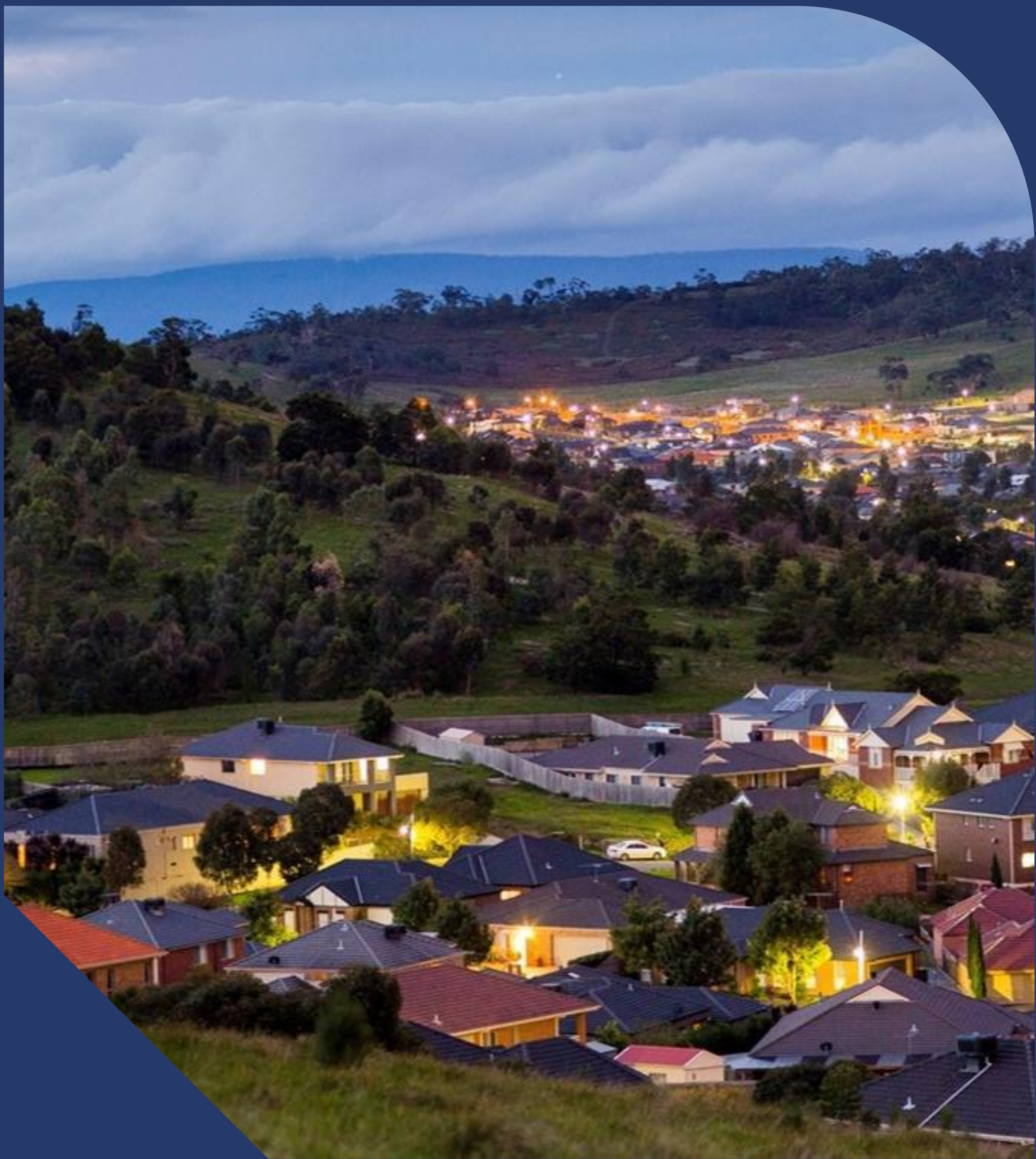
AusNet

Insulators – High and Medium Voltage

AMS – Electricity Distribution Network



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AusNet

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1. Executive Summary

This document is part of the suite of Asset Management Strategies relating to AusNets' 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 high (HV) and medium voltage (MV) Insulators in AusNets' Victorian electricity distribution network.

This strategy is focused on all HV and MV insulators supporting conductors on approximately 371,000 pole top structures. The insulator fleet consists of porcelain insulators (73%), polymeric insulators (12%), glass type insulators (10%) and cycloaliphatic epoxy insulators (5%). Electrical failure and mechanical failure are the two major failure modes of HV and MV insulators.

In order to manage the risk "as far as practicable" as per the Electricity Safety Act, it is recommended to replace HV and MV insulator with Catastrophic consequence and above moderate likelihood of failure.

Key asset management strategies for HV and MV insulators are listed in the below section.

1.1. Asset Strategy Summary

1.1.1. New Assets

- Install new assets as per STND-0027227-000 and Standard Maintenance Guideline SOP 70-03

1.1.2. Inspections and Monitoring

- Inspect insulators in conjunction with the inspection of other pole mounted assets in accordance with the criteria established in the Asset Inspection Manual 30-4111, and supported by the Insulator Identification Manual *30-4166*

1.1.3. Maintenance Planning

- Upon line conductor re-tying, identify insulator condition and replace if required
- Install animal/bird proofing if requires as per the Standard Maintenance Guideline SOP 70-03
- Re-fasten insulator attachments to crossarms or poles in conjunction with maintenance works
- Maintain HV and MV insulators as per Standard Maintenance Guideline SOP 70-03

1.1.4. Replacement Planning

- Replace insulators in conjunction with the replacement of poles and crossarms in accordance with the criteria established in the Asset Inspection Manual 30-4111 and Standard Maintenance Guideline SOP 70-03
- Reactively replace defective or fault insulators

2. Introduction

2.1. Purpose

The purpose of this document is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of high (HV) and medium voltage (MV) Insulators in AusNet's Victorian electricity distribution network. This document intends 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.

2.2. Scope

Included in this strategy is all HV and MV insulators associated with the AusNet electricity distribution network that operate at 66kV, 22kV, 12.7kV, 11kV and 6.6kV.

2.3. Asset Management Objectives

As stated in *AMS 01-01 Asset Management System Overview*, the high-level asset management objectives are:

- Operate to our risk appetite
- Optimise risk, cost and performance
- Improve network reliability
- Meet customer service objectives
- Reduce safety risks and meet our obligations
- Support the energy transition
- Increase community energy resilience
- Sustainability and modernisation of the network

As stated in *AMS 20-01 Electricity Distribution Network Asset Management Strategy*, the electricity distribution network objectives are:

- Improve network performance
- Leverage advances in technology and data analytics
- Reduce bushfire risk
- Reduce electric shocks from network assets
- Deliver REFCLs
- Meet metering compliance obligations
- Meet quality of supply obligations

3. Abbreviations and definitions

TERM	DEFINITION
HV	High Voltage
MV	Medium Voltage
PoF	Probability of Failure
CoF	Consequence of Failure

4. Asset Description

4.1. Function

HV and MV Insulators provide the following function:

- Provide a mechanical connection between live conductors and structures whilst insulating the structures from electrical current.

4.2. Population

4.2.1. Population Considerations

The population profile for HV and MV insulators 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 HV and MV insulators are essential for maintaining the integrity and reliability of the network.
- **Allocate resources efficiently:** Plan and allocate maintenance resources effectively by knowing the exact number and location of assets.
- **Risk management:** Assess and manage risks associated with different assets
- **Optimise maintenance schedules:** Develop optimised maintenance schedules based on the distribution and condition of assets.
- **Enhance reliability and safety:** Ensure that all components, including 66kV and 22kV insulators, meet the required standards for reliability and safety
- **Support strategic planning:** Inform long-term strategic planning and investment decisions.

4.2.2. Geographic Impact Areas

The AusNet electrical distribution network feeds electricity to 802,000 customers across eastern and north-eastern Victoria, and in Melbourne's north and east.

Notable examples include:

- **High Wind Areas:** High wind areas, particularly in elevated regions and open plains, subject HV and MV insulators to significant stress and fatigue.
- **Corrosive Areas:** Coastal areas and industrial regions where salt and pollutants are prevalent can cause corrosion of metallic components in HV and MV insulators.
- **Bushfire Areas:** Bushfire-prone areas, common in many parts of Victoria, pose a risk of fire damage to HV and MV insulator infrastructure.

4.2.3. Population Profile

The most up to date standard for insulators can be found in STND-0027227-000.

4.2.3.1. Population by Type

The distribution network has high and medium voltage line insulators supporting conductors on approximately 371,000 top structures. For insulation identification refer to Insulator Identification Manual.

Table 1 shows an overview of line insulators' population.

Table 1 - HV and MV Insulator Population

INSULATOR TYPE	% OF FLEET LOCATION
Post Type Tie Top 9 Shed	23%
Post Type Clamp Top 9 Shed	16%
Disk Type EPDM Low Pollution	12%
Post Type Tie Top 5 Shed	11%
Disk Type 255mm	10%
Post Tie Top 1250mm 11 Shed	4%
Post Type Tie Top Cycloaliphatic	4%
Pin Type Grey	3%
Post Type Clamp Top 5 Shed	2%
Disk Type Grey	2%
Post Type Tie Top 4 Shed	1%
Pin Type Brown	1%
Post Type Tie Top 16 Shed	1%
Post Clamp Top 1250mm 12 Shed	1%
Post Clamp Top 1250mm 17 Shed	1%
Post Clamp Top 1250mm 11 Shed	1%
Post Tie Top 1250mm 17 Shed	1%
Post Tie Top 1250mm 12 Shed	1%
Post Type Clamp Top 6 Shed	1%
Post Type Tie Top 12 Shed	1%
Disk Type Brown	<1%
Post Type Clamp Top Cycloaliphatic	<1%
Post Type Clamp Top 16 Shed	<1%
Wine Glass Type	<1%
Post Type Tie Top 15 Shed	<1%
Post Type Tie Top 6 Shed	<1%

Post Clamp Top 1250mm 13 Shed	<1%
Post Type Tie Top	<1%
Unknown	<1%
Strain Type	<1%
Pin Type Tie Top	<1%
Post Type Tie Top 13 Shed	<1%

4.2.3.2. Population by Material

Figure 1 shows approximately 73% of the insulator population is manufactured from porcelain, with the remaining fleet consisted of cycloaliphatic epoxy, glass and polymeric materials.

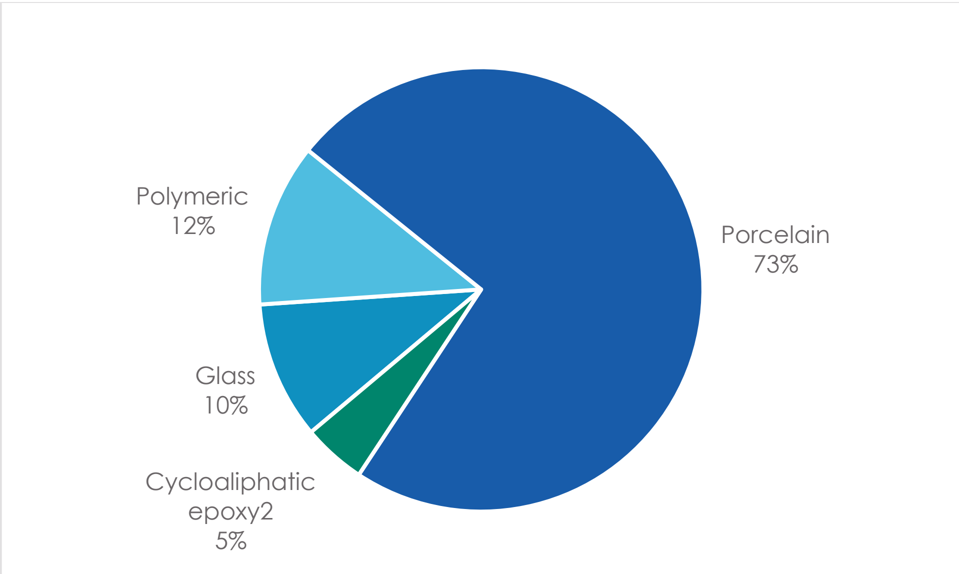

Figure 1: Population by Material

4.3. Age

4.3.1. Age Profile Considerations

Understanding the age profile of HV and MV insulators is essential for effective asset management and lifecycle planning. Knowing the age distribution of these assets helps in predicting their remaining useful life.

During the late 1970s, the pin type insulator was superseded by post type insulators.

The five-shed porcelain post insulator has been in service since the mid-1980s. There have been incidents reported on animal and bird flashovers on concrete poles due to short lengths (arc distance) of the five-shed insulators. Therefore, the five-shed post insulators were discontinued in 2003.

The nine shed porcelain post insulators are the current standard 22kV intermediate insulator across the distribution network on low pollution areas. They were first installed in the mid-1980s in portions of the network serving high population densities such as 'Urban' feeders.

In 2004, AusNet introduced a polymer post insulator made of Cycloaliphatic resins. In 2009, Cycloaliphatic insulators were discontinued in favour of light weight and competitively priced porcelain insulators.

Details of usage of different insulators type that used in different period of time can be found in the Insulator Identification Manual.

4.3.2. Age Profile

The average service age of the entire fleet of HV and MV insulators is 34 years with the standard deviation of 19 years. Figure 2 shows the age profile of HV and MV Insulators

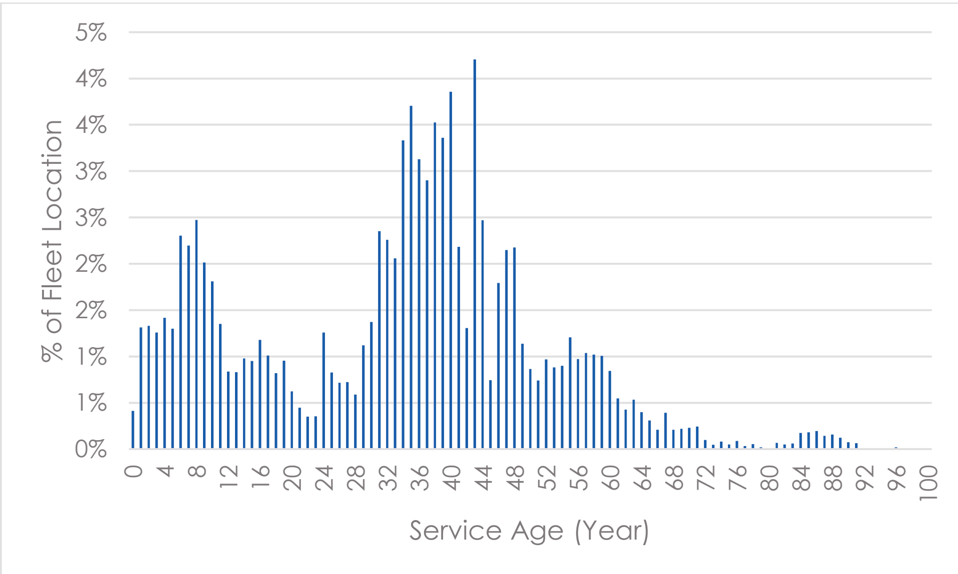

Figure 2 - Age Profile of HV and MV Insulators

5. Strategic Asset Management

5.1. Criticality

5.1.1. Risk and Criticality

To effectively manage the lifecycle of HV and MV insulators, it is essential to understand the criticality of these assets. This involves evaluating the potential impact of failures. The criticality assessment is a key component of asset management as it helps prioritise maintenance, upgrades, and replacements.

To measure the criticality of assets, AusNet utilises a risk and criticality approach. This approach involves evaluating both the likelihood of failure and the potential impact of such failures. The process starts by identifying key risk factors, including environmental exposure, historical performance data, and the results from regular condition assessments.

The criticality of each asset is determined by considering two main factors: the probability of failure (PoF) and the consequence of failure (CoF). The PoF is influenced by factors such as environmental conditions (e.g., high winds, corrosion, bushfire risk), and historical failure rates. Advanced diagnostic tools and inspections help in quantifying this probability. The CoF is assessed based on the potential impact on network reliability, safety, and service continuity. This includes the number of customers affected, the strategic importance of the asset in the network, and the cost of repairs and downtime.

A criticality matrix is used to map these factors, with the PoF on one axis and the CoF on the other. Assets that fall into the high-risk category (high PoF and high CoF) are prioritised for maintenance, upgrades, or replacement. This approach ensures that resources are allocated efficiently, focusing on assets that pose the greatest risk to network reliability and safety. Details of the Asset Risk Matrix can be found in Asset Risk Assessment Overview *AMS 01-09*.The risk matrix, showing the combination of PoF and CoF of HV and MV insulators is shown in Table 2. The greatest risk appears on the top right corner, whereas the lowest risks are at the bottom left corner.

Table 2 - Risk matrix of HV and MV Insulators

		Consequence				
		Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood	5	0	0	0	0	0
	4	0	0	0	0	0
	3	0	4	1892	6013	8229
	2	0	84	5391	14188	10682
	1	0	396	55643	136334	131951

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.

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 HV and MV insulators are detailed in the below section.

5.1.2.2. Electrical Failure

Electrical failure causes electrical current to track across or through the insulator often resulting in a pole or crossarm fires.

The fog pin type insulators form the oldest cohort of the MV insulator fleet. They frequently exhibit electrical tracking when:

- Airborne dust or salt pollution build up on the insulator surface following dry weather spell
- Subjected to light mist or rain, results in conductive paths across the insulator surface allowing electrical currents to pass to earth.

The passage of electrical currents can ignite timber crossarms at the insulator attachment point or timber poles at attachment point of the timber crossarm.

The physical design of the pin type insulators sheds inhibits self-cleaning of insulator surface on the underside of the sheds during normal rainfall. Service age and the degree of degradation of the insulating medium surface are the two major factors contribute to the failure of pin type insulators as the faster and higher levels of pollution build up will lead to electrical tracking.

5.1.2.3. Mechanical Failure

Mechanical failure of an insulator usually results in the attached electrical conductor falling from the supporting cross-arm which will lead to:

- High voltage injections into subsidiary low voltage circuits or fire ignition due to the live conductor making contact with other assets or ground

The most common pin fog type insulator used on the distribution network is the multi-piece design. It may exhibit mechanical failure due to

- moisture ingress,
- subsequent swelling of the cement jointing compound which used to join the sheds and the pin assembly

Cracking of the insulators may result in tracking and subsequent pole or cross-arm fire. The failure of the cement joint compound may result in the separation of the top shed, which has the function to hold the conductor from the insulator base.

Mechanical damage can also occur through lightning storm or by vandalism in some cases.

5.2. Performance

5.2.1. Performance Analysis

In the context the management of assets and asset types within an Electrical Distribution Networks, 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 infrastructure.

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.

5.2.2. Performance Profile

5.2.2.1. HV and MV Insulators Related Notifications

5.2.2.1.1. Failure by Year

Figure 3 shows HV and MV insulators related Notifications completed since 2018.
* this graph does not include count of storm replacements in 2022 and 2023

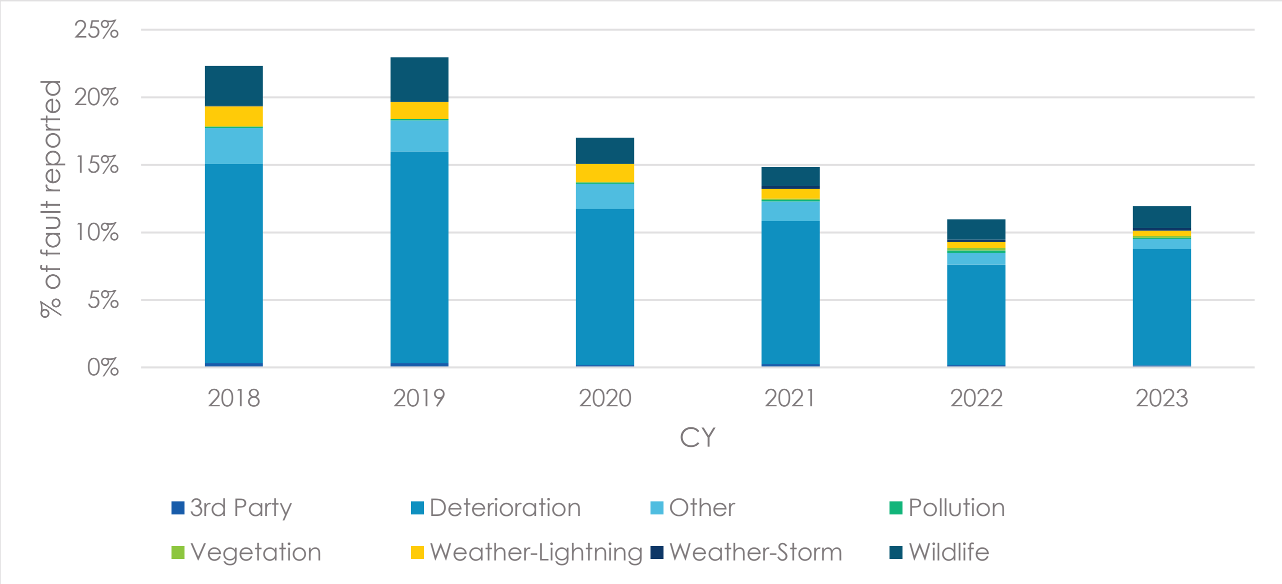

Figure 3 - HV and MV insulator Completed Notification per CY

5.2.2.1.2. Failure by Cause

Figure 4 shows deterioration is the major cause of failure.

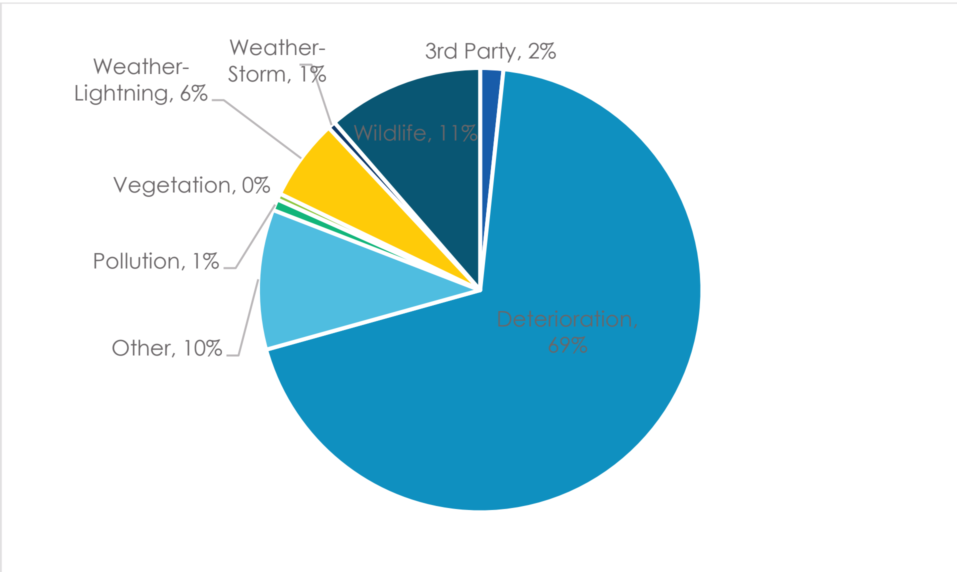

Figure 4 - Failure by Cause

6. Regulatory Framework

6.1. Compliance Factors

6.1.1. Regulatory and Legislative

Effectively managing compliance obligations specific to legislation and policies is a core element of Asset Class Planning and supports the sustainable operation and management of Network Assets. Ensuring adherence to relevant laws, policies and codes helps prevent legal and regulatory breaches, which can lead to significant penalties, operational disruptions, and reputational damage.

6.1.2. 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.

6.2. 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, 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. Asset Strategies

7.1. New Assets

7.1.1. 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.

Target activity apply to new asset is shown in Table 3.

Table 3 - Targeted Activities on New Assets

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Install new assets as per STND-0027227-000 and Standard Maintenance Guideline SOP 70-03

7.2. Inspections and Monitoring

7.2.1. Inspections and Monitoring Planning Considerations

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.

HV and MV insulators get inspected as part of the routine pole inspection as per the Asset Inspection Manual 30-4111. Inspection includes visual assessment of HV and MV insulators by trained asset inspectors using image stabilised binoculars from two position, with the purpose to detect cracking, damage, alignment pollution, tracking, missing insulators and/or metal stains from conductors.   If insulators show signs of deterioration indicating that the units may fail prior to the next scheduled inspection, a notification for rectification will be raised in the Enterprise Asset Management System – SAP.

Target activity apply on inspection and monitoring is shown in Table 4.

Table 4 - Targeted activities on inspection and monitoring on HV and MV insulators

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Inspect insulators in conjunction with the inspection of other pole mounted assets in accordance with the criteria established in the Asset Inspection Manual 30-4111, and supported by the Insulator Identification Manual *30-4166*.

7.3. Maintenance Planning

7.3.1. Maintenance Planning Considerations

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.

A list of targeted activities apply on maintenance planning is shown in Table 5

Table 5 - Targeted activities on maintenance planning

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Upon line conductor re-tying, identify insulator condition and replace if required
02	Install animal/bird proofing if requires as per the Standard Maintenance Guideline SOP 70-03.
03	Re-fasten insulator attachments to cross-arms or poles in conjunction with maintenance works
04	Maintain HV and MV insulators as per Standard Maintenance Guideline SOP 70-03

7.4. Replacement Planning

7.4.1. Replacement Planning Considerations

A strategic asset strategy for replacements provide 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.

A list of targeted activities applies to HV and MV insulators replacement is shown in Table 6

Table 6 - Targeted activities on HV and MV insulators replacement

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Replace insulators in conjunction with the replacement of cross-arm and poles in accordance with the criteria established in the Asset Inspection Manual 30-4111 and Standard Maintenance Guideline SOP 70-03.
02	Reactively replace defective or faulty insulators

8. Risk and Options Analysis

8.1. Overview

Replacement forecast is derived from the consequence and likelihood matrix in Section 5.1.1.

8.2. Replacement Forecast

In order to manage the risk “as far as practicable” as per *the Electricity Safety Act*, it is recommended to replace HV and MV insulator with Catastrophic consequence and above moderate likelihood of failure.

HV and MV insulators may also be replaced with other asset replacement works, for example, pole and/or crossarm replacement. SAP notification analysis shows that an estimated one-third of the HV and MV insulators will be replaced due to this reason.

9. Legislative References

NO.	TITLE	LINK
1	Electricity Safety Act 1998	HTTPS://CONTENT.LEGISLATION.VIC.GOV.AU/SITES/DEFAULT/FILES/2024-06/98-25AA083-AUTHORISED.PDF

10. Resource References

NO.	ID (LINK)	TITLE
1	STND-0027227-000	Overhead Insulators & attachments HV insulators selection guide for Overhead Lines
2	SOP70-03	Standard Maintenance Guideline
3	30-4111	Asset Inspection Manual
4	30-4166	Insulator Identification Manual
5	AMS 01-01	Asset Management System Overview
6	AMS 20-01	Electricity Distribution Network Asset Management Strategy
7	AMS 01-09	Asset Risk Assessment Overview
8	DES 10-06	Porcelain & Polymer Composite Insulators 66kV, 22kV & LV
9	ESMS 20-01	Electricity Safety Management Scheme: Electricity Distribution Network

11. Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE	APPROVED BY
1	20/10/08	P Bryant	First Edition	G Towns
2	26/10/09	P Bryant	2nd Edition. Removed regulatory life from 1	G Towns
3	24/11/09	P Bryant	3rd Edition. PV graph updates	G Towns
4	21/01/15	D Erzetic-Graziani J Stojkovski	Restructure and content update	J Bridge
5	24/06/19	I Kwan	Content update and review	P Ascione
6	07/10/24	I Kwan	Content update and review	

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