AMS – Victorian Electricity Transmission Network

Transmission Line Insulators (PUBLIC VERSION)

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1 Executive Summary

This document defines the asset management strategies for the Victorian electricity transmission network's population of transmission line insulators to maintain the safety, quality and security of supply. Insulators provide a mechanical connection between live conductors and structures whilst insulating the structures from electrical current.

1.1 Background

Approximately 89,000 insulator strings are in service on the transmission network as at November 2014. The majority of insulator strings are comprised of a number of linked discs made from either porcelain or glass with steel pins to form a continuous string. There are a growing number of polymeric insulators in operation which consist of composite polymer material that has a fibreglass core with a sheath made from silicone rubber or ethylene propylene diene monomer (EPDM).

AusNet Services has undertaken a large program of targeted insulator replacements which began in 2006. This program responded to increasing trends in insulator functional failures in the period between 2000 and 2007. Approximately 23,800 porcelain insulator strings comprising 27% of the total insulator fleet have been replaced with polymeric insulators since 2006.

As a result of this replacement program there have been no insulator functional failures since 2009.

1.2 Strategy

In order to maintain the performance and reliability improvements attained in recent years further selective insulator replacements are required.

AusNet Services has developed risk based models to assist with the application of formal risk assessments[1] as required by the Electrical Safety (Management) Regulations 2009. Approximately 2,900 insulator strings (3.3% of the insulator fleet) are forecast for replacement before 2022[2] due to combinations of deteriorated condition, and high failure consequence locations.[3]

Implementation of this selective replacement strategy, addressing both failure frequency and consequences is necessary to maintain public safety and assist in meeting the safety objectives set out in AusNet Services' MissionZero[4] strategy.

High level strategies recommended for prudent and efficient management of the transmission line insulator fleet are:

1.2.1 New Assets

- Current policy is to install polymeric insulators as part of insulator replacement programs. Polymeric insulators have an expected service life of 40 years which is considerably less than the porcelain, glass and mixed type (porcelain and glass) insulators.
- Polymeric insulators have been known to be attacked by birds if strung under dead line conditions. Provision will be made to prevent bird attack during project implementation planning.
- Fail-safe design concepts to be applied for insulation systems on new replacement of transmission line structures adjacent to high risk roadways and railways or proof test all insulator fittings prior to installation on towers across roads and railways.

1 Electrical Safety (Management) Regulations 2009 – Clause 11.

2 from 2015 to 2022, approximately seven years.

3 There is an approved project (XC76) to replace 2040 insulator strings on various transmission lines over five financial years from 2015/16 to 2019/20.

4 Mission zero is a company health and safety objective which aims at achieving zero injuries, zero tolerance, zero compromise and zero impacts.

1.2.2 Inspection

- Continue to assess the condition of transmission line insulators during structure climbing inspections which are conducted at a maximum interval of every 37 months.
- Develop policies for inspection, maintenance and ultimate replacement of polymeric insulators considering expected service life. These policies must include a condition assessment methodology.
- Import all relevant technical asset data including condition assessment grades into SAP.

1.2.3 Maintenance

- Replace defective insulator strings as part of corrective maintenance tasks. Complete string replacement is preferred as it is more economic and safer than replacement of an insulator from within a string of insulators.

1.2.4 Replacement

- Selectively replace high failure risk insulator strings representing up to 3.3% of line insulator fleet before 2022[5]. There is an approved project (XC76) to replace 2,040 insulator strings on various transmission lines over five financial years from 2015/16 to 2019/20.

[5] From 2015 to 2022, approximately seven years.

2 Introduction

2.1 Purpose

This document defines the asset management strategies for insulators on lines forming AusNet Services' electricity transmission network.

2.2 Scope

This asset management strategy applies to all transmission line insulators associated with the AusNet Services electricity transmission network that operate at voltages of 66 kV and above in the state of Victoria. The plan does not include asset management aspects of line insulators operating on the distribution network.

The strategies in this document are limited to maintaining design capabilities in terms of equipment performance and rating. Improvements in quality or capacity of supply are not included in the scope of this document.

3 Asset Summary

3.1 Population

Approximately 89,000 transmission line insulator strings are in service on the transmission network as at November 2014. The majority of insulator strings are comprised of a number of linked discs made from either porcelain or glass with steel pins to form a continuous string. The number of discs on a string increases with the operating voltage of the line. Typical numbers of porcelain or glass discs for different voltages are shown below in Table 1.

Voltage (kV)	Number of porcelain / glass discs
66	8
220	13 – 17
275	19
330	18 – 20
500	23 – 35

Table 1 – Number of porcelain / glass discs per insulator string

Since 2006 polymeric insulator strings have been introduced on the network. A polymeric string consists of composite polymer material that has a fibreglass core with a sheath made from silicone rubber or ethylene propylene diene monomer (EPDM). Unlike porcelain or glass strings which contain individual insulators joined together in series; polymeric strings contain a single continuous fibreglass core. The number of polymeric sheath rings surrounding the fibreglass core increase along with increasing operating voltage however these rings vary in size and number depending on the insulator manufacturer.

The population of transmission line insulators include four different types which are identified by materials used in their manufacture. Porcelain, glass or a mixture of both have historically been the preferred insulator type in Victoria since the 1950's. Advances in polymer manufacturing have triggered an increase in use of polymeric composite types over the last 15 years. Each different type of insulator displays different performance characteristics in terms of corrosion resistance, tensile strength and electrical insulation properties. The population of transmission line insulators operate at five standard voltages, 500 kV, 330 kV, 275 kV, 220 kV and 66 kV.

Figure 1 below displays photographs of the different insulator types in service on the transmission network

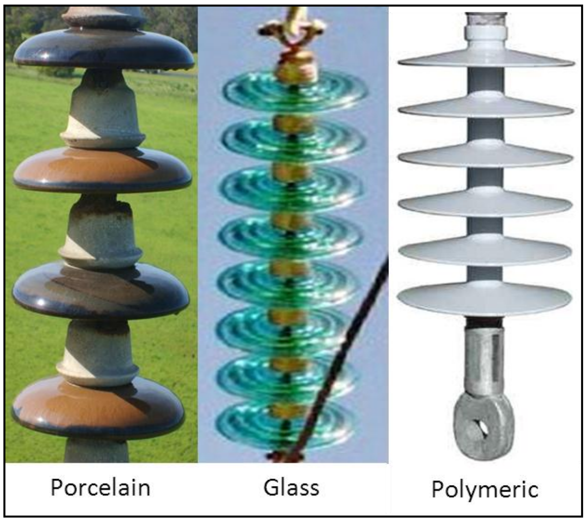


Figure 1 – Insulator types

Table 2 summarises the volumes of different types of insulators operating within each of the five voltages.

	Operating Voltage						
Type	**500 kV**	**330 kV**	**275 kV**	**220 kV**	**66 kV**	**O.O.S**	**Total**
Porcelain string	29,460	6,009	1,158	14,859	2,001	564	54,051
Polymeric string	2,382	750	12	20,721	0	0	23,865
Glass string	144	1902	30	7146	234	0	9,456
Mixed string (glass & porcelain)	48	270	0	1092	18	30	1,458
Grand Total	**32,034**	**8,931**	**1,200**	**43,818**	**2,253**	**594**	**88,830**

Table 2 – Transmission line insulator strings by voltage and type (as at November 2014)

Deteriorated porcelain and glass insulator strings have been proactively replaced since 2006. These insulators have been replaced with polymeric insulators.

Figure 2, below is a graphical representation of the transmission line insulator fleet by type and voltage cohorts.

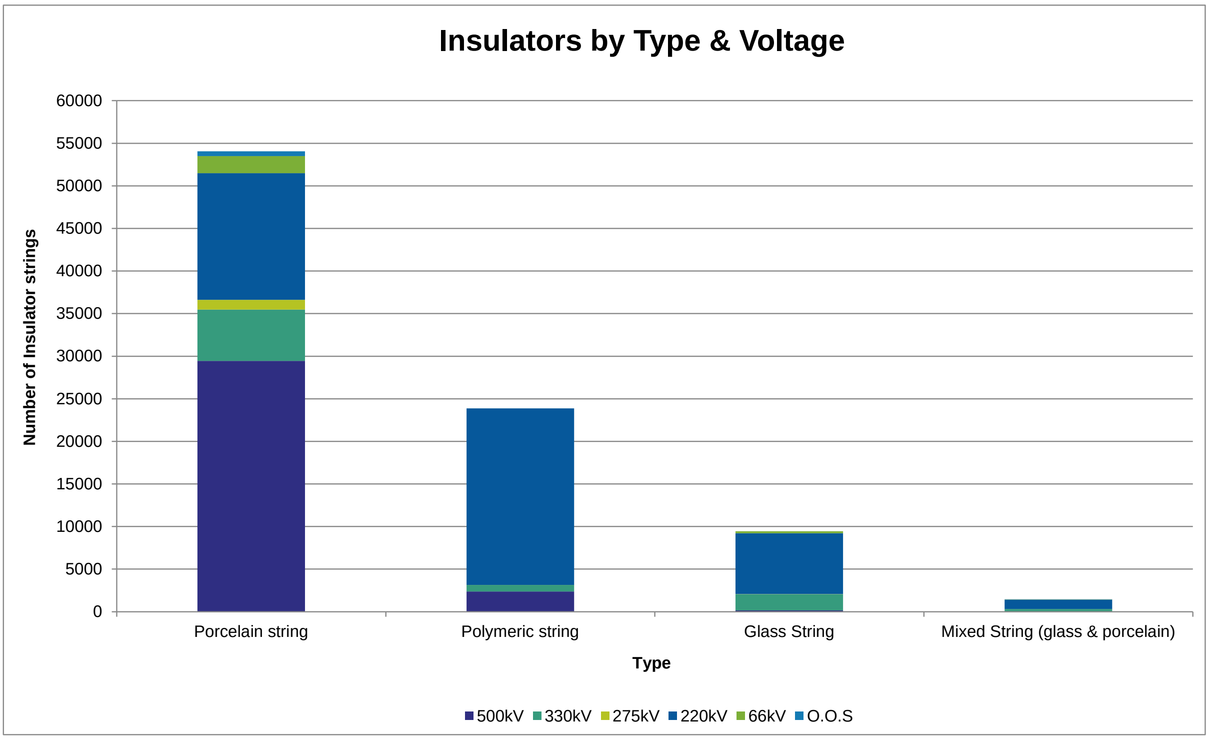


Figure 2 – Volumes of insulator strings by type and voltage

3.1.1 Corrosivity Zones

The transmission line network is exposed to varying levels of corrosivity depending on environmental factors. The two factors which have the greatest impact on levels of corrosivity include salt deposition experienced in coastal regions and air pollution caused by emissions from heavy industry. In order to manage the effects of corrosion in a prudent manner, corrosivity classifications are assigned to transmission line assets. There are a total of four corrosivity zones including very severe, severe, moderate and low.

Figure 3 shows the proportion of transmission line insulators located in each of the four corrosivity zones. A map displaying a spatial view of transmission line assets within the four corrosivity zones is included in Appendix A. Almost half of the transmission line insulators are situated in the low corrosivity zone. The HYTS – APD 500 kV lines are situated in the very severe corrosivity zone. They supply power to an industrial plant situated at Portland on Victoria's western coast. Heavy corrosion of porcelain insulators on these lines prompted their early replacement in 2010 after 29 years of service.

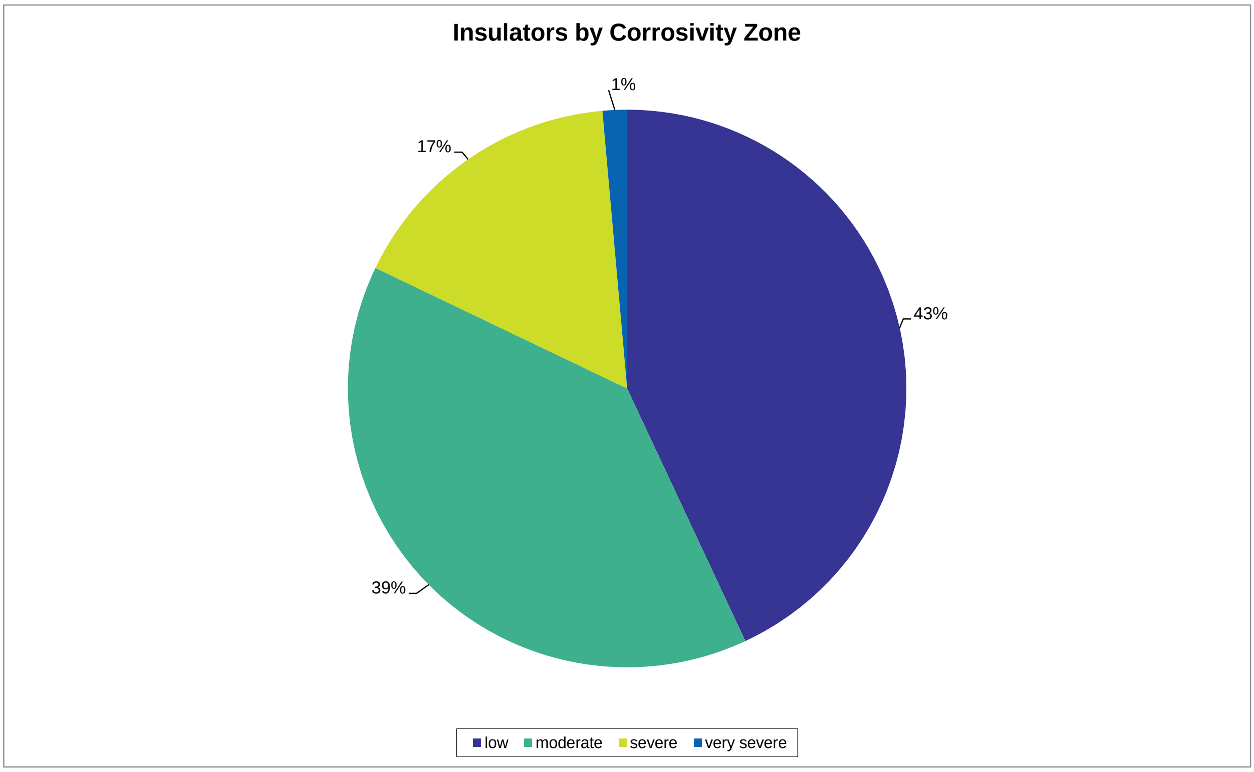


Figure 3 – Insulator strings by corrosivity zone

3.1.2 Connection Pins

Individual insulators are coupled together via a "cap and pin" mechanism. The transmission line insulator fleet contains insulators with two different pin diameters; 16 mm and 20 mm. Insulator pins form the mechanical interconnection which allows individual insulators to be connected in to strings whose length is determined by the operating voltage.

Figure 4 displays the volume of each insulator pin size against operating voltage. Seventy per cent of transmission line insulators have 20 mm pin sizes. Some 220 kV and 66 kV transmission lines have insulators with 16 mm pin sizes, equating to 30 per cent of the total insulator fleet respectively.

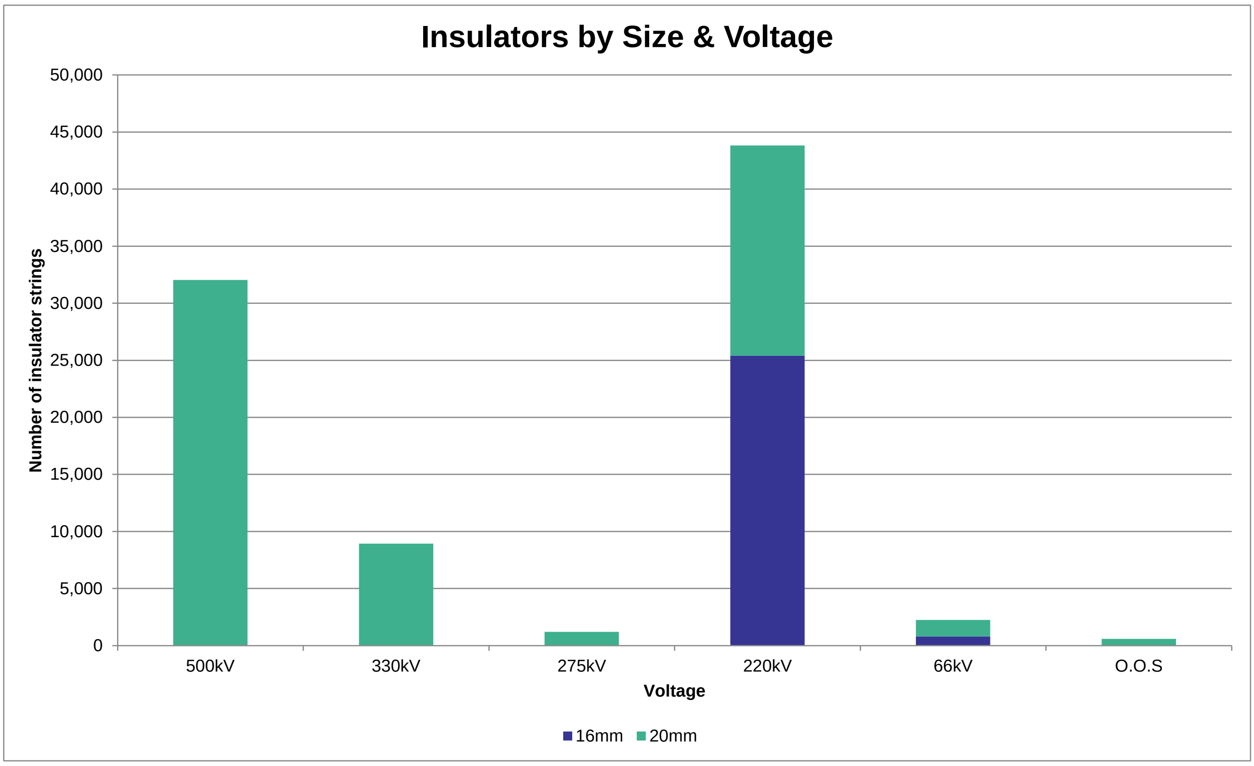


Figure 4 – Insulator strings by voltage and size of connection pin

3.2 Age Profile

The average service age[6] of the transmission line insulator strings is 29 years, as shown in Table 3 below. This average has been influenced by the progressive replacement of deteriorated insulator strings.

Voltage Class	Average Age
500 kV	34
330 kV	43
275 kV	26
220 kV	24
66 kV	37
OOS	45
All strings	**29**

Table 3 – Average age of transmission line insulator (as at November 2014)

[6] Note that AusNet Services' asset age data for insulators is based on the asset installation date, not the manufactured date.

Figure 5 shows the age of the transmission line insulator population by voltage. There are 3912 insulator strings with a service age exceeding 55 years; majority of these insulators operate on the 220 kV network.

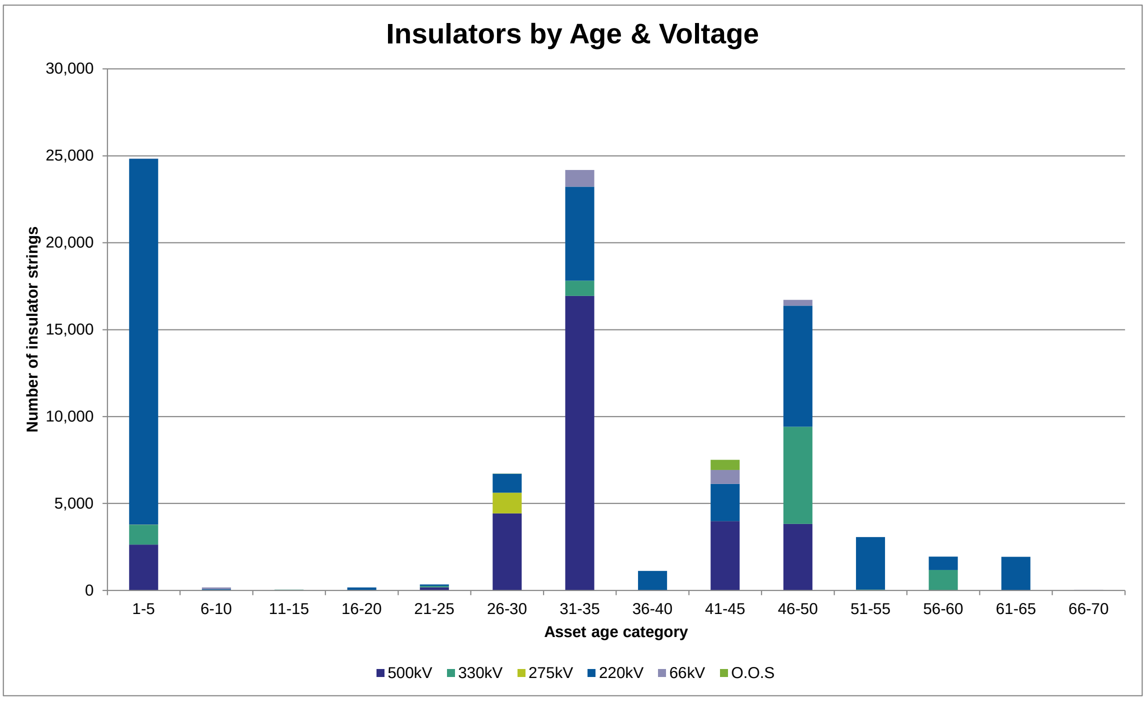


Figure 5 – Transmission line insulators Age Profile by Voltage (as at November 2014)

Figure 6 displays the age of the transmission line insulator population by type. The oldest transmission line insulators in the fleet are either the porcelain type or glass type or a mixture of both. Since the year 2000 the preferred type of transmission line insulator has been the polymeric type. The majority of insulator strings with an age of 15 years or less are polymeric types.

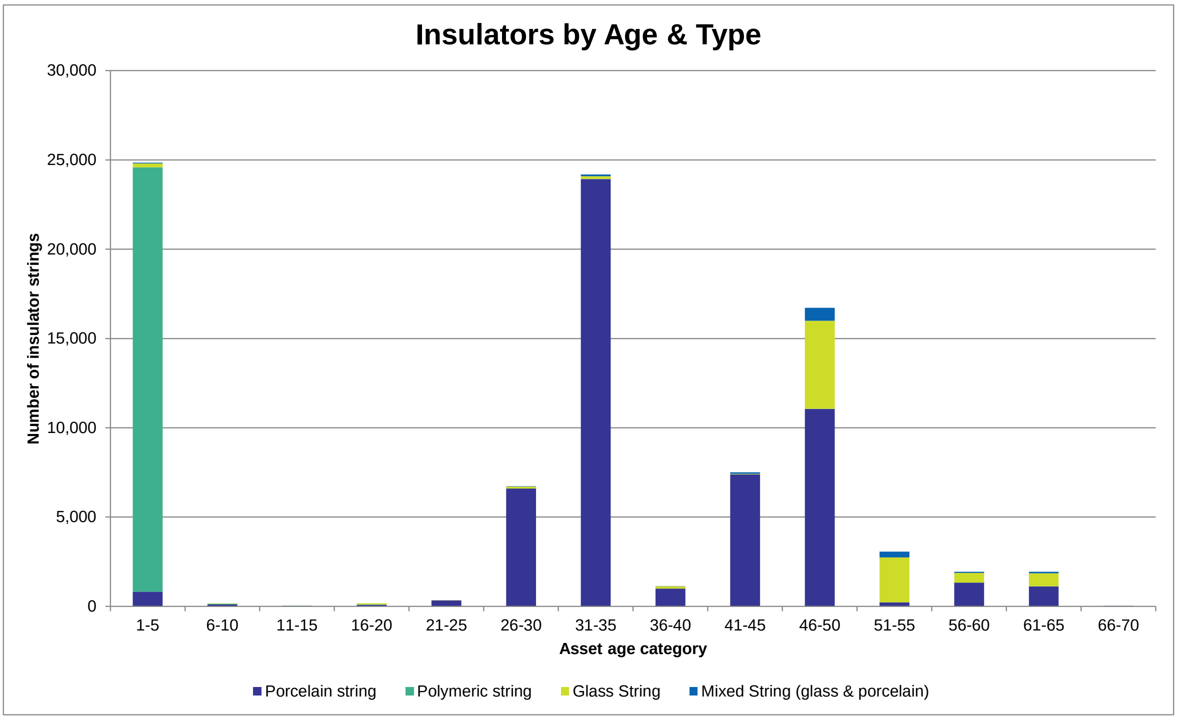


Figure 6 –Insulator Service Age by type (as at November 2014)

Figure 7 displays the change in transmission line insulator age since 2000. The average age of insulators has changed from 32 years in 2000 to 29 years in 2014. The shift in age of the insulator fleet is attributed to the risk based insulator replacement program. This program was introduced in response to trends in major insulator failures which began to increase in the period between 2000 and 2007. Eighty per cent of insulator strings have been replaced on structures which have delivered 50 years or more service.

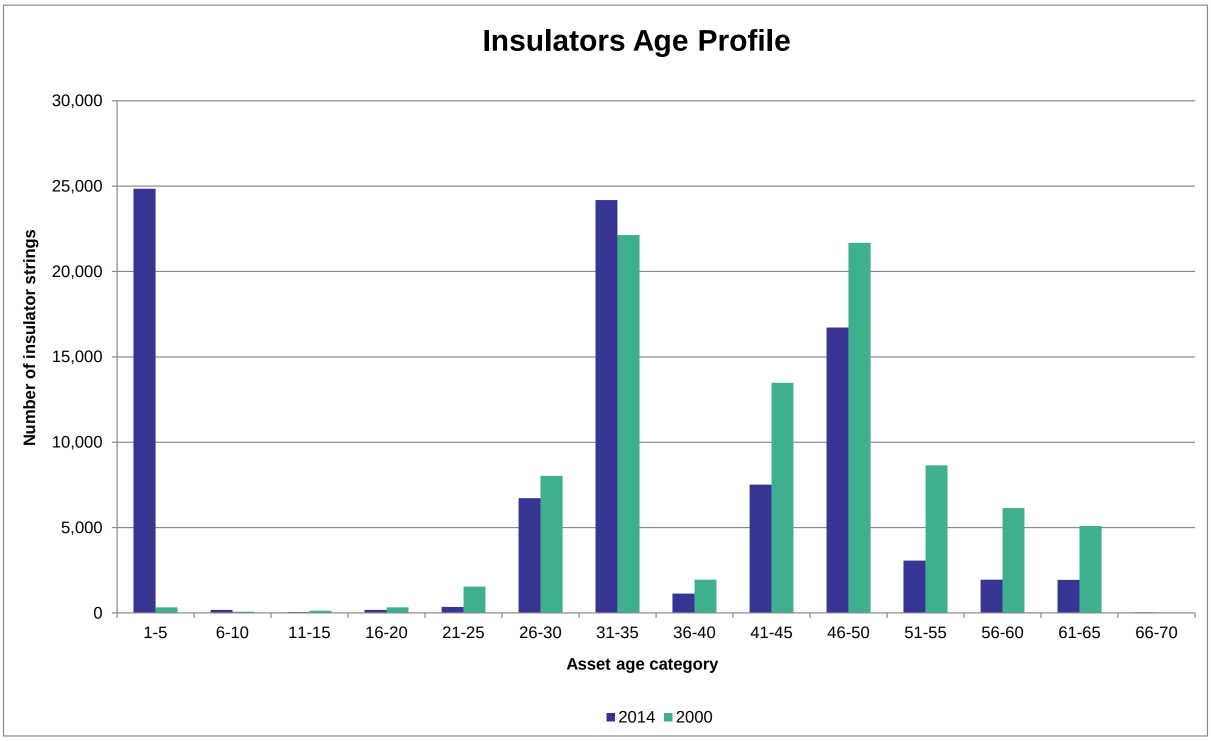


Figure 7 – Insulator service age change since 2000

3.3 Condition

Condition of transmission line insulators is assessed during regular tower climbing inspections. Insulators are assigned a condition grade from a scale between C1 and C5 against two different grading parameters, fitting wear and pin corrosion. The worst condition from both parameters is then used as the overall condition grade for each insulator string. Table 4 below outlines transmission line insulator condition grades and description against each different grading parameter.

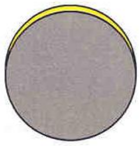
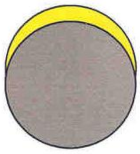
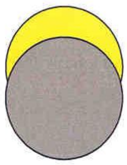
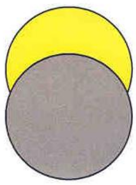
Condition grade	Fitting wear		Pin corrosion	
C1	No wear. First signs of rust		First signs of rust	
C2	10% wear		5% pin cross section loss or light rust	
C3	20% wear		10% pin cross section loss or flaky rust	
C4	30% wear		20% pin cross section loss or heavy flaky rust	
C5	50% wear		40% pin cross section loss or extreme rust	

Table 4 – Transmission line insulator condition grades and descriptions

Insulator condition grades are considered along with other factors such as service age, type, consequence of failure and structure design loading when taking decisions with respect to management of the insulator.

Figure 8 shows the condition of transmission line insulators by type. Fifty-four per cent of all insulator strings in service on the transmission network exhibit minimal fitting wear or light levels of rust in line with condition grades C1 or C2. A total of 3,009 insulator strings or 3.4 per cent of the total transmission insulator fleet currently exhibit levels of fitting wear or pin corrosion in line with condition grade C5.

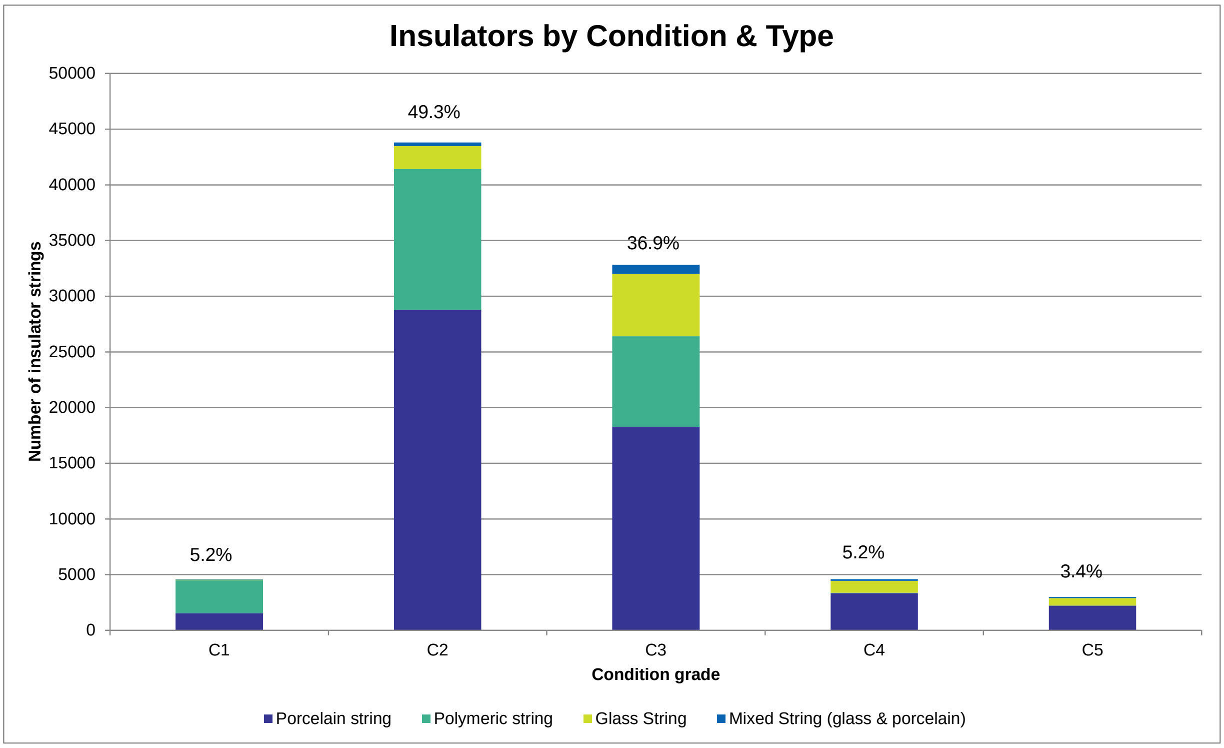


Figure 8 –Insulator condition by type

Figure 9 displays transmission line insulator condition by corrosivity zone. Only one per cent of transmission line insulators which are currently assessed as condition grade C5 are situated in the severe or very severe corrosivity zones.

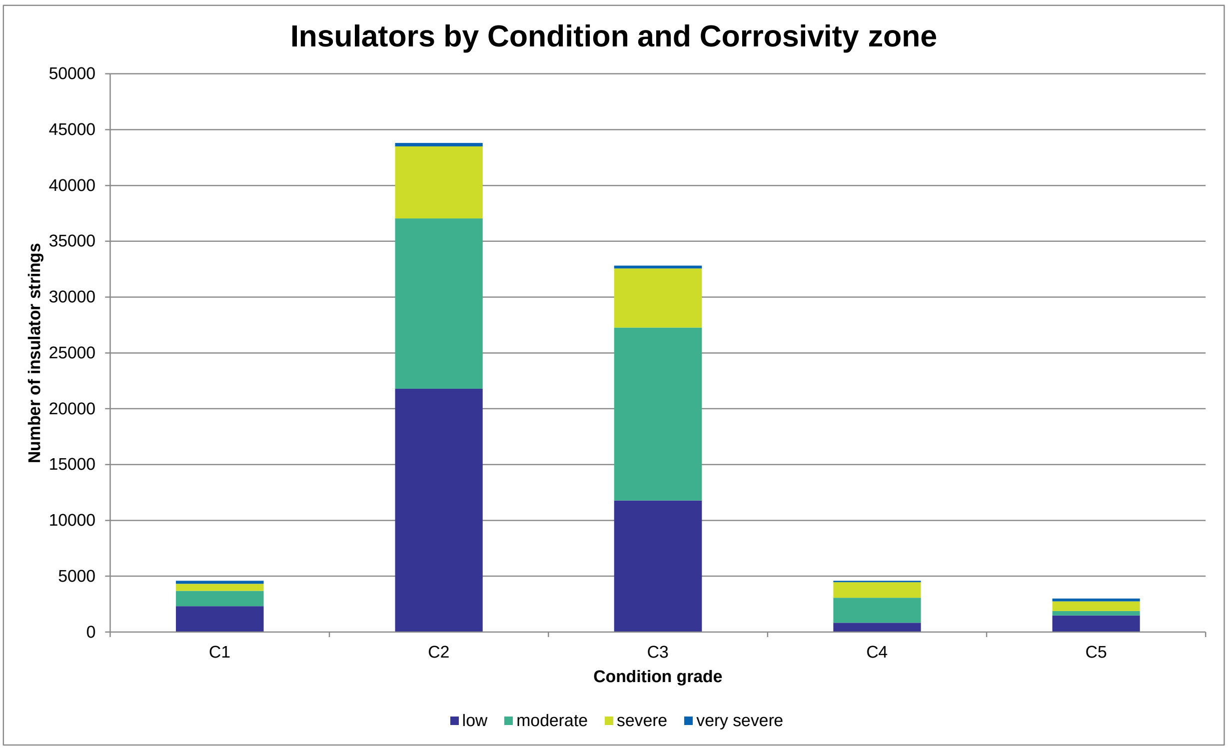


Figure 9 –Insulator condition by corrosivity zone

Figure 10 outlines the circuit for all transmission line insulators displaying very poor condition (C5). The lines displaying the large volume of insulators in the worst condition grade C5 are the MBTS-EPS No. 1 line and No.2 line. These insulators were mainly installed in 1950, they are made of porcelain, glass or a mixture of both with 16 mm connection pins. These lines are situated in the low corrosivity zone.

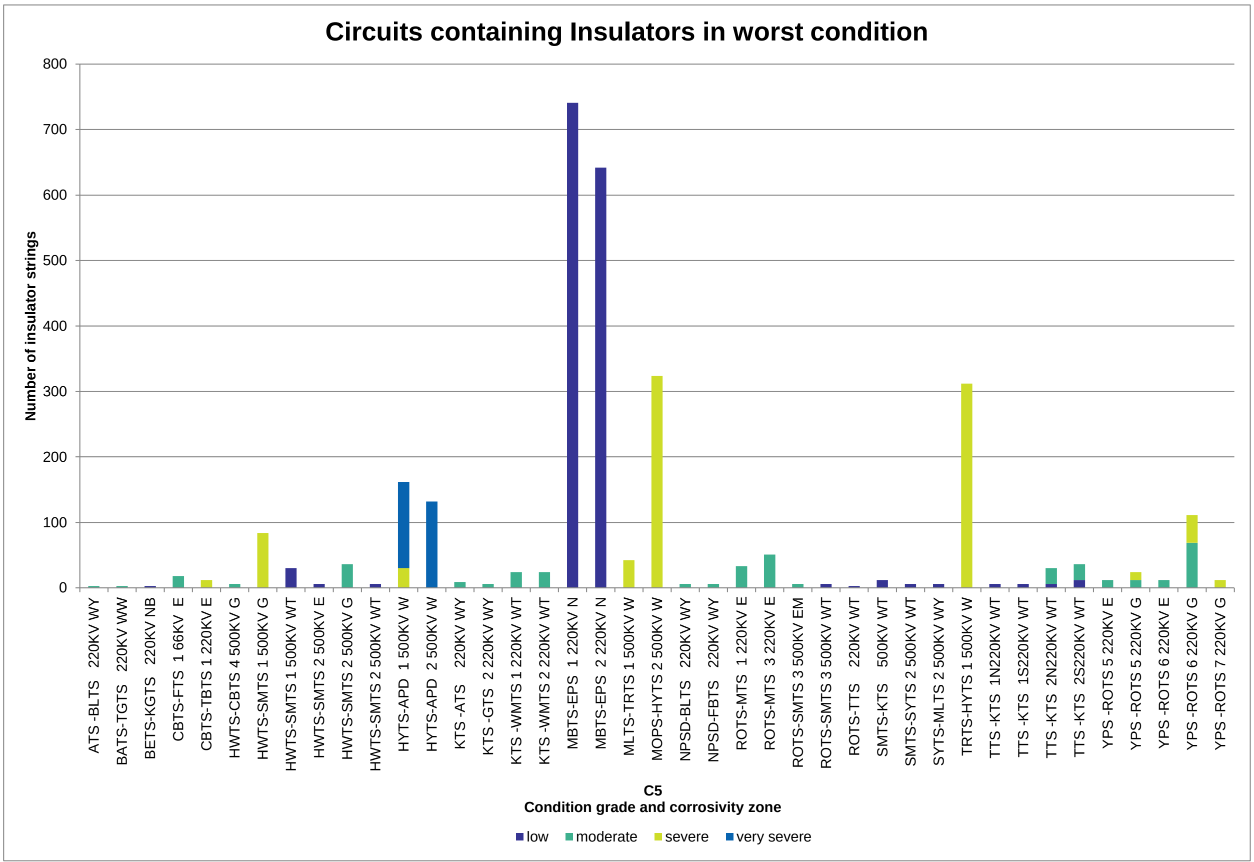


Figure 10 – Locations of worst condition transmission line insulators

3.4 Performance

3.4.1 Suspended failures

Defects that are detected and repaired as part of preventative maintenance tasks before they cause a functional failure (i.e. outage) are defined as suspended failure.

AusNet Services has adopted strict line patrolling and line inspection policies which are aimed at objectively assessing asset condition with a particular focus on assets which are not fit to remain in service. Line insulators deemed not fit for service are replaced via work orders raised in Asset Management System. Line insulators replaced via work orders do not cause transmission line functional failures and so are classified as suspended failures.

Over the last ten years there have been a total of 825 suspended insulator failures identified. The majority of suspended failures were caused by broken insulator discs and pollution, representing 40% and 34% of suspended failures respectively.

Suspended failure reports indicate that all broken insulators were porcelain or glass types which were cracked or chipped. Pollution of insulators is caused by local environmental factors such as salt deposition from coastal areas, dust in dry open areas or soot emitted from vehicles on busy roadways. Suspended failures due to pollution can be minimised by washing insulators in exposed areas regularly.

A high volume of electrically flat[7] insulator strings were identified and replaced in 2007, which increased the suspended insulator failures that year as illustrated in the following figure, Figure 11.

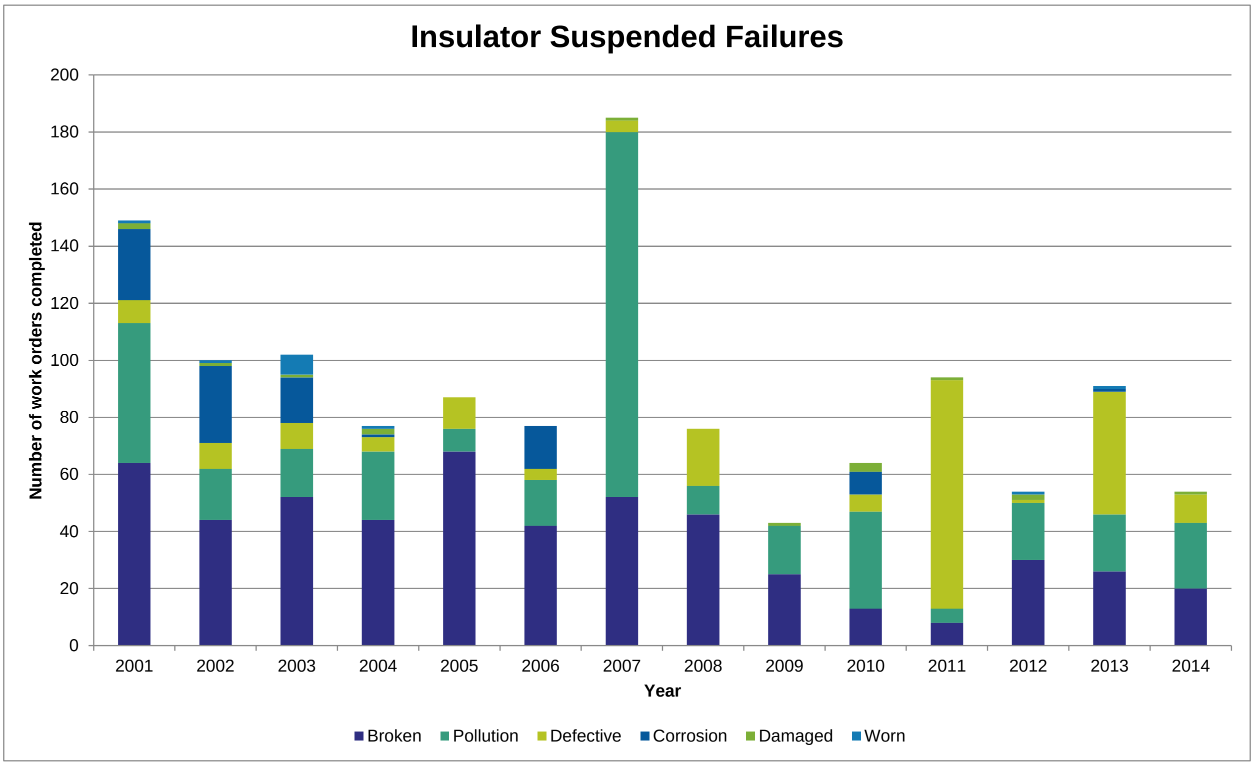


Figure 11 – History of suspended insulator failures

3.4.2 Functional failures

There have been 14 incidents of insulator functional failure over a period of 31 years. A functional failure occurs when an insulator string mechanically separates or sufficient discs electrically fail to interrupt the flow of electricity within the circuit.

The root cause of porcelain or glass insulator physical separation is a combination of insulator pin corrosion, fitting wear and metal fatigue of the insulator pin. Mechanical failure of polymer insulator may be due to birds chewing the sheds or over crimping in end fitting causing cracks in the core.

Electrical failure of porcelain or glass insulator may be due to cracking which creates a path for current to flow through the insulator body or by pollution deposits allowing current to track across the surface of the insulator. Moisture entering the core of polymer insulator if there is any unwanted gap between the core and weather sheds or contamination by salt leading to electrical erosion of sheds may cause electrical failure of the polymer insulator. Figure 12 displays the percentage split of total transmission line insulator failure modes.

[7] Flat insulator discs fail to provide sufficient electrical insulation which can lead flash overs between phase conductors and structures. Flash over events can result in conductor drops.

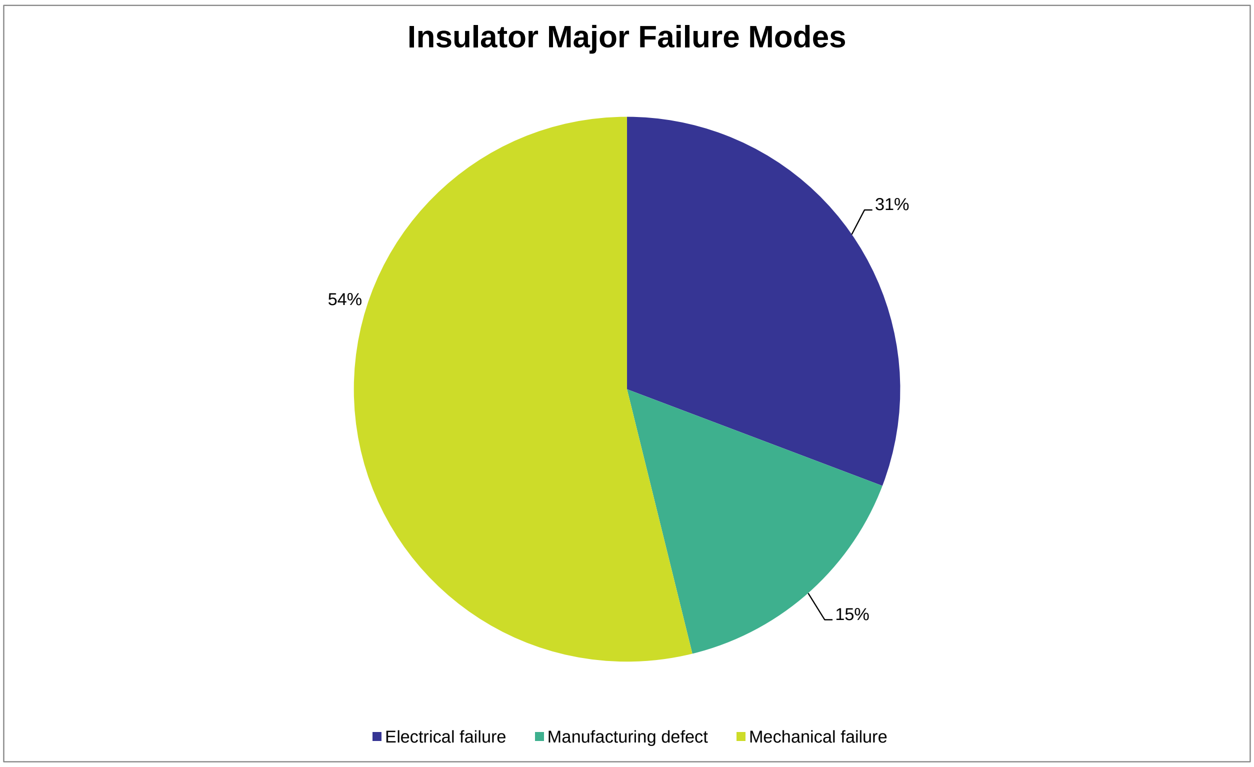


Figure 12 – Transmission line insulator failure modes

Reliability of the insulator fleet has improved since 2009 as a result of the replacement program commenced following the high concentration of failures experienced between 2003 and 2008. This planned insulator replacement program began in 2006 targeted insulators deemed to have high probabilities of failure based on condition, type and pin size. There have been no insulator functional failures since 2009. The Mean Time Before Failure (MTBF) of the fleet was approximately 4.79 years in 2014 improving slightly from 4.43 in 2009. This reflects a general increase in MTBF from its historically lowest point of 4.36 years in 2008. Figure 13 displays the change in insulator MTBF since 2003.

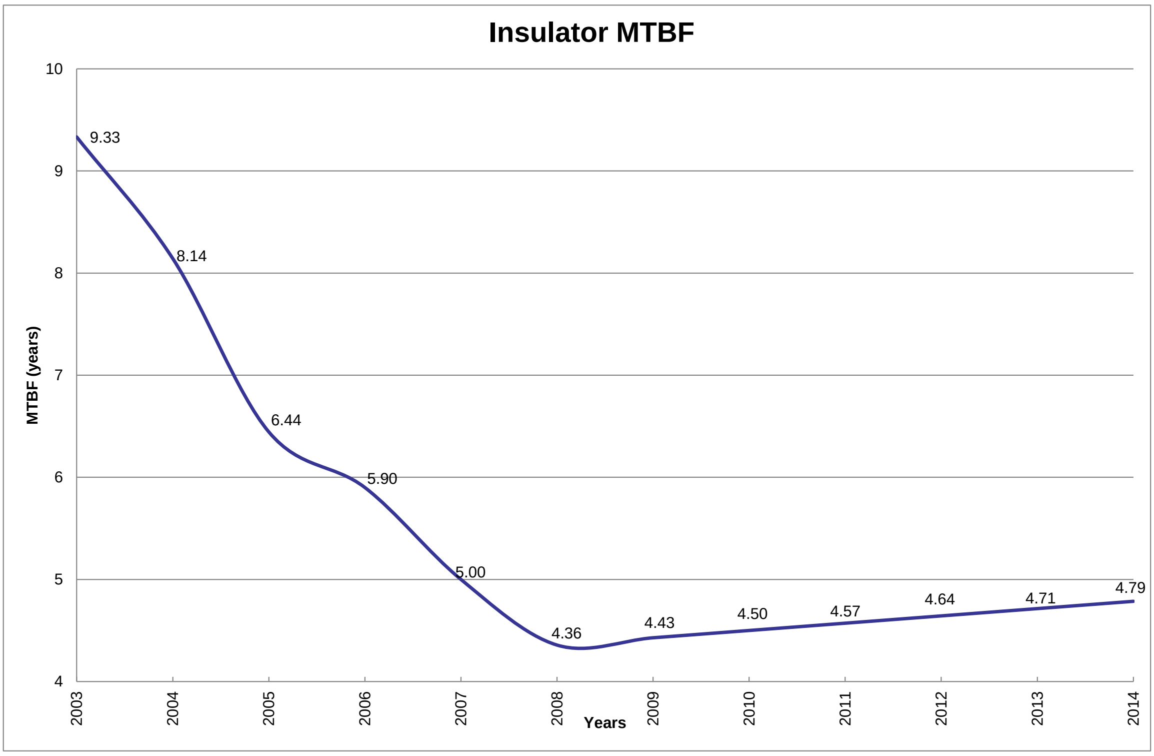


Figure 13 – Transmission line insulator MTBF

Fifty per cent of transmission line insulators which have failed have been from the porcelain cohort and 50% have been from the glass cohort. All 14 insulator functional failures occurred on insulators aged between 29 and 44 years with 36% of these failures occurring between the service age of 39 and 40 years. The mean service age at the time of failure for transmission line insulators is 39 years. Figure 14 shows the distribution of insulator ages at time of failure.

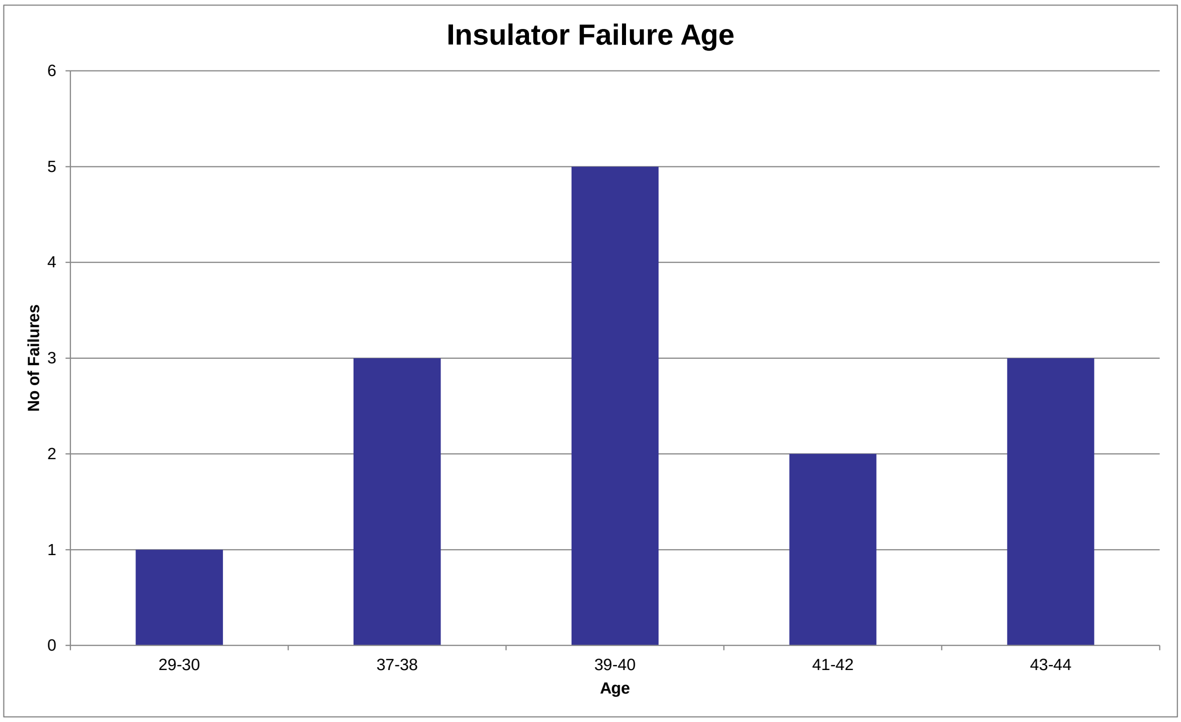


Figure 14 – Transmission line insulator age at time of failure

3.4.3 Failure Effects

Major insulator failures can lead to three different types of consequence including health and safety, bushfire ignition and network performance. These consequences can be quantified using the 1 – 5 scoring system shown on the vertical axis (consequence) of AusNet Services' risk matrix which is displayed in Figure 15.

Analysis of the MTBF for insulators guides the likelihood scoring in an objective fashion. A MTBF of 4.79 years indicates that there have been insulator functional failures once every 4.79 years on average which corresponds to an annual probability of 20 per cent. This probability aligns with a likelihood score of B on the AusNet Services risk matrix. This likelihood is applied to the network performance risk caused by an insulator functional failure. Not every major insulator failure presents health and safety risk or bushfire ignition risk to the public; the event will have to occur under exceptional circumstances as discussed in section 3.4.3.1 and 3.4.3.2 below. The probability is very low and aligns with a likelihood score of A on the AusNet Services risk matrix.

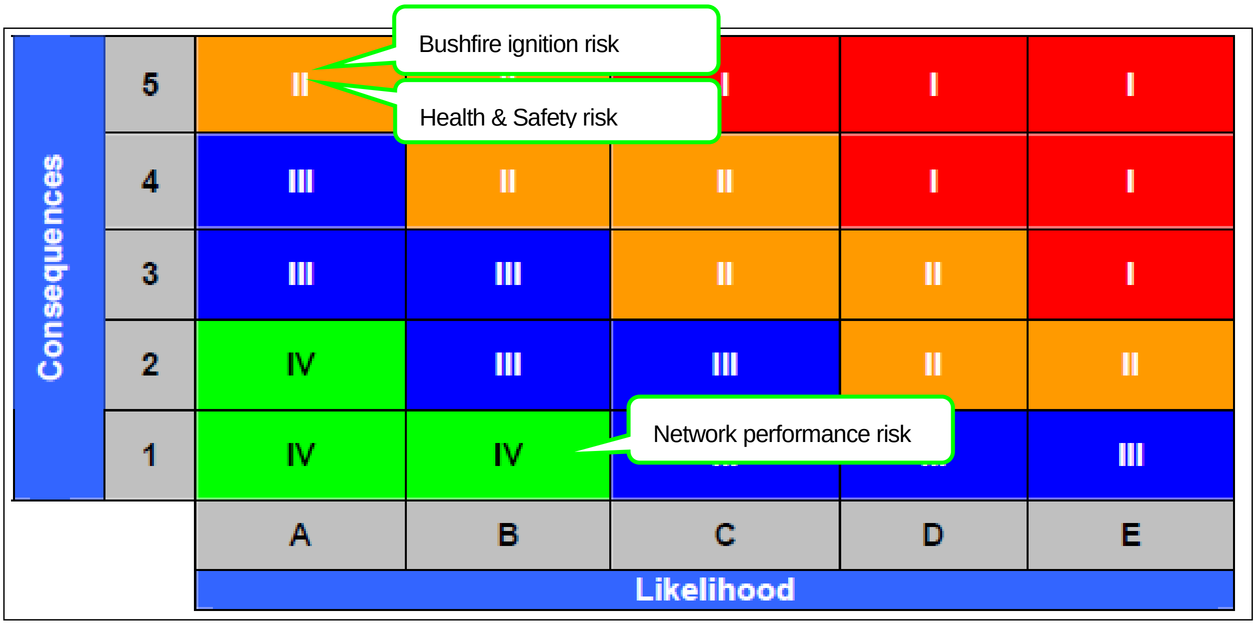


Figure 15 – AusNet Services' Risk Matrix[8]

3.4.3.1 Health and Safety

Transmission line easements traverse both public and private land where public access is restricted. In many instances easements are shared or located next to other infrastructure such as roads, railway lines, pipes and fences.

Major insulator failures can present health and safety risks to members of the public, AusNet Services' employees or AusNet Services' contractors accessing the transmission line easements. These risks are especially apparent on structures adjacent to roadways or railway lines as high volumes of people are exposed.

Using the results of a study performed by Vic Roads[9] in 1994, a quantitative consequence assessment of transmission line spans which cross roads and railways has been completed. The assessment has revealed that a major insulator failure could cause a health and safety incident with a maximum risk rating score of II as per the AusNet Services risk matrix.

There have been no instances of major insulator failures adjacent to roads or railways. The existing transmission line insulator replacement program has targeted insulators on towers at high risk locations including road and rail crossings as priorities.

[8] AusNet Services' Risk Management Framework – RM 001-2006.

[9] Bureau of Transport and Communications Economics (1994) The Costs of Road Accidents in Victoria – 1988.

3.4.3.2 Bushfire ignition

Faults on transmission lines can result in explosive failures of insulators which are capable of igniting ground fires. Some transmission lines are situated in easements through high density fuel loads in grasslands and forests. In extreme weather conditions ground fires started close to such fuel loads can develop into widespread bushfires.

Bushfire loss consequence modelling performed by Dr. Kevin Tolhurst[10] of Melbourne University has enabled the establishment of quantitative bushfire consequence values for transmission line assets. The bushfire loss consequence model demonstrates that a major insulator failure could trigger a bushfire incident with a maximum risk rating score of II as per the AusNet Services risk matrix. A map displaying the bushfire consequences associated with transmission line assets is included in Appendix B.

In 2007, a small grass was ignited following electrical failure of a porcelain insulator on the ROTS-SVTS No.2 line. A combination of pollution and morning fog on the insulator discs caused a flashover. The flashover caused a small amount of molten metal to fall to the ground resulting in a small grass fire. Moisture on the grass caused the fire to extinguish quickly.

3.4.3.3 Network constraints

The electricity transmission lines forming the National Electricity Market have high levels of redundancy under average loading conditions. However, at peak loading periods; transmission line failures can constrain generator connections causing a re-scheduling of generators in other states and load shedding may be required to provide network security for a subsequent un-related failure.

The Australian Energy Market Operator's (AEMO's) availability incentive scheme (AIS) quantifies the impact of Victorian electricity transmission network constraints on the operation of the National Electricity Market. AusNet Services pay AEMO the economic value associated with removing specific network assets from service at specific times within the seasonal and daily load cycles. The AIS provides suitable economic values for inclusion in dependability models as the failure effect costs of critical assets.

Major transmission line insulator failures result in system outages which negatively impact on performance levels within the incentive schemes. Impacts on the schemes are compounded when failures take place on radial lines. Financial penalties likely to be imposed can be calculated using guidelines set out by the AER. These calculations indicate that a major insulator failure would result in a maximum financial penalty corresponding with a maximum risk rating score of IV as per the AusNet Services risk matrix.

3.4.4 External performance benchmarking

AusNet Services participated in the 2013 ITOMS performance benchmarking study. The survey enables a participating TNSP to compare its performance relative to other TNSP's based on service and cost levels.

AusNet Services ranked above the average performance of other Australian and New Zealand transmission utilities in terms of service level (measured in fault/forced outages per circuit km) and cost level (measured in equivalent maintenance costs per circuit km) for 200 kV+ transmission voltage categories. However, the cost level for the 60-99 kV category is slightly higher than the average performance of other Australian and New Zealand transmission utilities.

The survey indicates that the maintenance strategies and costs are appropriate for our network. Figures 16 and 17 below display AusNet Services' relative performance in the 60-99 kV and 200 kV+ categories respectively.

[10] A Bushfire Risk Assessment for the AusNet Services HV Network in Victoria 2014.

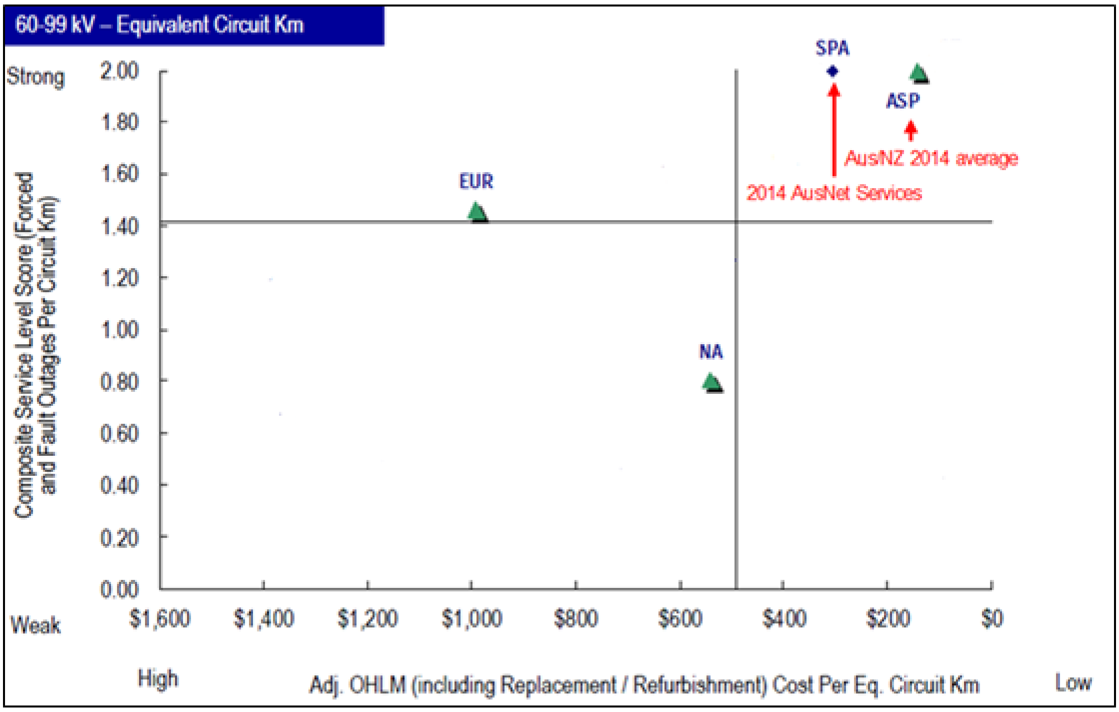


Figure 16 – ITOMS benchmarking 66 kV transmission lines

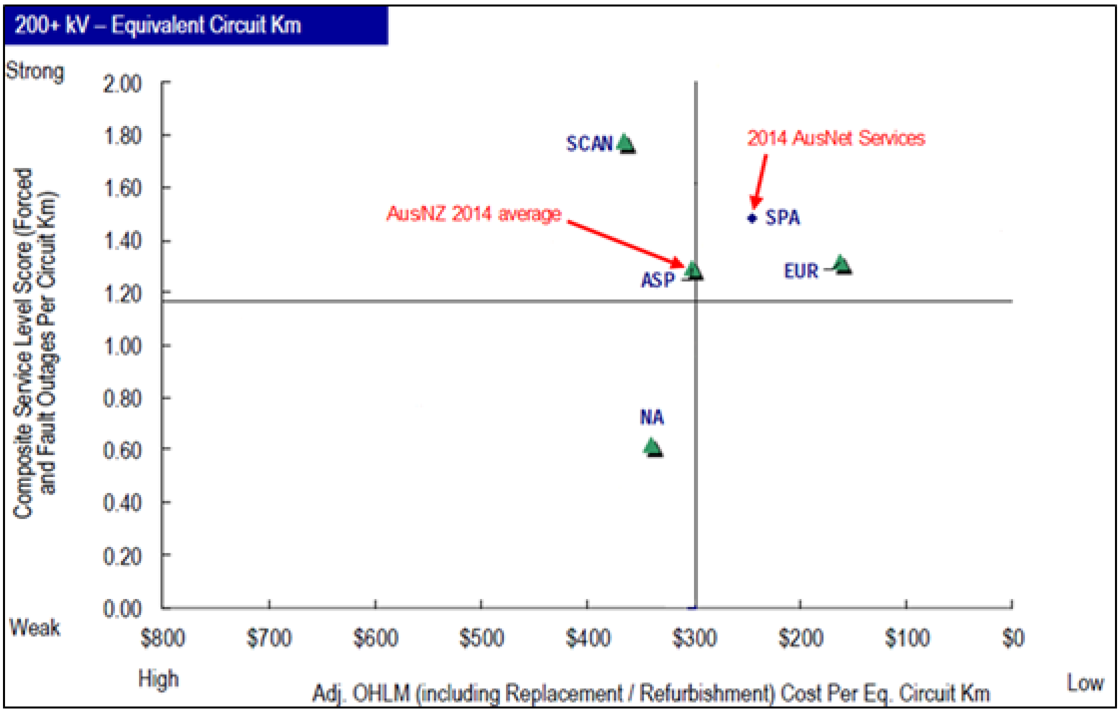


Figure 17 – ITOMS benchmarking 220 kV, 330 kV and 500 kV transmission lines

3.5 Key Issues

This key issues associated with the transmission line insulator fleet are as follows:

- Approximately nine per cent of transmission line insulators are displaying established signs of corrosion or worse. This includes insulators exhibiting condition grades C4 and C5.
- Corrosion of transmission line insulators is accelerated in some areas due to exposure to harsh environmental conditions.
- Some transmission line insulators have become aged which means that the probability of failure is increasing due to the adverse effects of thermal cycling and cement growth.
- Limited research literature is available on the negative affect that age based phenomenon such as thermal cycling and cement growth have on the probability of the major electrical failure mode occurring in glass or porcelain insulators.
- Functional failure of insulators on structures adjacent to road or rail crossings presents health and safety risks.
- Volumes of polymer composite insulators on the transmission line network are increasing due to insulator replacement program. Research to develop techniques for accessing the condition and the remaining expected service life of these insulators is ongoing.

4 Risk Assessment

This section discusses risk assessments relating to the insulator fleet. Reliability Centred Maintenance (RCM) techniques were used to guide the development of optimised asset replacement programs.

4.1 Dependability Management

Dependability management methodology brings together asset condition data, asset failure rates and the cost impact of asset failure to determine an economically justifiable level of replacement. This section summarises the reliability modelling of insulator fleet. It sums the probabilistic replacements and equivalent risk costs and identifies the economic replacements required to prudently maintain failure risks. Key inputs to this dependability process are asset condition, remaining service potential (RSP %), failure rate and the failure effects[11]. Insulators situated in the “very severe” and “severe” corrosivity zones have considerably shorter lifecycles when compared to assets in the “moderate” and “low” corrosivity zones.

AMS 20-11 Dependability Management provides more detail on the dependability management methodology.

4.2 Scenarios

The dependability analysis was performed in an excel spreadsheet. Two fundamental scenarios are used in these analyses – run to failure and risk optimised.

4.2.1 Run to Failure Scenario

The run to failure scenario assumes that no preventative replacement of an asset or assets is undertaken. It calculates the minimum total life cycle costs, associated with corrective replacements following in-service failures, required to maintain service from the asset(s) over the modelling period.

A total life cycle cost of [C.I.C] comprising the Effect Cost (health and safety, bushfire ignition and network performance) and reactive insulator replacement costs (labour, equipment and spare) are shown in Figure 18.

[C.I.C]

[11] Effect costs were calculated against each of the possible failure effects discussed in section 3.4.3 including health and safety, bushfire ignition and network performance. The total failure effect cost for each asset was taken as the sum of all failure effects.

Figure 18 shows that a run to failure strategy would result in a total effect cost of [C.I.C] over the next 10 year period. The effect cost is disproportionate to the replacement costs of approximately [C.I.C]. This effect cost is largely distributed between those assets assessed as Condition 3, Condition 4 or Condition 5.

Over the 10 year period, reliability modelling suggests that a run to failure strategy would result in 4,734 insulator string (5% of entire fleet) failures with associated replacement costs of $26 million (labour, equipment and spare purchases) over the 10 year period.

The run to failure scenario does not represent the minimum life cycle cost and is subsequently not recommended as an efficient use of limited resources or the most prudent investment for customers.

This scenario is not the most prudent investment for customers and is presented here for comparison with a risk optimised scenario described in the section below.

4.2.2 Risk Optimised Scenario

The risk optimised scenario selectively replaces assets in a planned manner wherever the costs of planned replacement are less than the effect costs associated with an asset failure within the selected planning period.

The effectiveness of the proposed preventative maintenance activity in increasing asset availability by reducing outage frequency or down time can be compared with that of the default strategy of running the asset to failure and then undertaking corrective maintenance. Similarly the relative efficiency of the proposed preventative maintenance can be measured by comparing its costs with those of the corrective maintenance.

Figure 19 shows a [C.I.C] total life cycle cost for the risk optimised management of insulators over the next ten years. It shows a significant [C.I.C] reduction in the total impact on customers and replacement costs compared with the run to failure scenario.

[C.I.C]

Figure 19 shows selective replacement of 3,810 insulator strings (4.3 % of the entire fleet) mainly in Condition 3, Condition 4 and Condition 5, will increase replacement costs from [C.I.C] [12] over the ten year period and provide a significant reduction in the impact on customers from [C.I.C].

Reliability modelling demonstrates that a Risk Optimised Scenario is the most economic use of limited resources and provides a significantly lower life cycle cost to customers.

[12] Replacement costs of insulator strings vary based on voltage levels and structure design loading (strain or suspension), refer to TRR 2017/18 – 2021/22 P50 Unit Rates – Primary, Civil, Secondary and Lines.

4.2.3 Replacement Forecast

AusNet Services has applied optimised RCM risk modelling techniques to the entire insulator fleet in order to establish a prioritised replacement program. This approach has employed probabilistic risk modelling techniques to establish a targeted and economic replacement program.

The dependability model recommends selective replacement of 3,810 insulator strings (4.3% of the entire fleet) mainly in Condition 3, Condition 4 and Condition 5 over the ten year period. Those insulators, located on spans which cross roads and railway lines, become economic for replacement when they exhibit flaky rust (C3 or C4). Other insulators which are situated in areas of lower consequence become economic for replacement when they show signs of pin section loss or heavy flaky rust (C4 or C5).

Approximately 2,900 insulation strings (3.3% of the insulator fleet) are forecast for replacement before 2022[13] (over the seven year period) due to combinations of deteriorated condition, advanced service age and high consequence locations.[14]

[13] From 2015 to 2022, approximately seven years.

[14] There is an approved project (XC76) to replace 2040 insulator strings on various transmission lines over five financial years from 2015/16 to 2019/20.

5 Strategies

High level strategies recommended for prudent and efficient management of the transmission line insulator fleet are:

5.1 New Assets

- Current policy is to install polymeric insulators as part of insulator replacement programs. Polymeric insulators have an expected service life of 40 years which is considerably less than the porcelain, glass and mixed type (porcelain and glass) insulators.
- Polymeric insulators have been known to be attacked by birds if strung under dead line conditions. Provision will be made to prevent bird attack during project implementation planning.
- Fail-safe design concepts to be applied for insulation systems on new replacement of transmission line structures adjacent to high risk roadways and railways or proof test all insulator fittings prior to installation on towers across roads and railways.

5.2 Inspection

- Continue to assess the condition of transmission line insulators during structure climbing inspections which are conducted at a maximum interval of every 37 months.
- Develop policies for inspection, maintenance and ultimate replacement of polymeric insulators considering expected service life. These policies must include a condition assessment methodology.
- Import all relevant technical asset data including condition assessment grades into SAP.

5.3 Maintenance

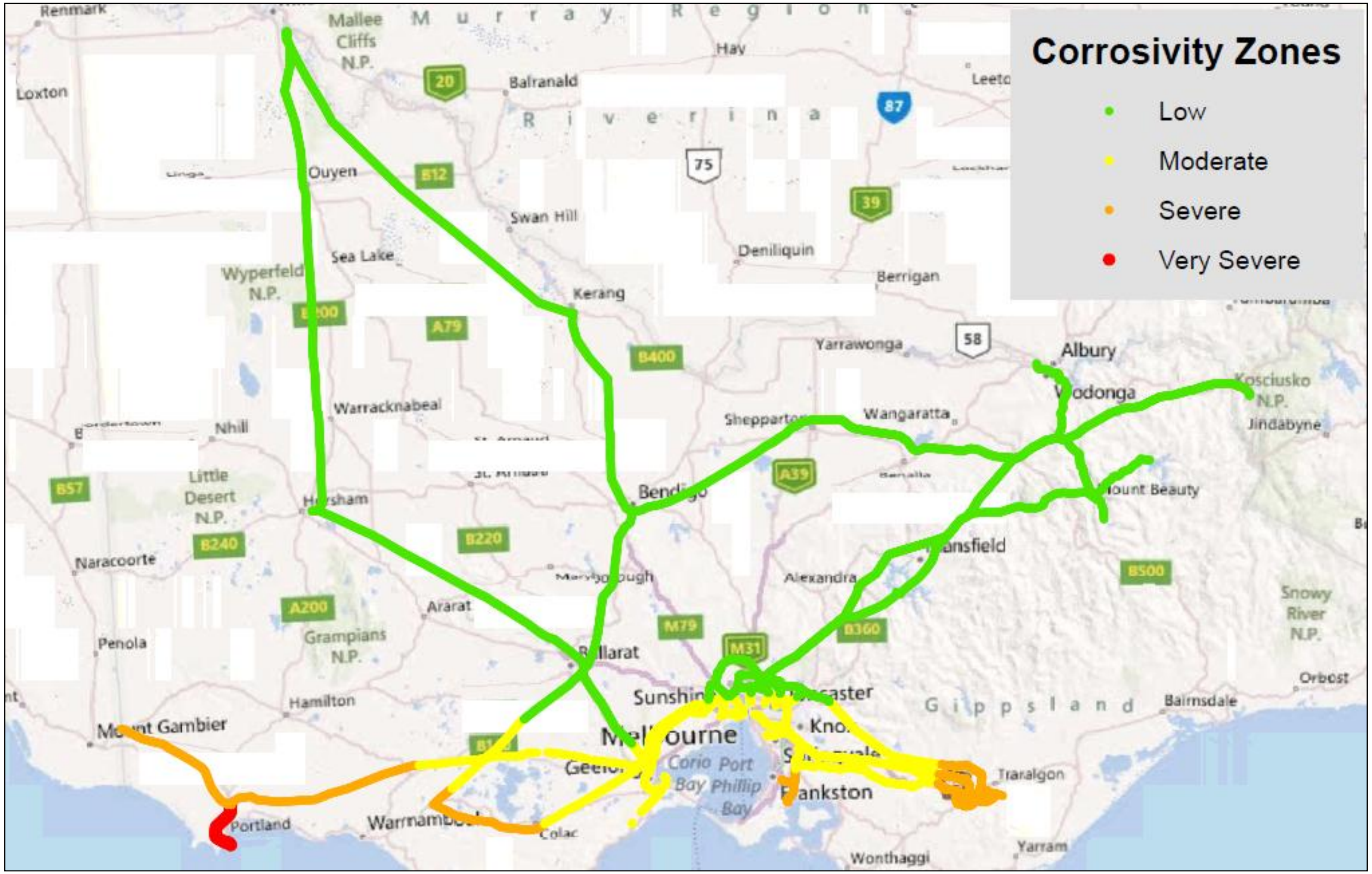
- Replace defective insulator strings as part of corrective maintenance tasks. Complete string replacement is preferred as it is more economic and safer than replacement of an insulator from within a string of insulators.

5.4 Replacement

- Selectively replace high failure risk insulator strings representing up to 3.3% of line insulator fleet before 2022[15]. There is an approved project (XC76) to replace 2,040 insulator strings on various transmission lines over five financial years from 2015/16 to 2019/20.

[15] From 2015 to 2022, approximately seven years.

Appendix A – Corrosivity Zones on the Victorian Transmission Network



Appendix B – Bushfire Consequences on the Victorian Transmission Network

[C.I.C]