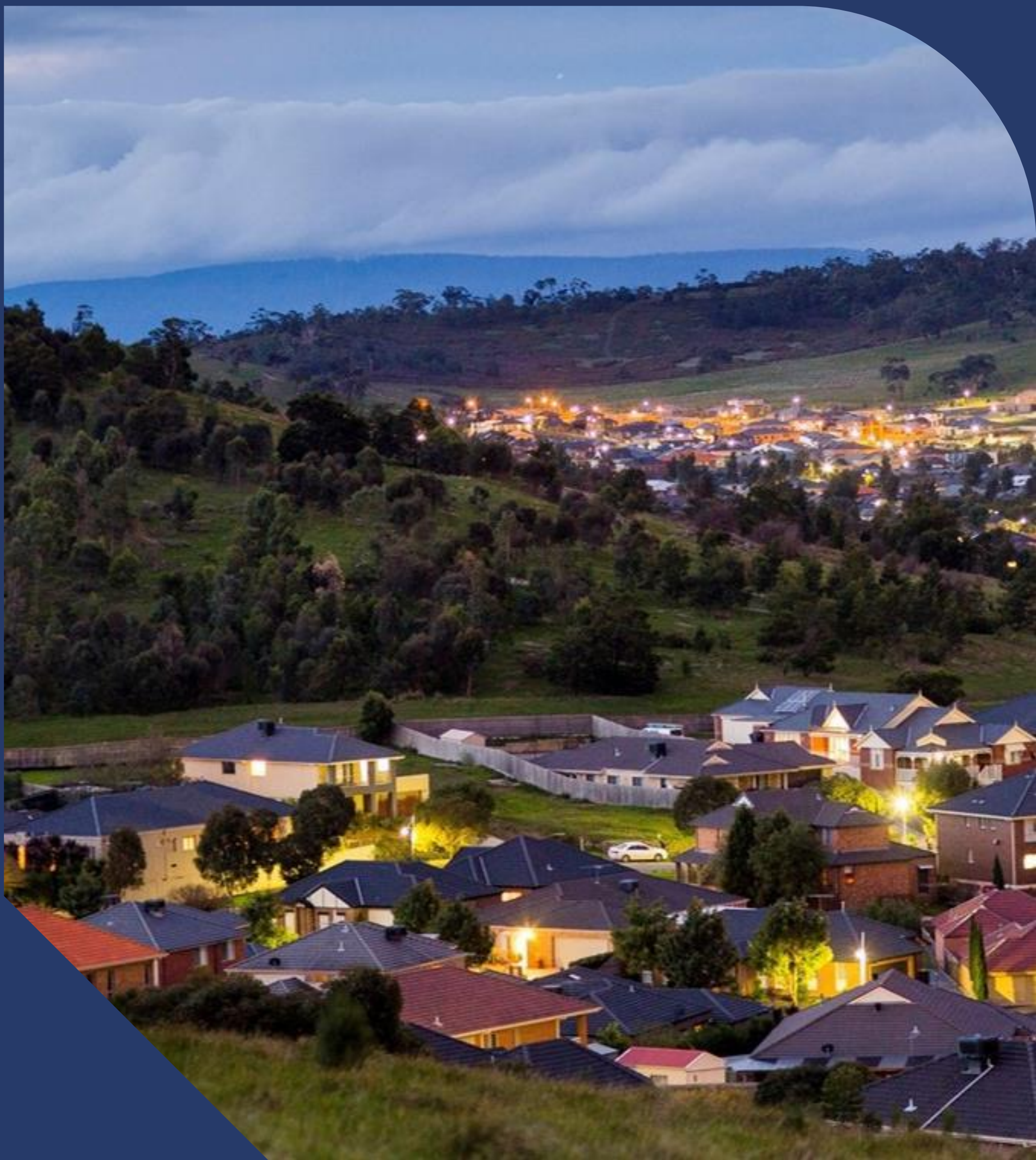
AusNet

Neutral Earthing Device

AMS – Electricity Distribution Network



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1. Executive Summary

This document is part of the suite of Asset Management Strategies relating to AusNet electricity distribution network. The purpose of this strategy is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of Neutral Earthing Devices.

Neutral Earthing Devices in this strategy is focused on Neutral Earthing Resisters (NER), Neutral Earthing Compensators (NEC) and Arc Suppression Coils (ASC) used in Rapid Earth Fault Current Limiting (REFCL) systems.

Neutral Earthing Devices in zone substations comprise of Neutral Earthing resistor (65.1%), Arc Suppression coils (32.5%) and Neutral Earthing Compensators (2.4%). Approximately 80% of NERs installed in zone substations compromise of 8-ohm type and the remaining 20% comprise of 75 ohm and 254-ohm resisters used in open cut mine customer substations. NECs are installed only in Yallourn Power Station (YPSS). All ASC are all relatively new installed under the REFCL program at various zone substations. These are installed in addition to the existing NERs at the zone substations for use when required under REFCL operation policy.

Proactive management of neutral earthing devices inspection, condition monitoring and replacement practice is required to ensure that stakeholder expectations of cost, safety, reliability and environmental performance are met.

The summary of proposed asset strategies is listed below.

1.1. Asset Strategies

1.1.1 New Assets

- Continue to purchase NERs to the latest specification with total resistance tolerance 0%/+10% and arc fault contained enclosure, and consider installing online health monitoring
- Continue to purchase NECs and arc suppression coils (ASC) to the latest specification.

1.1.2 Inspection

- Continue maintaining NERs in accordance with plant guidance information, PGI 02-01-04
- Carryout regular oil sampling of NECs and ASCs in accordance with PGI 02-01-04

1.1.3 Condition Monitoring

- Maintain online health monitoring at the existing ZSS NERs at BGE, BRA, WGL, WN, WO and BN

1.1.4 Spares

- Maintain strategic spares holding of complete 8-ohm NER and hold spare resister elements for [CIC] and [CIC] types
- Maintain strategic spares holding of NECs and ASCs as per spare holding policies

1.1.4 Replacement

- Proactively replace poor condition NERs under station rebuild projects or under Asset Replacement projects

2. Abbreviations and definitions

TERM	DEFINITION
NER	Neutral Earthing Resistors
NEC	Neutral earthing compensators
ASC	Arc Suppression Coils
GFN	Ground Fault Neutralisers
REFCL	Rapid Earth Fault Current Limiter
RCC	Residual Current Compensator
PGI	Plant Guidance and Information
SMI	Standard Maintenance Instructions
Zk	Work order Notifications associated with failures (unplanned power interruptions)
ZA	Work order Notifications associated with corrective actions from planned inspections

3. Introduction

3.1. Purpose

The purpose of this document is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of Neutral Earthing Devices installed in zone substations in AusNet Victorian electricity distribution network. This document is intended to be used to inform asset management decisions and communicate the basis for activities.

In addition, this document forms part of our Asset Management System for compliance with relevant standards and regulatory requirements. It is intended to demonstrate responsible asset management practices by outlining economically justified outcomes.

3.2. Scope

Included in this strategy is all neutral earthing resistors, neutral earthing compensators and arc suppression coils associated with the AusNet electricity distribution network that operate at voltages between earth potential and 22 kV, 11 kV and 6.6 kV.

The power transformer medium voltage winding neutral points within zone substations are directly connected to earth or via neutral earthing resistors (NERs), or in stations with delta-connected phases, through neutral earthing compensators (NECs). Ground Fault Neutralisers (GFN) using arc suppression coils are used to replace NERs for power transformer neutral earthing in bushfire risk areas to further mitigate bushfire ignition risks.

3.3. Asset Management Objectives

The high-level asset management objectives are outlined in *AMS 01-01 Asset Management System Overview*.

The electricity distribution network objectives are stated in *AMS 20-01 Electricity Distribution Network Asset Management Strategy*.

4. Asset Description

4.1. Function

NERs are passive devices, with no moving parts, protected from the weather within an enclosure and only operate during medium voltage network phase to earth faults. The NER limits the magnitude of the earth fault current that would flow on the occurrence of a phase to earth fault in a medium voltage circuit. This improves public safety by limiting the energy released at the fault location, reducing risk of bushfire ignition. The reduction in fault current magnitude also improves power quality by reducing the magnitude of operating voltage dips during phase to earth faults on medium voltage circuits. NERs can also be used to bring the single-phase short-circuit level to within the station equipment rating short-circuit level.

NECs are used to connect the neutral point of delta connected medium voltage windings the general mass of earth.

Arc suppression coils (ACS) under the GFN system is a relatively new technology introduced in Victorian electricity distribution networks under Rapid Earth Fault Clearance (REFCL) project. This new technology uses ACSs in place of NERs in identified areas under three tranches in zone substations. It helps to minimise the risk of fire ignition caused by phase to earth faults on medium voltage feeders in highest fire risk rural areas on recommendations of Royal Commission into 2009 bushfires.

4.2. Population

Population Considerations

The population profile for Neutral Earthing assets is crucial for effective lifecycle management. This profile includes detailed data on the quantity, types, locations, and specifications of these assets within the electrical distribution network.

A comprehensive understanding of the population profile allows asset managers to:

- **Identify critical assets:** Determine which neutral earthing devices are essential for maintaining the integrity and reliability of the network. For example, neutral earthing resistors (NERs) at key substations might be deemed essential and require more frequent inspections to ensure uninterrupted service.
- **Allocate resources efficiently:** Plan and allocate maintenance resources effectively by knowing the exact number and location of assets. For instance, knowing that a certain region has a high concentration of arc suppression coils (ASCs) can help in scheduling maintenance activities more efficiently.
- **Risk management:** Assess and manage risks associated with different assets. For example, if the population profile indicates that certain sections of the network with Arc suppression coils (ACS) are in bushfire-prone areas, additional protective measures can be implemented in those areas.
- **Optimise maintenance schedules:** Develop optimised maintenance schedules based on the distribution and condition of assets. For instance, NERs that protect critical feeder circuits from a zone substation might be scheduled for more frequent inspections and maintenance to prevent any potential failures.
- **Enhance reliability and safety:** Ensure that all components, including NERs, NECs, and ASCs, meet the required standards for reliability and safety. For example, if the profile reveals that certain NERs have outdated designs that no longer meet safety standards, these can be prioritised for replacement.
- **Support strategic planning:** Inform long-term strategic planning and investment decisions. For instance, the population profile might show that a significant portion of neutral earthing devices in a rapidly developing suburban area need upgrading to support increased demand, guiding future investment in that region.

Geographic Impact Areas

The AusNet electrical distribution network covers a significant portion of Victoria, including Melbourne's northern and eastern suburbs, and extends across eastern and north-eastern Victoria. This region encompasses a diverse range of geographic locations, each with specific environmental impacts on neutral earthing assets. Understanding these impacts is essential for effective asset management within the AusNet electrical distribution network.

Notable examples include:

- **High Wind Areas:** High wind areas, particularly in elevated regions and open plains, subject neutral earthing assets to significant stress and fatigue. Example: The structural integrity of neutral earthing devices in the elevated regions of the Dandenong Ranges must be robust enough to withstand high wind speeds, ensuring they remain securely in place and do not fail under stress.
- **Corrosive Areas:** Coastal areas and industrial regions where salt and pollutants are prevalent can cause corrosion of metallic components in neutral earthing assets. Example: Regular maintenance and the use of corrosion-resistant materials are crucial to prolong the lifespan of these assets. Neutral earthing devices in coastal towns like Wonthaggi require regular inspections and maintenance to mitigate the effects of salt-induced corrosion.
- **Bushfire Areas:** Bushfire-prone areas, common in many parts of Victoria, pose a risk of fire damage to neutral earthing infrastructure. Example: Fire-resistant materials and strategic vegetation management around installations are essential for reducing this risk. In the bushfire-prone regions of the Yarra Valley, neutral earthing assets must be designed to withstand high temperatures, and installations must be cleared of nearby vegetation to prevent fire spread.
- **Flood-Prone Areas:** Areas prone to flooding can impact the performance and integrity of neutral earthing assets. Example: Proper waterproofing and drainage systems are essential to protect these assets. In regions like Gippsland, where flooding is more frequent, neutral earthing devices must be installed with robust waterproofing measures to prevent water ingress and subsequent failures.
- **Seismic Zones:** Though less common, areas with potential seismic activity may require neutral earthing assets to be constructed with flexibility and resilience to absorb and dissipate seismic forces, reducing the risk of structural failure. Example: In areas near fault lines, neutral earthing devices may need to incorporate seismic-resistant features to ensure stability during earth tremors.

Population by Type

AusNet has three types of neutral earthing assets in the distribution network:

1. Neutral Earthing Resistors
2. Neutral Earthing Compensators
3. Arc Suppression Coils used in REFCL/GFN systems

There are multiple configurations and resistance values for these assets, each serving a specific function within the network.

Neutral Earthing Resistors (NERs)

- **Summary Explanation of Form and Function:** NERs are passive devices consisting of resistive elements designed to limit fault currents by dissipating electrical energy as heat. They are housed within weather-protected enclosures.
- **Purpose within the Asset Class:** NERs limit earth fault current magnitudes, enhancing safety and stability by reducing potential fire hazards and equipment damage.
- **Purpose within Network Design:** NERs improve power quality and public safety by limiting fault currents and maintaining voltage stability during faults, especially in rural and bushfire-prone areas.
- **Process Function:** During a fault, NERs limit the fault current, preventing excessive current from causing damage. They dissipate the fault energy as heat, protecting the medium voltage circuits.
- **Historical Application:** NERs have been used in the AusNet network for decades, with designs tailored to specific substation requirements (e.g., 22kV 8 ohm, 6.6kV 75 ohm, and 22kV 254-ohm resistors).

Neutral Earthing Compensators (NECs)

- **Summary Explanation of Form and Function:** NECs are oil-filled transformers with zigzag winding configurations, designed to connect the neutral point of delta-connected transformers to the earth.
- **Purpose within the Asset Class:** NECs provide a reference point for system voltages, ensuring effective fault management and network stability.
- **Purpose within Network Design:** NECs enhance system stability by connecting neutral points to the earth, improving the detection and management of earth faults.
- **Process Function:** NECs provide a low-impedance path to earth for unbalanced voltages, maintaining voltage balance and quickly identifying and managing earth faults.
- **Historical Application:** NECs have been in service in key substations like Morwell and Yallourn Power Stations for over five decades.

Arc Suppression Coils (ASC) in REFCL/GFN Systems

- **Summary Explanation of Form and Function:** ASCs, or Ground Fault Neutralisers, are used to limit fault currents by creating a resonant condition that suppresses the fault arc. They are a key component of the REFCL system.
- **Purpose within the Asset Class:** ASCs enhance bushfire safety and fault management by limiting fault currents to negligible levels, reducing fire risks.
- **Purpose within Network Design:** ASCs are crucial in bushfire-prone areas, forming part of the REFCL system to rapidly suppress fault currents and prevent fire hazards.
- **Process Function:** During a fault, ASCs generate a counteracting current that neutralises the fault current, reducing it to negligible levels within milliseconds.
- **Historical Application:** ASCs have been installed in the AusNet network since the REFCL project initiated post-2009 bushfires, significantly improving fault management in high-risk areas.

Population Profile

Neutral Earthing Devices in zone substations comprise of 54 off Neutral Earthing resistor (65.1%), 27 off Arc Suppression coils (32.5%) and 2 off Neutral Earthing Compensators (2.4%).

Neutral Earthing Resistors

AusNet has a total of 54 Neutral Earthing Resisters installed in AusNet zone substations as at end 2023. There are three resistance type designs in service in zone substations namely 8-ohm, 75 ohm and 254-ohm types. 75 ohm and 254-ohm designs are installed in open cut substations. The population of NERs by service voltage and value of resistance is given in figure 1.

Figure 1: Population of Neutral Earthing Resisters by Value of Resistance

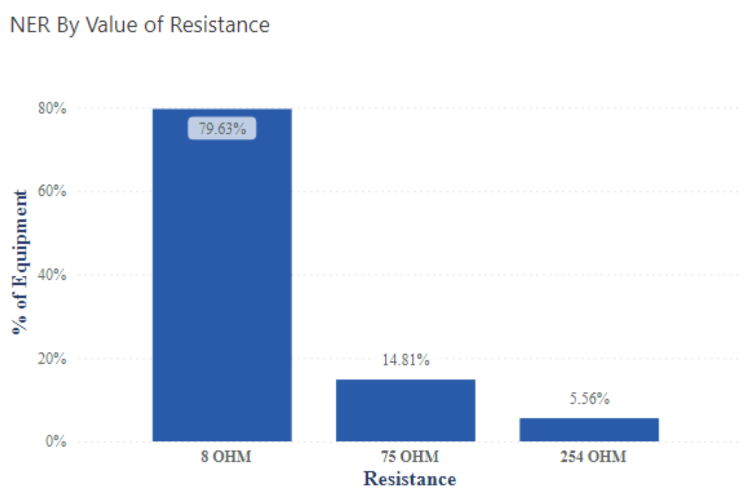
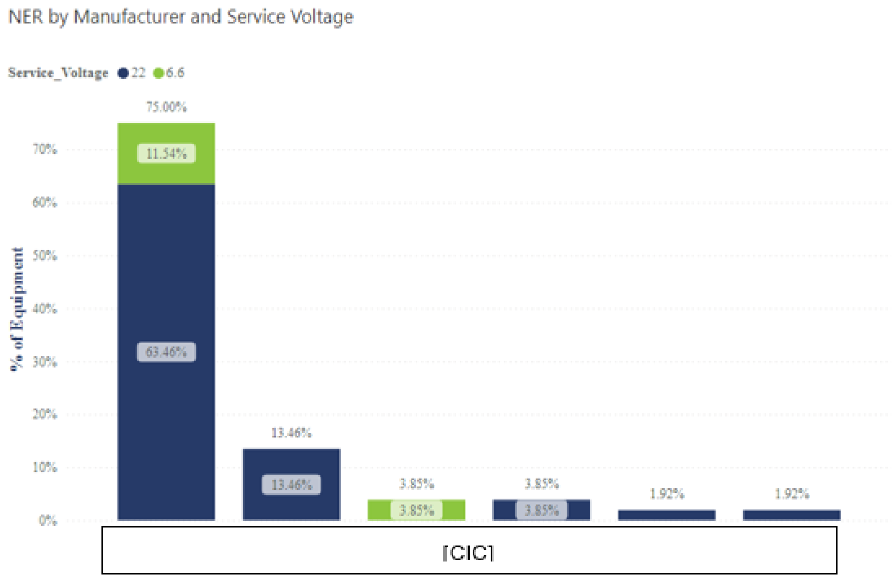


Figure 2 below provides the population of NERs by manufacturer. [CIC] NERs contribute to about 75% of the NER population.

Figure 2: NERs by Manufacturer and Service Voltage



Neutral Earthing Compensators

In the AusNet electricity distribution network, NECs are installed to connect the neutral point for delta-connected medium voltage windings to the general mass of earth. There are currently two NECs installed in Yallourn Power Station (YPSS). NECs are basically zigzag wound, oil-filled transformers. Technical details of NECs are shown in Table 1.

Table 1: NECs Installed in Zone Substations

Zone Substation	Description	Manufacturer	Rating	Neutral Connection
YPSS	No 1 NEC	[CIC]	11 kV, 5 Ohm/phase, 4500A/30 seconds	Direct earthed
YPSS	No 2 NEC	[CIC]	11 kV, 5 Ohm/phase, 4500A/30 seconds	Direct earthed

Arc Suppression Coil used in REFCL/GFN systems

The Rapid Earth Fault Current Limiter (REFCL) technology is being installed at number of AusNet zone substations is called a Ground Fault Neutralizer (GFN). The GFN helps to reduce the disruption of phase to earth faults on a network. It does this by using resonant earthing with an additional ‘residual current compensation feature’ which involves injecting current into an arc suppression coil at 180° out of phase with the residual fault current. This reduces the large fault current to less than five Amps and then close to zero Amps within 3 cycles or 60 milliseconds.

Currently there are 27 off 200A rated oil filled Arc Suppression Coils (ASC) being installed in various zone substations. They are all supplied mainly by the manufacturer, Swedish Neutral.

The purpose of the ASC is to compensate for the leakage current during an earth fault and along with a Residual Current Compensator (RCC) further reduce fault current by compensating for the active current during an earth fault. The ASC comes as one unit and is connected to the power transformer 22 kV neutral and comprise of arc suppression coil, tuning capacitor module, current transformers and manual control cabinet provide connections RCC located in the station control room.

4.3. Age Profile

Age Considerations

Understanding the age profile of neutral earthing assets is essential for effective asset management and lifecycle planning. Knowing the age distribution helps in predicting their remaining useful life and planning maintenance, upgrades, or replacements accordingly.

- **Neutral Earthing Resistors (NERs):** The age profile can indicate potential issues related to insulation degradation and metallic component corrosion. Older NERs may require more frequent inspections and condition assessments to ensure they continue to operate safely and efficiently. For example, proactive testing of insulation resistance in older NERs can prevent unexpected failures.
- **Neutral Earthing Compensators (NECs):** Over time, NECs can experience oil degradation and winding insulation breakdown due to thermal ageing. By analysing the age profile, asset managers can identify NECs at higher risk of failure and prioritise them for maintenance or replacement. For instance, replacing aging oil and monitoring winding insulation in NECs can prevent costly outages.
- **Arc Suppression Coils (ASCs):** The age profile of ASCs can reveal areas where insulation wear and component fatigue are likely. Regular inspections and maintenance based on age-related data can ensure these coils remain safe and functional. For example, replacing aging components in ASCs in high bushfire risk areas can prevent mechanical failures and enhance network resilience.

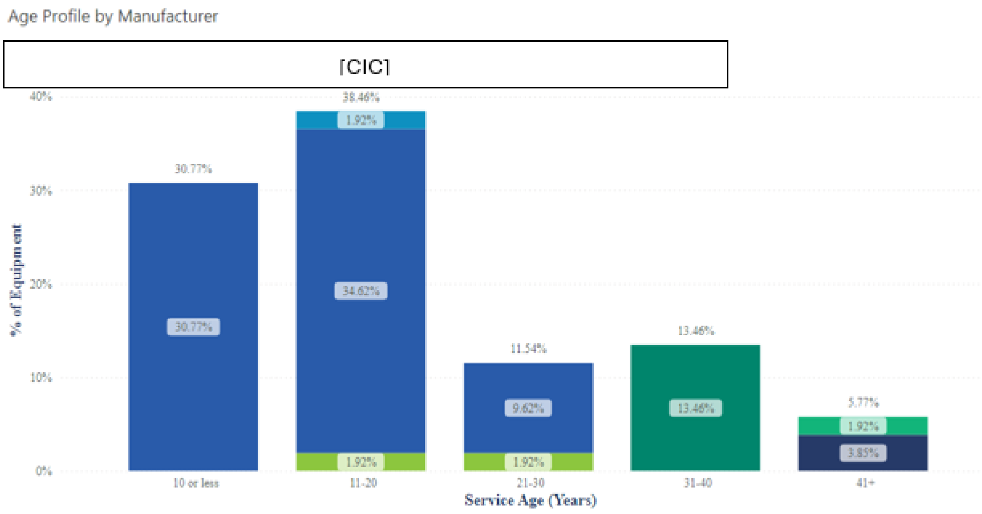
Age Profile

Neutral Earthing Resistors

The service age profile of zone substation NERs by value of resistance and by manufacturer is shown in figure 3 and 4 respectively. Average age of NERs is 17.7 years, oldest are the 75-ohm (48 years) and 254-ohm (47 years) types.

Figure 3: Age Profile of NERs by value of resistance

Figure 4: Age Profile of NERs by Manufacturer



Neutral Earthing Compensators

NECs that are in service at YPSS are new, and they are only 3 years old.

Arc Suppression Coils

All Arc Suppression Coils in service are relatively new and their average age is 4.3 years. Majority of them were installed after 2018.

5. Risk

AusNet maintains a risk management system designed in accordance with AS ISO 31000 Risk Management – Guidelines to ensure risks are effectively managed to provide greater certainty for the owners, employees, customers, suppliers, and the communities in which we operate.

The risk of each asset is calculated as the multiplication of probably of failure (PoF) of the asset and the consequence of failure (CoF). The risk is then extrapolated into the future accounting for forecast changes in PoF and CoF.

In the distribution network, AusNet aims to maintain risk. Risk treatments required to achieve this over time include replacement, refurbishment, and maintenance activities, and are developed based on current risk and extrapolated risk.

The overall approach to quantified asset risk management is detailed in AMS -01-09. Section 5.1, 5.2 and 5.3 of this document describe the considerations and methodologies to determine PoF, Cof, and risk treatments that are unique to Neutral Earthing Devices.

5.1. Probability of failure

An asset is deemed to have failed when it does not meet the functional requirements for which it was acquired. Both quantitative and qualitative analysis is used to assess the condition of the asset to determine the probability of failure and to estimate the remaining useful life. AMS 01-09 describes the detail methodologies used in calculating and deriving the probability of a failure considering the four key factors: asset life, asset utilization, location and physical condition.

5.1.1 Failure Causes

Neutral Earthing Devices are used to limit the magnitude of the earth fault current that would flow on the occurrence of a phase to earth fault in a medium voltage circuit. It improves public safety by limiting the energy released at the fault location, reducing risk of bushfire ignition. They rarely fail in service under normal operating network conditions but can fail under through fault current conditions.

Factors such as ageing, moisture ingress and corrosion, insulation degradation and repeated thorough fault are typical causes of failure usually the case of older Neutral Earthing devices.

5.1.2 Failure Modes

5.1.2.1 Application of Failure Modes

Understanding failure modes is an important tool that supports measuring the criticality of assets, especially when assessing the risk of potential failures and their potential impact on the overall system. By identifying and analysing the various ways in which an asset can fail (including the root causes and mechanisms of failure), asset managers can better predict and mitigate risks. This understanding allows for a more accurate assessment of the probability of failure (PoF) and the consequence of failure (CoF), which, as noted above, is a core aspect of how AusNet approaches determining asset criticality.

Failure Modes by Asset Class

As noted above, assessing failure modes and utilising the detailed information about each mode plays a crucial role in various aspects of Asset Management Planning. Understanding failure modes enhances the effectiveness of risk management efforts and ensures the optimal performance and reliability of assets within the electrical distribution network. Some notable failure modes for Neutral Earthing assets are detailed below.

Neutral Earthing Resistors (NERs)

- **Insulation Degradation:** The insulation of NER unit can degrade over time due to thermal ageing and environmental exposure, leading to reduced effectiveness and potential electrical faults. *Example:* High temperatures can accelerate the degradation of insulation in NERs, compromising their ability to limit fault currents effectively.
- **Corrosion:** Components of NERs, especially in coastal or industrial areas, can suffer from corrosion, affecting their structural integrity and performance. *Example:* Salt spray in coastal regions can accelerate corrosion of NERs, leading to premature failure.
- **Mechanical Wear:** Mechanical components of NERs can wear out over time, reducing their effectiveness. *Example:* Repeated fault conditions can wear down mechanical connections in NERs, necessitating maintenance or replacement.

Neutral Earthing Compensators (NECs)

- **Oil Degradation:** The insulating oil in NECs can degrade over time due to thermal ageing and contamination, reducing insulation effectiveness. *Example:* Oil quality in NECs can degrade due to oxidation and moisture ingress, requiring regular monitoring and maintenance.
- **Winding Insulation Breakdown:** The insulation of the windings can deteriorate over time, leading to reduced effectiveness and potential electrical faults. *Example:* High operating temperatures can accelerate insulation degradation in NECs, necessitating regular condition assessments.
- **Corrosion:** The metal components in NECs can corrode due to environmental exposure, affecting their performance. *Example:* Corrosion of the tank and fittings in NECs can compromise their structural integrity and functionality.

Arc Suppression Coils (ASCs) in REFCL/GFN Systems

- **Insulation Wear:** The insulation material of ASCs can wear out due to thermal cycling and environmental exposure, reducing their effectiveness. *Example:* Thermal cycling in ASCs can cause insulation materials to crack and degrade, compromising their performance.
- **Mechanical Stress:** Components of ASCs can suffer from mechanical stress and fatigue, leading to failures. *Example:* Repeated fault clearings can stress the mechanical components of ASCs, necessitating inspections and maintenance.
- **Environmental Degradation:** ASCs in harsh environments can degrade faster due to exposure to pollutants and corrosive elements. *Example:* Pollutants in industrial areas can accelerate the degradation of ASCs, requiring more frequent maintenance.

5.1.3 Probability of Failure Assessments

As per the methods of calculation described in section 3 of AMS 01-09, the conditional PoF for Neutral Earthing Devices is derived from health index based on asset life, asset utilisation, location and asset physical condition based on observed condition.

5.2. Consequence

Failure of a Neutral earthing devices has the potential of resulting in community and public safety risk, customer power quality also clear the faulty device affecting customers and restoration delays.

Following key consequences of NED failure effects have been considered viewed through two lenses.

1. Safety impact,
2. Community impact due to outages (unserved energy)

The detail methodology of the consequence assessment is described in AMS -01-09.

5.3. Risk Treatment

Risk treatments are required to maintain risk by targeting reduction of PoF or CoF depending on the nature of the risk. Treatment measures include asset replacement, asset refurbishment, inspections, testing or system redesign, and are achieved through capital projects or operational expenditure. Risk treatment options are described in the section on 'Risk Treatment' in AMS 01-09.

Capital replacement is a major component of asset risk management. The prerequisites for replacing assets:

- replacement of an asset will result in a material risk reduction
- risks can't be feasibly managed through maintenance or refurbishment
- monetised risk exceeds the replacement cost – ie replacement is economic.

6. Performance

6.1. Performance Analysis

6.1.1. Performance Analysis

In the context of asset management for Neutral Earthing assets, assessing asset performance is a vital tool for effective lifecycle management. Performance information provides a comprehensive understanding of how these assets behave under various conditions, enabling asset managers to make informed decisions that enhance the reliability, safety, and efficiency of the electrical distribution network.

Performance data helps identify trends and patterns in asset behaviour, which are crucial for making strategic decisions regarding maintenance, upgrades, and replacements. Understanding how assets perform over time allows for proactive management, reducing the risk of unexpected failures. The assessment employed by AusNet involves analysing failure trends and any significant impacts resulting from failure, which provides valuable insights into the health and reliability of the assets.

6.1.2 Performance Profile

Figure 5 to 7 below shows the ZA & Zk notifications and by defect type during the period 2020 – 2024 in Neutral Earthing Resisters and ZA notifications by age group.

Figure 5: ZA & Zk notifications during the period 2020 – 2024 -Neutral Earthing Resisters

Figure 6: ZA & Zk notification damage type during the period 2020 – 2024 - Neutral Earthing Resisters

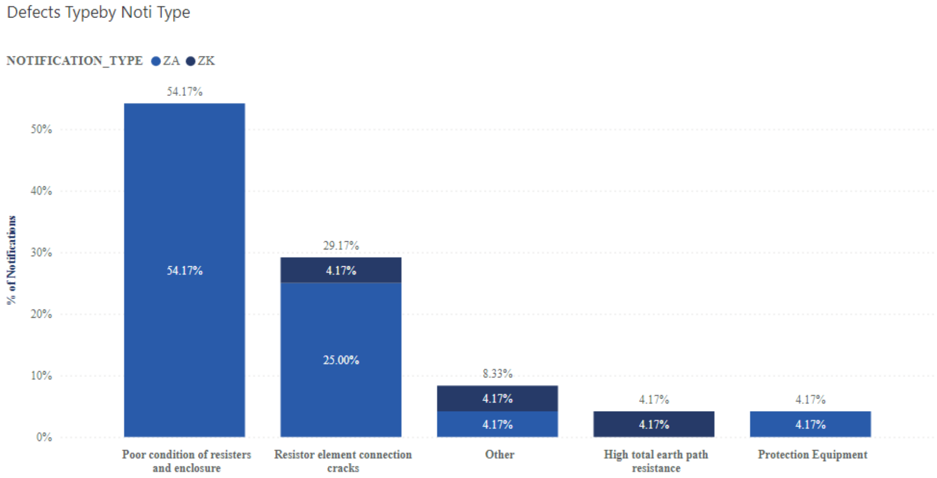
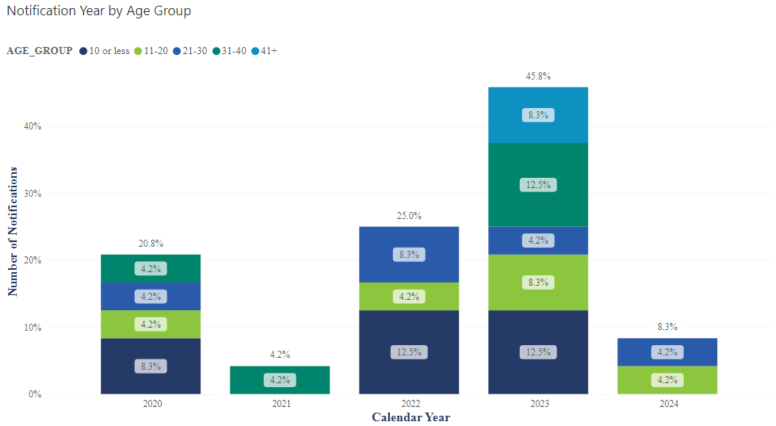


Figure 7: ZA notifications by age group during the period 2020 – 2024 - Neutral Earthing Resisters



Figures 8 and 9 below show the ZA & Zk notifications and by defect type during the period 2020 – 2024 in Arc Suppression Coils.

Figure 8: ZA & Zk notifications during the period 2020 – 2024 -Arc Suppression Coil

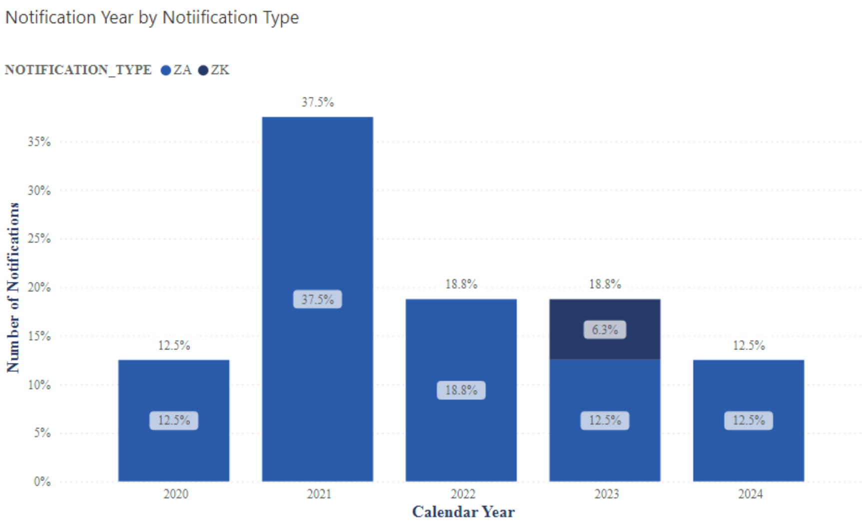


Figure 9: ZA & Zk notification damage type during the period 2020 – 2024 – Arc Suppression Coil

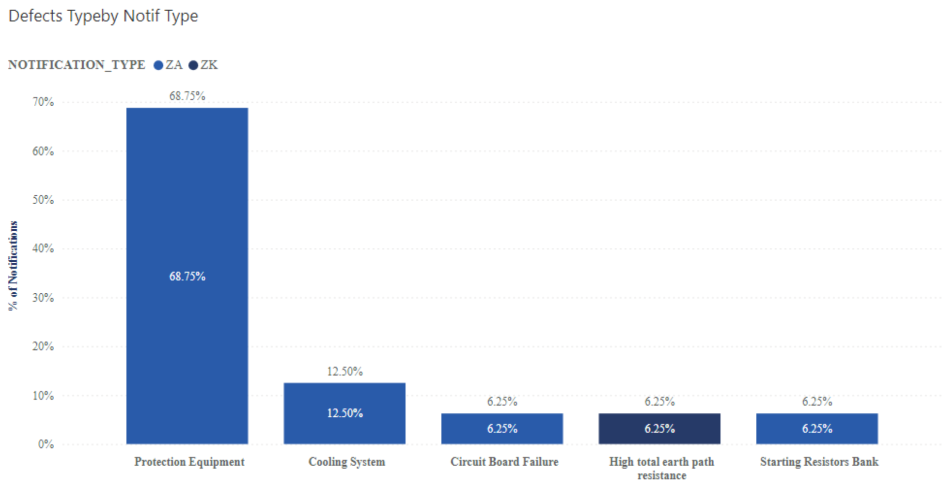


Figure 10 and 11 shows the ZA and Zk notification rate per year/Total population during the period 2020 -2024.

Figure 10: Zk notification rate during the period 2020 -2024 by Equipment Type

ZK Notifications

EQUIPMENT_TYPE	Count of Notification	Population	Notitifcations / year/Total population
Resistor	3	57	1.7%
Arc Suppression Coils	1	27	1.2%
Compensator		2	

Figure 11: ZA notification rate during the period 2020 -2024 by Equipment Type

ZA Notifications

EQUIPMENT_TYPE	Count of Notification	Population	Notitifcations / year/Total population
Neutral Earthing Resister	20	57	4.7%
Arc Suppression Coils	15	27	3.5%
Neutral Earthing Compensator		2	

Neutral Earthing Device performance notification analysis revealed following issues.

1. It is observed the Zk failure notifications contributed to only approximately 12.5% against ZA notifications (87.5%) over the period 2020 -24 in NERs. Key reason being hidden failures are found during planned maintenance inspections. The key find is poor condition of resister, resister element cracks high total earth path resistance which contribute to more than 80 % of defects in NERs. (refer Figure 5 and 6) It is also noted that 50% of NER defects are reported during ZA inspections in NERs that are more than 20 years old but similar percentage of defects were reported from less than 20-year-old NERs. (refer figure 7)
2. Arc suppression Coils in relation to NER are relatively new, but it is noted that Zk failure notifications contributed to (6.3%) against ZA notifications (93.7%) over the period 2020-2024 in arc suppression coils. They were mainly due to associated protection equipment (68.8%), cooling system (12.5%), circuit board failures (6.3%), high total earth path resistance (6.3%) and starting resistor bank issues (6.3%). (refer figures 8 and 9)
3. It is also noted that most Zk failure notifications reported in the same period 2020-2024 were associated with NERs (1.7%) against ASCs (1.2%) per year /total population. ZA notifications reported for the same period for NERs, and ASCs were 4.7% and 3.5% per year per total population. (refer Figure 10 and 11)
4. It was noted there was only one failure notifications reported from ASCs during the period 2020 -2024.

Above observations indicate the necessity of reviewing the planned maintenance regime of NERs and ASCs due to younger assets having defects reported. It would be prudent to consider replacing the very poor condition NERs during planned maintenance inspections or replace during station augmentation projects or asset replacement projects. Also consider other options such as; review design of NERs and ASCs for future procurement of equipment with improved design and quality. Refer section 8.1 & 8.3.

7. Related Matters

7.1. Regulatory Framework

Compliance Factors

Regulatory and Legislative Reference

No compliance consideration for Neutral Earthing Devices involved.

Technical Standards and Procedures

Effectively managing compliance with technical standards and operational procedures is an important element of Asset Class Planning. Adhering to these standards ensures that the assets are designed, constructed, maintained, and operated in a manner that meets industry best practices, enhances safety, and ensures reliability. Compliance with technical standards helps prevent asset failures, reduces risks, and ensures interoperability within the electrical distribution network. For example, ensuring that all components of various asset types are installed and maintained according to Australian Standards can prevent unplanned failure and operational faults, enhancing network reliability.

Refer to Station Design Manual for detailed guidance notes and references, supplied to support the assessment of this factor and the ways it impacts and influences the management of this Asset Class.

7.2. External Factors

Technical Factors

Understanding and managing the technical factors that can directly impact the lifecycle planning for Network Assets across all the AusNet Asset Classes is a core element of effective asset management. These factors encompass various design, engineering, and technical performance considerations that directly impact the ability to manage and maintain these assets efficiently. Ensuring that Network Assets meet specific technical performance standards is vital for maintaining the reliability and safety of the electrical distribution network. For example, selecting construction materials with appropriate durability and weather resistance is essential to prevent faults and ensure consistent performance under varying environmental conditions.

Environmental Factors

Environmental Management

Effectively managing obligations specific to environmental management is a core element of Asset Class Planning and supports the sustainable operation and management of Civil Infrastructure. Ensuring adherence to relevant environmental laws and standards helps prevent legal and regulatory breaches, which can lead to significant penalties, operational disruptions, and reputational damage.

Stakeholder/ Social Factors

Social Factors

Understanding social factors is essential for the effective management of critical network infrastructure assets. Social factors, including community expectations, public safety, and environmental impacts, play a significant role in shaping asset management strategies. Ensuring that these social considerations are addressed helps build public trust, maintain social license to operate, and enhance the organisation's reputation. For instance, ensuring that maintenance activities for Civil Infrastructure do not disrupt local communities or pose safety risks is crucial for maintaining public support and compliance with social responsibilities.

Stakeholder Factors

Understanding the requirements of stakeholders with a direct interest in the assets associated with the [Civil Infrastructure] asset class is an important aspect of effective asset management. Key stakeholders, including customers, regulatory bodies, and industry partners, have specific expectations that influence asset management strategies and operational decisions. Ensuring clear communication and alignment with these requirements helps maintain regulatory compliance, enhance service reliability, and build robust partnerships. For example, customers expect reliable infrastructure and timely responses to issues, which requires minimal disruption during maintenance activities of Civil Infrastructure. Similarly, regulatory bodies impose standards that must be adhered to, such as safety requirements for buildings and environmental systems, to avoid legal penalties and ensure operational legitimacy.

7.3. Internal Factors

Training and Competency Factors

Effective training and competency development is a core element of asset class. Ensuring that asset managers, engineers, operational staff, and field personnel possess the necessary skills and knowledge is crucial for maintaining the reliability, safety, and efficiency of the asset network. Competent staff can effectively perform inspections, maintenance, and repairs, preventing asset failures and minimising downtime. Continuous training helps in keeping up with technological advancements, regulatory changes, and best practices, thereby enhancing overall asset management performance.

Resource Management Factors

Resource Management is a core element of asset class planning for Network Assets. Proper oversight ensures that the management of AusNet's resource bases meets stringent quality and performance standards, which is essential for preventing asset failures, managing risks, and maintaining compliance with regulatory requirements. Effective resource management contributes to cost efficiency via activities such as leveraging the expertise of specialised in-house skills and contractors while avoiding hidden costs associated with inefficiencies and non-compliance.

There are three critical sub-categories of consideration for this factor. These sub-categories are:

- Resourcing strategies
- Outsourcing
- Supply Chain Management[i]

Economic Factors

Economic factors significantly influence the lifecycle management of network assets, impacting financial stability, investment decisions, and overall network performance. Major contracts being tendered, such as those for infrastructure development, maintenance, and technology upgrades, can materially affect asset management. These contracts involve substantial investments, requiring rigorous management to align with long-term asset goals, mitigate risks, and control costs. Effective contract management ensures that service providers deliver value, supporting the network's reliability and performance while maintaining financial health.

Material developments and significant commercial agreements also play pivotal roles in the economic landscape of asset management. Developments like new regulatory requirements or technological advancements can alter network needs, necessitating strategic adjustments in asset management. Commercial agreements, including customer service agreements, dictate service levels, performance metrics, and penalties, impacting operational priorities. Regular reviews of these agreements ensure adaptability to changing economic conditions, customer expectations, and regulatory landscapes. Additionally, planned renewal programmes and changes to asset types and purchasing strategies must be evaluated for their financial impact to ensure efficient resource allocation. By addressing these economic factors, AusNet can manage financial risks, optimise investments, and support robust lifecycle models, aligning financial planning with operational goals and regulatory requirements.

Safety Factors

Safety is a paramount concern in the management of electricity distribution network assets, as outlined in **ESMS 20-01**. Effective asset management planning and activities are crucial for protecting employees, contractors, the public, and the environment from potential hazards associated with electrical infrastructure. Ensuring adherence to safety regulations and standards through diligent asset management helps prevent accidents, minimise risks, and maintain the integrity of the network.

Targeted asset management activities include conducting regular safety audits and risk assessments, maintaining a robust Bushfire Mitigation Plan, continuously improving asset inspection and maintenance programmes, providing ongoing safety training and competency assessments, regularly reviewing and updating emergency response plans, engaging with the community to raise awareness about electrical safety, and adopting new technologies and practices to enhance network safety. By integrating these safety-focused activities into asset management planning, AusNet can effectively minimise safety risks "as far as practicable," as outlined in the Electricity Safety Act 1998 and reflected in ESMS 20-01.

7.4. Future Developments

Technology and Innovation Factors

Effectively managing the process of tracking future technology developments and innovations is a core element of asset class planning. Staying informed about technological advancements ensures that asset management practices remain up-to-date, efficient, and competitive. Innovations can lead to improved materials, better monitoring systems, and enhanced maintenance techniques that increase the reliability, safety, and longevity of critical infrastructure. For example, advancements in diagnostic tools for detecting early signs of wear and the development of advanced materials for asset components can significantly enhance their performance and maintenance. For technology and innovation, this is a process that looks to existing technologies, processes, or practices that have been proven in the market and have already been taken to market.

Research and Development Factors

Effectively managing the process of investing in research and development (R&D) and seeking funds for R&D activities is a core element of asset class planning. R&D investment ensures that the organisation stays at the forefront of technological advancements, develops innovative solutions to emerging challenges, and enhances the reliability, safety, and efficiency of its assets. For example, developing new materials with improved structural properties for buildings or advanced monitoring systems for environmental systems can significantly extend their lifespan and reduce maintenance costs. Research and development is the process of researching and investing in an idea, process, practice, or technology that has not been realised in the market yet; it is a step before tracking innovation and technology because the investment to build and take the item to market still needs to be proven and undertaken.

Continuous Improvement

Continuous Improvement (CIP) is a critical lynchpin process in the overall application of asset management, particularly for managing Distribution Assets. CIP ensures that asset management practices remain effective, efficient, and adaptive to changing conditions and emerging challenges. By consistently seeking ways to enhance processes, technologies, and strategies, organisations can maintain high levels of performance, reliability, and safety. For example, regularly updating maintenance protocols for buildings, environmental systems, and security fences based on feedback and new insights can prevent issues before they become major problems, thereby extending the lifespan of critical infrastructure.

Best practice asset management promotes a culture of continuous improvement, encouraging organisations to regularly evaluate their asset management systems, identify areas for enhancement, and implement changes. This iterative process involves monitoring performance, analysing data, and applying lessons learned to refine practices. By focusing on CIP, organisations can ensure that their asset management activities remain dynamic, resilient, and aligned with best practices and strategic objectives. This approach not only enhances the overall efficiency and effectiveness of asset management but also supports long-term sustainability and success. CIP differs from technology and innovation as well as R&D because it involves the ongoing enhancement of existing processes and practices based on real-world feedback and performance data, rather than the development and introduction of new technologies or the exploration of unproven ideas.

8. Asset Strategies

8.1. New Assets

New Asset Considerations

A strategic asset strategy for the introduction of new assets provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of asset upgrades or changes, detailing the conditions under which new assets may be introduced into the network. This is not a like-for-like replacement but rather a strategic change or upgrade to a different type of asset to enhance reliability, improve efficiency, and incorporate advanced technologies. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for integrating new assets into the AusNet network.

Targeted Activities (New Asset Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to purchase NERs to the latest specification with total resistance tolerance 0%/+10% and arc fault contained enclosure, and consider installing online health monitoring
02	Continue to purchase NECs and arc suppression coils (ASC) to the latest specification.
03	Consider incorporating design improvements to improve performance of NERs and ASCs

8.2. Inspections and Monitoring

A strategic plan for inspections and monitoring provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the ideal framework and objectives for conducting inspections and monitoring activities, such as enhancing reliability, improving efficiency, and incorporating advanced technologies. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for establishing comprehensive inspection and monitoring protocols within the AusNet network.

Targeted Activities (Inspection and Monitoring Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Carryout regular oil sampling of NECs and ASCs in accordance with PGI 02-01-04
02	Maintain online health monitoring of existing ZSS NERs at BGE, BRA, WGL, WN, WO and BN.

REF	DETAILS OF MATERIAL CONSIDERATIONS
03	**NER Condition Monitoring** NER is a single system neutral point earthing device in zone substations essentially required to be in circuit 100% of time to safely operate the electricity distribution network at all times. Defective NERs are occasionally found after about 10 -15 years in operation. Resister defects normally come to know during planned inspection or after an inspection following protection mal operation found sometimes during phase to ground faults. Based on historical failures, older NERs of certain types are inspected more frequently than others, yet resister defects are found during maintenance inspections. In order to overcome this issue, an online health monitoring scheme was introduced recently on few older NERs may need setting changes to make it more effective and expand the application to other NERs passed midlife.

8.3. Maintenance Planning

A strategic plan for maintenance provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the ideal framework and objectives for conducting maintenance activities, such as enhancing reliability, improving efficiency, and incorporating advanced technologies. It serves as a roadmap that guides the decision-making process for establishing comprehensive maintenance protocols within the AusNet network. This involves creating a structured approach to regular maintenance activities to ensure optimal performance and longevity.

Targeted Activities (Inspection and Monitoring Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue maintaining NERs in accordance with plant guidance information, PGI 02-01-04, review planned maintenance regime of NERs and ASCs.

8.4. Renewals Planning

A strategic asset strategy for renewals and replacements provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of asset refurbishments or like-for-like replacements, detailing the conditions under which existing assets may be renewed or replaced within the network. This process ensures continued reliability and efficiency, manages obsolescence, and maintains adequate spares. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for renewing or replacing assets within the AusNet network.

Targeted Activities (Renewal Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Maintain strategic spares holding of complete 8-ohm NER and hold spare resistor elements for [CIC]and [CIC] types
02	Maintain strategic spares holding of NECs and ASCs as per spare holding policies
03	Proactively replace / or replace resister elements in poorly performing NERs

8.5. Decommissioning

A strategic asset strategy for decommissioning provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of safely and efficiently removing assets from service, detailing the conditions under which decommissioning may occur. It ensures that the process is conducted in a way that minimises disruption, manages environmental impacts, and complies with regulatory requirements. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for decommissioning assets from within the AusNet network.

9. Legislative References

STATE	REGULATOR	REFERENCE
VIC	WorkSafe Victoria	Occupational Health and Safety Act 2004
VIC	Energy safe Victoria	Electricity Safety (Bushfire Mitigation) Regulations 2013

10. Resource References

NO.	TITLE	DOCUMENT TITLE
1	QMS 20-04	Documented information Control
2	AMS 01-09	Asset Risk Assessment Overview
3	AS ISO 31000	Risk Management – Guidelines
4	AMS 01-01	Asset Management System Overview
5	AMS 20-01	Electricity Distribution Network Asset Management Strategy
6	PGI 02-01-04	Summary of Maintenance Intervals – Distribution Plant Guidance and Information
7	SDM	Station Design Manual

11. Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE	APPROVED BY
1	22/12/08	SB, NB	Initial Draft	
2	29/12/08	SD	Comments by SD	
3	04/03/09	NB	Included RCM analysis	
4	24/04/09	GL	Review and update	
5	31/08/09	DR, SD, GL	Included comments re failure modes and consequences	
6	19/11/09	Nilima Bapat Stuart Dick	Editorial changes and consistency checks	
7	30/12/10	NB, GL	Included new NERs, recent failures and maintenance inspection frequency	
8	18/02/11	NB, SD	Minor changes, update of strategies (item 8.1) & Appendix 1	
9	09/01/15	P Seneviratne D Meade N Boteju	Review and update	J Bridge
10	18/06/19	N Boteju	Review and update	P Ascione
11	22/01/2025	N Boteju	Review and update	

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