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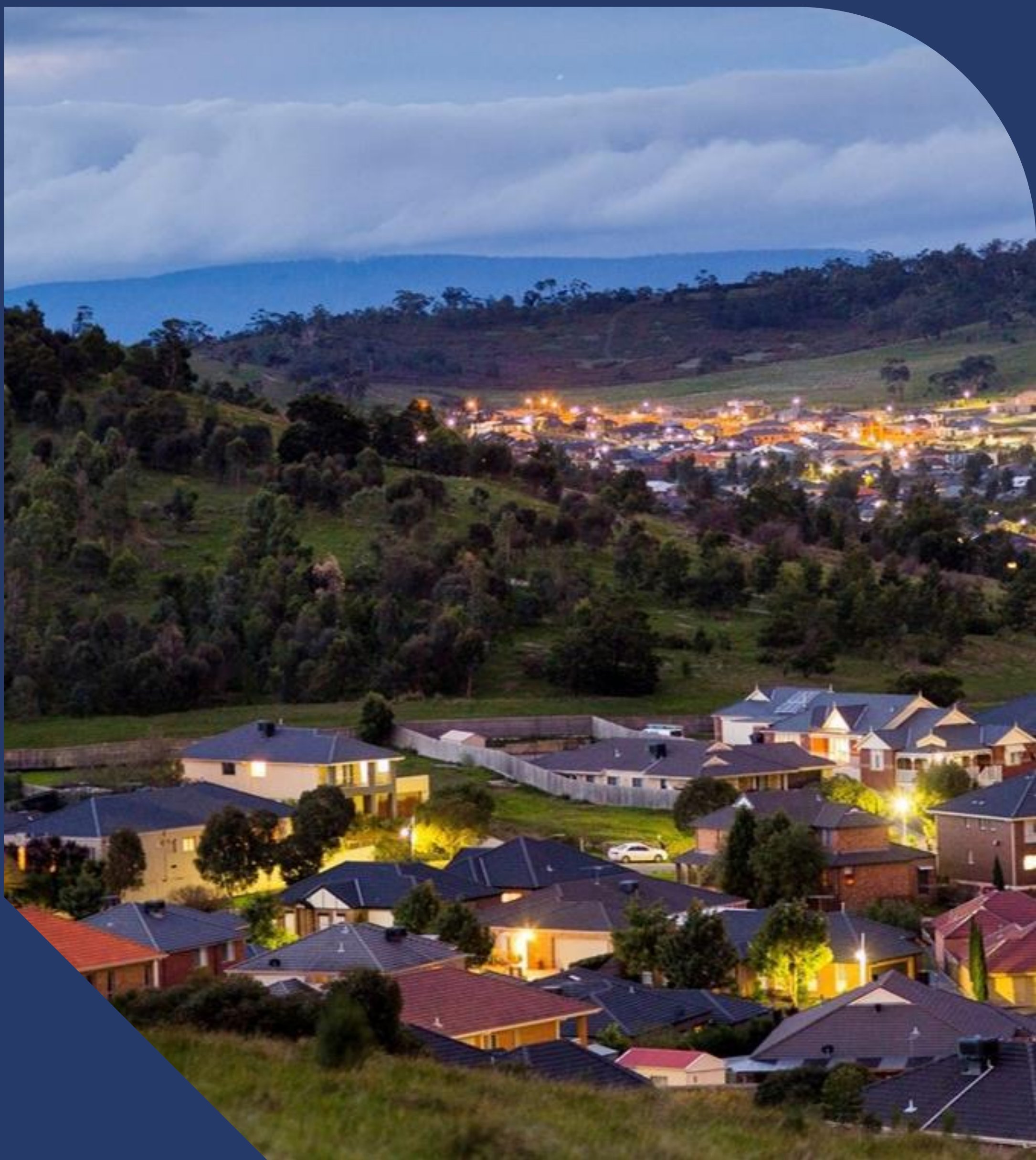
Line Voltage Regulators

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 line voltage regulators in AusNet Services' Victorian electricity distribution network.

This strategy applies to medium voltage (MV) line voltage regulators (VR) locations installed on the electricity distribution network lines. This strategy excludes station located 66kV voltage regulators.

Ongoing proactive management of line voltage regulators installation, inspection, maintenance and replacement practice is required to ensure AusNet Services meet stakeholder expectations of cost, safety, reliability and environmental performance. The summary of proposed asset strategies is list below.

1.1. New Assets

- All new line voltage regulators shall be installed with SCADA monitoring and control
- Continue replacing three-phase line voltage regulators with three single-phase units
- Adopt standardisation of single-phase line voltage regulator sizes

1.2. Inspection and Monitoring

In conjunction with other maintenance works:

- Continue the effort to align line voltage regulator condition assessment with zone substation power transformer condition assessment (AMS 20-71)
- Record additional condition assessment metrics or health indices during routine maintenance
- Inspect line voltage regulators at three-month intervals (non-SCADA monitored line voltage regulators), as per PGI 02-01-04
- Use the auto-diagnostic capability of new single-phase line voltage regulators and map more diagnostic parameters to SCADA
- Continue using Advanced Meter Interval (AMI) 'smart meter' data to validate line voltage regulator performance
- Review existing fault reporting methodologies and codes

1.3. Maintenance

- Continue routine maintenance works; oil testing, oil reconditioning, oil replacement, overhaul and tank works as per PGI 02-01-04
- Expand current library of standard maintenance instructions (SMI) to incorporate the remaining on load tap changers without an existing SMI
- Implement regular training of maintenance personnel by manufactures of primary units and secondary relay employed including regular interface with manufacturers to understand fleet performance issues.

1.4. Obsolescence and Spares Management

- Undertake strategic spare stock level assessment
- Maintain sufficient spare components for existing three-phase units
- Maintain sufficient spares policy for single-phase units to allow complete replacement and maintenance at the depot.

1.5. Replacements

- Replace 15 three-phase line voltage regulators with three single-phase line voltage regulators in the 2021-2025 reset period
- Prioritise the future replacements so to address the future reverse flow regulation requirements on each feeder as required due to increased embedded solar generation capacity.

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 line voltage regulators. The document is intended 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 medium voltage (MV) line voltage regulators installed on the electricity distribution network.

Excluded from this strategy is station located 66kV voltage regulators, which are addressed in AMS 20-71.

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
OLTC	On load tap change
REFCL	Rapid Earth Fault Current Limiter
MVA	Maximum yearly load
PUF	Power utilisation factor
CM	Corrective maintenance
AMI	Advanced meter interval
SMI	Standard maintenance instructions

4. Asset Description

4.1. Function Summary

The voltage along a distribution line drops as the distance from the zone substation increases. The voltage on the distribution line also decreases as the load increases.

Low voltages can occur during periods of heavy electrical demand, such as during heat waves, when air conditioners are running. High voltages can occur during periods of low electrical demand, such as during the middle of the day in residential areas when many people are at work and this problem may be exacerbated when high levels of residential solar is installed.

The Electricity Distribution Code prescribes the range within which voltages must be maintained. Overvoltage and under voltages (that is voltages outside the range prescribed in the Electricity Distribution Code), may cause appliances to operate less efficiently or to overheat and fail prematurely.

Line voltage regulators are installed on distribution feeders to raise or lower the voltage to compensate for the voltage drop along the feeder to ensure all customers receive a voltage within the range prescribed in the Electricity Distribution Code. Very long feeders may require multiple voltage regulators between the zone substation and the end of the feeder.

4.2. Population

4.2.1. Population Considerations

The population profile for Medium Voltage (MV) Line Voltage Regulators 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 MV line voltage regulators are essential for maintaining the integrity and reliability of the network. For example, a three-phase regulator located on a critical feeder supplying a major industrial area 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 single-phase regulators 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 MV line voltage regulators are installed in bushfire-prone areas, additional protective measures can be implemented in those areas to prevent outages during fire seasons.
- **Optimise maintenance schedules:** Develop optimised maintenance schedules based on the distribution and condition of assets. For instance, MV line voltage regulators that form the backbone of long rural feeders might be scheduled for more frequent inspections and maintenance to prevent any potential voltage drops that could affect remote communities.
- **Enhance reliability and safety:** Ensure that all components, including three-phase and single-phase regulators, meet the required standards for reliability and safety. For example, if the profile reveals that certain regulators have outdated control units 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 MV line voltage regulators 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) line voltage regulators. 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 line voltage regulators to significant stress and fatigue. *Example:* The structural integrity of pole-mounted MV line voltage regulators 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 line voltage regulators. *Example:* Regular maintenance and the use of corrosion-resistant materials are crucial to prolong the lifespan of these regulators. MV line voltage regulators 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 line voltage regulator infrastructure. *Example:* Fire-resistant materials and strategic vegetation management around regulator installations are essential for reducing this risk. In the bushfire-prone regions of the Yarra Valley, MV line voltage regulators 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 MV line voltage regulators, especially those that are ground-mounted. *Example:* Proper waterproofing and drainage systems are essential to protect these assets. In regions like Gippsland, where flooding is more frequent, ground-mounted MV line voltage regulators 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 line voltage regulators 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, MV line voltage regulators may need to incorporate seismic-resistant features to ensure stability during earth tremors.

4.2.3. Population by Type

AusNet Services has three-line voltage regulator configurations on the distribution network:

1. One three-phase regulator
2. Three single-phase regulators
3. One single-phase regulator

There are 171 regulator tanks across multiple sites in AusNet network. Each site has one of the three configurations listed above.

One Three-Phase Regulator

- **Summary Explanation of Form and Function:** A three-phase regulator consists of a single unit that includes mechanisms, on-load tap changers (OLTC), winding tanks, and a controller. It is designed to manage and regulate voltage across all three phases of an electrical distribution feeder simultaneously.
- **Purpose within the Asset Class:** The three-phase regulator serves to maintain voltage levels within prescribed limits across a three-phase distribution feeder, ensuring consistent and reliable voltage delivery to end-users.
- **Purpose within the Network Design:** In the network design, a three-phase regulator is strategically installed along three-phase feeders, particularly those with substantial load variations or long distances from the zone

substation. Its purpose is to compensate for voltage drops and fluctuations, thereby stabilising the voltage supplied to all connected customers.

- **Process Function:** The regulator continuously monitors the voltage levels and adjusts the tap settings on the OLTC to either raise or lower the voltage as needed. This process ensures that voltage levels remain within the required range despite changes in load or distance from the power source.

Three Single-Phase Regulators

- **Summary Explanation of Form and Function**: This configuration involves three individual single-phase regulators, each with its own mechanism, OLTC, winding tank, and controller. They operate independently but are typically coordinated by a single controller (CL7) or individual controllers (CL6 or CL7) for each phase.
- **Purpose within the Asset Class:** Three single-phase regulators provide finer control over the voltage on each phase of a three-phase feeder. This configuration is particularly useful for addressing imbalances and phase-specific voltage issues.
- **Purpose within the Network Design**: In the network design, these regulators are installed on three-phase feeders where phase imbalances are common, or where precise voltage control is required. They allow for independent regulation of each phase, which is beneficial in areas with significant phase load differences or high levels of distributed generation (such as solar power).
- **Process Function:** Each single-phase regulator independently monitors and adjusts the voltage for its respective phase. The regulators work together to ensure balanced voltage levels across all three phases, enhancing the stability and efficiency of the power supply.

One Single-Phase Regulator

- **Summary Explanation of Form and Function:** A single-phase regulator is designed to manage and regulate voltage on single-phase distribution feeders. It includes a mechanism, OLTC, winding tank, and a controller (CL6 or CL7). This type is typically pole-mounted.
- **Purpose within the Asset Class:** The single-phase regulator is essential for maintaining voltage levels within prescribed limits on single-phase distribution feeders, which are common in rural and remote areas.
- **Purpose within the Network Design:** In the network design, single-phase regulators are installed on single-phase feeders to ensure consistent voltage delivery to customers, particularly those at the ends of long feeders where voltage drops are more pronounced.
- **Process Function:** The regulator continuously monitors the voltage level on the single-phase feeder and adjusts the tap settings on the OLTC to raise or lower the voltage as required. This regulation process ensures that the voltage remains stable and within the required range, providing reliable power to end-users.
- **Historical Context:** All new installations, except those on single-phase networks, are three single-phase regulators. Three single-phase regulators present advantages when compared to the older three-phase units.

  Some of the advantages include:

  - greater voltage control, achieved by the single-phase units ability to tap on individual phases);
  - SCADA connectivity;
  - reverse flow regulation functionality; and
  - increased maintenance efficiency, achieved by swapping a defective single-phase unit with one in good working order on site and returning the defective one to the depot to perform maintenance, investigation and repair.

One three-phase regulator | Three single-phase regulators | One single-phase regulator

Figure 1: Line Voltage Regulator Configurations

On feeders where Rapid Earth Fault Current Limiter (REFCL) technology is mandated (refer to Section 0), the voltage regulator configuration is different than on the rest of feeders by installing a single controller (CL7) to ensure the tapping of all three phases is done at the same time. This is required so that the three phases are voltage balanced for the use of REFCL.

The reminder of the feeders may have individual controllers (CL6 or CL7) for each phase thus allowing a greater voltage control.

4.2.4. Population Profile

The breakdown of population by regulator configuration is presented in **Error! Reference source not found.**.

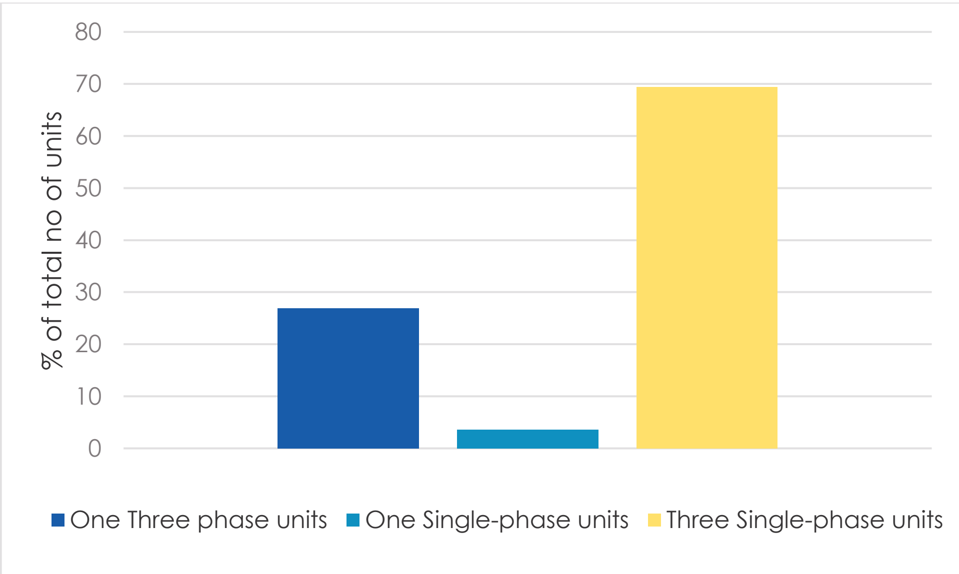

Figure 2 - Voltage regulator units by configuration

4.3. Age

An in-depth understanding of the age profile of Medium Voltage (MV) line voltage regulators 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.

4.3.1. Age Considerations

One Three-Phase Regulator:

- Age-Related Issues:
  - Older three-phase regulators may experience mechanical wear and insulation degradation.
  - For example, three-phase regulators installed over 20 years ago in high load areas may require more frequent inspections and potential upgrades to ensure ongoing reliability and performance.

Three Single-Phase Regulators:

- Age-Related Issues:
  - Single-phase regulators tend to be newer installations compared to three-phase units.
  - However, older units may have outdated control systems that require upgrades.
  - For example, single-phase regulators installed in rural areas 15 years ago may need controller upgrades to improve their performance and integration with modern SCADA systems.

One Single-Phase Regulator:

- Age-Related Issues:
  - Single-phase regulators can vary widely in age, with older units potentially facing insulation wear and mechanical degradation.
  - For example, single-phase regulators in remote areas installed over 25 years ago may require replacement to ensure they meet current performance and safety standards.

Historical Application

- Historical Considerations:
  - Historically, three-phase regulators were the standard installation for many years, but recent trends favour the use of three single-phase regulators due to their greater control and flexibility.
  - Older installations may still rely on the three-phase configuration, and as such, these units might be prioritised for upgrades or replacements based on their age and condition.
  - The adoption of Rapid Earth Fault Current Limiter (REFCL) technology has also influenced the configuration and control strategies of MV line voltage regulators, particularly requiring newer control systems to manage the voltage balance across phases.

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 Line Voltage Regulators.

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

Insulation Degradation:

- Description: The insulation material can degrade over time due to thermal aging and environmental exposure, leading to reduced effectiveness and potential electrical faults.
- Example: High temperatures can accelerate the decomposition of insulation materials in MV line voltage regulators, compromising their ability to maintain proper voltage regulation.
- Historical Application: Moisture ingress can cause internal metal parts to corrode and seize the operating mechanism, resulting in operational failures.

Mechanical Wear:

- Description: 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 MV line voltage regulators may wear down the mechanical components, leading to slower or incomplete voltage adjustments during load changes.
- Historical Application: Mechanical components, particularly in older models, are prone to wear, necessitating proactive maintenance to prevent operational failures.

Environmental Degradation:

- Description: 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 MV line voltage regulators, leading to premature failure.
- Historical Application: Coastal installations often face accelerated degradation due to salt corrosion, necessitating more frequent inspections and maintenance.

Moisture Ingress:

- Description: Water or moisture can penetrate the unit, leading to corrosion of internal components and reduced insulation effectiveness.
- Example: In high humidity areas, moisture ingress can corrode the internal components of MV line voltage regulators, compromising reliability.
- Historical Application: Moisture ingress over time can lead to internal corrosion and mechanical failures, especially in older units.

Thermal Overload:

- Description: Excessive current flow can cause overheating, leading to thermal degradation and potential failure of the regulator.
- Example: Sustained high current can cause MV line voltage regulators to overheat, leading to component failure and reduced voltage regulation effectiveness.
- Historical Application: Overheating due to high loads can degrade insulation and mechanical components, reducing the lifespan of the regulator.

Component Fatigue:

- Description: Repeated operations and load changes can cause fatigue in the components, reducing their effectiveness over time.
- Example: Regular exposure to varying load conditions can wear out the internal components in MV line voltage regulators, making them less reliable.
- Historical Application: Continuous operation under varying load conditions can lead to fatigue and eventual failure of key components.

Specific Failure Modes by Type

One Three-Phase Regulator

- Insulation Degradation: Thermal aging and environmental exposure can reduce the effectiveness of insulation, leading to potential electrical faults.
- Mechanical Wear: Frequent operations can wear down mechanical components, leading to slower or incomplete voltage adjustments.
- Environmental Degradation: Exposure to harsh environments can lead to corrosion of metal components, necessitating more frequent maintenance.

Three Single-Phase Regulators

- Insulation Degradation: Each single-phase unit can suffer from insulation breakdown due to thermal aging, requiring regular inspections.
- Mechanical Wear: Independent operation of each phase can lead to wear on mechanical components, affecting overall system reliability.
- Environmental Degradation: Coastal and high-pollution areas can accelerate the degradation of individual units, requiring targeted maintenance strategies.

One Single-Phase Regulator

- Insulation Degradation: Single-phase regulators, especially in remote areas, can experience insulation breakdown over time, affecting voltage regulation.

- Mechanical Wear: Frequent load changes can cause wear and fatigue in the mechanical components, reducing reliability.
- Environmental Degradation: Harsh environmental conditions can lead to accelerated corrosion and degradation, necessitating proactive maintenance.

5.2. Consequence of Failure

The consequences of voltage regulator failure are allocated into five consequence bands based on their economic impact as the result of the failure. These consequence impacts are irrespective of the likelihood of the actual failure.

The following failure impact were considered;

- Supply Risk – interruptions to customer supplies;
- Bush fire ignition – risk of fire ignition in summer months due to overloading of downstream plant;
- Public safety and environmental – risk of electrical shock due to high volts at customer end;
- Compliance – failure to supply electricity to the quality required by the code hence attracting penalties; and
- Collateral damage – appliance damage due to low/high volts at customer end.

5.2.1. Supply Risk

A line voltage regulator mal-operation can trip the upstream feeder circuit breaker taking thousands of customers out of supply.

Line voltage regulators are usually required on remote locations towards the end of the feeders where the voltage drop occurs. Thus, intervention time (travelling to site only) to restore power supply may take up to 3 hours.

Such an event may incur a significant reliability incentive scheme penalty.

5.2.2. Bushfire Ignition

There is no record of fires started by line voltage regulators in the past.

Bush fire ignition is mitigated in later designs using single-phase units with covered conductor, concrete bunded foundation area, maintained bare earth surrounds to fence.

5.2.3. Public Safety and Environment

A mal-operation of the line voltage regulator can result in high volts at the customer end.

The most significant environmental risk is accidental oil spill. This hazard is mitigated by design. All ground mounted line voltage regulator sites are have bunded spill barriers. Major leak would require clean up of surrounding soil.

5.2.4. Compliance

Line voltage regulators are required in the network to ensure that all customers and particularly remote customers receive electricity at a quality within the code (Clause 4 of the Electricity Distribution Code).

A mal-operation of the line voltage regulator may result in high or low volts at the customer end hence out of code voltage.

5.2.5. Collateral Damage

A line voltage regulator maloperation can result in high/low volts at the customer end. This in turn can result in customer appliance damage. AusNet Services are liable for all damaged customer appliance due to voltage fluctuation

6. Performance

6.1. Performance Analysis

In the context of asset management for Medium Voltage (MV) Line Voltage Regulators, 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 3 illustrates the yearly corrective maintenance (CM) trend on Line Voltage Regulator.

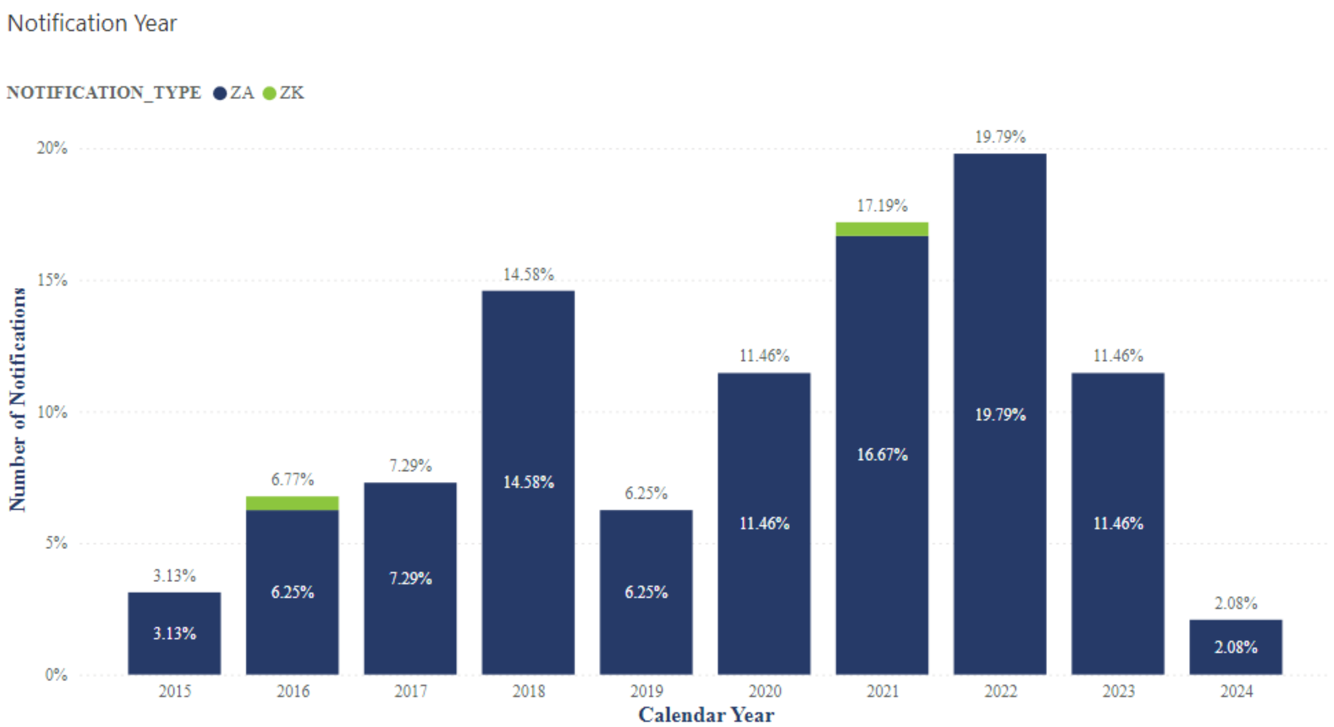

Figure 3 - Number of notifications per year

Asset performance is assessed by analysing the defects and unassisted failures of the line voltage regulators. The analysis includes failure trend, damage component and number of corrective maintenance work orders.

Figure 4 shows a change in notofocations on all line Voltage Regulators.

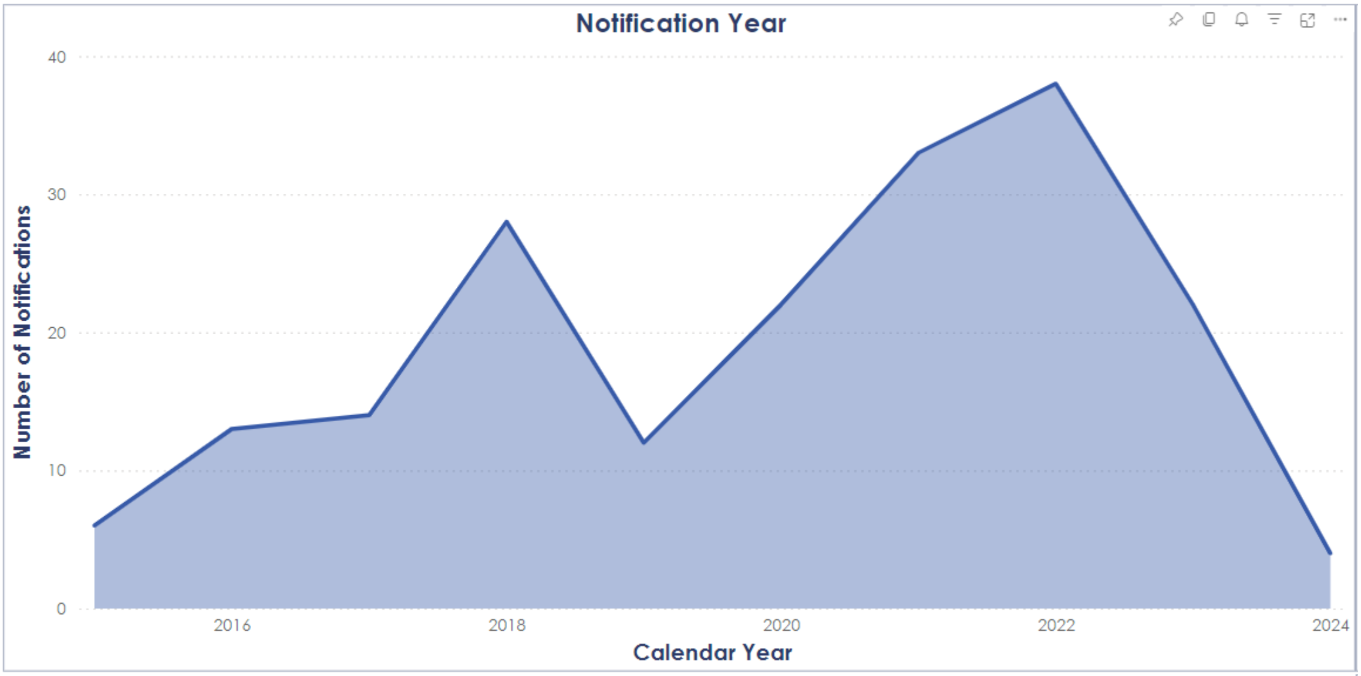

Figure 4 - Number of notifications trend

As the line voltage regulator fleet is being renewed and new line voltage regulator sites are built to new standard there are less issues with oil leaks, core and windings and property maintenance. However, new component failures have appeared, such as issues with cables connecting the single-phase line voltage regulators and control box together and control box software troubleshooting.

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.

Targeted Activities (Compliance Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	**Compliance** The Electricity Distribution Code regulates the distribution of electricity by a distributor to its customers. Clause 4 details the regulatory obligations for the quality of supply for several parameters, including voltage. The **Error! Reference source not found.** is reproduced from the Electricity Distribution Code and lists the standard nominal voltage variations allowed. Line voltage regulators are key assets in managing voltage levels to maintain compliance with the Electricity Distribution Code.
02	**Rapid Earth Fault Current Limiter (REFCL)** In line with the Victorian Electrical Safety (Bushfire Mitigation) Amendment Regulations 2016 AusNet Services needs to install the Rapid Earth Fault Current Limiter (REFCL). The installation and application of REFCL technology are governed by two key legislations: (1) Electricity Safety (Bushfire Mitigation) Regulations 2013 (2) Electricity Safety Act 1998 With the introduction of REFCL on designated zone substations and feeders there is a requirement to perform network capacitance to earth balancing. AusNet Services is utilising several methods to achieve minimal capacitive unbalance (or network capacitance to earth imbalance). The key aspect involving new design three single-phase line voltage regulators is maintaining the downstream feeder phases balanced by employing a single controller, which ensures the on load tap changers on each phase are tapping at the same time. The older three-phase line voltage regulator design are not impacted by REFCL design requirements.

As per note 01 above "Targeted Activities (Compliance Factors)", Standard Nominal Voltage Variations

STANDARD NOMINAL VOLTAGE VARIATIONS				
Voltage Level in kV	Voltage Range for Time Periods			Impulse Voltage
	Steady State	Less than 1 minute	Less than 10 seconds	
< 1.0	+10% - 6%	+14% - 10%	Phase to Earth +50%-100% Phase to Phase +20%-100%	6 kV peak
1-6.6	± 6 %	± 10%	Phase to Earth +80%-100%	60 kV peak
11	(± 10 %		Phase to Phase +20%-100%	95 kV peak
22	Rural Areas)			150 kV peak
66	± 10%	± 15%	Phase to Earth +50%-100% Phase to Phase +20%-100%	325 kV peak

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.

7.2.3. Stakeholder/ Social Factors

Social Factors

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

Stakeholder Factors

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

7.3. Internal Factors

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.

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**.

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.

Targeted Activities (New Asset Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	All new line voltage regulators shall be installed with SCADA monitoring and control
02	Continue replacing three-phase line voltage regulators with three single-phase units
03	Adopt standardisation of single phase line voltage regulator sizes

8.2. Inspections and Monitoring

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

Targeted Activities (Inspection and Monitoring Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Condition assessments involving regular oil and non-invasive investigations, as well as planned overhauls are performed in accordance with the SAP maintenance cycles as stated in PGI-02-01-04.
02	Given the complexity of the equipment, it is not possible to assign an overall condition score upon a site visit. The condition scores are calculated by a subject matter expert taking into account various inputs such as visual inspection of the external part of line voltage regulator components, oil sampling investigation results, number of tap operations and past work orders.
03	An opportunity exists to improve the inspection process on the new generation line voltage regulators. The controller has auto-diagnostic capability and is SCADA connected. This opens the opportunity to receive a set of predefined parameters via SCADA, such as the number of tap operations and percentage of contact wear.

REF	DETAILS OF MATERIAL CONSIDERATIONS
04	**In conjunction with other maintenance works**: • Continue the effort to align line voltage regulator condition assessment with zone substation power transformer condition assessment (AMS 20-71) • Record additional condition assessment metrics or health indices during routine maintenance • Inspect line voltage regulators at three-month intervals (non-SCADA monitored line voltage regulators), as per PGI 02-01-04 • Use the auto-diagnostic capability of new single-phase line voltage regulators and map more diagnostic parameters to SCADA • Continue using Advanced Meter Interval (AMI) 'smart meter' data to validate line voltage regulator performance • Review existing fault reporting methodologies and codes

8.3. Maintenance Planning

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

Targeted Activities (Inspection and Monitoring Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Continue routine maintenance works; oil testing, oil reconditioning, oil replacement, overhaul and tank works as per PGI 02-01-04
02	Expand current library of standard maintenance instructions (SMI) to incorporate the remaining on load tap changers without an existing SMI
03	Implement regular training of maintenance personnel by manufactures of primary units and secondary relay employed including regular interface with manufacturers to understand fleet performance issues.

8.4. Renewals Planning

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

Targeted Activities (Renewal Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Replace three-phase line voltage regulators with three single-phase line voltage regulators in the 2026-2030 reset period.
02	Prioritise the future replacements so to address the future reverse flow regulation requirements on each feeder as required due to increased embedded solar generation capacity.
03	Obsolescence and Spares Management • Undertake strategic spare stock level assessment • Maintain sufficient spare components for existing three-phase units • Maintain sufficient spares policy for single-phase units to allow complete replacement and maintenance at the depot.

8.5. Decommissioning

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

9. Legislative References

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	1995/96	D Postlethwaite	Initial document	
2	30/04/09	A Thomaidis	General Revision	G Towns
3	25/11/09	D Postlethwaite	Added 2011-2015 replacement volumes	G Towns
4	28/11/09	D Postlethwaite	Updated references to supporting documents	G Towns
5	18/03/10	L Gore	Updated maintenance, overhaul and spares sections	G Towns
6	-	M Butson	Spares section relocated to 2.6	S DeSilva
7	06/03/15	J Gibson T Gowland	Review, Update and Revised Structure	J Bridge
8	03/06/2019	A Bugheanu	Update strategy for 2021-2025 EDPR submission	P Ascione
9	31/01/2025	H Tayal	New Template and Update	D McCrohan

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