AusNet

Gas Network

Corrosion Protection Strategy

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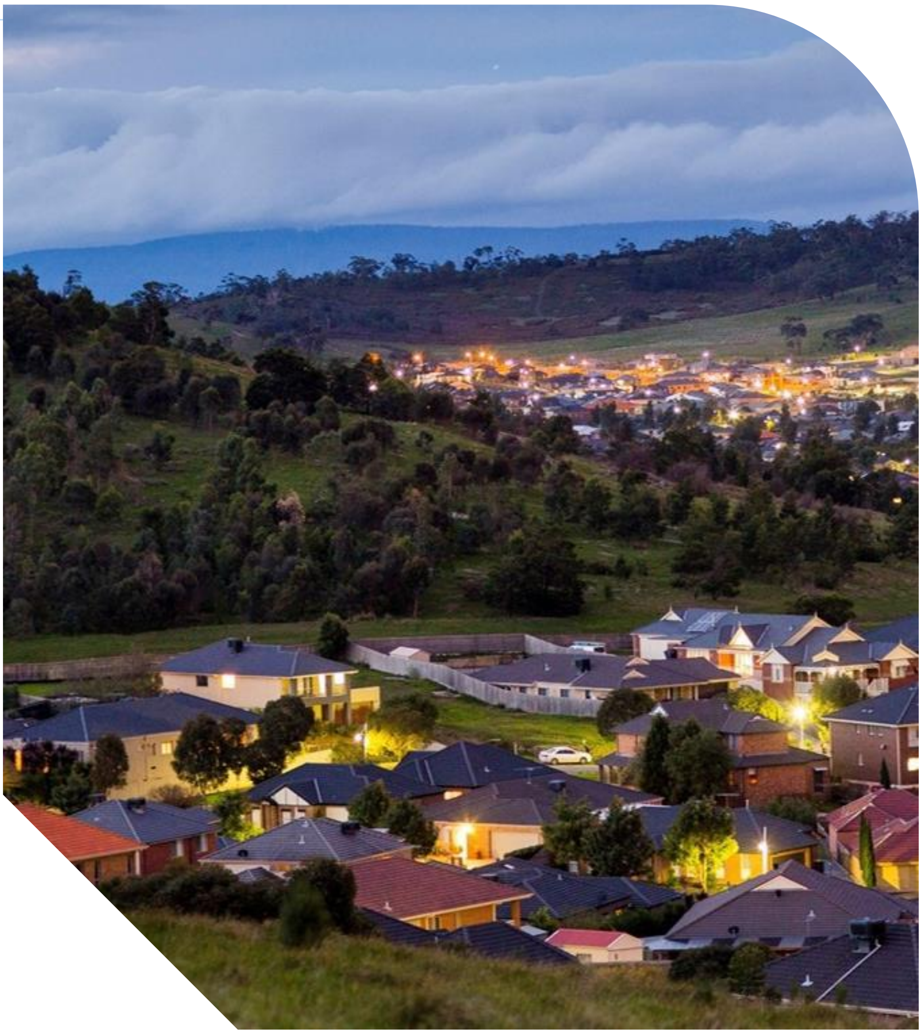

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Executive Summary

This document outlines the strategy to maintain safe and reliable operations through the use of corrosion protection assets. AusNet Services utilises cathodic protection, and associated systems, to actively defend against corrosion of buried steel assets within its gas transmission and distribution networks.

The gas transmission and distribution system feature 196 active cathodic protection units of various current outputs that protect 2,683km of steel pipeline and mains. All 181.5 km of the transmission network is cathodically protected. However, approximately 15% of steel mains cannot be effectively cathodically protected. Network cathodic protection is also aided by approximately 851 magnesium sacrificial anode bed sites, stray current drainage sites, earthing sites, and numerous surge protection devices.

The performance of these systems is monitored via test point boxes dispersed throughout the network and routine maintenance is performed to meet regulatory obligations and ensure the systems effectively protect the steel assets. Capital programs are established to replace assets that have reached the end of their effective life and require replacement. These programs aim to achieve the following four key objectives:

- Maintain network Safety in accordance with AusNet Services' Gas Safety Case through ensuring its gas pipelines and mains networks are adequately cathodically protected to the prescribed levels. This ensures minimal corrosion, reduced leakage and hence improved public safety.
- Maintain top quartile operating efficiency and the general integrity of the network through the mitigation of corrosion. Reduced corrosion rates improve asset life, ensuring the integrity of the networks.
- Undertake prudent and sustainable network investment to ensure the maximisation of asset life.
- Delivery of services valued by our customers through the reduction of both planned and unplanned works required for leakage repair and mains renewal works.

The following capital projects are planned over the 2024-28 access arrangement period.

Table 1: Planned Corrosion Protection Capex Summary ($2022, $'000)

PROGRAM		2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
			[C.I.C]				

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1. Document Overview

1.1. Purpose

This document articulates AusNet Services' approach to the management of its corrosion protection assets. The document is for use by:

- Internal staff and senior management; and
- Regulators – Economic, Technical and Safety.

The Cathodic Protection Strategy is one of several plant strategies developed and maintained for the management of AusNet Services' Gas Distribution Network. It has the following objectives:

- Articulate the key areas of focus in relation to asset management, key risks, key programs, costs and service standard outcomes for the asset group.
- Define the linkages of the asset group to the overarching asset management strategy and the underpinning asset management plan.

1.2. Scope

This scope of this strategy incorporates the following categories:

- CPUs
- Anode Beds
- Sacrificial Anodes
- Remote Monitoring
- Remote Survey
- CPSs

1.3. Glossary

Cathodic Protection (CP)

Reduction or elimination of corrosion by means of inducing a small direct current into a steel structure.

CPS

Cathodic Protection System.

CPU

An impressed current cathodic protection unit providing corrosion protection on the distribution system. These units have registered permits required under the cathodic protection Regulations.

Coating Defect Survey

A survey conducted by traversing directly above a coated main along its length using equipment and techniques designed to identify any defects in the coating. Methods in common use include "Pearson" and Direct Current Voltage Gradient (DCVG).

Coil (Electromagnetic coil) Survey

An electromagnetic tracing technique for locating points of failed insulation or electrical contact to other metallic structures.

Direct Current Voltage Gradient (DCVG) Survey

A type of coating quality assessment survey conducted by traversing above the pipeline using equipment that applies pulsating DC electrical signals to identify coating defects.

Distribution Area

An electrically isolated area of the distribution system which is used for assessing and maintaining the effectiveness of corrosion protection systems.

Distribution System

In the context of this document, the distribution system comprises all steel mains and services in the High and Medium Pressure system, i.e. those able to be cathodically protected.

Drainage Bond

An electrical connection from a point in the distribution system connected to tram or train substations to prevent adverse effects from stray currents. These installations may have associated equipment to control the level of flowing current.

Electrical Isolation

The effective electrical separation of structures to be protected from other structures and electrical systems. Achieved by the installation of insulating flanges, monolithic insulating joints and insulating couplings.

Electrolysis
A very severe form of corrosion caused by stray electric currents from the tram and train systems.

Galvanic (Sacrificial) Anode

A block of metal which provides protection by preferentially sacrificing itself instead of allowing the steel to corrode. (Magnesium is commonly used for underground service, although sometimes zinc is preferred. Refer to AS 2239 for further details).

Impressed Current Systems

A cathodic protection system in which the driving voltage for the protective current between the structure and the anode is supplied by an external direct current power source.

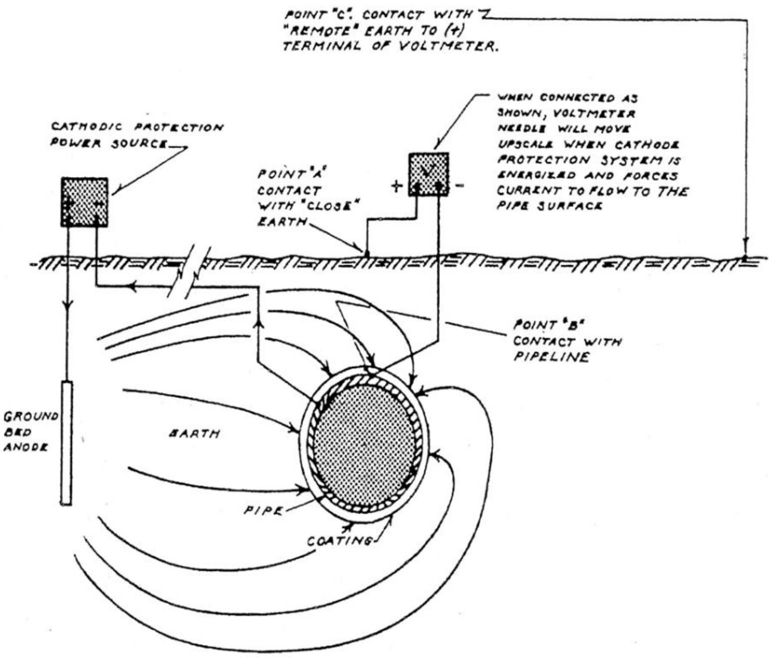

Figure 1: Impressed Current Cathodic Protection Schematic

Loop Resistivity Test

A loop resistivity test calculates the resistance of an anode bed, via monitoring a CP unit's potential voltage and current outputs. The higher the resistance of the anode bed, the higher its level of deterioration.

Pearson Survey

A type of coating quality assessment survey conducted by traversing above the main using equipment that applies audio frequency electrical signals (typically 1 kHz) to identify coating defects.

Spot Potential Reading

A measurement of pipe-to-soil potential taken at a given location at a particular point in time. Such readings can be used to assess protection status where potentials do not vary with time. However, in circumstances where potentials fluctuate due to telluric or stray current influences, recordings of potential over a period of time (usually 24 hours) are necessary.

Stray Current Electrolysis

A form of corrosion, often severe, caused by "stray" electrical current entering the ground from the tram and train systems, which then affects buried metallic structures.

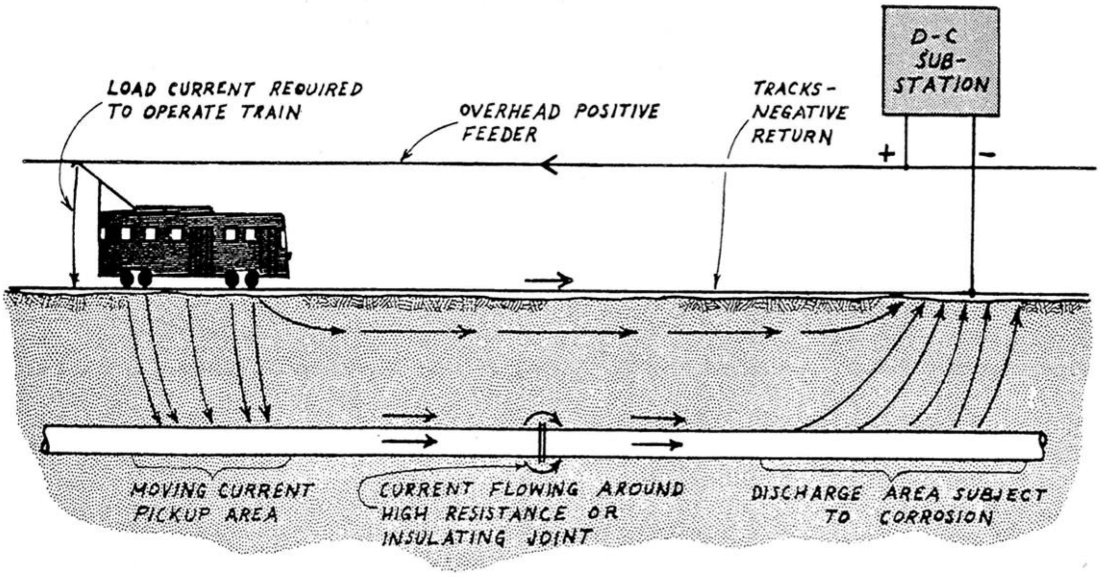

Figure 2: Stray Current Corrosion Induced by DC Transit Systems

Stray Current Electrolysis Testing

This testing is performed to identify any stray currents and interference connections that may be entering the ground from the tram and train system. This testing is carried out in a five (5) year cycle in conjunction with the Victorian Electrolysis committee or as determined via the implementation of a test model.

Test Point

A conveniently located termination point for electrical cables connected to a buried pipeline or main. This allows measurement of pipeline potential; and is the principal method of assessing the effectiveness of corrosion protection. Test points are also required for coating quality surveys and electromagnetic coil surveys to investigate losses in protection.

Thyristor Drainage Unit (TDU)

Equipment installed in tram or train substations to provide sufficient negative voltage for drainage bonds to be effective. Normally controlled in proportion to substation load.

Variable Conductance Drainage Bond (VCDB)

Electronic equipment to control the current in a drainage bond. In this case it is controlled by the protected structures potential. In some cases may also have a DC supply to provide sufficient protective current.

VEC

The Victorian Electrolysis Committee who co-ordinates testing required to monitor and maintain effective protection from stray currents caused mainly by the operation of the train and tram systems. They also administer the Cathodic Protection permits and regulations.

1.4. Asset Management Framework

Figure 3 below provides an overview of AusNet Services asset management framework. This framework is centred around the objective to operate the network in top quartile of efficiency benchmarks with an aim to care for customers and strive to make energy more affordable.

The Gas asset management strategy plays a key role in ensuring alignment between asset management objectives, corporate objectives, and stakeholder requirement. This document is one of the strategies providing visibility on network performance, issues, risks, and investment required to support delivery of safe and reliable service and achieve the long-term objectives of the gas distribution network.

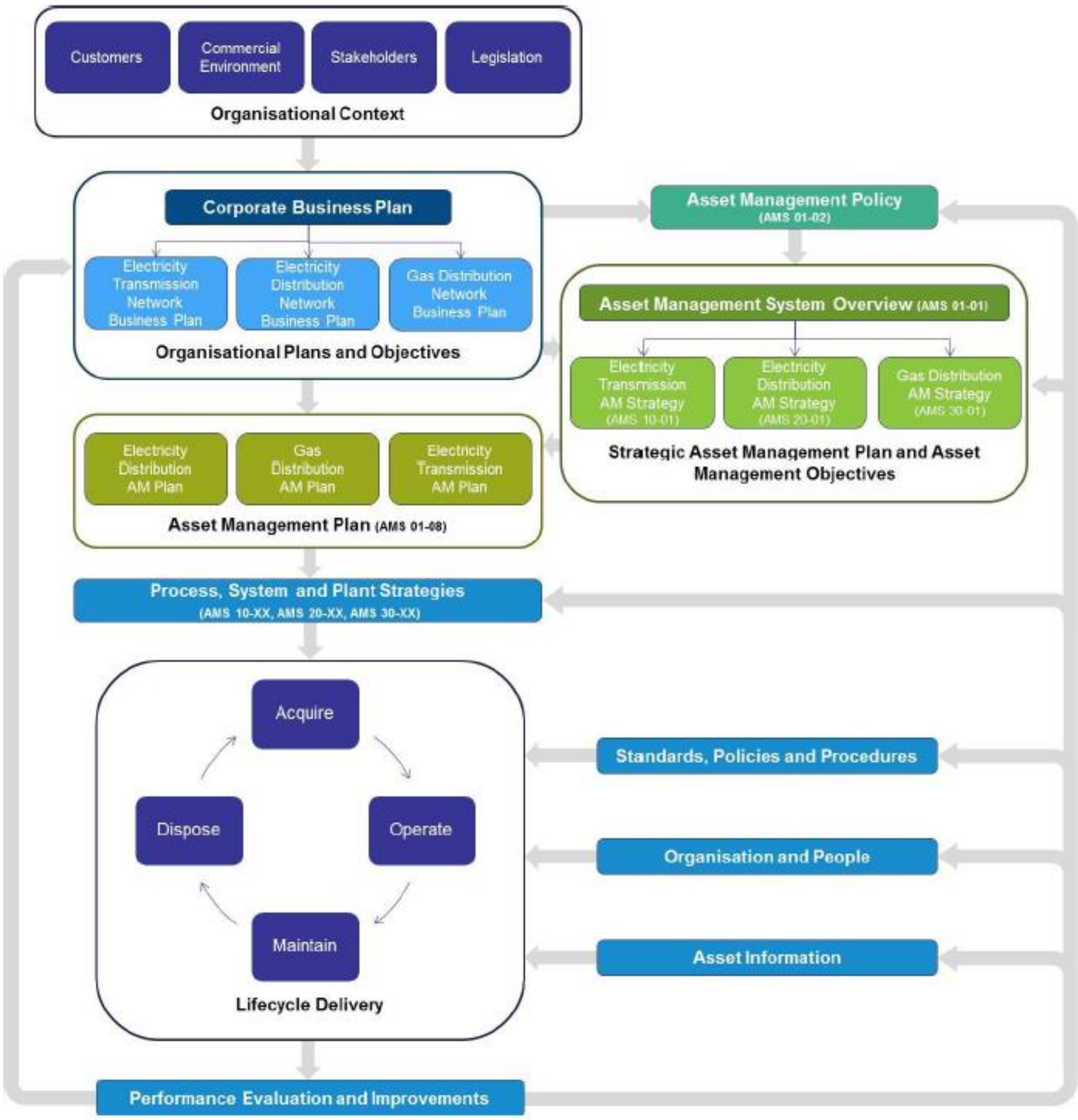

Figure 3: Ausnet Services Asset Management Framework

1.5. References

The following references are applicable to and underpin the design, operation and maintenance of Corrosion Protection Systems:

- AS 2239 – Galvanic (sacrificial) anodes for cathodic protection
- AS 4645.1 – Gas Distribution Networks
- AS 4645.2 – Gas Distribution Networks – Steel pipe systems
- AS 2885 – Pipeline – Gas and Liquid Petroleum
- AS 2832 – Cathodic Protection of Metals
- AS 4827.1 – Coating Defect Survey for Buried Pipelines
- AS 4853 – Electrical Hazards on Metallic Pipelines.
- Victorian Government Cathodic Protection Regulations
- Corrosion Protection Services Manual
- Cathodic Protection Training and Reference Manual
- CPS 2308 – Policy – Protection from Electrical Surges and Induced Voltages on Gas Pipelines
- TS 2314 – Guide – Cathodic Protection Distribution System
- CPS 2315 – Guide – Cathodic Protection Transmission System

2. Alignment with Drivers

AusNet Services' purpose statement is "Connecting communities with energy and to accelerate a sustainable future". This statement places the customer (as individuals and communities) at the forefront as a business driver and acknowledges the critical relationship with their energy supply and usage. The following diagrams shows that Customers are a key theme linking the Corporate Business Strategy with the Gas Network Vision and Gas Network Objectives, which influence the key plant strategies forming the basis of the regulatory submission.

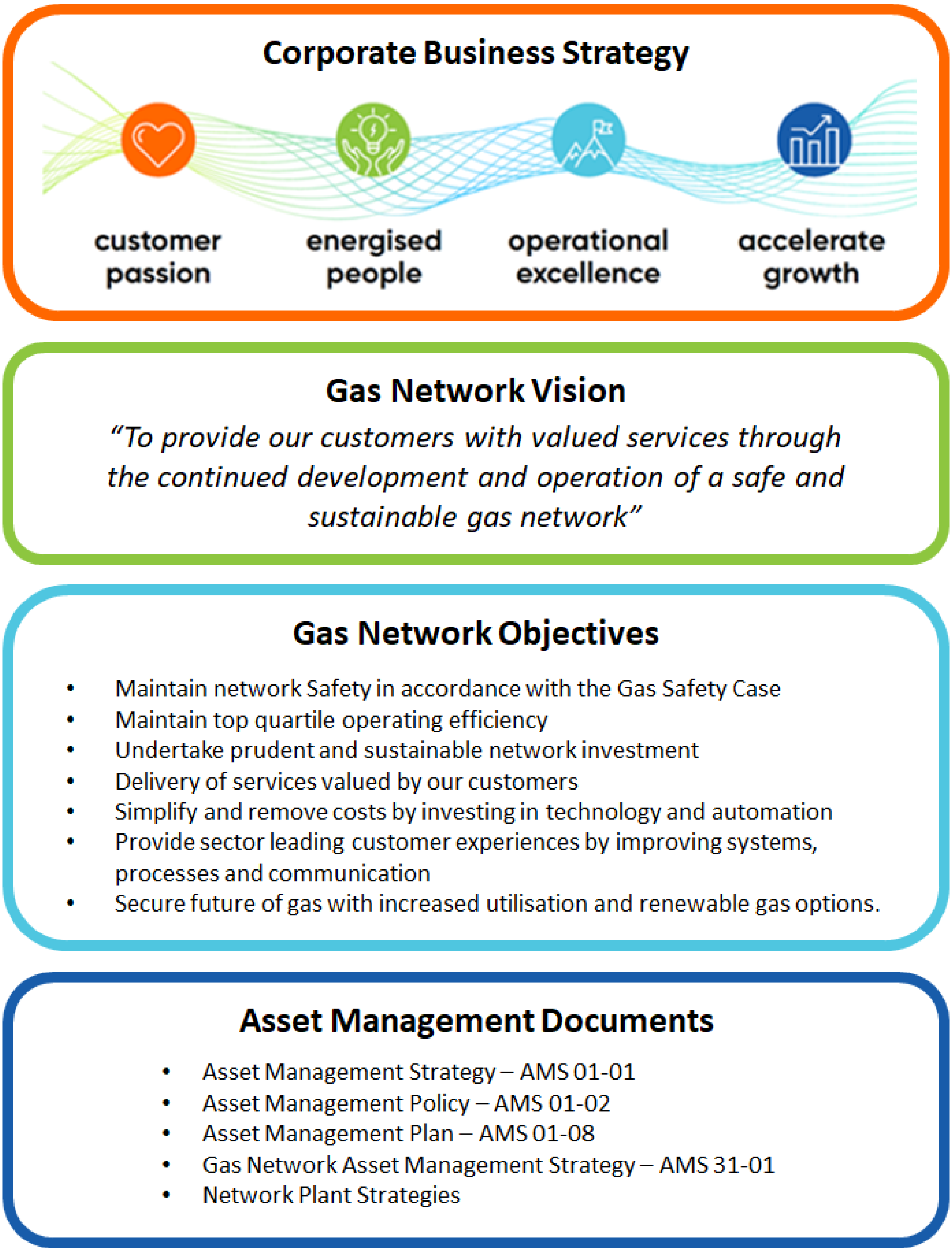

Figure 4: The Business Strategy, Network Vision and Objectives all centre around our customers

The Gas Network Objectives align with the four Corporate Business Objectives as shown below:

Maintain network Safety in accordance with the Gas Safety Case.

Maintaining network safety supports our commitment to "Mission Zero", ensuring our people go home safety at the end of the day. This is one of the strategic priorities of the "energised people" corporate objective.

Maintain top quartile operating efficiency.

AusNet Services aspires to operate all three of its core networks in the top quartile of efficiency benchmarks. This aligns with the "operational excellence" corporate objective.

Undertake prudent and sustainable network investment.

This network objective supports AusNet Services' obligation to undertake prudent and sustainable network investment, as defined in the National Gas Rules and Gas Distribution System Code. This in turn aligns with the "operational excellence" corporate objective.

Delivery of valued services to our customers.

AusNet Services strives to better understand our customers (their needs and behaviours) in order to deliver the services they value. This aligns with the "customer passion" corporate objective.

Simplify and remove costs by investing in technology and automation.

By working more efficiently, AusNet Services improves its "operational excellence" and provides better value for customers.

Provide sector leading customer experiences by improving systems, process and communication.

Similarly, improving how we work increases efficiency, thereby improving "operational excellence".

Secure future of gas with increased utilisation and renewable gas options.

Exploration of renewable gas options and the role gas will play in the energy ecosystem of the future will support the "accelerate growth" corporate objective.

3. Asset Overview

3.1. Introduction

Corrosion of a metal is an electrochemical reaction between it and the surrounding environment which results in the reduction of metal mass. Thus, corrosion is a combination of chemical effects with an associated flow of electrical energy (corrosion current).

The primary method of preventing corrosion on steel structures is via the use of protective coatings that prevent exposure of the metallic surface. However, no coating is perfect and over the life of the asset, through damage and wear, the coating will inevitably deteriorate, exposing points of the metallic surface to corrosive action.

Cathodic protection is an electrochemical technique for preventing corrosion of exposed metal surfaces. The process involves the application of a direct electrical current to a metal surface from an external source flowing in opposition to the original corrosion current. In this way, the metals natural tendency to react with its environment is effectively 'cancelled out'. The external source can be either a commercial power source (impressed current systems) or through connection to galvanic metals (sacrificial anode systems).

Cathodic protection is used extensively throughout the AusNet Services gas transmission and distribution network as a means of arresting corrosion and extending asset life. Effective application of cathodic protection can provide complete protection to any exposed areas for the life of the structure.

Only buried and coated, electrically conductive, ferrous metal mains are cathodically protected. Uncoated mains are unable to be effectively protected due to current dissipation to the surrounding soil.

3.2. Asset Profile

3.2.1. Cathodic Protection Units

The AusNet Services gas transmission and distribution system features 196 active cathodic protection units of various current outputs that protect approximately 2,680km of steel pipeline and mains. All 181.55km of transmission network is fully cathodically protected. 398 km of steel main is dispersed within the distribution system that cannot be effectively protected due to its electrical isolation, poor coated pipeline and high soil resistivity.

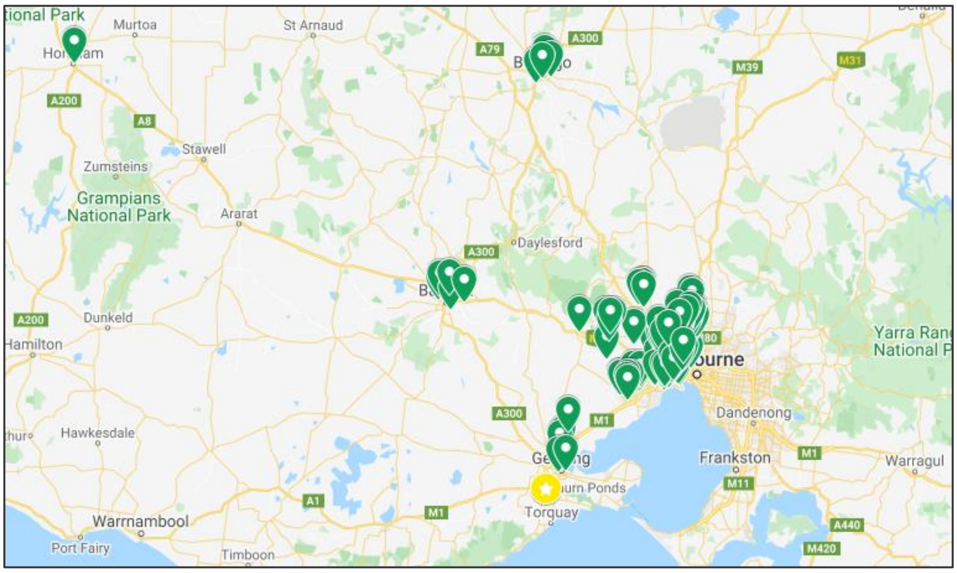

Figure 1: Locations of AusNet Services' Cathodic Protection Units

The map in Figure 5, above, highlights the distribution of AusNet Services' impressed current CPU systems. They are primarily concentrated around the western Melbourne area, with additional units in some regional centres (Ballarat, Bendigo, Geelong and Horsham). In a number of regional towns, the cathodic protection of the steel network is provided by electrical bonding at the City Gate sites. In this way AusNet Services' network piggy backs off the protection systems of APA GasNet's transmission pipeline network. AusNet Services monitors the performance and effectiveness of these systems via test points installed in each network.

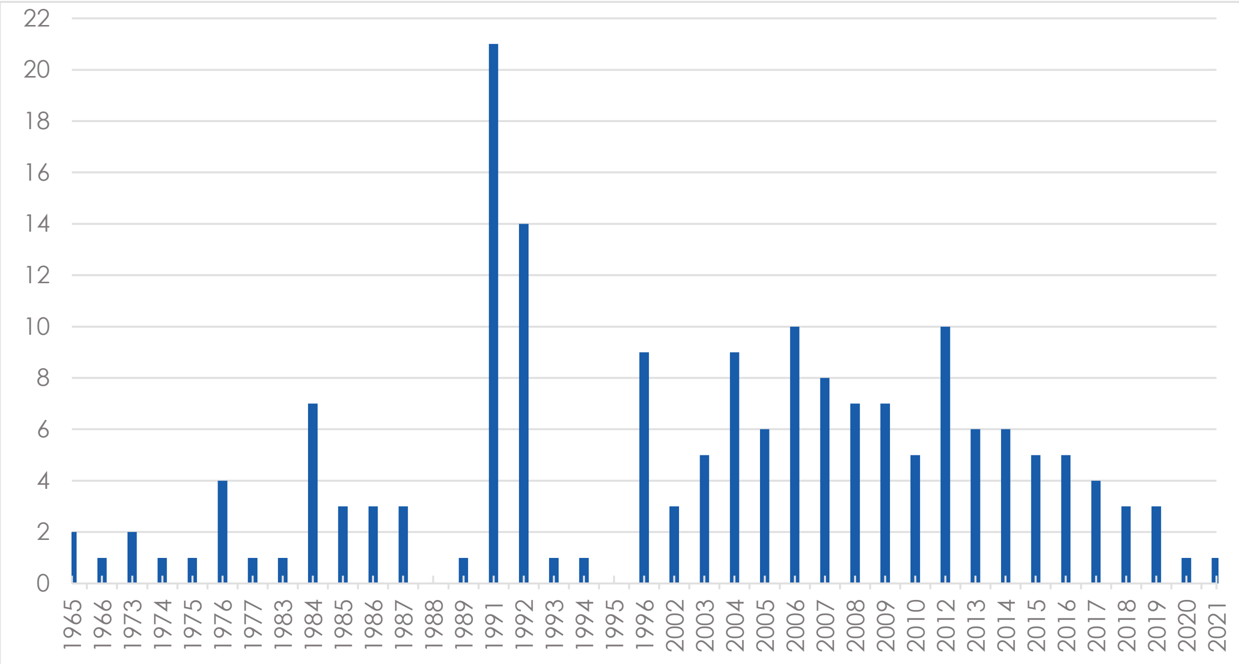

Figure 2: No. of CPUs by Year of Installation

Error! Reference source not found. Figure 6, above, shows the recorded initial install date of the in service cathodic protection units currently installed on the network.[1]

196 CPUs were installed between 1965 and 2021. The recent trend indicates the efficiency in the CP process is being achieved as required installations have decreased since 2012.

3.2.2. Sacrificial Anodes

At present the network contains approximately 875 magnesium sacrificial anode sites. 784 of these provide low levels of cathodic protection to the steel distribution network. The remainder support the systems protecting the transmission network. Sacrificial anodes decay at varied rates that depend on the environment they are situated in and the rate of corrosion on the associated main or pipeline. These installations are monitored via associated test points and replaced when they are no longer effective indicated by their low output.

3.2.3. Test Points

Test points are installed as per the recommendations of AS 2832.1 – Cathodic Protection of Metals – Pipes and Cables.

Tests Points are installed at a suitable distance along the pipeline asset ensuring that the 'protective currents' can be measured at all the sections of the pipelines. Table 2 below, extracted from AS 2832, identifies the requirement for distances between the test points for different scenarios.

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1 Source: Master List CPU Installation.

Table 1: Maximum Test Point Spacing – AS 2832

Area Classification	Uncoated or Poorly Coated Structures	Well Coated Structures
Broad – rural	1,000m	5,000m
Semi – rural	500m	2,000m
Suburban and high-rise	500m	500m
Low density dwelling	500m	1,000m

AS 2832 also recommends test points be installed at the following locations:

- At rail crossings, road crossings and at waterways.
- At steel casings, on the casing and on the structure.
- Adjacent to insulating joints and at structure terminations.
- At highly corrosive soil locations.
- At likely sources and discharge points of stray currents.
- Adjacent to air/electrolyte interfaces.
- At close proximity to foreign structures and at crossings with foreign structures.

At present, AusNet Services currently has 2,947 test points installed throughout the distribution network and 452 covering the 181.55km of transmission pipeline in operation.

3.2.4. Surge Protection Assets

Various surge protection devices are installed throughout the network to protect both personnel and equipment. This includes insulated flanges and monolithic joints positioned to electrically isolate sections of pipework. These devices are in turn fitted with NiCad batteries, thyristors, isolating spark gaps or Govan boxes to provide an electrical path for any large surge spikes to dissipate to earth.

3.2.5. Stray Current Mitigation System

Stray current drainage systems are also installed throughout the network to remove unwanted stray current caused by traction systems in the steel pipe networks. The gas network features:

- 63 on the distribution system (10 tram network related, 52 train network related, 1 other);
- 22 on the transmission system (2 tram network related, 18 train network related, 2 other).

These assets are connected to AusNet Services' buried pipes enabling stray current protection mechanism. These assets are operated and maintained by Electrolysis Group of Energy Safe Victoria ensuring a wholesome protection mechanism encompassing other utilities (eg: rail, tram, roads, pipelines, electricity etc.) is established.

3.3. Asset Performance

The performance and function of cathodic protection systems is monitored by means of test point potential level surveys. The results of which are detailed in monthly reports along with other CP issues, coil survey results, coating fault survey results, VEC testing details and any other relevant matters. The protection criterion specified in Section 2.2.2.2 of AS 2832.1 states that the potential of a fully protected structure should be more negative than -850mV Vs. a saturated copper/copper-sulphate reference electrode.

The Gas Maintenance Plan, AMS 30-02, sets minimum target levels for the percentage of protected steel mains to be within this range. These are listed in Table 3 below.

Table 2: Target CP Protection Levels

AREA	TARGET PROTECTION LEVEL
Licensed Pipelines (Transmission)	98%
High Pressure	90%
Medium Pressure	85%
Low Pressure	80%

Potential surveys conducted on the networks monitor the cathodic protection voltages to ascertain if these target levels are being reached. Figure 7 below shows the historical average performance of these systems, since 2002.

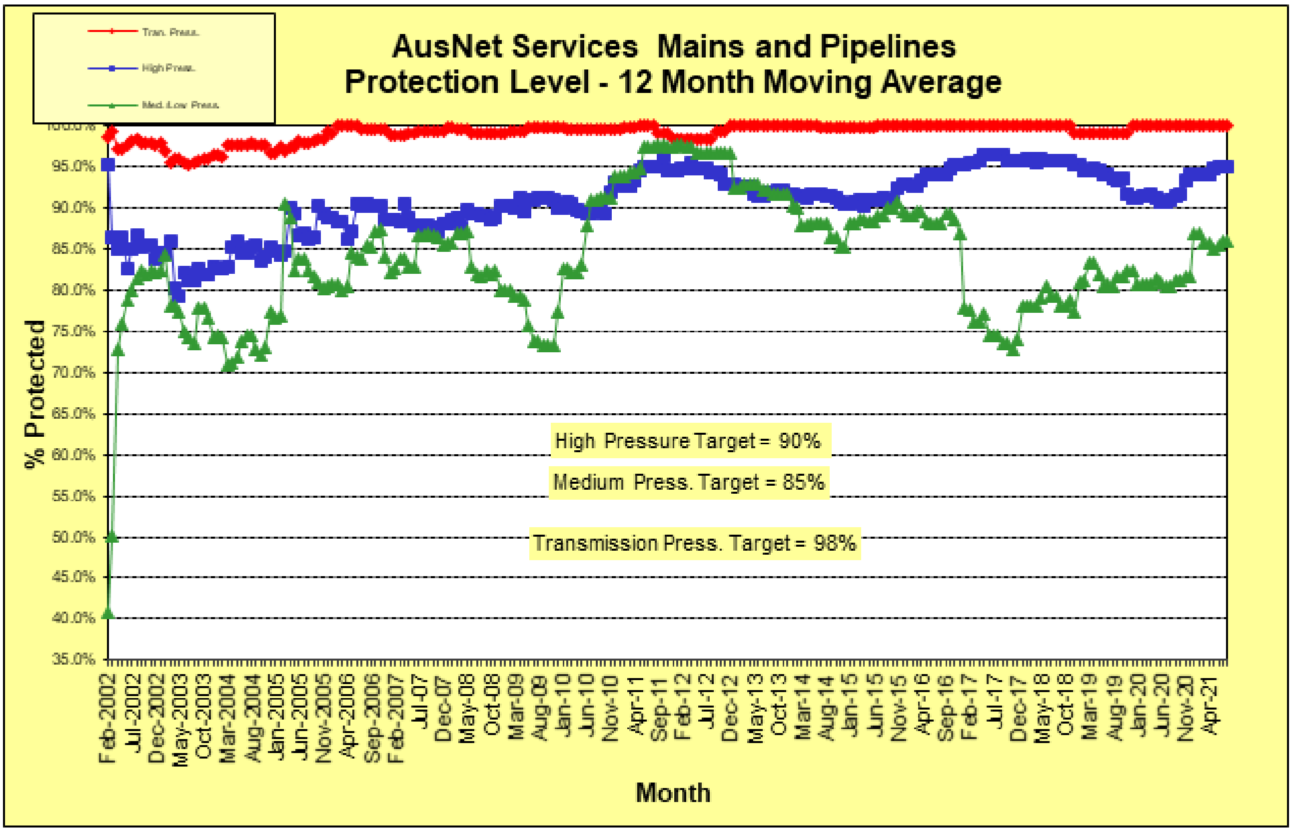

Figure 3: Historical Cathodic Protection Performance

The effectiveness of a CPS is dependent on a number of variables. Some issues that affect CPS performance, and hence measured pipeline potentials are:

- **Soil Moisture Content:** The moisture content of the soil affects its electrical resistance, and hence the ability of the cathodic protection system to replace lost electrons. As such, periods of drought will see a decline in system performance. This is evident in **Error! Reference source not found.** for the October 2009 to July 2010 period for the localised medium pressure network, which saw a period of drought followed by heavy rain. The geographical area that AusNet Services serves also sees lower average rainfalls than the east of the state.
- **Soil Composition:** The soil resistivity, and hence system performance, will also vary based upon the soil composition in which both the anode bed and protected asset lie.
- **Anode Bed Condition:** A cathodic protection system's performance will start to decline over time as its associated anode bed is depleted. The system's performance and life can be renewed by simply replacing the anode bed of the unit.

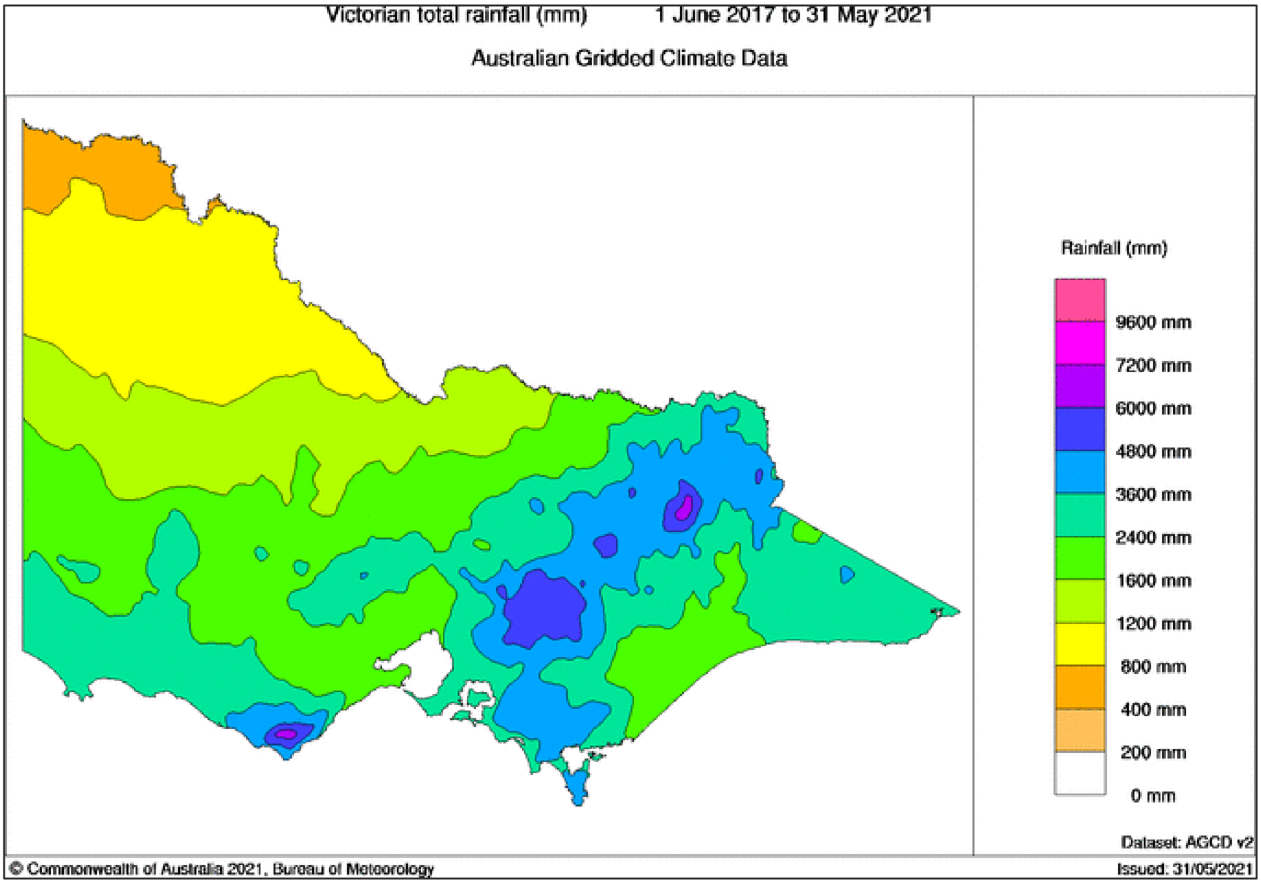

Figure 4: Victoria 4 Year Historical Rainfall

4. Detailed CAPEX requirements

The corrosion protection works program aims to maximise the life of buried steel pipes. The works program to 2021/22 has been determined by analysing the performance of the CPSs and designing works to meet the protection levels in accordance with the Gas Safety Case. The program consists of installing additional CPUs, upgrading of existing systems, installing surge protection and replacement of anode beds.

4.1. Program Drivers

This section outlines the business drivers and strategic alignment common to all corrosion protection capital programs detailed in the following sections. Any unique drivers are listed under the relevant programs.

Cathodic Protection

The primary driver behind the use of CPSs, and all works programs associated with it, is to maintain the integrity of the network. It's effective deployment and use throughout both the distribution and transmission networks ensures that the probability and hence the overall risk of corrosion of its steel assets is mitigated.

CPSs, by their nature, also prolong the useful life of the assets they are designed to protect from corrosion. The useful life of steel pipeline assets is maximised by installing and maintaining adequate CPSs.

Stray Current Drainage

Stray currents from train and tram systems can cause extensive damage to buried steel structures. Accordingly, the effects of stray currents are monitored by co-ordinated testing of structures near train and tram substations. These testing and mitigation works are mandated by the VEC.

Standards

Due to the importance of cathodic protection, the ability of stray currents to impinge on nearby assets, and the dangers of electrical interference, a number of standards and codes govern the use of CPSs.

By adhering to all standards (shown in section **Error! Reference source not found.**) related to cathodic protection and associated systems, the integrity of the networks is maintained. The integrity of the transmission and distribution system is maintained by minimising corrosion through the application of CPSs. This protects the capacity of the networks and hence the levels of supply available to customers.

Cathodic Protection Levels

The use of cathodic protection as a means of limiting corrosion induced leakage throughout the network is a key measure listed in the Gas Safety Case. Therefore, appropriate cathodic protection potentials, at or above the set target levels, must be maintained.

4.2. Phasing and Financial Disclosure

All programs within the Corrosion Protection Strategy are defined in Australian Financial Years 2024 to 2028 consistent with the requirements of the GDSC, and the reporting requirements of the Australian Energy Regulator (AER).

All financial figures quoted within this document, including all historic and forecasted expenditure – unless otherwise specifically stated – have the following characteristics:

- Real Expenditure / Cost (reference year = 2021);
- Direct Expenditure only (i.e. excludes overheads and corporate finance costs); and
- In units of $1,000 (i.e. '000).

4.3. New CPU Installation

4.3.1. Introduction

New CPUs installed by AusNet Services to maintain ongoing protective current in gas transmission and distribution networks. CPUs are powered by electrical connection and require a metered 240V electrical connection. As such, the units are typically mounted directly to an electricity pole or in proximity to their base. The systems also require placement of an anode bed, sized in accordance with the units output. These anode beds are typically laid in a nearby nature strip or other suitable area. The system is then wired via a Test Box, to the steel main it protects. The units must also be registered and licensed with the VEC which restricts the maximum output of the unit.

Figure 5: Typical CPU Installation

The requirement of protective current increases as pipelines age and their coating system deteriorates with age. The deteriorated coating leads to leaking of the protective currents. i.e. CPUs are required to put out more current and therefore deplete faster in comparison to the CPUs installed at newer pipelines.

4.3.2. Works Program

The installation of CPUs is required on an ongoing basis to maintain ongoing protective current in gas transmission and distribution networks. A program involving the installation of new cathodic protection units has been undertaken over the last 14-15 years.

This program has begun to stabilise cathodic protection levels on the steel pipeline network at the desired levels of protection and coverage. The works have also been aimed at eliminating AusNet Services' reliance on third party cathodic protection units; those owned and operated by APA Group.

Moving away from this reliance ensures that AusNet Services has oversight and control of the cathodic protection of our assets. The proposed volume of new units is expected to remain at current levels in order to fully protect and cover the network.

The ongoing program has brought efficiencies in terms of reducing the required size of CPUs to maintain protective currents. Based on current Cathodic Current performance, it has been determined that only small CPS (up to 2 Amps) are required instead of the previously proposed bigger CPUs.

An average cost of [C.I.C] is identified by the authorised Corrosion Contractor. These costs are based on 2021 costs. These costs also include the installation of remote data logger in each new Cathodic Protection cabinet.

Table 4 below identifies the number of CPUs and the suburbs where these CPUs are required:

Table 3: New CPU Installation Program

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
				[C.I.C]			

The projected costs are based on the costs incurred during 2021 works.

4.4. Small Anode Bed Replacement

4.4.1. Introduction

If during potential surveys the protection level (mains potential) of an area is found to be below the optimal level, then the output of the CPUs in the area is increased. However, if this does not improve the surveyed potential levels, this may indicate a problem with the anode bed of the CPU.

As the anode bed of a CPU will be consumed as part of its function, it must be renewed when the level of deterioration becomes excessive. The rate of this deterioration is directly proportional to the load placed on the unit (by the selected output level and level of corrosion on the main being protected). To verify the state of an anode bed, a loop resistivity test is performed.

Once an anode bed is replaced, the output of the CP unit will again be at its maximum and the life of the unit renewed.

Figure 6: A Small Anode Bed Installation (Single Anode)

4.4.2. Works Program

The volume of anode bed replacements needed to maintain output levels increase as the total number of cathodic protection units utilised within the network increases. The number of replacements required in any given year is also dependant on each site's load and environmental conditions.

An average small anode bed replacement cost of [C.I.C] is assumed based on costs from the 2022 program.

Table 4: Small Anode Bed Replacement Program

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
				[C.I.C]			

4.5. Large Anode Bed Replacement

4.5.1. Introduction

The size of a CPU's anode bed is directly related to the maximum output of the unit. The larger the unit, the larger the anode bed required to provide adequate corrosion protection of the steel assets. Large anode beds consist of multiple metal anodes, usually 5 to 6, laid either vertically or horizontally in a bed of conducting earth backfill. These anodes are wired together, increasing the available output of the cathodic protection unit, and hence the level of corrosion protection. These larger units also deplete over time, requiring replacement when their failure is identified.

Figure 7: Large Anode Bed Installation (Multiple Anodes)

4.5.2. Works Program

The number of replacements required in any given year is dependent on each sites load and environmental conditions. It is expected that one replacement per year is sufficient in maintaining protection levels.

An average anode bed replacement cost of $45,000 per site is received from the contractor.

Table 5: Large Anode Bed Replacement Program

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
				[C.I.C]			

4.6. New Sacrificial Anode

4.6.1. Introduction

The alternative to powered impressed current systems for active corrosion protection is the use of sacrificial anodes. These systems are capable of providing approximately 200 mA of potential to the main or pipeline to which they are connected. These systems function by electrically connecting a sacrificial anode, usually a bar of magnesium or zinc, to the main via a test point. This sacrificial anode is preferentially corroded instead of the main to which it is attached as it supplies electrons to replace those in the main lost to corrosive action. The system usually consists of four 10kg anodes.

For sites or buried pipes requiring less than an additional 200mA of potential to achieve adequate cathodic protection levels and which do not have a feasible source of electrical connection the installation of new sacrificial anodes is preferred. Due to their substantially lower upfront capital cost, lack of monthly monitoring requirements, and lower current output levels, they are considered more economic and technically feasible than full impressed current systems.

Sacrificial anode beds also become necessary when there is CP interference issues from nearby buried steel infrastructure.

4.6.2. Works Program

Based on current unit rates and previous works performed the programs expenditure is estimated as shown in Table 7.

Table 6: New Sacrificial Anode Program

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
				[C.I.C]			

4.7. Replace Expiring Sacrificial Anode

4.7.1. Introduction

During routine potential surveys, the current output of the sacrificial anodes is measured via their associated test point. If the current measured is approaching nil then the anode is generally depleted and requires replacement.

4.7.2. Works Program

Based on current unit rates and previous works performed the programs expenditure is estimated that 4 units per years is consistent with maintaining protection levels. The program is shown in Table 8 below.

Table 7: Replace Expiring Sacrificial Anode Program

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
				[C.I.C]			

4.8. CPU Remote Monitoring

Installation of "remotely read data loggers" in CPUs to remotely monitor current output at prioritised locations.

Based on number of the current CPUs with no remote data loggers and previous works performed the programs expenditure is estimated as shown in Table 9.

Table 9: CPU Remote Monitoring Program

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
			[C.I.C]				

4.9. City Gate Remote Potential Survey

Installation of remotely read data logger test points in City Gate locations to remotely measure the potential of the pipelines. This program is important in enhancing the reliability of the CPS.

The twenty-one (21) city gates out of total forty-three (43) city gates are installed with remote data loggers. The table below identifies which City Gates already have remote data loggers:

Table 10: City Gate Remote Potential Survey Program

SR NO.	CITY GATE FACILITIES	COMMISSIONING DATE	LOCATION (METRO / REGIONAL)	REMOTE DATA LOGGERS INSTALLED
1	Corio City Gate	04-Jan-71	R	Y
2	Melton City Gate	24-May-74	M	Y
3	Ararat City Gate	13-May-98	R	Y
4	Stawell City Gate	23-Jul-98	R	Y
5	Horsham City Gate	09-Aug-98	R	Y
6	Ballarat City Gate	03-Feb-78	R	Y
7	Bendigo City Gate	26-Jul-73	R	Y
8	Derrimut City Gate	25-May-94	M	Y
9	Daylesford City Gate	19-Apr-83	R	Y
10	Castlemaine City Gate	10-Oct-73	R	Y
11	Sydenham City Gate	20-Nov-89	M	Y
12	Sunbury City Gate	09-Mar-79	M	Y
13	Kyneton City Gate	19-Aug-81	R	Y
14	Maryborough City Gate	18-Jul-80	R	Y
15	Allansford City Gate	01-Jan-87	R	Y

16	Koroit City Gate	05-Oct-83	R	Y
17	Portland City Gate	18-May-93	R	Y
18	Lara City Gate	10-Nov-73	R	Y
19	Hamilton City Gate	04-Jul-95	R	Y
20	Craigieburn City Gate (Brick & Pipe Factory)	17-Jun-77	M	Y
21	Colac City Gate City Gate	17-Jan-01	R	Y
22	Bacchus Marsh	18-Oct-73	R	N
23	Ballan City Gate	21-May-76	R	N
24	Wallace City Gate	01-Jun-83	R	N
25	Rockbank City Gate	09-Jan-97	M	N
26	Diggers Rest City Gate	27-Apr-83	M	N
27	Fitzgeralds Road City Gate	19-Apr-94	M	N
28	Hoppers Crossing City Gate	06-May-70	M	N
29	Forsyth Road City Gate	09-May-80	M	N
30	Old Snydes Road City Gate	14-Jul-87	M	N
31	Lock Avenue City Gate	24-Jun-82	M	N
32	Avalon City Gate	04-Dec-85	R	N
33	Cobden City Gate	04-Sep-94	R	N
34	Woodend City Gate	01-Feb-06	R	N
35	Lancefield City Gate	01-Feb-06	R	N
36	Wyndham Vale City Gate	12-May-09	M	N
37	Plumpton City Gate	17-Jun-08	M	N
38	Mount Cottrell City Gate	26-Oct-15	M	N
39	Winchelsea City Gate	13-Apr-16	R	N
40	Avoca City Gate	01-Mar-17	R	N
41	Bannockburn City Gate	15-Dec-17	R	N
42	Lovely Banks City Gate	Oct-21	R	N
43	Parwan City Gate	2022	R	N

The assessment was carried out and ten (10) City Gates were identified where further installation of remote data loggers will improve reliability and monitoring of the continual performance of CPS in the pipe network associated with the City Gate.

Table 11 below identifies the City Gates with expenditure for installing remote data loggers at the City Gate.

Table 11: City Gate Remote Potential Survey Program

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
				[C.I.C]			

4.10. Miscellaneous CPS

4.10.1. Introduction

A number of minor items are required as necessary adjuncts to the main CPS. These items allow the monitoring of the systems performance, mitigate the effects of stray currents, protect from electrical surges and drain induced currents. The miscellaneous CPS program also covers all other CPS related capital works not expressly covered by the other programs planned.

4.10.2. Scope

This program includes the following and any other unforeseen CPS capital works:

- **Replacement of equipment damaged / destroyed by electrical surges**

  This includes replacement of surge arrestors (battery packs, thyristors), monolithic joints, insulated flanges, and in extreme cases the replacement of pit lids after explosive events.

- **Test point installations**

  As the network expands, and polyethylene mains renewals isolate sections of old steel mains, the installation of additional test points becomes required.

- **Current drainage point installations**

  AusNet Services' network is predominately located within a high stray current area, with a number of major train and tram lines running throughout the area. The outcome of VEC surveys may reveal the need to install current drainage systems to combat these stray currents.

- **Electrical bonding / isolation works**

  Through the course of alterations to the network, via augmentations and mains replacements, it may become necessary to either electrically bond, or isolate, particular networks to ensure adequate cathodic protection system performance.

- **Utility isolation works / service replacement**

  Through the use of potential and coiling surveys, drains on the cathodic protection system may be identified. Potential drains are often located at points where the gas main has 'touched' other metallic assets in the area, and become electrically bonded to them. To remove these drains from the system, and ensure the full potential of the cathodic protection system is utilised, alteration works may be required to separate them.

- **ICCP Cabinet Replacement**

Replacement of the old/deteriorated ICCP above ground cabinet may be required.In 2020 two cabintes were identified for replacement.

- **Earthing Works as a result of LFI / EPR Studies**
  - The Low Frequency Induction (LFI) and Earth Potential Rise (EPR) study and ongoing review is an essential requirement of AS 4853-2012. The sources and consequences of electrical hazards change throughout the operating life of a pipeline, and therefore pipelines at risk of electrical hazards shall have their risk management plan reviewed every 5 years.
  - The mitigation works as a consequence of LFI/EPR studies include installation of earthing mechanism (installation of earthing rods or electrical bonding via cable) with the associated buried structures to eliminate unwanted potential rises induced by nearby electrical infrastructure.
  - Until 2021, LFI and EPR has been undertaken on Licence 64, 99 and 82 pipelines. Mitigations measures have been installed at Licence 64 and 82. The remainder of the 17 licenced pipelines will require a LFI/EPR study. This requirement has been emphasised by Energy Safe Victoria via their Electrolysis Committee and a guideline document which they published in 2021. The priority plan has been developed to achieve optimal outcomes and to ensure that the mitigation measures are implemented in a wholesome manner.

Below is the list of the pipelines where the mitigation measures will be required from 2023 to 2028 consequent of the LFI/EPR studies.

Table 12: Pipeline Licences requiring mitigation measures

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28
Pipeline License	PL 203	PL 17	PL 84	PL 19	PL 18	PL 57

4.10.3. Works Program

Based on previous works performed the programs expenditure is estimated as follows:

Table 13: Miscellaneous CPS Program

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28	2024-28 TOTAL
				[C.I.C]			

5. Alignment with network objectives

Each project / program of the corrosion protection strategy for the gas transmission and distribution network is aligned with AusNet Services' key network objectives aiming to:

- Maintain network Safety in accordance with the Gas Safety Case;
- Maintain top quartile operating efficiency;
- Undertake prudent and sustainable network investment;
- Delivery of services valued by our customers;
- Simplify and remove costs by investing in technology and automation;
- Provide sector leading customer experiences by improving systems, processes and communication; and
- Secure future of gas with increased utilisation and renewable gas options.

Specifically, this is accomplished through the following means.

5.1. Network Resilience and Reliability

The installation of cathodic protection equipment is directly targeted at maintaining network resilience. Through the deployment of CPSs throughout the gas transmission and distribution network, AusNet Services actively defends against the corrosion of its buried steel assets. This resilience of the network results in decreased corrosion and induced leakage. This improves the services provided to our customers along with our operating efficiency.

5.2. Compliance

Due to the importance of cathodic protection, the ability of stray currents to impinge on nearby assets, and the dangers of electrical surges and other electrical interference, a number of standards and codes mandate and guide the use of cathodic protection units and associated systems. These include, but are not limited to, the following:

- AS 2885 – Pipelines – Gas and Liquid Petroleum
- AS 4645.2 – Gas distribution networks – Steel pipe systems
- AS 2832 – Guide to the Cathodic Protection of Metals
- AS 4853 – Electrical hazards on metallic pipelines
- AS 2239 – Galvanic (Sacrificial) Anodes for Cathodic Protection
- Victorian Government Cathodic Protection Regulations – 1988
- Railways of Australia Code
- NACE RP-01-69 (1991) Recommended Practice for Control of External Corrosion on Underground or Submerged Metallic Piping Systems

The use of cathodic protection is a feature of AusNet Services' Gas Safety Case, a primary tool for ensuring the safe operation of the network.

As an employer AusNet Services is required by law to provide a safe working environment for its employees and is required to comply with relevant codes and standards, such as AS/NZS 4853 – Electrical hazards on metallic pipelines, which specifies acceptable electrical limits on pipelines.

5.3. Safety

Cathodic protection mitigates the risk of gas escapes on steel pipes and hence maintains the safety of the network and the surrounding public. The use of cathodic protection is a feature of AusNet Services' Gas Safety Case, a primary tool for ensuring the safe operation of the network.

As an employer, AusNet Services is required by law to provide a safe working environment for its employees and is required to comply with relevant codes and standards, such as AS/NZS 4853 – Electrical hazards on metallic pipelines, which specifies acceptable electrical limits on pipelines.

By ensuring that the transmission and distribution networks are adequately protected from electrical surges and other electrical interferences, AusNet Services ensures a safe working environment for its employees, and the safety of the public.

5.4. Sustainability

Corrosion of steel pipes causes a reduction in the wall thickness of the pipe. Corrosion eventually leads to a loss of containment resulting in leakage of natural gas containing Methane, a greenhouse gas, to the atmosphere. Corrosion of the mains also accelerates the aging process of the pipe and shortens its expected life. As a result, the pipe must be renewed prematurely. By maintaining adequate levels of corrosion protection, leakage of natural gas can be minimised, the asset life of the main maximised and replacement works deferred. This therefore constitutes prudent investment in the network.

6. OPEX Overview

All maintenance practices are carried out in accordance with the following references.

- AS 4645.2 – Gas distribution networks – Steel pipe systems
- AS 2885 Pipeline – Gas and Liquid Petroleum
- AS 2832 Cathodic Protection of Metals
- AS 2239 Galvanic (sacrificial) Anodes for Cathodic Protection
- Victorian Government Cathodic Protection Regulations – 1998
- Corrosion Protection Services Manual
- Technical Standard CPS 2315 (Cathodic Protection – Transmission Systems)

6.1. Potential Survey (Transmission)

At intervals not exceeding six (6) months a potential survey of the pipeline, including tests for stray current electrolysis must be performed. This survey ensures an acceptable level of protection is being maintained on the pipeline. The steel pipeline is considered protected when the potential on all parts of its surface is equal to or more negative than -850mV relative to a saturated copper/copper sulphate reference electrode. A summary of the results of these surveys is submitted annually to the Chief Electrical Inspector. AusNet Services' target protection level for its transmission mains is 98%.

6.2. Potential Survey (Distribution)

At intervals not exceeding six (6) months on high risk networks and intervals not exceeding twelve (12) months on lower risk networks a potential survey of the protected steel pipe is performed. This survey provides an acceptable level of protection is being maintained on the steel pipe. The target protection levels are:

- High pressure pipe 90%;
- Medium pressure pipe 85%;
- Low pressure pipe 80%.

6.3. CPU Maintenance

All CPUs are monitored at monthly intervals. Identified faults are repaired to ensure that the protected asset is being protected satisfactory.

6.4. Coating Defect Survey

Transmission pipeline coating assessment surveys are carried out at 5 year intervals.

Following the non-destructive coating survey, AusNet Services carries out dig ups to visually validate identified coating faults. The number of dig ups is considered based on the overall risk profile of the pipeline such as age of the asset and type of coating, result of previous dig ups, potential loss of gas supply, public safety, environmental damage, etc.

6.5. Coiling Survey

Location of unintentional earthed contacts to buried mains is required to facilitate their subsequent removal and to allow the cathodic protection system to function efficiency.

6.6. Stray Current Electrolysis Testing

This testing is undertaken in conjunction with the VEC and is performed to identify any stray currents and interference connections that may be entering the ground from the tram and train system. This testing is carried out in a five (5) year cycle. The testing is governed by the VEC and is not subject to variation by AusNet Services.

6.7. Protection from Electrical Surges and Induced Voltage

All surge protection devices are inspected for effective operation at twelve (12) month intervals. Polarisation cells are checked for electrolyte level every twelve (12) months.

Where protection devices fail the protection requirements, the device is reassessed, and the installation redesigned as necessary.

Polarisation cells have their electrical characteristics measured every five (5) to (6) years.

Such measurements normally require laboratory testing. Only cells, which have the required electrical characteristics, are returned to service.

6.8. LFI / EPR Study on Licence Pipelines

The objective of the LFI and EPR study is to review the licensed gas transmission pipelines in terms of safety to personnel and assess the potential for AC corrosion.

AusNet Services has undertaken initial review of three gas transmission pipelines which include:

- Pipeline Licence 82
- Pipeline Licence 64
- Pipeline Licence 99

The remaining 17 pipelines also require LFI / EPR studies, to develop an initial and base risk criterion.

Following the initial assessment as per AS 4853-2012 all the buried pipelines will be required to undergo LFI/EPR review every 5 years to manage the ongoing electrical hazards. The sources and consequences of electrical hazards change throughout the operating life of a pipeline, and therefore pipelines at risk of electrical hazards shall have their risk management plan reviewed every 5 years.

The following data becomes the basis for the study:

- Physical and operating parameters for high voltage transmission and distribution powerlines in proximity to the pipelines. These parameters include: powerline tower/pole geometry, conductor electrical characteristics, phase to earth fault currents, fault clearance times, frequency of fault occurrence, resistance of tower/pole earthing, EPR data for towers/poles and around zone & terminal substations.

- Pipeline physical and electrical data include pipeline diameter, wall thickness, coating type & thickness, effective resistance to earth, location of items such as insulating joints, cathodic protection equipment, polarisation cells, and any AC earthing.

The above data is used to calculate LFI and EPR voltage levels using recognised 'pipeline LFI analysis software' or mathematical analysis in accordance with the methodology shown in AS/NZS 4853. Consequently, the risk of electrical hazards to personnel is determined in accordance with AS/NZS 4853.

The deliverables of this study include a report detailing the threats identified, assessments conducted, together with suggested mitigation or remedial measures should any be required. This report will include details of the relevant data that has been acquired for the purposes of carrying out the analysis, such as powerline physical parameters, phase to earth fault currents, frequency of fault occurrence, fault clearance time, pipeline coating parameters, soil resistivities, AC voltage under steady state powerline operation.

The following licenced pipelines are required to be tested within the GAAR 2024 - 2028:

Table 14: OPEX on LFI / EPR Studies

	JAN-JUN 2023	2023-24	2024-25	2025-26	2026-27	2027-28
			[C.I.C]			

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