Asset Management Plan

Transmission Line Insulator Assemblies

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Responsibilities

This document is the responsibility of the Network Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

The approval of this document is the responsibility of the General Manager, Strategic Asset Management.

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- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

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Reference documents

R954721 – TasNetworks Strategic Asset Management Plan

R40766 – TasNetworks Asset Management Policy

R909655 – TasNetworks Risk Management Framework

Record of revisions

Revision	Details	Date
4.0	Revised document structure into new template Updated tables throughout document Updated risk assessment	31/10/2017
5.0	Revised document structure into new template Updated tables throughout document Updated risk assessment	

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1. Purpose

The purpose of this document is to describe for transmission line insulator assemblies and related assets:

- TasNetworks' approach to asset management, as reflected through its legislative and regulatory obligations and strategic plans
- The key projects and programs underpinning its activities
- Forecast CAPEX and OPEX, including the basis upon which these forecasts are derived

2. Scope

This document covers all transmission line insulator assemblies owned and maintained by TasNetworks.

3. Management strategy and objectives

This asset management plan has been developed to align with TasNetworks' Asset Management Policy, Strategic Asset Management Plan and Strategic Objectives. This management plan describes the asset management strategies and programs undertaken to manage the transmission line insulator assemblies.

For these assets the management strategy focuses on the following objectives:

- Safety will continue to be our top priority and we will continue to ensure that our safety performance continues to improve.
- Service performance will be maintained at current overall network service levels, whilst service to poorly performing reliability communities will be improved to meet regulatory requirements.
- Cost performance will be improved through prioritisation and efficiency improvements that enable us provide predictable and lowest sustainable pricing to our customers.
- Customer engagement will be improved to ensure that we understand customer needs, and incorporate these into our decision making to maximise value to them.
- Our program of work will be developed and delivered on time and within budget.

4. Description of the asset portfolio

Insulator assemblies mechanically support and electrically separate and insulate energised conductors from their support structures in a safe and secure manner, compatible with the operating voltage and mechanical strength of the insulators. Insulator assemblies are one of the key components of a transmission line and failures can cause conductor drop and or a circuit outage.

TasNetworks has approximately 42,000 insulator assemblies in service, most of which are glass or porcelain disc insulator assemblies. Since 1999 a small number of synthetic insulators have also been installed on the transmission network.

A summary of TasNetworks' disc insulator population is provided in Table 1.

Table 1 Insulator population (October 2022)

Insulator Material	Insulator Design	Size	Population (Strings)	Percentage of total
Glass	Disc	16mm	21,246	51
		20mm	10,940	26
Porcelain	Disc	16mm	4,288	10
		20mm	3,098	7
	Post		150	<1
Synthetic			2518	5
Total			**42240**	**100**

4.1 Transmission line insulator assembly types

Insulator assemblies are designed to withstand power frequency voltage and imposed overvoltages (switching surge or lightning voltages), mechanical load conditions and varying environmental pollution levels.

On 110 kV transmission circuits TasNetworks utilises insulator assemblies with a minimum 70kN electromechanical failure rating, 16mm fitting and breakdown insulation level of 450 kV.

On 220 kV transmission circuits TasNetworks utilises insulator assemblies with a minimum 160kN electromechanical failure rating, 20mm fitting and breakdown insulation level of 950 kV.

4.2 Glass and porcelain disc insulators

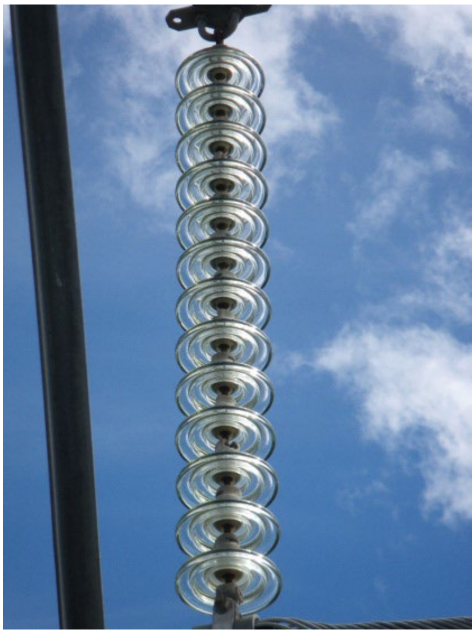
Where disc insulators are utilised, an insulator assembly normally comprises seven insulator discs at 110 kV, or thirteen discs at 220 kV, with one extra disc utilised for insulator assemblies located within switchyards to ensure appropriate insulation coordination.

Historically, TasNetworks has utilised either glass or porcelain insulator discs within its insulator assemblies. Porcelain and glass insulator discs are not mixed within a single insulator string, and in most locations a transmission circuit will consist wholly of either glass or porcelain insulator strings.

Metal fittings are cemented into the porcelain or glass discs to allow the units to be coupled together to form an insulator string or assembly. A ball is usually fitted to the underside of the disc and a socket to the top side. Each disc-to-disc joint is secured with a security clip to prevent mechanical separation. All of these components, including the cement, may deteriorate in service and result in electrical insulation breakdown (flashover), or mechanical failure (separation) resulting in the attached conductor falling.

Glass insulator discs, shown in Figure 1, are the preferred material for new transmission lines, as the glass is tempered and will shatter when they fail. This provides field personnel with a clear and visible indication of the failed insulator disc, facilitating swift identification and commencement of repair activities.

Figure 1 220 kV glass disc insulator assembly



Porcelain insulator assemblies, shown in Figure 2, have been utilised extensively in the past, and upon failure would normally be replaced with a similar porcelain insulator assembly. These insulators are able to withstand attempts at vandalism more effectively than glass insulators. However, porcelain insulators are not preferred for new transmission lines, as failure can manifest itself in a small puncture of the insulator disc that is often visibly undetectable by field personnel, requiring costly condition monitoring.

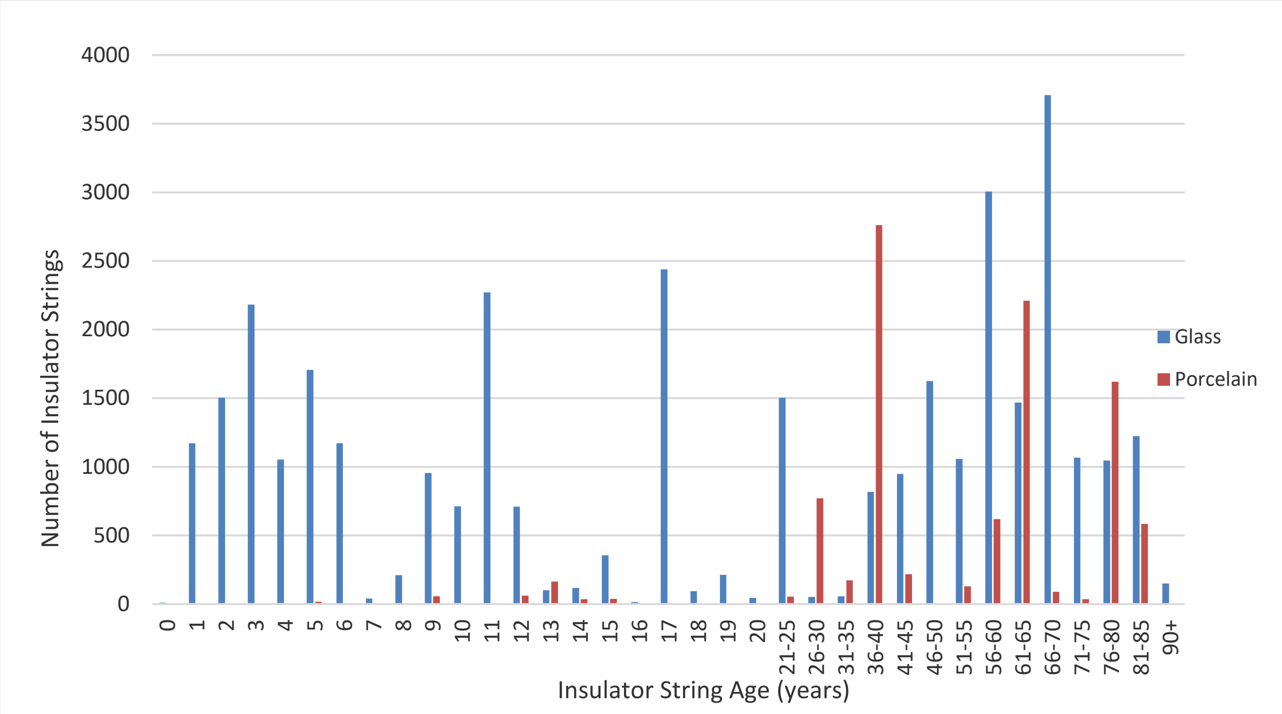
Figure 2 220 kV porcelain disc insulator assembly

The design of TasNetworks' disc insulator assemblies is sufficiently robust to permit the failure of up to two discs before live line work activities are restricted.

TasNetworks has utilised various different colours in both its glass and porcelain insulators. These colours have no bearing on the reliability and performance of the insulator, and have been chosen to ensure the insulator assemblies blend in with the surrounding vegetation and terrain.

The age profile of TasNetworks' 110 kV and 220 kV disc insulators is presented in Figure 3. Noting that the volumes in recent years are reflective of a combination of replacement volumes, new transmission lines and augmentations.

Figure 3 Glass disc insulator age profile (October 2022)



The service life of TasNetworks' glass disc insulators has been better than industry standard, however industry experience and good engineering practice suggests that increases in asset deterioration are likely to become increasingly evident on insulator strings above 50 years of age, and that asset renewal activities should continue to ensure that the risk posed by TasNetworks' fleet of aged glass disc insulators is maintained at an acceptable level.

Similarly, the service life of TasNetworks' porcelain disc insulators has been well above industry standard. However, industry experience and good engineering practice suggests that increases in asset deterioration are likely to become evident, and that asset renewal activities should continue to ensure that the risk posed by TasNetworks' fleet of aged porcelain insulators is maintained at an acceptable level.

4.3 Synthetic insulators

The use of synthetic insulator assemblies by TasNetworks is not widespread, and has typically occurred where either there has been a specific requirement that could not be met through the use of disc insulators (e.g. in a high pollution area or where greater ground clearance is required), or where TasNetworks has wanted to gain experience in the installation, operation and maintenance of synthetic insulator assemblies for the purposes of assessing their suitability in other applications.

Depending on the line design and associated insulator strength requirements, both long rod and standoff synthetic insulators have been used by TasNetworks.

Figure 4 shows typical synthetic post and suspension insulator assemblies.

Figure 4 Post and long rod synthetic insulators

Table 2 Synthetic insulator population

Transmission line	Voltage (kV)	Insulators
TL409 Waddamana-Parknook	110	2
TL414 Hadspen-Norwood	110	9
TL415 Burnie-Smithton	110	6
TL417 Tarraleah-New Norfolk (East)	110	3
TL429 Palmerston-Avoca	110	109
TL430 Chapel Street-Creek Road (East)	110	2

Transmission line	Voltage (kV)	Insulators
TL436 Knights Road-Kermandie	110	9
TL437 Sheffield-Devonport	110	66
TL440 Wesley Vale Spur	110	54
TL446 Waratah-Savage River	110	63
TL447 George Town-Temco	110	8
TL456 Triabunna Spur	110	81
TL463 New Norfolk-Creek Road	110	6
TL469 Electrona Spur	110	21
TL471 Hadspen-Trevallyn	110	24
TL472 Trevallyn-Mowbray	110	21
TL479 Norwood - Scottsdale	110	1,494
TL480 Derby Spur	110	360
TL481 Chapel St-Chapel St Junction	110	21
TL483 Bell Bay Three Spur	110	24
TL484 Huon River Spur	110	93
TL529 George Town-Longreach Junction	220	3
TL530 Tamar Valley Spur	220	39
Grand total		**2,518**

The majority of TasNetworks' 110 kV and 220 kV synthetic insulators are relatively young, with only 10 per cent of the insulators older than 20 years of age.

4.4 Porcelain post insulators

A relatively small number of porcelain post insulators have been installed on the transmission network. Porcelain post insulators are no longer installed by TasNetworks, but historically were typically used as an option to obtain additional ground clearance. A typical post installation is shown in 0.

Table 3 Porcelain post insulator population

Transmission line	Voltage (kV)	Insulators
TL404 Creek Road-Risdon	110	3
TL409 Waddamana-Parknook	110	16
TL413 Palmerston-Trevallyn	110	3
TL414 Hadspen-Norwood	110	12
TL425 Waddamana-Tungatinah (North)	110	12
TL445 Burnie-Waratah	110	3
TL502 Liapootah-Palmerston No. 1	220	3
TL524 Tribute Spur	220	2
TL456 Triabunna Spur	110	28
TL471 Hadspen-Trevallyn	110	6
TL484 Huon River Spur	110	60
Grand Total		**148**

Figure 5 Porcelain post insulators

TasNetworks' population of 110 kV and 220 kV porcelain post-type insulators is relatively small, with most being less than 20 years of age. This population is currently being managed with a condition based approach.

5. Associated risk

5.1 Risk management framework

TasNetworks has developed a Risk Management Framework for the purposes of assessing and managing its business risks, and for ensuring a consistent and structured approach is applied to the management of risk.

An assessment of the risks associated with transmission line insulator assemblies has been undertaken in accordance with the Risk Management Framework.

The quantification of risk is supported by the Health Based Risk Management (**HBRM**) framework. This approach allows the risks of individual assets to be quantified against the defined assessment.

Due to the level of risk identified in some of the assessment criteria a requirement to actively manage these risks has been identified.

5.2 Asset Condition Summary

5.2.1 Defect management practices

All insulator assemblies undergo periodic testing and or routine visual inspections, depending on the type, with any defective assets recorded and prioritised within TasNetworks' asset management system in accordance with the "Transmission Line Defect Priority Standard". These defects are then issued to TasNetworks' contractors for action within the specified time frames.

All replacement disc insulators will generally be glass, except where other factors dictate that synthetic or porcelain insulators are preferred.

Where tests indicate that three or more insulators are defective, TasNetworks will restrict live-line work activities at that location until either the insulator string is replaced, or the individual defective insulator discs are replaced.

The analysis of historical defects for particular insulator types can be useful in identifying systemic or emerging failure modes, with the results of this analysis influencing operational or capital expenditure. This information is detailed within TasNetworks' condition assessment reports, with a summary of the outcomes of this analysis provided in section 5.2.2.

Some photos of typical insulator defects are presented in Figure 6.

Figure 6 Typical insulator defects

5.2.2 Insulator assembly defects

Since 2009-10 only one P1 insulator assembly defect has been identified on the network.[1] Together with the reduction in P2 defects over the last three years, this is indicative of the effective and timely manner in which lower priority defects are identified and rectified, preventing P2 and P3 defects from developing into P1 defects. This also reflects the effectiveness of TasNetworks' targeted insulator replacement program.

Over the last three years there has been a reduction in most categories of insulator defects. The only exception to this is the number of insulator failures due to lightning flashover, with this slight increase corresponding to a rise in lightning storm activity.

As these assets age, it is expected that an insulator replacement program will continue to be required to ensure that TasNetworks' risk profile is sufficiently mitigated.

5.2.3 Porcelain insulator voltage gradient testing

TasNetworks undertakes annual voltage gradient testing on 10 per cent of all porcelain insulator strings that are greater than 20 years old. Based on the current age profile of TasNetworks' porcelain insulators, this results in approximately 10,000 insulator strings being tested per year. These tests are useful in identifying insulator discs that have had their insulation properties compromised through lightning strikes or other causes.

Over the last three years approximately 4 per cent of the tested strings failed the gradient voltage assessment. It is reasonable to assume that similar failure rates will be experienced in the future, resulting in an ongoing replacement rate of at least 400 insulator strings per year as a result of the voltage gradient test program.

Where there are sufficient failed insulator strings, TasNetworks will package this work into a capital replacement program, and will also include adjacent insulators of the same type and vintage that are likely to exhibit similar poor performance in the future.

5.2.4 Insulator leakage current measurements

The measurement of insulator leakage current can provide an indication of insulation deterioration. Leakage counters have been installed in the Tamar Valley at the locations shown below, however the system is currently not in operation due to the maintenance cost of the system outweighing the benefits it provided. Any future infrastructure development in this or other areas of the state may require the installation of additional leakage counters on a case by case basis.

[1] A P1 defect is a high risk defect where asset failure is deemed to be imminent. TasNetworks aims to minimise P1 defects as they pose a risk of asset failure and their short rectification timeframe means that they usually effect the delivery of planned work.

Table 4 Surge counter locations

Box	Transmission Circuit	Tower	Phase	Thresholds (mA)
1	Palmerston–George Town No 2	T242	A	100 / 200 / 300
2	George Town–Comalco No 5	T1	B	100 / 200 / 300
3	George Town–Temco No 2	T3	A	100 / 150 / 200
4	George Town–Comalco No 4	T4	A	100 / 150 / 200
5	George Town–Temco No 1	T7	A	100 / 150 / 200
6	George Town–Temco No 2	T7	A	100 / 150 / 200

Analysis of data at each of these sites while the system was in operation showed that some sites are experiencing a material number of leakage current events. This is not unexpected given the proximity of this site to both dust and sea mist, however there was no material impact on circuit reliability. TasNetworks' insulator washing program is considered cost effective and adequate to mitigate the risk of insulator flashover on this and other transmission circuits.

5.2.5 Synthetic insulator condition monitoring

Other than visual inspection, there are no tests currently available for the assessment of synthetic insulator condition. While TasNetworks' synthetic insulator population is still relatively young, to mitigate this risk TasNetworks will continue to keep abreast of global condition assessment practices and introduce any suitable testing regimes where appropriate.

Thermal imaging, recently undertaken after the failure of a synthetic post type insulator, may prove useful in the future in identifying defective synthetic insulators. TasNetworks will continue to evaluate the effectiveness of this form of condition monitoring and consider its inclusion in the broader suite of routine condition monitoring activities.

5.3 Special operational and design issues

5.3.1 Operational issues

There are no systemic operational issues associated with TasNetworks' insulator assemblies. There are, however, a number of structures in the West Coast and North West regions of the network where insulator flash-overs, as a result of lightning strikes, are more frequent than in the general population. Under the transmission line isokeraunic protection enhancement program, in a trial that concluded in 2017-18, TasNetworks trialled augmenting structure earthing to mitigate double circuit transmission line outages due to back flash. The program augmented the structure earthing at a number of tower locations, selected due to their location, original footing resistance and or history of poor lighting performance. The program lowered the footing's resistance, providing a corresponding increase in the size of lightning strikes which can be withstood and reducing the likelihood of a double circuit back-flashover from the structure to conductors. The completion of the program has resulted in lines being either removed from the Vulnerable list or removed in the future after the required proving period.

5.3.2 Design issues

5.3.2.1 Synthetic horizontal post insulators

In September 2009 TasNetworks experienced a mechanical failure of a synthetic post type insulator on the Savage River Spur 110 kV transmission line. Following this unplanned outage, a thorough review of the transmission line's design and the insulator failure was conducted by engineering consultants and the manufacturer, respectively. The conclusion of these investigations was that no remedial actions were recommended.

A second failure of the same type of insulator occurred in June 2013 on the same transmission line, and in this instance the insulator was sent back to the manufacturer to facilitate an examination through dissection of the insulator. The manufacturer produced a report from this examination which found that mechanical failure of the insulator had resulted in a crack developing in the fibreglass centre of the insulator and that over time this crack had extended to the point where electrical failure occurred by means of flash-under. The report also concluded that complete mechanical failure would have eventually occurred, similar to that experienced in 2009.

Figure 7 Cracking of fibreglass rod of insulator on TL446T232 (2013 failure)[2]

Subsequent to the June 2013 failure, TasNetworks performed visual, infrared and corona scans of the insulators remaining in-service on the Savage River Spur 110 kV transmission line to determine their condition. The condition monitoring results highlighted a level of thermal hot-spots on insulators that were indicative of mechanical and electrical insulation breakdown.

Those reviews led TasNetworks to believe that the insulators in question had deteriorated significantly since their installation, were in poor condition and now posed a significant security of supply risk to TasNetworks, as well as a safety risk, where the failure of an insulator could cause a conductor to fall to the ground, the worst consequence being personal harm or bushfire.

As a result, these post insulators installed on the Savage River Spur 110 kV transmission line were replaced and a review of other transmission lines that utilise this type of post insulators resulted in all others being replaced. A similar review of all composite insulators installed in a similar horizontal post insulator arrangement has taken place and all synthetic horizontal post insulators are currently being monitored for similar failures modes.

5.3.2.2 Zinc collars

To reduce the rate of corrosion and improve the performance of TasNetworks' porcelain and glass insulators, TasNetworks specifies the use of a zinc collar on all new insulator discs. This collar acts as a sacrificial anode, preventing premature asset degradation. This practice should be continued.

[2] Viewed from the base of the insulator

5.3.2.3 Hooks

Hooks are often used to support insulators from support structures, and conductors from insulators. However, hooks can pose a number of issues where live line maintenance or construction activities are required. This is due to conductor suspension clamps sometimes 'jamming' onto hooks and being difficult to unhook. Also, the cold end hook may dislodge when lifting the conductor, causing the insulator string to fall. This exposes personnel to risk and increases the likelihood of a circuit outage during these activities. When a transmission lines are upgraded, consideration is given to removing hooks from service. This decision will be based on the importance of the transmission line, the risk of the conductor falling in a number of spans and any history of hook failure or dislodgement.

5.4 Failure Rates

TasNetworks experiences a very low incidence of insulator failure, with eight failures experienced since 1990 due to poor condition. Of these, five were due to pollution and two due to mechanical failure.

Pollution caused three fault outages in the George Town region in the late 1990s and two fault outages near Risdon Substation in 2008 and 2017. TasNetworks' insulator washing program has proven to be sufficient to mitigate the future risk of failure at George Town, while TasNetworks' inspection regime is deemed to be sufficient to mitigate the risk at Risdon Substation. The pollution performance at these sites will be monitored on a continuous basis.

In 2001 TasNetworks experienced an insulator failure on the Lindisfarne–Rokeby No. 2–Sorell 110 kV transmission circuit during strong winds. Subsequent investigation found that over time the ball joint on the bottom disc had worn away, causing the bottom disc and connected conductor to fall and flashover to ground. As this is the only insulator defect in more than twenty years to have escaped detection and resulted in a fault outage, TasNetworks considers that this is a rare occurrence and that its inspection regimes are adequate in the detection of such defects.

In January 2004 TasNetworks experienced an insulator string failure on the Sheffield–Paloona 110kV transmission circuit during severe weather conditions. Subsequent investigation found that a lightning flashover had led to a mechanical failure of several discs resulting in a conductor drop. To prevent a reoccurrence of such an incident, TasNetworks' subsequent assessment of the failure mode recommended that the aging porcelain insulators on the Sheffield–Burnie 110kV transmission line, which supports the Sheffield–Paloona 110 kV circuit, should be replaced with glass disc insulators. This insulator replacement was undertaken in 2005.

Section 5.3.2.1 discusses two synthetic horizontal post insulator failures experienced on the Savage River Spur 110 kV transmission line.

5.5 Asset risks

The following areas have been identified as risk areas in the management of insulator assemblies and are discussed below and summarised in Table 5.

5.5.1 Defective insulator resulting in conductor to drop

Insulators are subject to damage by natural causes (e.g. lightning), corrosion and, occasionally, vandalism (shooting). Failure to identify defective insulators can result in a live conductor dropping to the ground, adversely impacting safety of the public and TasNetworks personnel, increasing the risk of a fire start and adversely impacting customer supply and network reliability.

Condition monitoring, both routine and post fault, can detect these defects. Aerial inspections are the most cost-effective way to inspect these assets to reduce loss of supply events and prevent vegetation fires. In no-fly zones, ground inspections must be undertaken to complete the condition assessments every 3 years. Other opportunities also present for ground inspection on an occasional basis.

5.5.2 Synthetic insulators failure

Some insulators are considered more likely to exhibit accelerated degradation and subsequent failure. These insulators must be monitored more intensively to ensure reliability of the transmission network.

5.5.3 Accelerated corrosion causes premature insulator failure

Transmission lines close to aggressive atmospheres (industrial and/or marine) are susceptible to premature failure and should be closely monitored and maintained.

5.5.4 Aged insulators will fail due to deterioration

Aged porcelain insulators have an increased risk of failure. These assets must be closely monitored and maintained so that transmission line safety and reliability is maintained.

5.5.5 Insulator contamination

Air born containments from industrial emissions and salt laden environments can build up on transmission line insulators, leading to insulator flashover from increased conductivity and leakage current. Similarly, a build up of acidic ash following a bushfire can result in insulators being exposed to surface damage and tracking if there is insufficient rain to clean the insulators. Failure to assess and maintain insulators in a contamination free state decreases insulator life and transmission line reliability.

The washing of insulators on transmission lines sections exposed to industrial emissions and salt laden environments has proven to be effective in mitigating the build-up of contaminants. Post bushfire assessments of transmission lines can also identify line sections at risk of ash build up so that mitigation measures can be implemented.

Table 5 Summary of transmission line insulator assembly risks

Risk Identification		**Risk Analysis (Inherent)**				
Asset	**Risk Description**	**Category**	**Likelihood**	**Consequence**	**Risk Rank**	**Treatment Plan Yes / No**
Defective insulator fails, causing a conductor to drop	Insulators are subject to damage by natural causes (e.g. lightning), corrosion and occasionally vandalism (shooting). Condition monitoring, both routine and post fault, can detect these defects. Aerial inspections are the most cost-effective way to inspect these assets to reduce loss of supply events and prevent vegetation fires.	Safety and People	Rare	Severe	Medium	Yes
		Customer	Unlikely	Minor	Low	
		Financial	Unlikely	Minor	Low	
		Regulatory Compliance	Unlikely	Minor	Low	
		Network Performance	Unlikely	Moderate	Medium	
		Reputation	Unlikely	Minor	Low	
		Environment & Community	Rare	Severe	Medium	
Synthetic insulators	Some insulators are considered more likely to exhibit accelerated degradation and subsequent failure. These insulators must be monitored more intensively.	Safety and People	Rare	Severe	Medium	Yes
		Customer	Unlikely	Minor	Low	
		Financial	Unlikely	Minor	Low	
		Regulatory Compliance	Unlikely	Minor	Low	
		Network Performance	Unlikely	Moderate	Medium	
		Reputation	Unlikely	Minor	Low	
		Environment & Community	Rare	Minor	Low	

Risk Identification		Risk Analysis (Inherent)				
Asset	**Risk Description**	**Category**	**Likelihood**	**Consequence**	**Risk Rank**	**Treatment Plan Yes / No**
Accelerated corrosion causes premature insulator failure	Transmission lines close to aggressive atmospheres (industrial and/or marine) are susceptible to premature failure and should be closely monitored and maintained.	Safety and People	Rare	Severe	Medium	Yes
		Customer	Unlikely	Minor	Low	
		Financial	Unlikely	Minor	Low	
		Regulatory Compliance	Unlikely	Minor	Low	
		Network Performance	Unlikely	Moderate	Medium	
		Reputation	Unlikely	Minor	Low	
		Environment & Community	Rare	Severe	Medium	
Aged insulators will fail due to deterioration.	Aged porcelain insulators have an increased risk of failure. These assets must be closely monitored and maintained.	Safety and People	Rare	Severe	Medium	Yes
		Customer	Unlikely	Minor	Low	
		Financial	Unlikely	Minor	Low	
		Regulatory Compliance	Unlikely	Minor	Low	
		Network Performance	Unlikely	Moderate	Medium	
		Reputation	Unlikely	Minor	Low	
		Environment & Community	Rare	Severe	Medium	

Risk Identification		**Risk Analysis (Inherent)**				
Asset	**Risk Description**	**Category**	**Likelihood**	**Consequence**	**Risk Rank**	**Treatment Plan Yes / No**
Insulator contamination	Insulator contamination results line flashover and outage	Safety and People	Rare	Severe	Medium	Yes
		Customer	Unlikely	Minor	Low	
		Financial	Unlikely	Minor	Low	
		Regulatory Compliance	Unlikely	Minor	Low	
		Network Performance	Unlikely	Moderate	Medium	
		Reputation	Unlikely	Minor	Low	
		Environment & Community	Rare	Severe	Medium	

6. Whole of life management plan

6.1 Maintenance strategy

The good performance of transmission line insulator assemblies is achieved through the implementation of regular preventive and corrective maintenance activities. These preventive and corrective maintenance practices are reviewed on a regular basis taking into account:

- past performance;
- industry practice (derived from participation in technical forums, benchmarking exercises and discussions with other transmission companies); and
- the availability of new technologies.

As insulators assemblies age, different life cycle issues and failure modes arise and must be captured in the preventative and corrective practices.

6.2 Preventive and corrective maintenance (OPEX)

6.2.1 Preventative maintenance

Preventive maintenance is, by its nature, a planned and scheduled maintenance activity that is completed to a predetermined scope, and consists of:

- Condition assessment – the routine inspection, testing and monitoring of assets to ascertain their condition.
- Maintenance (routine and condition based) – assets are maintained either on predetermined frequency basis (time-based) or in response to findings arising from condition assessment activities.

TasNetworks has adopted internationally recognised procedures for the assessment and maintenance of its transmission line insulator assemblies. Condition assessments by air and by ground each have their merits, which must be balanced to achieve an optimum level of cost effectiveness and overall outcomes efficiency.

After consideration of the many factors applying to Tasmania's geography, climatic conditions and the history of known deterioration of transmission line insulator assemblies in this environment, TasNetworks has adopted the preventive maintenance strategies summarised in Table 6.

Table 6 Transmission line insulator assemblies' inspection and test strategies

Strategy	Frequency	Description
'Detailed methodical' aerial condition assessment	5 year cycle	A detailed condition assessment is conducted utilising a helicopter (approximately 20 per cent of total assemblies per year). Effective for approximately 97 per cent of the transmission line population over the 3 year period. The remainder are subject to a climbing condition assessment. Where damaged or corroded insulator assemblies are observed, a defect will be recorded for remedial action.
'Detailed methodical' climbing condition assessment	5 year cycle	A detailed condition assessment is conducted by climbing individual structures. Only applicable where 'no-fly' areas prevent the usage of a helicopter and applies to approximately 3 per cent of total structures over the 3 year period. Where damaged or corroded insulator assemblies are observed, a defect will be recorded for remedial action.

Strategy	Frequency	Description
Ground-based inspections (non-climbing)	Annually	Applies to the 80 per cent of total assemblies that did not receive a 'detailed methodical' inspection. A visual inspection aimed at identifying obvious defects that could impair the electrical or structural integrity of the transmission line. Where damaged or corroded insulator assemblies are observed, a defect will be recorded for remedial action.
Porcelain insulator testing	10 year cycle	Testing of porcelain insulators is required once the insulator reaches 20 years of age and then every 10 years thereafter (focusing on critical transmission lines, or insulators known to pose a higher risk to TasNetworks).
Other inspections/tests	As required	Porcelain insulators known to have incurred a lightning strike(s) will be inspected and/or tested to determine if they require replacement. In corrosive atmospheres, leakage tests will be conducted where condition deterioration is forecast or observed to be rapid. Polluted insulators will be washed to prolong life, and defective units will be replaced on an "as required" basis. Where there is a lack of condition information, TasNetworks will remove one or more insulator assemblies from service and perform stress tests to determine the remaining strength in the unit(s).

6.2.2 Corrective maintenance

In the event of a fault condition TasNetworks will arrange for corrective maintenance to occur to either replace the asset or undertake other activities, such as insulator washing, to restore the asset to an appropriate level of service.

6.2.3 Summary of Opex expenditure

Table 7 Summary of Opex programs and expenditure

Project/Program	Func. Area	Program Data										
		Financial year	**FY20**	**FY21**	**FY22**	**FY23**	**FY24**	**FY25**	**FY26**	**FY27**	**FY28**	**FY29**
Transmission Line Routine Inspections	PMTRI	**Expenditure ($m)**	$1.45	$1.45	$1.45	$1.45	$1.45	$1.45	$1.45	$1.45	$1.45	$1.45
Transmission Line Insulator Assembly Preventative Maintenance	PMINA	**Expenditure ($m)**	$0.29	$0.32	$0.34	$0.29	$0.30	$0.29	$0.32	$0.34	$0.29	$0.30
Transmission Line Insulator Assembly Corrective Maintenance	CMINA	**Expenditure ($m)**	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02

6.3 Reliability and quality maintained (CAPEX)

The cost of asset replacement activities meeting the capitalisation requirements outlined within TasNetworks' Asset Accounting Standard can be capitalised. These capital projects are detailed below. Asset replacement activities not meeting these requirements will be undertaken as operational expenditure.

6.3.1 Insulator replacement program

As a result of test results, defects and other condition information, and bearing in mind fleet management considerations, the transmission line insulator assembly replacement program aims to replace approximately 4000 insulator strings in a 5 year cycle. Additional insulator string replacements may also be undertaken when it is advantageous to do so, such as when replacing conductor sections, to minimise outage times and ensure network reliability as least cost.

6.3.2 Details of future Capex projects/programs

Table 8 Program/project details

Project/Program description	Functional area	HBRM Document Id. (IES)
Transmission Line Insulator Assembly Replacement Program	RENTL	PRJ000643

6.4 Spares management

TasNetworks' maintains appropriate levels of asset spares for emergency response and other activities as defined within the System Spares Policy R517373.

6.5 End of life management

When defective insulator string assemblies are removed from service the individual insulator discs are inspected and retained as spare holdings if found to be in good condition. Defective insulators are recycled or suitably disposed of in registered disposal areas.

7. Related standards and documentation

The following documents have been used either in the development of this management plan, or provide supporting information to it.

TasNetworks documents:

1. TNM-GS-809-510-05 – Transmission line defect prioritisation standard (draft)
2. Asset Condition Review – project report June16 FINAL – R503361
3. Memorandum, Waratah-Savage River 110 kV TL446, HLPI Failure, TD Consulting Engineers, 28th October 2009 (D10/5390)
4. R517373 System Spares Policy

Technical requirements for new insulator assemblies are detailed in the following standards/specifications:

5. R1112043 High Voltage Disc Insulator Standard
6. R1037048 Transmission Line Design Standard
7. R1047190 Transmission Line Normative to the Design Standard
8. R2079583 Transmission Construction Standard
9. D11/33093 Live Line Work Standard
10. D08/81931 Temporary Earthing of Overhead Transmission Circuits
11. D05/2191 Access Control Form

Other standards and documents:

12. AS7000:2016 – Overhead line design – Detailed procedures
13. AS1154.1-2009 – Insulator and conductor fittings for overhead power lines – Performance, material, general requirements and dimensions