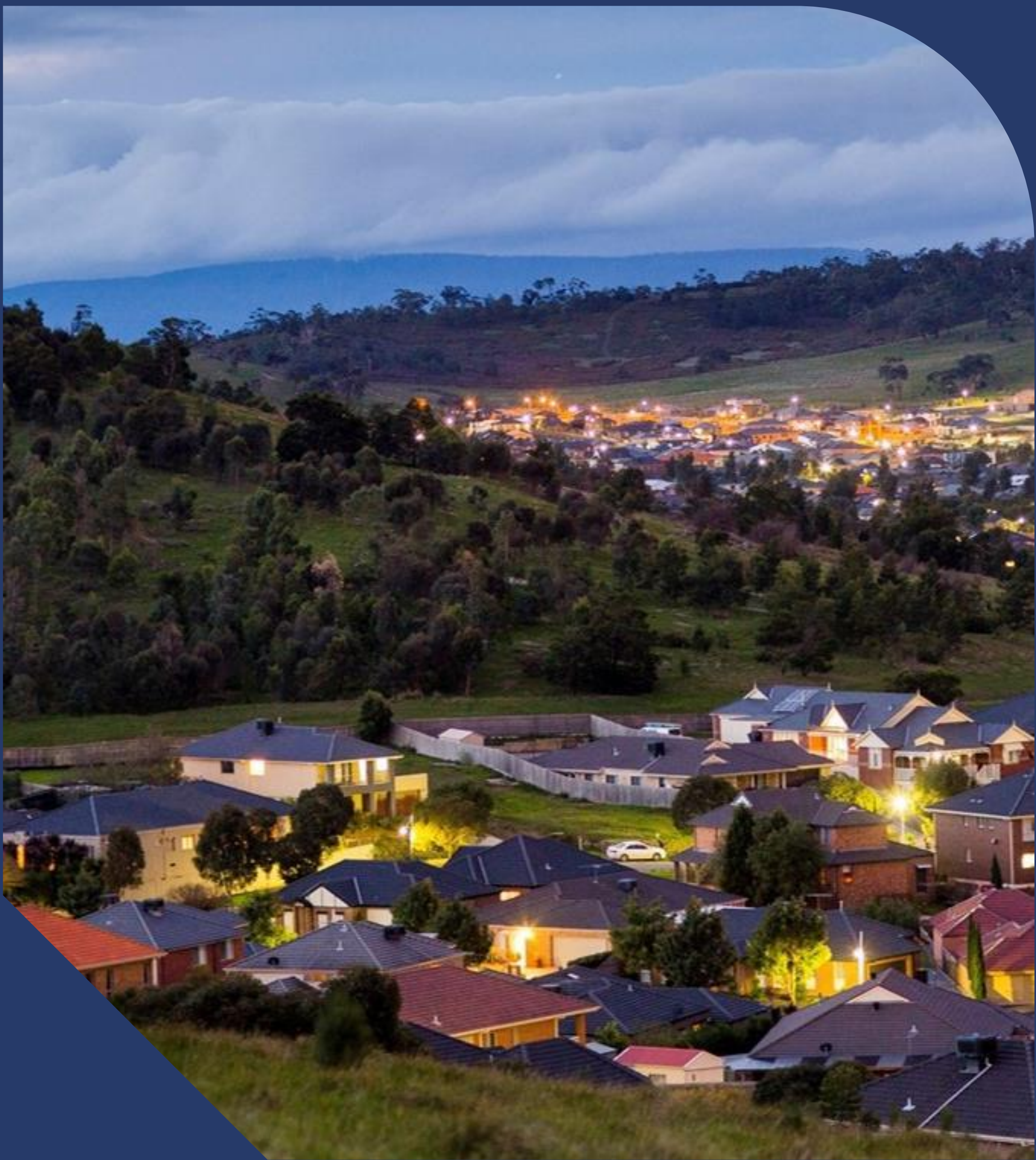
AusNet

MV Fuse Switch Disconnectors

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 Services' 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 medium voltage (MV) Fuse Switch Disconnectors (FSDs) in AusNet Services' Victorian electricity distribution network.

This strategy is focused on the FSDs protecting distribution substations, SWER substations, SWER isolating transformers, line voltage regulators, pole top capacitors and distribution network spur circuits. The main types of MV FSDs installed are Expulsion Drop Out (EDO) unit, Boric Acid Type, Powder Filled Fuse Unit, Fault Tamer Unit and Energy Limited Fuse.

Through the 1980s and 1990s large numbers of EDO type FSDs were replaced in order to minimise the bushfire ignition risk in rural areas. Hence, the existing populations of Boric Acid and Fault Tamer FSDs are relatively young. Since 2017, the Victorian Government has mandated the rollout of Rapid Earth Fault Current Limiter (REFCL) installations across nominated zone substations in AusNet Services' network. Single-phase switching operations or protection operations that do not clear faults three-phase have a risk of causing a mal operation of the REFCL and a feeder trip as a result. This becomes more of a risk as the shunt capacitance being switched becomes larger. Moreover, back-fed faults pose a safety risk as these high impedance faults are sometimes not identified by protection.

Various operations are available for addressing the risk and each fuse requires a protection review to determine the best option In general, the failure modes of MV FSDs include; "hang-ups", "candling", bird or animal initiated arcing faults and corrosion initiated insulator failures. MV FSD failures can cause sustained supply outages, quality of supply events, bushfire ignitions and present safety risks.

1.1. New Assets

- Install Boric Acid and Fault Tamer FSDs on new MV installations
- Establish group fused SWER and single phase circuits to optimise the application of FSDs
- Install Fuse Saver units in series with selected line fuses

1.2. Inspections and Monitoring

- Inspect MV FSDs in accordance with Asset Inspection Manual 30-4111
- Continue to monitor failure rates of discrete types of MV FSD and adjust focussed replacement programs if required
- Monitor 'hang-up' or 'candling' rate of Boric Acid Fuses
- Monitor the performance of Energy Limiting Fuse (ELF) FSDs on existing fleet

1.3. Replacement

- Progressively replace EDO fuse in high consequence risk areas.
- Review and replace MV FSDs as per REFCL requirement - 30-4161-09-02 HV Line Fusing Protection Design Principles.
- In conjunction with pole or crossarm replacement, replace EDO fuses with Boric Acid or Fault Tamer units as per the Standard Maintenance Guidelines SOP 70-03

1.4. Research and Development

- Investigate the use of mechanical fusing device (vacuum breaker) or alternative designs to replace MV FSDs.
- Establish formal procedure and standard data guideline to ensure that the quantity and type of MV FSDs are accurately recorded in the Enterprise Asset Management System.

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 medium voltage (MV) Fuse Switch Disconnectors (FSDs) 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 MV FSDs protecting distribution substations, sections of single wire earth return (SWER) lines, and single-phase spurs on medium voltage feeders in AusNet distribution network.

2.3. 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.

3. Abbreviations and definitions

TERM	DEFINITION
MV	Medium voltage
FSD	Fuse Switch Disconnectors
SWER	Single wire earth return
EDO	Expulsion Drop Out
REFCL	Rapid Earth Fault Current Limiter
ACR	Automatic circuit recloser
URC	Unit Replacement Cost
ELF	Energy Limited Fuses
VCR	Value of Customer Reliability
MTTR	Mean time to restore
DARP	Distribution Annual Planning Report
DOMS	Distribution Outage Management System
STPIS	Service Targe Performance Incentive Scheme
PoF	Probability of Failure
CoF	Consequence of Failure

4. Asset Description

4.1. Function Summary

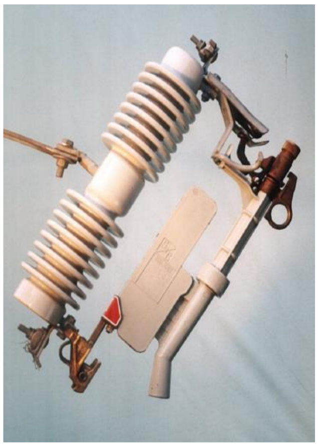
Medium voltage (MV) Fuse Switch Disconnectors (FSDs) provide the following functions:

- Over-current protection to detect and disconnect faulty electrical equipment or sections of medium voltage line or insulated cable
- Manual disconnection facilities to isolate electrical equipment and sections of line or cable from voltage sources, which enable the application of protective earth device. Hence, it provides a safe working condition for line workers
- In conjunction with "load buster" devices, it provides single-phase switching facilities which enable the manual energisation and de-energisation of electrical equipment or sections of line or cable.

EDO FSD

Powder filled FSD

Boric acid FSD



Fault tamer FSD

Figure 1: Four main MV FSDs

4.2. Population

4.2.1. Population Considerations

The population profile for Medium Voltage (MV) Fuse Switch Disconnectors (FSDs) is fundamental planning information for lifecycle planning because population management is an essential planning pillar 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 MV FSDs are essential for maintaining the integrity and reliability of the network. For example, a particular Boric Acid Type FSD protecting a critical distribution substation 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 Expulsion Drop Out (EDO) Units 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 Fault Tamer Fuse Units 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, Powder Filled Fuse Units that protect high-energy fault locations might be scheduled for more frequent inspections and maintenance to prevent any potential failures.
- Enhance reliability and safety: Ensure that all components, including Boric Acid Type, Expulsion Drop Out (EDO) Units, Powder Filled Fuse Units, Fault Tamer Fuse Units, and Energy Limited Fuses, meet the required standards for reliability and safety. For example, if the profile reveals that certain EDO Units have outdated components 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 Energy Limited Fuses in a rapidly developing suburban area need upgrading to support increased demand, guiding future investment in that region.

4.2.2. Geographic Impact Areas

The AusNet Services 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 Medium Voltage (MV) Fuse Switch Disconnectors (FSDs). Understanding these impacts is essential for effective asset management within the AusNet Services electrical distribution network.

Notable examples include:

- High Wind Areas: High wind areas, particularly in elevated regions and open plains, subject MV FSDs to significant stress and fatigue. Example: The structural integrity of Boric Acid Type FSDs 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 MV FSDs. Example: Regular maintenance and the use of corrosion-resistant materials are crucial to prolong the lifespan of these FSDs. Expulsion Drop Out (EDO) Units 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 MV FSD infrastructure. Example: Fire-resistant materials and strategic vegetation management around FSD installations are essential for reducing this risk. In the bushfire-prone regions of the Yarra Valley, Powder Filled Fuse Units 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 underground MV FSDs. Example: Proper waterproofing and drainage systems are essential to protect these assets. In regions like Gippsland, where flooding is more frequent, Fault Tamer Fuse Units 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 MV FSDs 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, Energy Limited Fuses may need to incorporate seismic-resistant features to ensure stability during earth tremors.

4.2.3. Population by Type

The following types of FSDs are installed in the AusNet Electrical Distribution Network (EDN):

- Boric Acid Type
- Expulsion Drop Out (EDO) Unit
- Powder Filled Fuse Unit
- Fault Tamer Fuse Unit
- Energy Limited Fuse

Boric Acid Type

Asset Type Summary Information

- Summary Explanation of Form and Function: The Boric Acid Type FSD consists of a fuse element contained within a tube lined with boric acid. When the fuse operates, a spring-driven arcing rod is drawn through the boric acid, which decomposes to produce steam and water vapour, extinguishing the arc.
- Purpose within the Asset Class: This type of FSD is primarily used to protect distribution substations and line sections, providing reliable over-current protection.
- Purpose within the Network Design: Boric Acid Type FSDs are deployed to ensure that electrical faults are quickly isolated, maintaining network stability and preventing damage to other equipment.
- Process Function: The fuse link melts under fault conditions, allowing the arcing rod to move and create an arc-extinguishing environment, effectively breaking the circuit and isolating the faulted section.
- Historical Application:
  - Boric Acid FSDs were introduced in the mid-1980s.
  - They are currently the primary fuse protection device employed to protect distribution substations and line sections.
  - They make up approximately 60% of the total MV FSD population.
  - During operation, the melting of the fuse link allows a tensioned spring to draw an arcing rod through a tube lined with boric acid. The elongating arc generates high temperatures which decompose the boric acid creating water vapour and steam which extinguish the arc. The spring drives the arcing rod though a seal in the top of the fuse element to trip the latching mechanism in the top contact and allow the fuse element to pivot and disconnect the faulted circuit.

Expulsion Drop Out (EDO) Unit

Asset Type Summary Information

- Summary Explanation of Form and Function: The EDO Unit features a fuse link housed in a carrier that expels the melted fuse link when a fault occurs. Early models were double-vented, while later models are single-vented with a fire choke to catch molten particles.
- Purpose within the Asset Class: EDO Units serve as over-current protection devices, primarily for overhead lines and distribution substations, providing a visual indication of fuse operation.
- Purpose within the Network Design: These units are critical for disconnecting faulted sections, especially in remote and rural areas, ensuring continuity of service and preventing extended outages.
- Process Function: Upon melting, the fuse link generates hot gases that expel the remnants, allowing the carrier to pivot and disconnect the circuit, thus isolating the fault.
- Historical Application:
  - Expulsion Drop Out (EDO) FSDs were introduced to the distribution network during the earliest days of electrification of the State.

- Earlier models of EDOs were of a type referred to as "double vented," meaning when the fuse operates the hot material is expelled from both top and bottom ends of the fuse carrier.
- The "double vented" contact and carrier combinations present higher risks of sustained supply outages and fire ignition due to uncontrolled expulsion of arcing products during operation and the relative ease with which birds or animals can short circuit the upper electrical contact to FSD mounting bracket.
- Later models have modified fuse carriers which vent from the bottom end only into a fire choke that catches any molten fuse particles. The single-vented EDOs were introduced around 1985.
- In operation, the combination of a spring-tensioned fuse link and the super-heated gases created by the arc across the melted fuse link expel the remnants of the fuse link from the fuse carrier allowing the hinges and trunnions at the base of the carrier to pivot. The pivoting motion releases the top contact of the fuse carrier from its mating contact on the fuse mount and the faulted circuit is thus disconnected.
- AusNet ceased installing new EDO fuse units around the year 2000. The population is reducing as units are progressively removed or replaced from service.

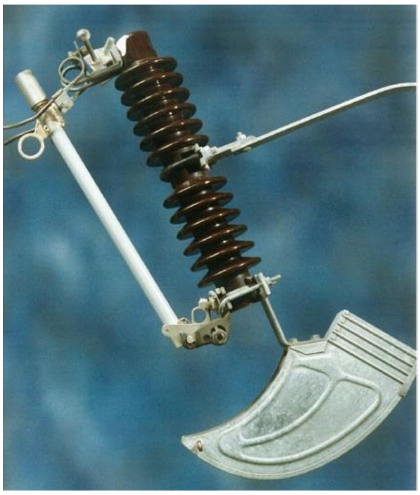


Figure 2: EDO with double vented carrier and fixed fire choke

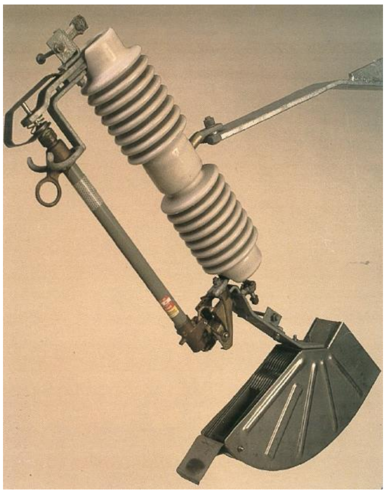


Figure 3: EDO with single vented carrier and fixed fire choke

Powder Filled Fuse Unit

Asset Type Summary Information

- Summary Explanation of Form and Function: The Powder Filled Fuse Unit contains a fuse link surrounded by quartzite sand within a porcelain barrel. When the fuse operates, the sand vitrifies, absorbing the arc energy and forming an insulating compound.
- Purpose within the Asset Class: These units are used in high-energy fault locations to protect substations, line voltage regulators, and underground cables, providing robust over-current protection.
- Purpose within the Network Design: Powder Filled Fuse Units are essential for ensuring the safety and reliability of critical network components, especially where high fault currents are expected.
- Process Function: The melting fuse link vitrifies the surrounding sand, which absorbs the arc energy and forms an insulating layer, preventing further current flow and isolating the faulted section.
- Historical Application:
  - Powder Filled Fuse units are employed in high energy fault locations to protect distribution substations, line voltage regulators, underground cables, and line sections.
  - The installation of outdoor Powder Filled Fuse units ceased around the year 2000, and the population is progressively declining.

- New indoor installations utilising ring main switchgear may utilise full range powder filled fuses, provided the transformer fuse size requirements are met.
- The Powder Filled fuse element consists of a porcelain barrel containing a fuse link wound around an insulating former. The ends of the barrel are sealed by the electrical contacts and the space between the fuse link former and the barrel is filled with quartzite sand.
- When the fuse link melts, the quartzite sand vitrifies, absorbing the electrical arcing energy and forming an insulating fulgurite compound.
- The melting of the fuse link also releases a thermal striker which drives a rod against the inside of one electrical contact to provide external indication of the correct fuse operation.
- Powder Filled FSDs do not trip the fuse element clear of the mounting bracket upon operation, release of the fuse element is a manual operation.

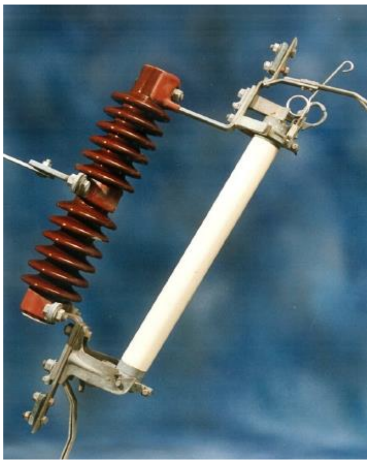


Figure 4 - Brown insulator Powder Filled FSD

Figure 5 - Grey Insulator Powder Filled FSD

Fault Tamer Fuse Unit

Asset Type Summary Information

- Summary Explanation of Form and Function: The Fault Tamer Fuse Unit combines two fuse elements in a series: one for low-energy faults and a current-limiting element for high-energy faults. It operates similarly to both EDO and Powder Filled FSDs.
- Purpose within the Asset Class: Introduced as a replacement for EDO units, Fault Tamer Fuse Units provide enhanced protection by addressing both low and high energy faults, making them versatile and reliable.
- Purpose within the Network Design: These units enhance network protection by efficiently handling a wide range of fault conditions, ensuring minimal disruption and improved safety.
- Process Function: The first element handles low-energy faults similarly to an EDO, while the current-limiting element interrupts high-energy faults, limiting current and energy let-through, thus protecting the circuit.
- Historical Application:
    - The Fault Tamer FSD was introduced in 2003 as a replacement for EDO FSDs.
    - The Fault Tamer FSD has two fuse elements arranged in a series electrical circuit. The first element is designed to operate for low energy faults in a fashion similar to that of an EDO.
    - The second element is a current limiting design to interrupt high-energy faults and operates in a manner similar to that of a powder filled fuse.
    - It serves in the electricity distribution network to protect distribution substations and line sections in both high and low energy fault locations.

Energy Limited Fuse

Asset Type Summary Information

- Summary Explanation of Form and Function: The Energy Limited Fuse (ELF) is a current-limiting dropout fuse with a low-current section and a high-current section within a single housing. It is designed for mounting in standard fuse mounts used for EDOs and Fault Tamer FSDs.
- Purpose within the Asset Class: ELFs provide comprehensive protection by limiting both current and energy during fault conditions, increasing operational safety and reducing fire risks.
- Purpose within the Network Design: ELFs are crucial for protecting distribution substations and line sections, especially in areas prone to high fault currents, enhancing overall network resilience.
- Process Function: The low-current section clears all currents high enough to melt the element, while the high-current section controls arc voltage and limits energy let-through during high-current faults, ensuring safe disconnection and fault isolation.
- Historical Application:
    - Energy Limited Fuses (ELF) were introduced in 2013.
    - The ELF current limiting dropout fuse is a full range current limiting fuse designed for mounting in an industry standard interchangeable fuse mount, that is presently used for EDOs and Fault Tamer Fuse Unit.
    - The full range current-limiting rating ensures reliable operation over a wide range of overloads and fault currents.
    - The element construction consists of two separate actions (low-current section and high-current section) which are self-contained in a single housing.
    - The low-current section provides consistent, reliable clearing of all currents high enough to melt the element.
    - The high-current section is a punched-hole ribbon design which controls peak arc voltage levels and limits both current and energy (I2t) let-through levels during high-current fault clearing operation.
    - The ELF dropout fuse operates relatively quietly, without expelling any material (unlike expulsion fuses). This increases safety for operational staff and reduces fire ignition risks.
    - In addition, the drop open design makes locating the fault easy. If the ELF fuse has operated and the drop out actuator is found to be operated, then the fuse cannot be re-used. In this instance, replacement with a new ELF fuse is required.

Figure 6: Energy Limited Fuse

4.2.4. Population Profile

The AusNet Services electrical distribution network has approximately 61,000 sites installed with 128,000 FSDs protecting distribution substations, SWER substations, SWER isolating transformers, line voltage regulators, pole top capacitors and distribution network spur circuits.

Figure 5 shows that the population percentage of MV FSDs by type.

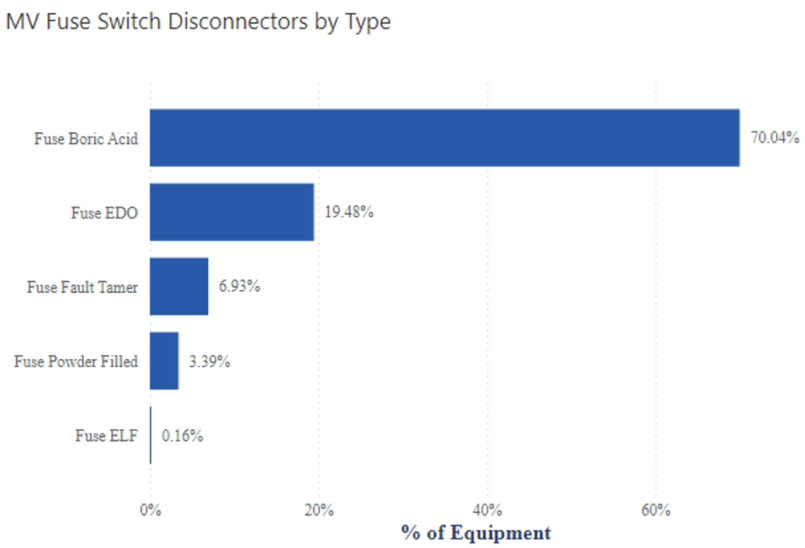


Figure 7 - Mv Fuse Switch Disconnectors by Type

4.3. Age Profile

4.3.1. Age Considerations

An in-depth understanding of the age profile of Medium Voltage (MV) Fuse Switch Disconnectors (FSDs) is crucial for effective asset management and lifecycle planning. Knowing the age distribution of these assets helps in predicting their remaining useful life and planning maintenance, upgrades, or replacements accordingly.

- Boric Acid Type: The age profile of Boric Acid Type FSDs can indicate potential issues related to the decomposition of boric acid and the wear of mechanical components. Older units may require more frequent inspections and condition assessments to ensure they continue to operate safely and efficiently. For example, proactive testing and monitoring of the arc extinguishing mechanism in older Boric Acid Type FSDs can prevent unexpected failures and extend their service life.
- Expulsion Drop Out (EDO) Unit: Over time, EDO Units can experience mechanical wear and degradation of the fuse carrier. By analysing the age profile, asset managers can identify units that are at higher risk of failure and prioritise them for maintenance or replacement. For instance, replacing aging EDO Units in remote areas can prevent costly outages and enhance network reliability.
- Powder Filled Fuse Unit: Powder Filled Fuse Units can suffer from insulation deterioration and moisture ingress as they age. Understanding their age profile allows for targeted interventions to replace or refurbish units that are most vulnerable. For example, replacing sections of Powder Filled Fuse Units in older parts of the network can reduce the risk of power outages and improve overall service quality.
- Fault Tamer Fuse Unit: The age profile of Fault Tamer Fuse Units can reveal areas where mechanical wear and internal component fatigue are likely. Regular inspections and maintenance based on age-related data can ensure these units remain safe and functional. For example, replacing aging Fault Tamer Fuse Units in high energy fault areas can prevent mechanical failures and enhance network resilience.
- Energy Limited Fuse: As Energy Limited Fuses age, they can be prone to insulation breakdown and exposure to environmental factors. By monitoring their age, asset managers can plan timely replacements and avoid potential safety hazards. For instance, replacing old Energy Limited Fuses in bushfire-prone areas can mitigate the effects of high fault currents and extend the operational lifespan of these fuses.

4.3.2. Age Profile

Age Profile Figure 6 shows MV FSDs by service age.

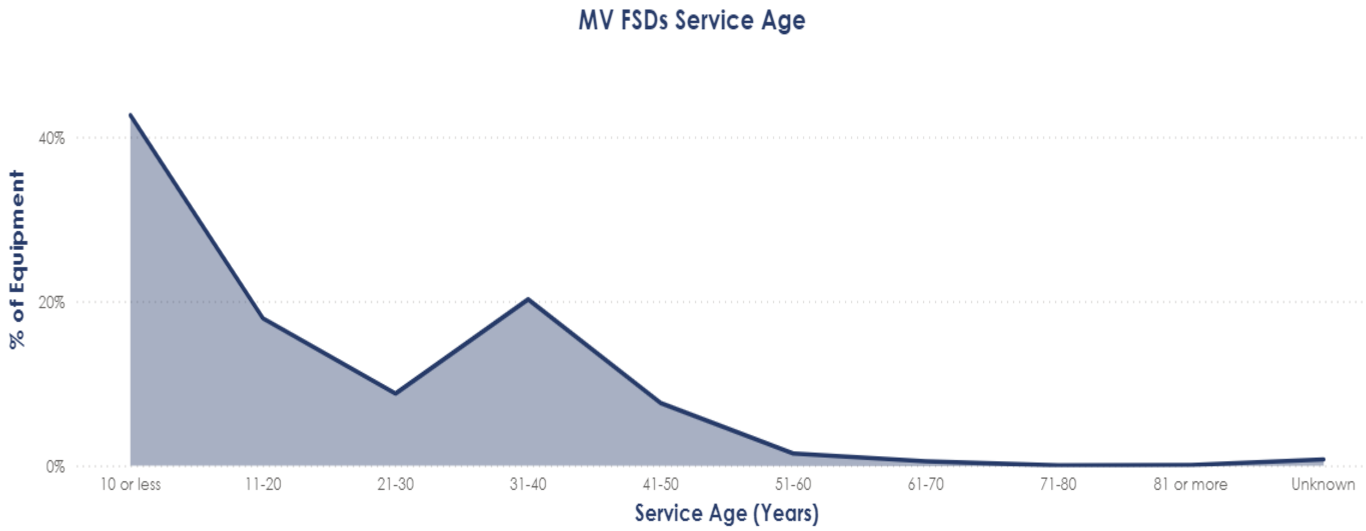


Figure 8 - MV FSDs by Service Age

5. Asset 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 FSDs.

5.1. Probability of Failure

Refer to AMS 01-09 Asset Risk Assessment Overview, section 2.3.2.24 for probability of failure methodology. The analysis of each asset should include four categories: asset service life, asset utilisation/duty factor, location, and the measured or observed physical condition of the asset.

5.1.1. 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 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.

General Failure Modes Common to FSDs

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 Medium Voltage (MV) Fuse Switch Disconnectors (FSDs) are detailed below.

- Insulation Degradation: The insulation material can degrade over time due to thermal aging and environmental exposure, leading to reduced arc-extinguishing effectiveness and potential electrical faults. Example: In boric acid type FSDs, high temperatures can accelerate the decomposition of the boric acid, compromising its ability to extinguish electrical arcs effectively. Historical Application: Moisture ingress can cause internal metal parts to corrode and seize the operating mechanism, resulting in hang-ups.
- Mechanical Wear: Components such as arcing rods, springs, and hinge mechanisms can suffer from wear and fatigue, affecting the device's ability to operate correctly. Example: Frequent operations of FSDs may wear down the mechanical components, leading to slower or incomplete disconnection during faults. Historical Application: Early models of EDO fuse carriers are prone to weathering, electrical tracking, and corrosion of hinge pivots.
- Environmental Degradation: Exposure to harsh environments, such as coastal areas or high pollution zones, can lead to corrosion of metal components and degradation of insulation. Example: Salt spray in coastal regions can accelerate the corrosion of metal parts in EDO units, leading to premature failure. Historical Application: EDO insulators have proven susceptibility to electrical tracking in high pollution areas such as those near the Gippsland coast.
- Moisture Ingress: Water or moisture can penetrate the FSD unit, leading to corrosion of internal components and reduced insulation effectiveness. Example: In high humidity areas, moisture ingress can corrode the internal components of fault tamer fuse units, compromising reliability. Historical Application: Moisture ingress over a long period may cause internal metal parts in boric acid type FSDs to corrode and seize the operating mechanism.

- Thermal Overload: Excessive current flow can cause the fuse element to overheat, leading to thermal degradation and potential failure of the FSD. Example: Sustained high current can cause powder filled fuses to overheat, leading to melting of the fuse element and failure to clear the fault. Historical Application: Misapplication of limited range powder filled fuse units can lead to "candling" and failure to adequately clear low energy fault currents.
- Mechanical Fragility: The fuse barrels, especially those made of porcelain, can be fragile and susceptible to mechanical damage during handling, transport, and installation. Example: Powder filled fuse units require careful handling to avoid breaking the porcelain barrel. Historical Application: Three-inch diameter powder filled fuse elements are too heavy to handle by operating sticks, requiring hand fitting from an elevating work platform.
- Component Fatigue: Repeated fault clearing can cause fatigue in the fuse elements, reducing their effectiveness over time. Example: Regular exposure to fault currents can wear out the internal fuse elements in fault tamer units, making them less reliable for future faults. Historical Application: Fuse links used in EDO type FSDs has proven susceptible to hang-ups during low energy faults.
- Candling: Certain fuse elements can fail to clear low energy fault currents properly, continuing to conduct a low level of fault current and generating significant heat, which can cause the fuse element to become fragile and disintegrate. Example: Powder filled fuse units are prone to "candling," where the fuse element smoulders without properly clearing the fault. Historical Application: Misapplication of powder filled FSDs can lead to candling, presenting a serious safety risk with falling porcelain fragments, molten silica, and hot metal fittings.
- Electrical Trees: Repeated electrical stresses can cause the development of electrical trees within the insulation material, leading to breakdown and failure. Example: Electrical trees can form in energy limited fuses due to repeated voltage surges, eventually leading to insulation breakdown. Historical Application: Energy Limited Fuses (ELF) are designed to handle a wide range of fault currents, ensuring reliable operation over various conditions.
- External Arcing Faults: External arcing faults can occur when birds or animals bridge the air space between the energised portions of the FSD and the earthed portions of a pole or crossarm. Example: Powder filled fuse units can experience external arcing faults initiated by wildlife. Historical Application: External arcing faults from the powder filled mounting bracket to the top or bottom electrical contacts are predominantly initiated by birds or animals.
- UV Degradation: Ultraviolet (UV) radiation can degrade the external housing of the fuse, particularly in outdoor installations, reducing its mechanical strength and protection. Example: Prolonged exposure to sunlight can cause the plastic housing of energy limited fuses to become brittle and crack, exposing internal components. Historical Application: The full range current-limiting rating of Energy Limited Fuses ensures reliable operation over a wide range of overloads and fault currents.

Failure Modes by Asset Type

Boric Acid Type

- Insulation Degradation: The boric acid lining can degrade over time due to thermal aging and exposure to environmental conditions, leading to reduced arc-extinguishing effectiveness. Historical Application:
  - Introduced in the mid-1980s.
  - Currently the primary fuse protection device employed to protect distribution substations and line sections.
  - Makes up approximately 60% of the total MV FSD population.
- Mechanical Wear: Components such as the arcing rod and spring mechanisms can suffer from wear and fatigue, affecting the device's ability to operate correctly. Historical Application:
  - During operation, the melting of the fuse link allows a tensioned spring to draw an arcing rod through a tube lined with boric acid. The elongating arc generates high temperatures which decompose the boric acid creating water vapour and steam which extinguish the arc.
  - The spring drives the arcing rod though a seal in the top of the fuse element to trip the latching mechanism in the top contact and allow the fuse element to pivot and disconnect the faulted circuit.
- Moisture Ingress: Over a long period, moisture ingress can cause the internal metal parts to corrode and seize the operating mechanism, resulting in hang-ups. Historical Application:

  - AusNet experienced a number of Boric Acid fuse hang-ups across the network. Extensive investigations involving manufacturers were carried out to find the root cause and rectify the problems. No conclusive evidence to pin point a particular cause was able to be determined.
  - AusNet has since approved a new supplier to source a sealed fuse tube. However, it is too early to come to any conclusion on the performance of these sealed types against the breathing types.

Expulsion Drop Out (EDO) Unit

- Mechanical Damage: The fuse carrier and contact points can be damaged by physical forces or corrosion, leading to operational failures. Historical Application:
  - Introduced to the distribution network during the earliest days of electrification of the State.
  - Earlier models of EDOs were of a type referred to as "double vented," meaning when the fuse operates the hot material is expelled from both top and bottom ends of the fuse carrier.
  - The "double vented" contact and carrier combinations present higher risks of sustained supply outages and fire ignition due to uncontrolled expulsion of arcing products during operation and the relative ease with which birds or animals can short circuit the upper electrical contact to FSD mounting bracket.
- Environmental Degradation: Exposure to harsh environments, such as coastal areas, can lead to corrosion of the metal components, compromising the unit's structural integrity. Historical Application:
  - Later models have modified fuse carriers which vent from the bottom end only into a fire choke that catches any molten fuse particles. The single-vented EDOs were introduced around 1985.
  - In operation, the combination of a spring-tensioned fuse link and the super-heated gases created by the arc across the melted fuse link expel the remnants of the fuse link from the fuse carrier allowing the hinges and trunnions at the base of the carrier to pivot. The pivoting motion releases the top contact of the fuse carrier from its mating contact on the fuse mount and the faulted circuit is thus disconnected.
  - AusNet ceased installing new EDO fuse units around the year 2000. The population is reducing as units are progressively removed or replaced from service.
  - EDO insulators have proven susceptibility to electrical tracking in high pollution areas such as those near the Gippsland coast. The cement securing the galvanised steel mounting bracket in the porcelain insulator has also failed in a marine environment. Essentially, mounting insulators have a relatively long life but corrosion, arcing damage and loss of spring tension in the electrical contacts determine end of practical life. It is not economic to refit contacts to existing mounting insulators.
- Fuse Link Susceptibility: The fuse link used in EDO type FSDs has proven susceptible to hang-ups (also known as candling) during low energy faults. Historical Application:
  - Early model EDO fuse carriers are prone to weathering, electrical tracking, corrosion of hinge pivots, and arcing damage to top contacts.
  - Post-1989 fuse carriers have higher mechanical strength, superior weathering resistance, and greater electrical insulation but are still prone to arcing damage on the top contacts. Deterioration is accelerated in aggressive coastal environments and high rainfall areas such as Alpine forests.

Powder Filled Fuse Unit

- Insulation Breakdown: The quartzite sand used in the fuse can become contaminated or compacted, reducing its effectiveness in arc suppression. Historical Application:
  - Employed in high energy fault locations to protect distribution substations, line voltage regulators, underground cables, and line sections.
  - The installation of outdoor Powder Filled Fuse units ceased around the year 2000, and the population is progressively declining.
  - New indoor installations utilising ring main switchgear may utilise full range powder filled fuses, provided the transformer fuse size requirements are met.
- Thermal Overload: Excessive current flow can cause the fuse element to overheat, leading to thermal degradation and potential failure of the fuse. Historical Application:
  - The Powder Filled fuse element consists of a porcelain barrel containing a fuse link wound around an insulating former. The ends of the barrel are sealed by the electrical contacts and the space between the fuse link former and the barrel is filled with quartzite sand.

  - When the fuse link melts, the quartzite sand vitrifies, absorbing the electrical arcing energy and forming an insulating fulgurite compound.
  - The melting of the fuse link also releases a thermal striker which drives a rod against the inside of one electrical contact to provide external indication of the correct fuse operation.
  - Powder Filled FSDs do not trip the fuse element clear of the mounting bracket upon operation, release of the fuse element is a manual operation.
- Mechanical Fragility: The fuse barrels used in powder filled FSDs are relatively fragile as they are made of porcelain and require careful handling, transport, and storage. Mechanical damage presents the operator with safety hazards associated with sharp porcelain fragments. Historical Application:
  - Three-inch diameter powder filled fuse elements are too heavy to handle by operating sticks. Operators must hand fit these fuse elements from an elevating work platform.
- Candling: Some fuse elements for powder filled FSDs are not rated for correct operation across the broad range of fault currents experienced in the distribution network. Misapplication of such limited range units usually means correct operation for high energy faults but presents the possibility of "candling" (smouldering) and failing to adequately clear low energy fault currents. Historical Application:
  - "Candling" occurs when the fuse element continues to conduct a low level of fault current and generates significant heat in the contents and insulating barrel of the fuse element. Under such conditions the fuse element becomes fragile and can disintegrate when disturbed by an operator, and falling porcelain fragments, molten silica, and hot metal fittings present a serious safety risk.
- External Arcing Faults: External arcing faults from the powder filled mounting bracket to the top or bottom electrical contacts is predominantly initiated by birds or animals bridging the air space between the energised portions of the FSD and the earthed portions of a pole or crossarm.

Fault Tamer Fuse Unit

- Component Fatigue: Repeated fault clearing can cause fatigue in the fuse elements, reducing their effectiveness over time. Historical Application:
  - The Fault Tamer FSD was introduced in 2003 as a replacement for EDO FSDs.
  - The Fault Tamer FSD has two fuse elements arranged in a series electrical circuit. The first element is designed to operate for low energy faults in a fashion similar to that of an EDO.
  - The second element is a current limiting design to interrupt high-energy faults and operates in a manner similar to that of a powder filled fuse.
  - It serves in the electricity distribution network to protect distribution substations and line sections in both high and low energy fault locations.
- Moisture Ingress: Water or moisture can enter the fuse unit, leading to corrosion and degradation of the internal components. Historical Application:
  - Fault Tamer fuses were introduced around 2003 and were mainly used on substation structures. During the initial days, there were few fire-related incidents. However, with some improvements to the product, the performance of these fuse units has been satisfactory. They are not considered as a major bushfire risk item.

Energy Limited Fuse

- Electrical Trees: Repeated electrical stresses can cause the development of electrical trees within the fuse material, leading to insulation breakdown. Historical Application:
  - Energy Limited Fuses (ELF) were introduced in 2013.
  - The ELF current limiting dropout fuse is a full range current limiting fuse designed for mounting in an industry standard interchangeable fuse mount, that is presently used for EDOs and Fault Tamer Fuse Unit.
- UV Degradation: Ultraviolet (UV) radiation can degrade the external housing of the fuse, particularly in outdoor installations, reducing its mechanical strength and protection. Historical Application:
  - The full range current-limiting rating ensures reliable operation over a wide range of overloads and fault currents.
  - The element construction consists of two separate actions (low-current section and high-current section) which are self-contained in a single housing.

- The low-current section provides consistent, reliable clearing of all currents high enough to melt the element.
- The high-current section is a punched-hole ribbon design which controls peak arc voltage levels and limits both current and energy (I2t) let-through levels during high-current fault clearing operation.
- The ELF dropout fuse operates relatively quietly, without expelling any material (unlike expulsion fuses). This increases safety for operational staff and reduces fire ignition risks.
- In addition, the drop open design makes locating the fault easy. If the ELF fuse has operated and the drop out actuator is found to be operated, then the fuse cannot be re-used. In this instance, replacement with a new ELF fuse is required.

5.1.2. Probability of Failure Assessment

Refer to AMS 01-09 section 2.4 for methodology of likelihood assessment. FSDs are analysed using only asset service life data for likelihood assessment. Weibull distribution is then used to determine parameters for calculating probability of failure (PoF) and its remaining life.

5.1.3. Likelihood Profile

The likelihood profile across the asset categories in figure 9.

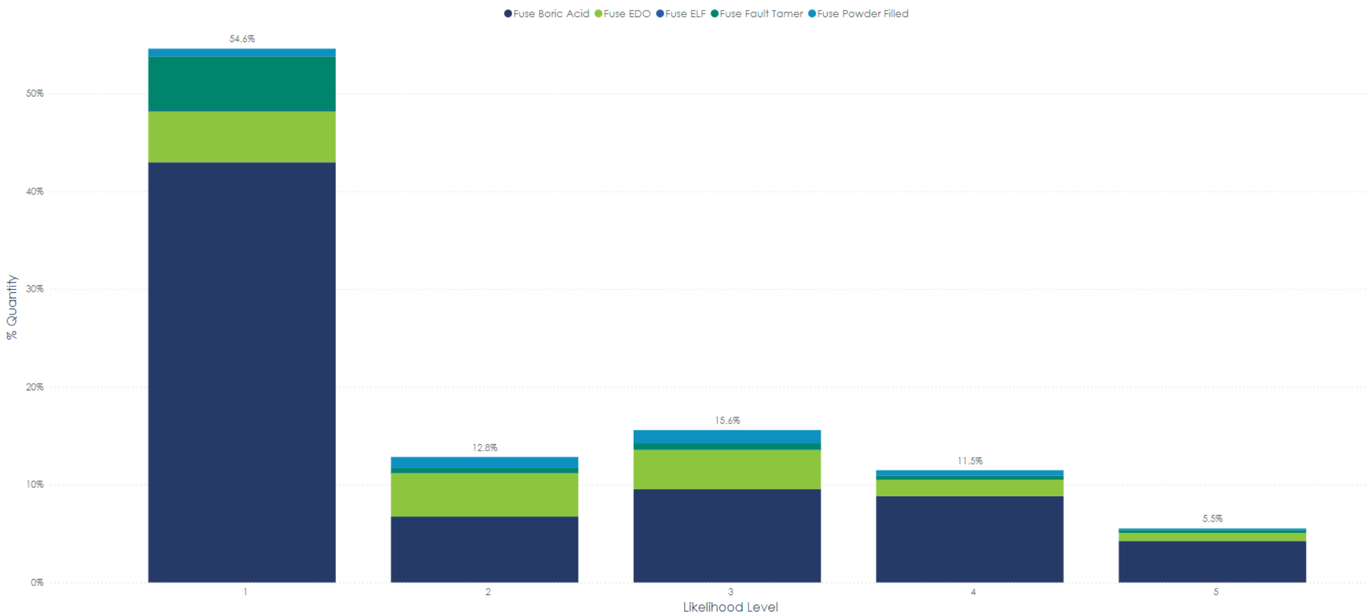


Figure 8 - Likelihood of MV FSD failure by Type

5.2. Consequence of Failure

Refer to AMS 01-09 section 2 for methodology of consequence of failure.

A malfunction in a medium voltage (MV) FSD can lead to an increased number of customers impacted by faults Additionally, there is a potential safety risk associated with MV FSD that could endanger employees or the public and negatively affect the environment. For example, a failure in FSD that results in a candling could potentially lead to injuries to employees or members of the public.

The costs related to the failure of MV FSD are generally evaluated from three key perspectives: Safety, Environmental Impact, and Customer Impact, as applicable. Each type of MV FSD may be associated with one or more of these consequence categories. A summary of each perspective is presented in Table 2.

TABLE 2: CONSEQUENCE LENSES

SAFETY	Threat to health and safety of public and employees
ENVIRONMENT	Bushfire damage
CUSTOMER	Loss of Supply to Customer Loss of primary plant

5.2.1. Safety Cost of Consequence

The safety cost associated with the consequences of MV FSD is assessed based on their impact on human safety. The consequence of Fuse candling or hung up in a pole top location. Event tree analysis is employed to determine the safety consequences.

Refer to *AMS 01-09-02* for event tree diagram of relay safety consequence of failure.

5.2.2. Environmental Cost of Consequence

The environmental costs and implications associated with MV FSDs are assessed in the context of their geographical locations, taking into account prevailing weather patterns that may increase the risk of bushfires, land use classifications, and housing density considerations. Event tree analysis is employed to determine the environmental consequences.

Refer to *AMS 01-09-02* for event tree diagram of relay environmental consequence of failure.

5.2.3. Customer Cost of Consequence

The customer costs associated with supply interruptions are financial implications arising from customers not receiving energy. For MV FSDs, these costs are calculated based on the output of the Zone Substation, which reflects the value of customer risk. The load is then evenly distributed across the number of wire sections separated by an MV switch or ACR. This calculation takes into account the outage duration and the number of sections impacted, adopting a staged approach to approximate the restoration process.

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

In the context of asset management for Medium Voltage (MV) Fuse Switch Disconnectors (FSDs), 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.

6.2. Performance Profile

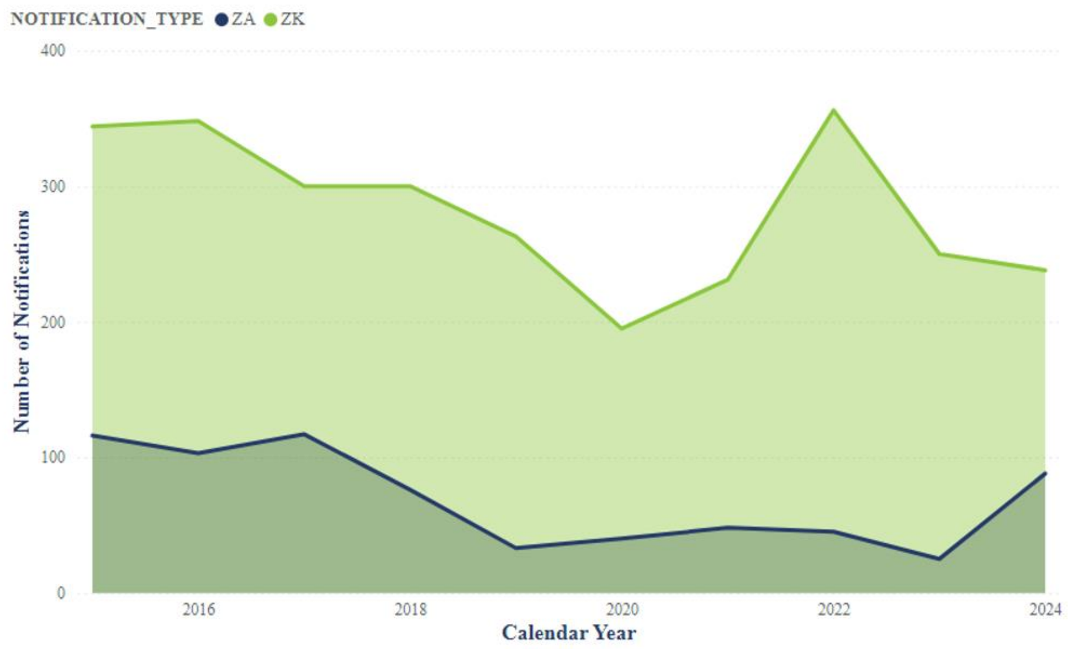


Figure 1 - Number of MV FSD Failures Annually

7. Related Matters

7.1. Regulatory Framework

7.1.1. Compliance Factors

Regulatory and Legislative Reference

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.

Note: further to the above, **Section Eight (8)** provides a quick reference table for the legislative and regulatory laws, acts, and policies that are of material consideration for this Asset Class (with links to the reference material).

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.

Rapid Earth Fault Current Limiter (REFCL)

The Victorian Government has mandated the rollout of Rapid Earth Fault Current Limiter (REFCL) installations across nominated zone substations in AusNets network.

Twenty-two zone substations and the associated 22kV feeders will be modified to allow for resonant earthing. REFCL performance criteria specified in *REF 30-09 Maintaining Capacitive Balance Policy* requires the dissymmetry of the network to be less than 100mA. As with the *REF 30-06 Network Capacitive Balancing Policy*, AusNet will maintain the balance of each three-phase automatic circuit recloser (ACR) and each sectionaliser section so that a switching operations should not cause the neutral current to be displaced by more than 100mA.

Single-phase switching operations or protection operations that do not clear faults three-phase have a risk of causing a mal-operation of the REFCL and a feeder trip as a result. This becomes more of a risk as the shunt capacitance being switched becomes larger. Moreover, back-fed faults pose a safety risk as these high impedance faults are sometimes not identified by protection.

Various operations are available for addressing the risk and each fuse requires a protection review to determine the best option, which include:

- Replacing a number of fuses with an ACR
- Re-conducting
- Installing a new version of the Fusesaver
- Replacing the fuse units with a solid link
- Reliability review of the likelihood a fuse operation

Details of these options can be found in *30-4161-09-02 HV Line Fusing Protection Design Principles*.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Rapid Earth Fault Current Limiter (REFCL) installations across nominated zone substations in AusNets network

7.2. External Factors

7.2.1. 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.

7.2.2. Environmental Factors

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.

7.3. Internal Factors

7.3.1. 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.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue to provide internal staff as well as Ausnet partner in training, education and industry knowledge management of MV FSD

7.3.2. 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 sub-categories of consideration for this factor, which are:

- Resourcing strategies
- Outsourcing
- Supply Chain Management

7.3.3. 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. 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.

7.3.4. 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**.

7.4. Future Developments

7.4.1. 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**.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Trial trip savers
02	Pilot project of new types of fuses to diversify the fleet

7.4.2. 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**.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Investigate the use of mechanical fusing device (vacuum breaker) or alternative designs to replace MV FSDs. AusNet is currently investigating the use of a mechanical fusing device (vacuum breaker) to replace MV FSDs, which will offer following advantages. • Eliminate fuse hang-ups resulting in no fire risks;

	• Can be easily insulated to offer animal/bird protection; and • Tripping can be synchronised to achieve three-phase switching specially in REFCL areas. It is intended that these new devices to be initially used on new installation in REFCL areas and specified codified (high bushfire risk) areas.

7.4.3. Continuous Improvement

Continuous Improvement (CIP) is a critical lynchpin process in the overall application of asset management, particularly for managing Fuse Switch Disconnectors. 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.

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**.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Establish formal procedure and standard data guideline to ensure that the quantity and type of MV FSDs are accurately recorded in the Asset Management System.

8. Asset Strategies

8.1. New Assets

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.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Install Boric Acid and Fault Tamer FSDs on new MV installations
02	Establish group fused SWER and single-phase circuits to optimise the application of FSDs
03	Install Fuse Saver units in series with selected line fuses
04	EDO fuse units are no longer being installed on new and replacement work. They are being replaced with Boric Acid or Fault Tamer fuse units. Historical EDO targeted replacement volume can be found in the Electricity Network Works Program document. As part of the pole or crossarm replacement, EDO and Powder Filled Fuse units will be replaced at the same time. Fuse units will be replaced by either Boric Acid or Fault Tamer units.
05	MV FSDs located in the REFCL areas are currently under review at the time of the writing and may subject to replacement.

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.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Inspect MV FSDs in accordance with Asset Inspection Manual 30-4111
02	Continue to monitor failure rates of discrete types of MV FSD and adjust focussed replacement programs if required

REF	DETAILS OF MATERIAL CONSIDERATIONS
03	Monitor 'hang-up' or 'candling' rate of Boric Acid Fuses
04	Monitor the performance of Energy Limiting Fuse (ELF) FSDs on existing fleet
05	MV FSDs are being inspected as part of the routine line inspection as per the *Asset Inspection Manual* *30-4111* and supported by the *HV Fuse and Surge Arrester Identification Manual* *30-4162*. The inspection includes visual assessment of MV FSDs and recording of any defects. If fuse units 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.

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.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	The standard maintenance guideline of MV FSD is detailed in the *SOP 70-03*.

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.

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Progressively replace EDO fuse in high consequence risk areas.
02	Review and replace MV FSDs as per REFCL requirement - 30-4161-09-02 HV Line Fusing Protection Design Principles.
03	In conjunction with pole or crossarm replacement, replace EDO fuses with Boric Acid or Fault Tamer units as per the Standard Maintenance Guidelines SOP 70-03.

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
2	Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016	https://content.legislation.vic.gov.au/sites/default/files/29fcbe85-2f8a-3b84-8b52-bb1b9cd9f395_16-032sra%20authorised.pdf

10. Resource References

NO.	TITLE	LINK
1	Asset Management System Overview	AMS 01-01
2	Electricity Distribution Network Asset Management Strategy	AMS 20-01
3	Maintaining Capacitive Balance Policy	REF 30-09
4	Network Capacitive Balancing Policy	REF 30-06
5	Asset Inspection Manual	30-4111
6	HV Fuse and Surge Arrester Identification Manual	30-4162
7	SMG: Distribution and SubTransmission Lines Assets	SOP 70-03
8	HV Line Fusing Protection Design Principles	30-4161-09-02
9	Asset Risk Assessment Overview	AMS 01-09
10	Consequences Analysis - Addendum	AMS 01-09-02
11	Electricity Safety Management Scheme	ESMS 20-01
12	HV Fuse and Surge Arrestor Identification Manual	30-4162
13	Risk Management – Guidelines	AS ISO 31000

11. Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE	APPROVED BY
1	16/12/08	D Postlethwaite S DeSilva	Initial document	
2	19/02/09	D Postlethwaite S DeSilva	Revised failure rates and replacement forecasts	G Towns
3	24/06/09	D Postlethwaite	Update based on feedback from protection engineers	G Towns
4	25/11/09	D Postlethwaite	Forecast replacements in executive summary	G Towns
5	24/05/12	P Seneviratne S DeSilva	Revised EDO strategy. Impact of FLC Model – refer sec 1.0, 2.8.1, 2.8.3, 4.1.2, 4.3.3 & subsequent revised strategies sections 1.1, 5.4.	J Bridge
6	09/01/15	P Seneviratne S DeSilva	Review and update	J Bridge
7	04/06/2019	I Kwan	Review and update	P Ascione
8	31/01/2025	H Tayal	New Template and update	D McCrohan

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