
AMS – Victorian Electricity Transmission Network

Transmission Line Structure Foundations

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Transmission Line Structure Foundations

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Contact

This document is the responsibility of the Asset Management division, AusNet Services. Please contact the indicated owner of the document with any inquiries.

John Dyer
 AusNet Services
 Level 31, 2 Southbank Boulevard
 Melbourne Victoria 3006
 Ph: (03) 9695 6000

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Transmission Line Structure Foundations

1 Executive Summary

There are approximately 13,000 transmission line structures in service in the transmission network. These structures are supported by six different types of foundations which comprise all components which are located below a point 300mm above the ground line. Different types of structure foundations in service include pier and slab, grillage, pyramid, tripod, bored (augured) and piled.

Transmission line structure foundations are subject to routine condition assessment. Structure footings are generally in good condition. AusNet Services has intrusively inspected and tested footings since 2002. Life extension works (SOXS) such as the application of protective paint and footing reinforcement is performed as part of this process. It is intended to continue these works over the upcoming years as functional failures of footings present a high risk.

Some corrosion protection of below ground steel work is achieved through the use of cathodic protection systems. Impressed Current Cathodic Protection (ICCP) has been installed at 24 locations, some at initial construction to protect deep piled foundations from stray DC rail traction currents and some later in life to minimise the negative effects of galvanic (Cu/Zn) currents from terminal station earth grids.

Under line fault conditions electrical fault currents may discharge through tower foundations and create earth potential rise (EPR) at the tower legs and in soil surrounding the structure foundations. AusNet Services has completed an earth resistance testing program aimed at managing risks associated with EPR.

Strategies for transmission line structure foundations are:

- Continue to perform visual inspection of structure footings as part of the routine inspection cycle.
- Continue to monitor the status of the tower site and foundation for flooding, vegetation and erosion to assure the safe performance of all structures.
- Continue to perform life extension works on damaged or corroded footings identified as part of the SOXS program.
- Continue the program of inspections for cathodic protection systems. The effectiveness of cathodic protection systems is maintained by inspecting and replenishing anodes.
- Implement the use of Field Mobile Inspection (FMI) technologies to automatically update the asset information system with condition assessment data.

Transmission Line Structure Foundations

2 Introduction

2.1 Purpose

This document defines the asset management strategies for transmission line structure foundations forming part of AusNet Services' Victorian electricity transmission network.

2.2 Scope

This asset management strategy applies to all transmission line structure foundations and communications towers foundations associated with AusNet Services' electricity transmission network that support circuits operating at voltages of 66kV and above. This strategy does not include asset management aspects of structure foundations operating on the distribution network and structures situated within zone substations or terminal stations.

The strategies in this document are limited to maintaining existing equipment performance. Improvements in quality or capacity of supply are not included in the scope of this document.

Transmission Line Structure Foundations

3 Asset Summary

3.1 Population

There are approximately 13,000 transmission line structures¹ in service in the transmission network.

Transmission line structures support live conductors via strings of line insulators and dedicated lattice communications towers support communications equipment. Structure foundations comprise all components which are located below a point 300mm above the ground line. Different types of structure foundations in service include pier and slab, grillage, pyramid, tripod, bored (augured) and piled. Table 1 below provides a brief description of each different structure foundation type.

Foundation	Description
Grillage	Tower leg extends to the foundation base where it connects to a steel grillage.
Pyramid	Four steel members join to the tower leg to form a pyramid shape. This style of foundation may include a grillage or concrete slab at the base.
Tripod	Tower leg extends to the base and two bracing members rise from the base to provide support to the leg. This style of foundation will typically have a concrete slab at the base.
Bored (augured)	A bored foundation is created by drilling a hole in the ground, positioning the tower leg inside a reinforcing cage and backfilling with concrete. The base of the hole may sometimes be under-reamed.
Pier and slab	This foundation type encases the tower leg in reinforced concrete down to a reinforced concrete base.
Piled	Consists of a steel tube driven into the ground and backfilled with concrete, encasing the tower leg. May also use driven solid steel or reinforced concrete piles.

Table 1 – Structure foundation types

Bored or augured foundations are the most common types in use on the Victorian network comprising 39% of installations. This type of foundation is the most common due to its relative ease of construction, low cost and high reliability. Grillage and pier and slab base foundations make up the majority of the remaining foundation type, contributing to 27% and 26% respectively. Figure 1 displays the different types of structure foundations.

Dedicated lattice structures supporting communications equipment

¹ AMS 10-77 Transmission Line Structures.

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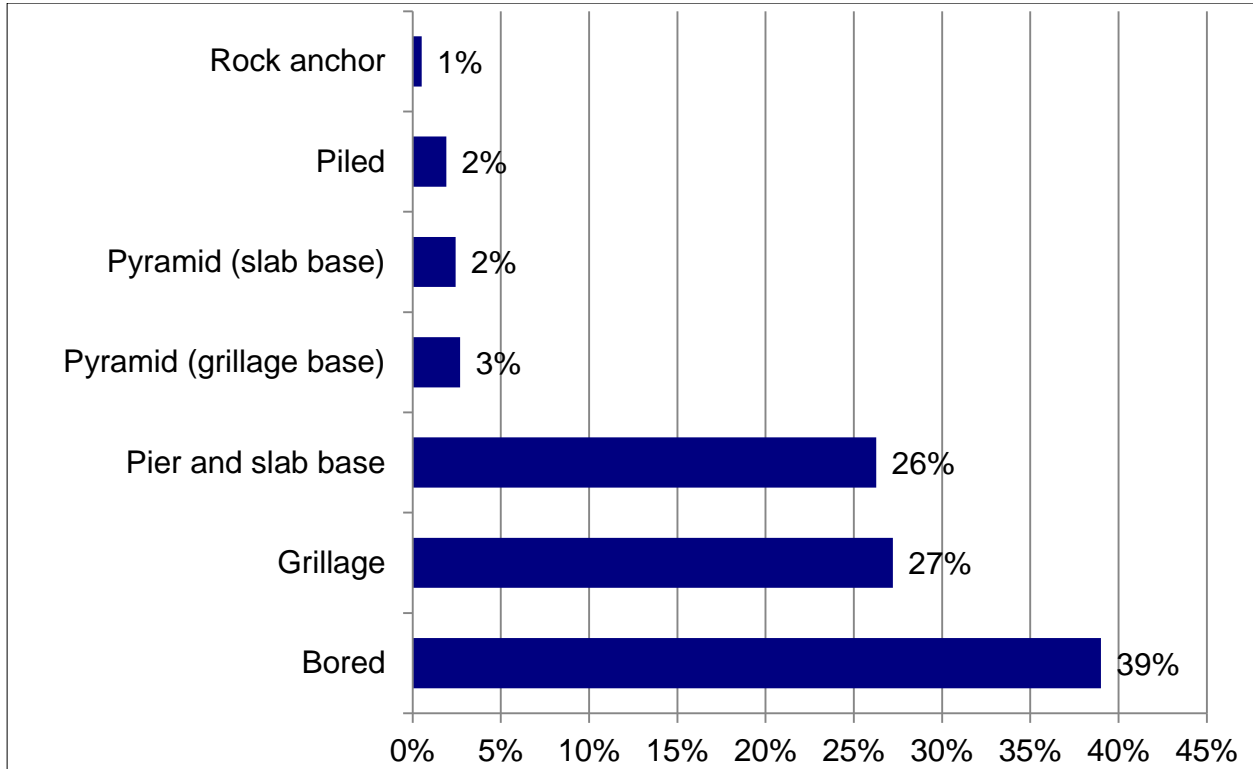


Figure 1 – Structure foundations by type

3.2 Age Profile

The Victorian transmission network initially consisted of 220kV lines built to connect Melbourne and large towns in the North West and North East of the state to generators in the La Trobe Valley.

Construction of 220kV lines first began in 1950. Connection to the New South Wales network was later achieved via 330kV lines built between the late 1950s and early 1980s. Lines operating at 500kV from the Latrobe Valley to Melbourne were constructed in the 1970s providing further capacity to meet demand growth and to support heavy industry in South West Victoria.

Transmission line structure foundations have the same age profile as their corresponding transmission line structures. The average age² of the transmission line structure foundation population is 44.9 years. Table 2 displays the average age of structure foundations on the Victorian network by operating voltage. Structure foundations on the 220kV network have the highest average age closely followed by the 330kV structures.

Voltage Class	Average Age
500kV	36.4
330kV	47.0
275kV	26.0
220kV	48.6
66kV	38.6
Overall Average	44.9

Table 2 – Average age of transmission line structure foundations (as at February 2015)

² Service age data for structure foundations is currently based on the construction date.

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Figure 2 displays the age profile of transmission line foundations and their respective structures by voltage class.³

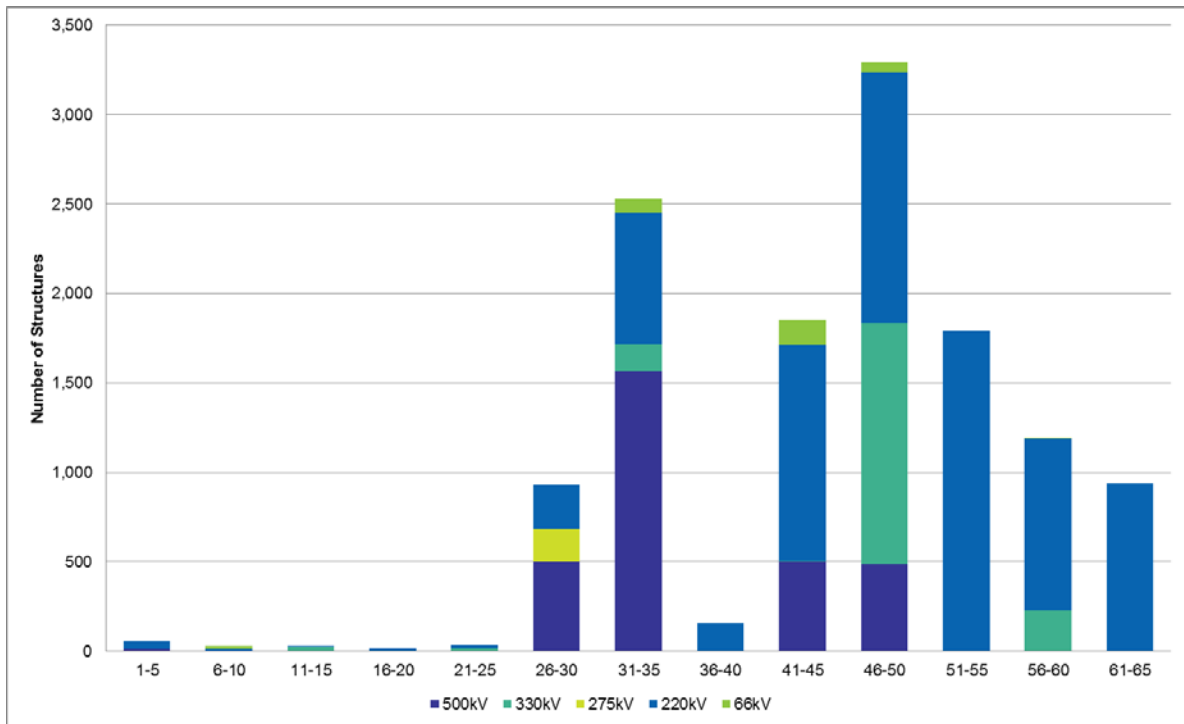


Figure 2 – Structure foundation age profile

The structure foundations age profile roughly reflects that of a normal distribution with a mean age of approximately 45 and a standard deviation of approximately 6 years. This is significant from an asset replacement perspective as subject to different environmental conditions it is possible that large proportions of the fleet may require replacement within relatively short time frames.

3.3 Condition

The condition assessment focuses on transmission line structure footings. Structure footings are assessed taking into consideration three major components, namely the physical condition of the structure footings against corrosion / wear, the number of unscheduled and emergency work orders issued against the tower footings and the service life of the footing (which has the same service life of the foundation).

3.3.1 Overall Condition

At the present time structure footings are generally in good condition. Approximately 45 per cent of structure footings have no rust or have been painted and approximately 54 per cent are exhibiting first signs of rust. It should be noted that these results reflect conditions at the footings ground line and may not be representative of below ground conditions.

³ AMS 10-77 Transmission Line Structures.

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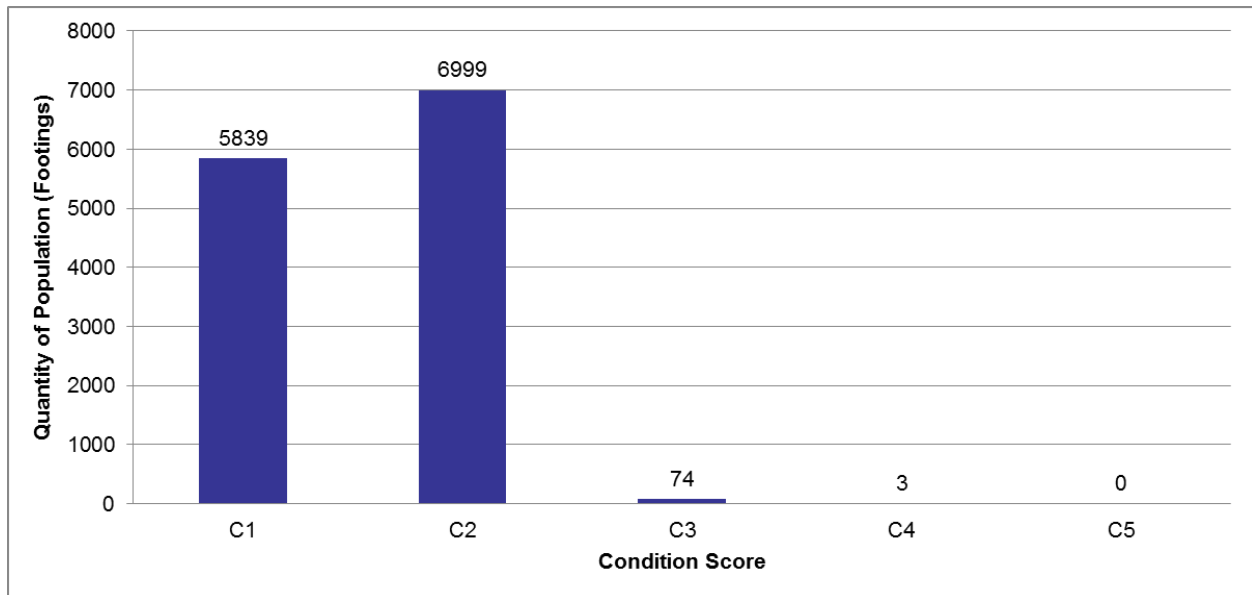


Figure 3 – Structure Footing Condition

Figure 3 above shows that over 99% of the footings are in a C1 or C2 condition with less than 1% of the fleet in a C3 or C4 condition. This is attributed to the SOXS program which has been effective in preventing any unexpected failures whilst improving the conditions of the footings.

Sections 3.3.1.1 through 3.3.1.3 outline the important factors taken into consideration to perform the overall condition assessment for footings.

3.3.1.1 Physical Condition

The assessment of the condition of transmission line structure footings are aligned to routine tower inspections. To identify ground-level corrosion of direct buried tower leg steelwork it is necessary to perform shallow excavations at the tower legs and inspect the exposed steelwork. The most common and visible form of corrosion is at ground level where oxygen is abundant and members are subject to constant wetting and drying, solar radiation and greater thermal cycling. Tower leg members and braces can also be damaged following impact from vehicles or farming machinery. Above ground leg to concrete interfaces may be assessed by visual inspection and do not require excavation.

Footings are assigned a condition grade from a scale between C1 and C5 against two different grading parameters; leg / brace and members.

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Figure 4 below outlines structure footing condition grades and a description against each different grading parameter.


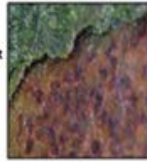
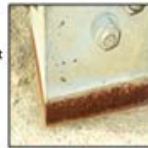

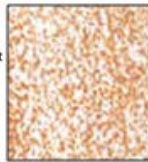
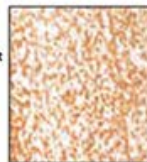
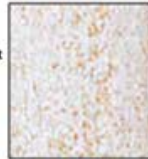
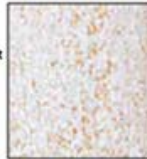

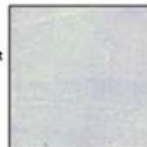
Transmission Line Condition Codes		
CODE	Tower Leg/Brace	Members
5	Flake Rust 	Flake Rust 
4	Rust 	No Zinc 
3	50% rust 	50% rust 
2	First rust 	First rust 
1	No rust or Painted 	No rust 

Figure 4 – Transmission line structure footings condition grades and descriptions

3.3.1.2 Work Orders Issued

Work orders are considered in the analysis as the number of times a structure's footing has to be maintained in order to give an indication of its general health / condition. Work orders are issued on an ad-hoc basis to address defects identified during routine inspections (i.e. Climbing Patrols and Easement Patrols). A work order analysis can be found in section 3.4.1.

3.3.1.3 Service Life

Although service life or age is not a major contributor in the deterioration of the footings' strength compared to the amount of corrosion and wear, this criteria is included in the analysis as it relates to the design standards and construction methodology used at the time the structure was built.

Current design standards and practices use more stringent requirements that are based on deterministic studies. These use probabilistic principles to identify the type of environment and loads the structure and its footings will be exposed to and support.

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3.3.2 66 kV Footings

Figure 5 shows that the 66 kV transmission line structure footings are generally in good condition. The SOXS program, which has been effective in preventing any unexpected failures, has contributed to the good condition of 66 kV footings.

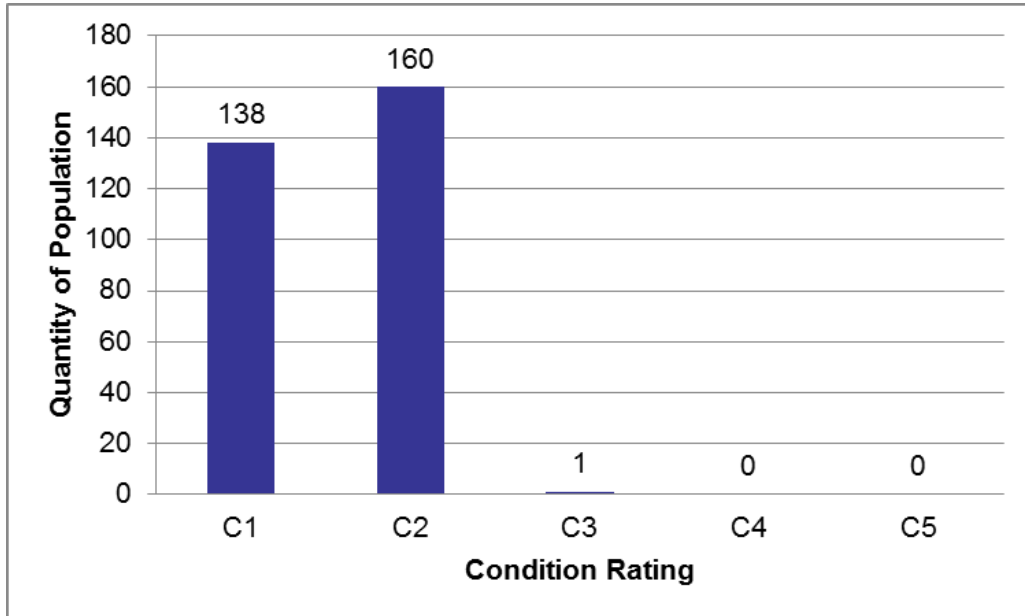


Figure 5 – Condition assessment of the 66 kV footings

3.3.3 220 kV Footings

Figure 6 shows that in the 220 kV transmission line structure footings are generally in good condition. The SOXS program, which has been effective in preventing any unexpected failures, has contributed to the good condition of 220 kV footings.

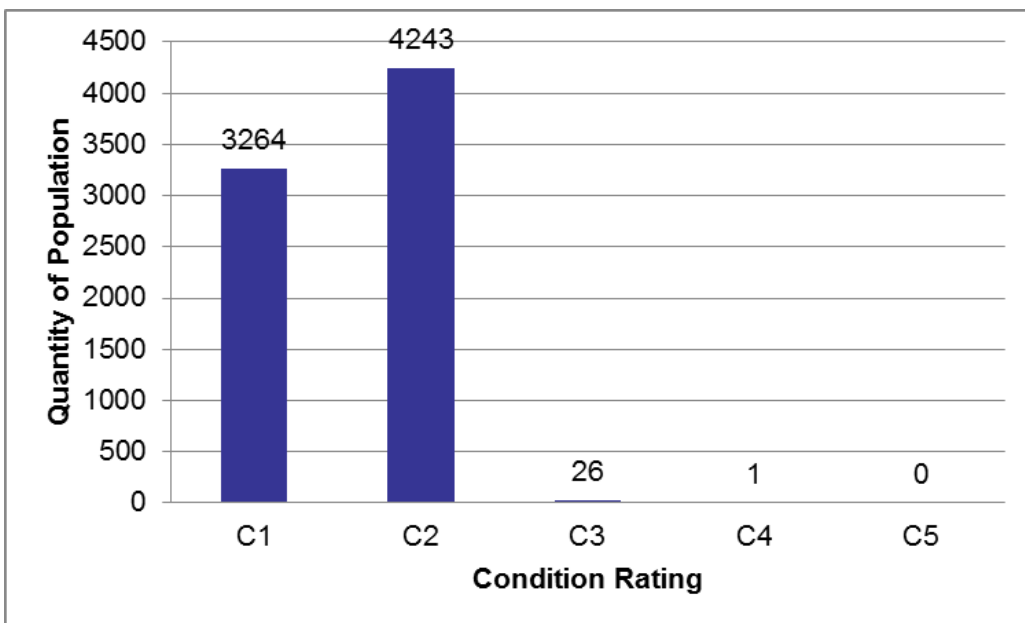


Figure 6 – Condition assessment of the 220 kV footings

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3.3.4 275 kV Footings

Figure 7 shows that the 275 kV transmission line structure footings are generally in good condition and showing first signs of rust. All 275 kV footings are located in the south west of Victoria in a benign environment. The good condition of these footings is expected in a non-aggressive environment like this.

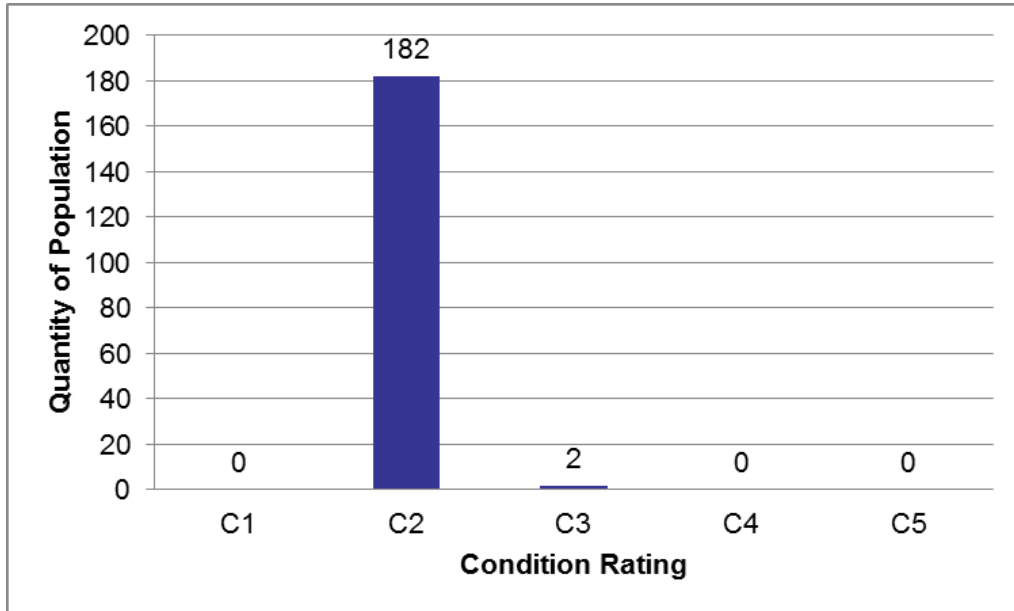


Figure 7 – Condition assessment of the 275 kV footings

3.3.5 330 kV Footings

Figure 8 shows that the majority of the 330 kV transmission line structure footings are generally in good condition. The majority of the 330 kV footings are located in the northern area of Victoria in a benign environment. The good condition of these footings is expected in a non-aggressive environment like this.

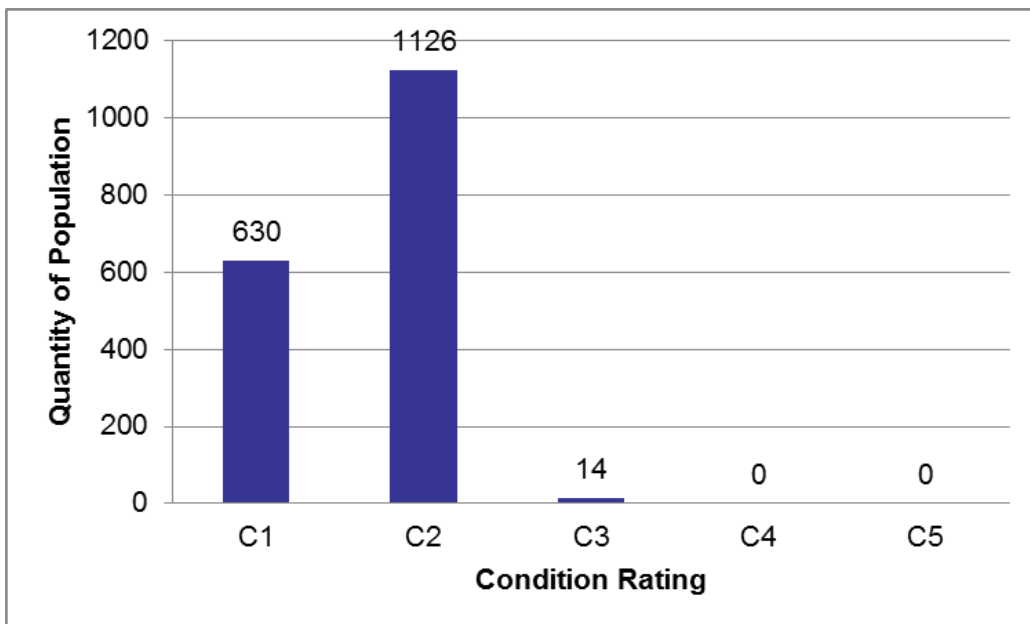


Figure 8 – Condition assessment of the 330 kV footings

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3.3.6 500 kV Footings

Figure 9 shows that majority of the 500 kV transmission line structure footings are generally in good condition. The SOXS program, which has been effective in preventing any unexpected failures, has contributed to the good condition of 500 kV footings.

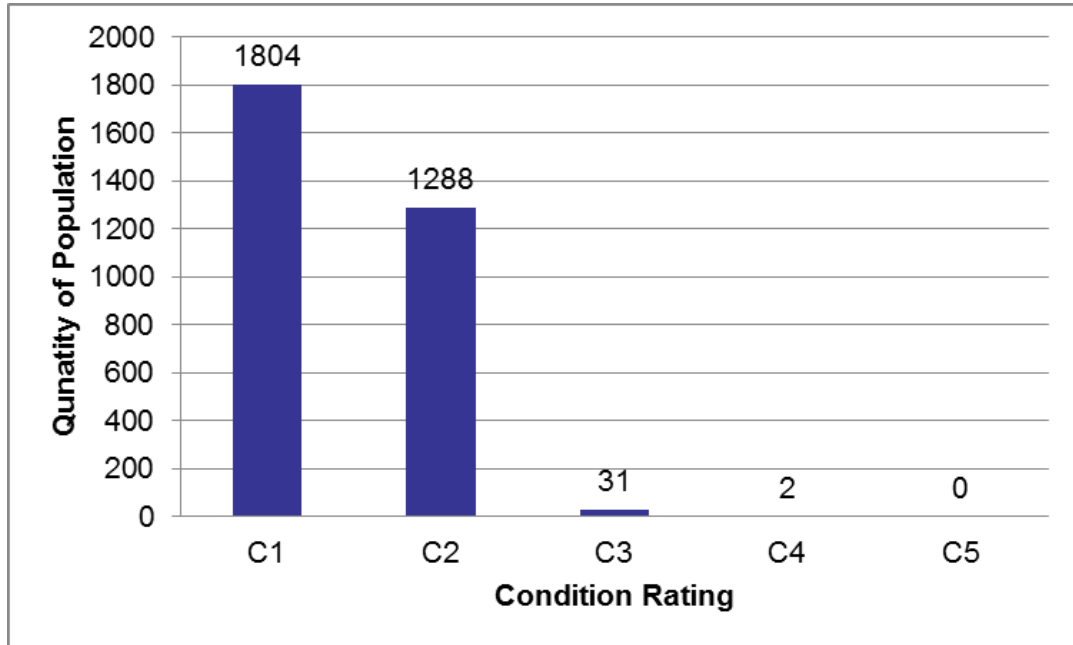


Figure 9 – Condition assessment of the 500 kV footings

3.4 Performance

3.4.1 Work order analysis

AusNet Services has implemented line patrolling and line inspection practices which provide information for objectively estimating the Remaining Service Potential (RSP) of transmission line components or assets and where necessary undertake a timely remedial action. Transmission line structure foundations which require remedial works are actioned via work orders. Structure foundations actioned via work orders do not cause transmission line functional failures and so are classified as suspended failures for RCM asset management purposes.

Over the last ten years there have been a total of 913 suspended failures. The majority of suspended failures were caused by corrosion, representing 55% of the total suspended failures in the period. In most cases rust was found on the tower legs at the ground line where the mix of air and moisture most promotes corrosion. Corrective actions taken to address corroded tower legs involves member strengthening if section loss is identified, cleaning of rusted members and the application of protective paint.

Eight suspended failures were caused by heavy rain and subsequent flooding of tower foundations since 2005. Foundation flooding adds buoyancy to soil reducing the effective weight of foundation overburden and therefore reducing the foundations resistance to conductor uplift forces. Work orders were raised in all cases to drain the tower foundations in order to prevent soil movement which could otherwise trigger tower collapse under wind event conditions.

Figure 10 displays suspended failures by cause over the last ten years. Peaks in volumes of work orders reflect corrosion and wear based issues which formulated early project scopes at the beginning of the SOXS program. Failure rates for corroded tower legs and braces have reduced considerably over the last four years.

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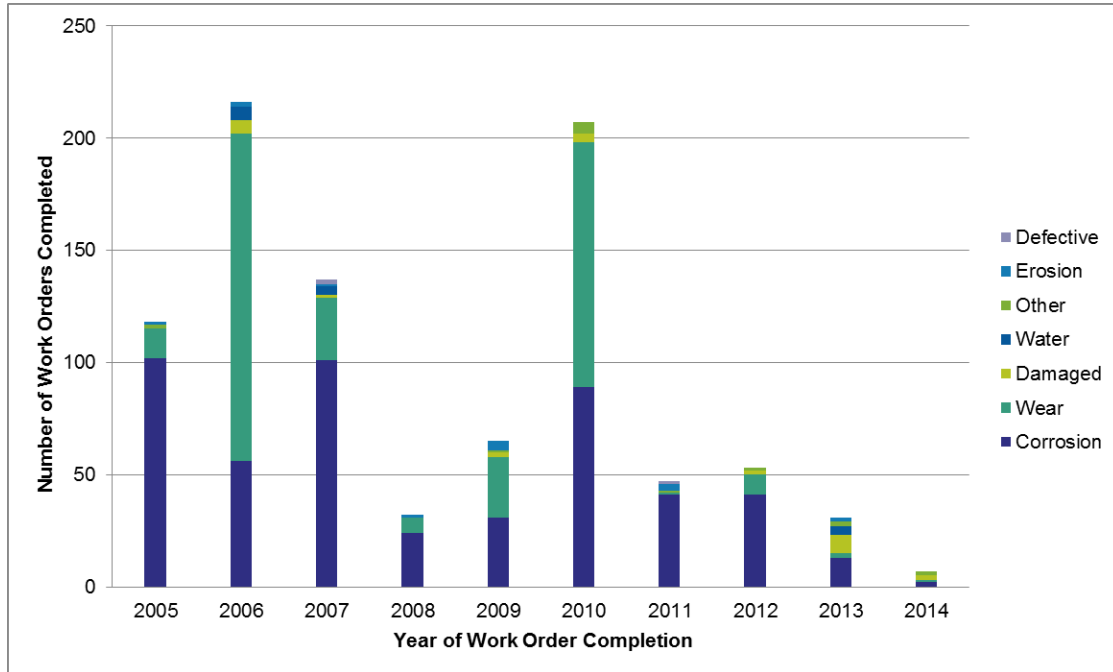


Figure 10 – History of suspended foundation failures

3.4.2 Functional failures

There have been 3 incidents of structure foundation functional failures since 1958. In this context a functional failure of the structure’s foundation results in a functional failure of the transmission line. Such a failure prevents the safe flow of electricity from one terminal station to another which has marginal market costs and in some cases unserved energy costs to the community. Other risk costs arising from a functional failure of a structure’s foundation include unplanned structure replacement, and potential public safety risks associated with failures near roads, railway lines or in areas defined as a high bush fire risk.

Although unrelated, all three incidents took place within a period of two years in the late 1950’s when the transmission network was still under construction. These failures were caused by inadequate strength of grillage type foundation designs. Following these incidents, a program of foundation strengthening works targeting structures with grillage foundation designs was undertaken. Since the completion of this strengthening program in 1968 there have been no foundation failures in Victoria. Table 3 summarises the history of foundation functional failures.

Circuit	Tower No.	Year constructed	Year Failed	Failure mode	Failure cause
EPS-TTS	190	1955	1959	grillage foundation failure	Inadequate strength
MBTS-EPS	not recorded	1955	1958	grillage foundation failure	Inadequate strength
MLTS-TGTS	88	1957	1958	grillage foundation failure	Inadequate strength

Table 3 – Summary of structure functional failures

3.4.3 Consequence of functional failure

Functional failures of structure foundations can result in conductors falling to the ground or onto phase conductors below and can have significant effects or consequences. This type of failure can lead to three different consequence types including health and safety, bushfire ignition and network performance. These consequences are discussed in the following sections and can be qualified using the 1 – 5 scoring system shown on the vertical axis of AusNet Services’ risk matrix which is displayed in Figure 11.

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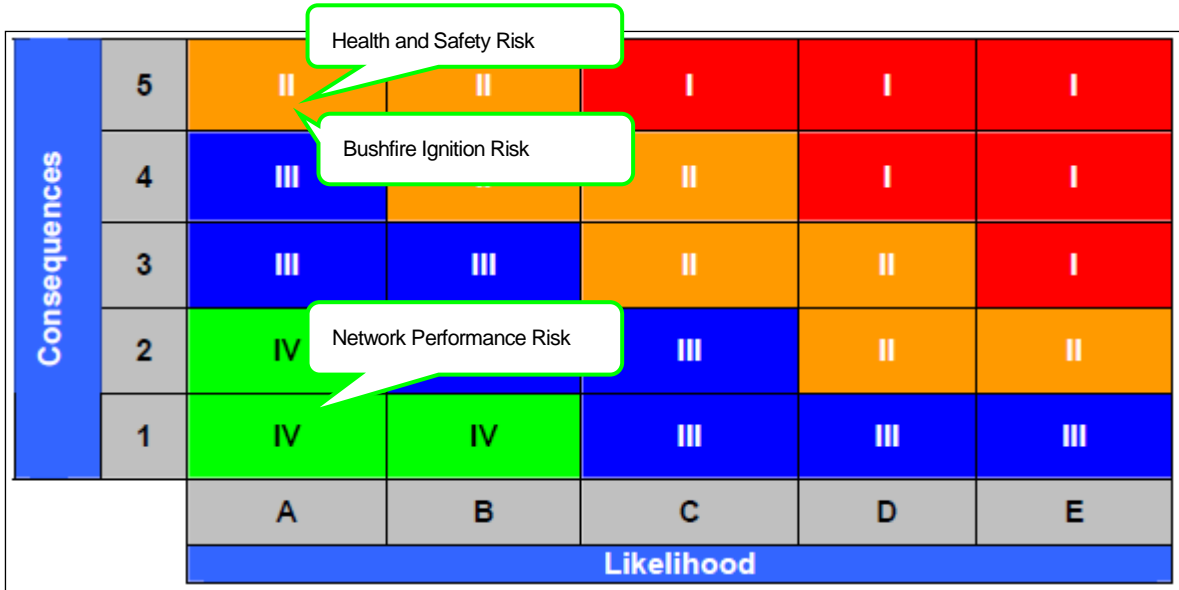


Figure 11 – AusNet Services’ Risk Matrix⁴

3.4.3.1 Health and Safety

Transmission line easements traverse both public and private land where public access to the easement is not restricted. In many instances easements are shared or located next to other infrastructure such as roads, railway lines, pipelines and fences.

Structure foundation functional failures can present health and safety risks to members of the public, or workers accessing the transmission line easements. These risks are especially apparent on structures adjacent to roadways or railway lines where high volumes of people are potentially exposed.

Using the results of a study performed by Vic Roads⁵ in 1994, a quantitative consequence assessment of transmission line spans which cross roads and railways has been completed. The assessment has revealed that a structure foundation functional failure corresponds with a maximum risk rating score of II as per AusNet Services’ risk matrix. There have been no instances of structure foundation functional failures adjacent to roads or railways.

3.4.3.2 Bushfire ignition

The bushfire loss consequence model demonstrates that a structure foundation functional failure corresponds 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 structures is included in AMS 10-77 Transmission Line Structures.

There have been no instances of fire ignition following a functional failure of a structure foundation.

3.4.3.3 Network performance

AusNet Services participates in a number of network performance incentive schemes which are designed to ensure that Victorian electricity consumers and NEM participants are provided with appropriate levels of service. The schemes provide financial rewards for improving network availability and service standards and impose financial penalties for declining network availability and service standards.

Structure foundation functional failures result in system outages which negatively impact on performance levels within the incentive schemes. Impacts on the schemes are compounded when failures occur on radial lines. Financial penalties likely to be imposed can be calculated using guidelines set out by the AER. These calculations indicate that structure foundation functional failure corresponds with a maximum risk rating score of II on the AusNet Services risk matrix.

⁴ AusNet Services Risk Management Framework – RM 001-2006.

⁵ Bureau of Transport and Communications Economics (1994) The Costs of Road Accidents in Victoria – 1988.

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In addition to the cost of financial penalties, foundation failures would require costly emergency response works. The deployment of temporary bypass or Emergency Relief Structures (ERS) would be required in order to rebuild the failed structure(s). Assembly of the ERS is made difficult on some circuits by the remoteness of the easement and challenging terrain.

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.

Presented in Figure 12 and Figure 13, 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 other Australian and New Zealand transmission utilities.

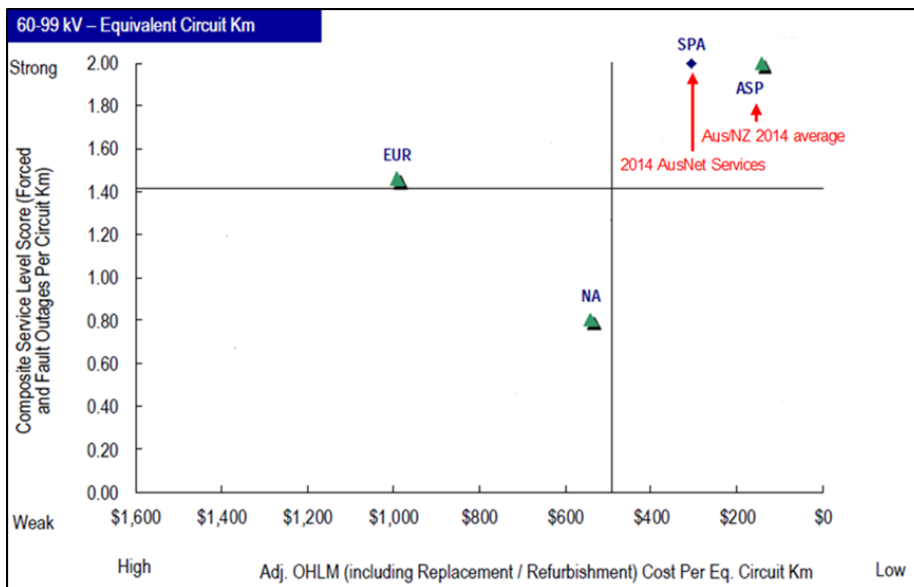


Figure 12 – ITOMS benchmarking 66 kV transmission lines.

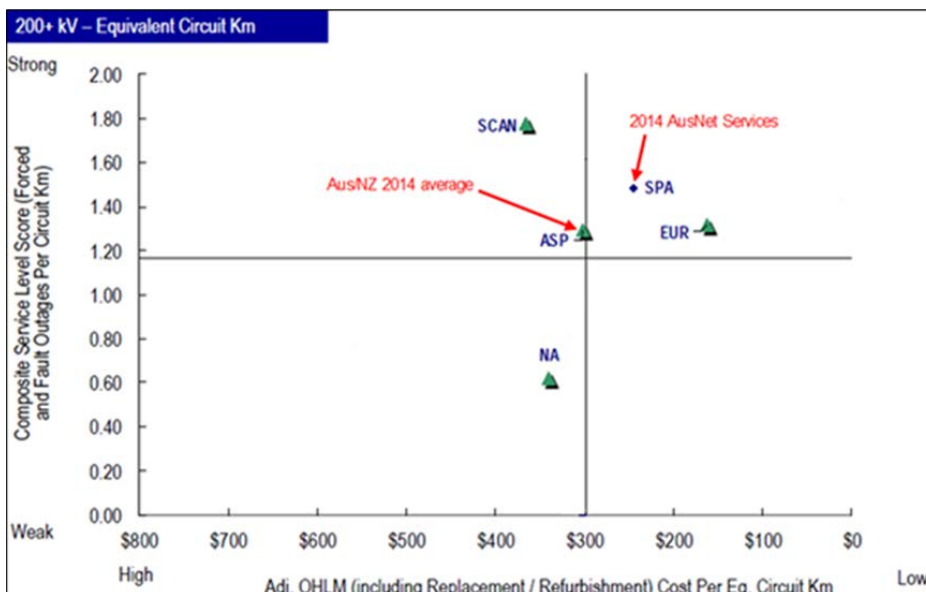


Figure 13 – ITOMS benchmarking 220 kV, 330 kV and 500 kV transmission lines.

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4 Risk Assessment

There are two different types of risk assessments performed for transmission line structure foundations. These risk assessments are based on the results from intrusive inspection and testing of footings (SOXS) and structure earth tests. Remedial actions identified as a result of risk assessments performed may include the installation of cathodic protection systems; which are also discussed in this section.

4.1 Intrusive Inspection and Testing of Structure Footings

4.1.1 Inspection and testing process

In 2001 AusNet Services began intrusive inspections targeting direct buried steel legs; this program is known as the SOXS program. This process involves the excavation of the top end of footings (400mm to 500mm below ground) which enables a visual inspection of otherwise buried footing legs. For the majority of footing legs inspected most will have minimal zinc loss which will be coated with a tough protective paint coating, footings are then back filled.

If significant rust or metal loss is discovered, the excavation is continued down the leg to ensure that compromised members do not remain undiscovered. With appropriate precautions such as tower guying, the entire footing may be excavated for detailed inspection. Once excavated the footing members are sandblasted until clean, steel loss is then measured using callipers and recorded on an inspection sheet. Remedial actions are implemented depending on the amount of section loss identified.

If less than 10% section loss is detected the footing steelwork is painted with Ultra High Build (UHB) epoxy paint or Glass flake vinyl ester paint systems to protect exposed steelwork. If more than 10% section loss is identified, engineering assessments are performed to determine what remedial actions are required. Typical actions include the replacement or reinforcement of badly corroded or damaged members.

Light strain or suspension towers are usually reinforced using steel angle splices which are bolted across the deteriorated section of the member(s)⁶. Degraded footings of heavy strain towers situated next to station racks cannot be economically or safely repaired due to high unbalanced conductor loading so full rating and longevity is restored through the use of concrete piles driven on either side of the existing footing with a tie-beam connecting the piles with the tower leg at a ground level plinth.

The SOXS program targets direct buried steel footings as a priority as these are amongst the earliest built lines and primarily targets direct buried steel footings which were situated close to terminal stations. Direct buried steel footings are prioritised based on the criticality of the line. Structures supported by other footing types are inspected during recurrent tower inspections as detailed in section 3.3.1.1.

Figure 14 illustrates the percentage of footings completed each year, as an accumulated fleet total and the future forecasts of the SOXS program. Approximately 50% of footings were completed by the end of the 2011/12 financial year. AusNet Services intends to continue the SOXS program over the upcoming years. The drivers and of the program are discussed in section 4.1.2.

⁶ AMS 10—77 Transmission Line Structures.

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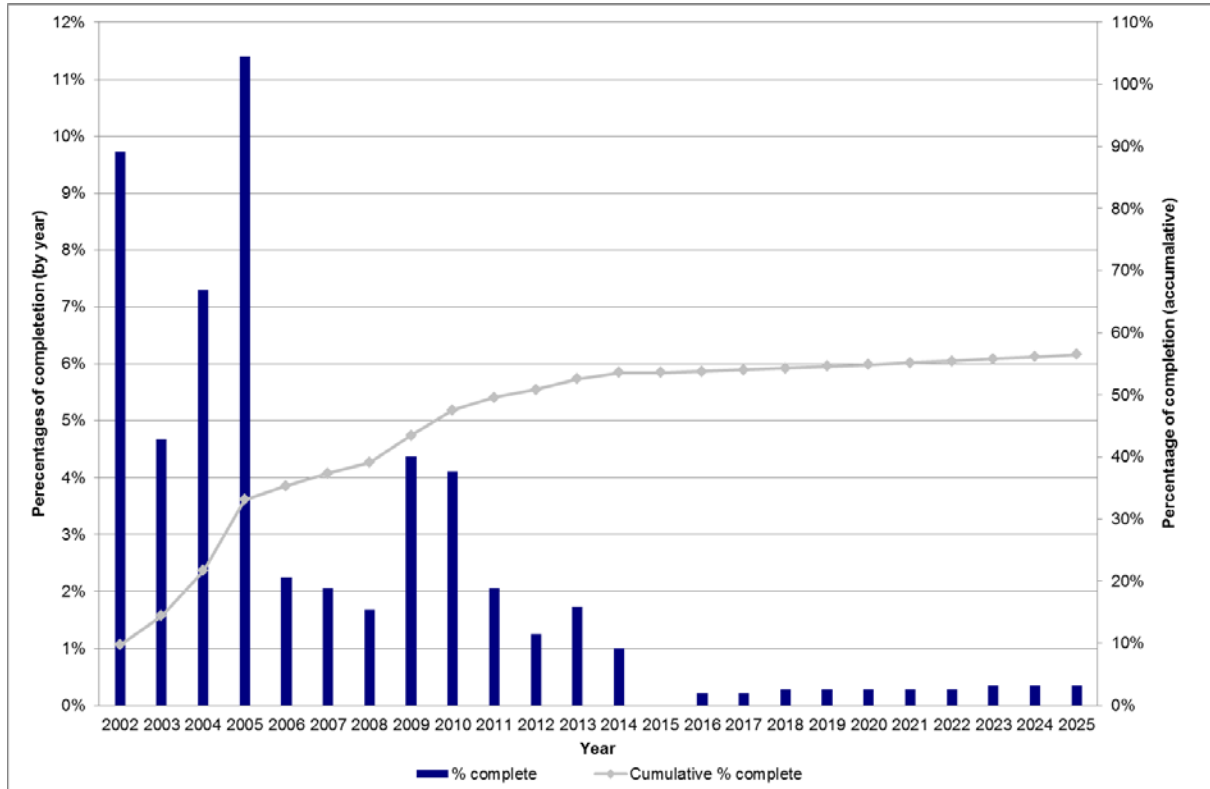


Figure 14 – SOXS program progress and forecast

A process map of risk based decision making used as part of the intrusive and testing process is displayed in Figure 15.

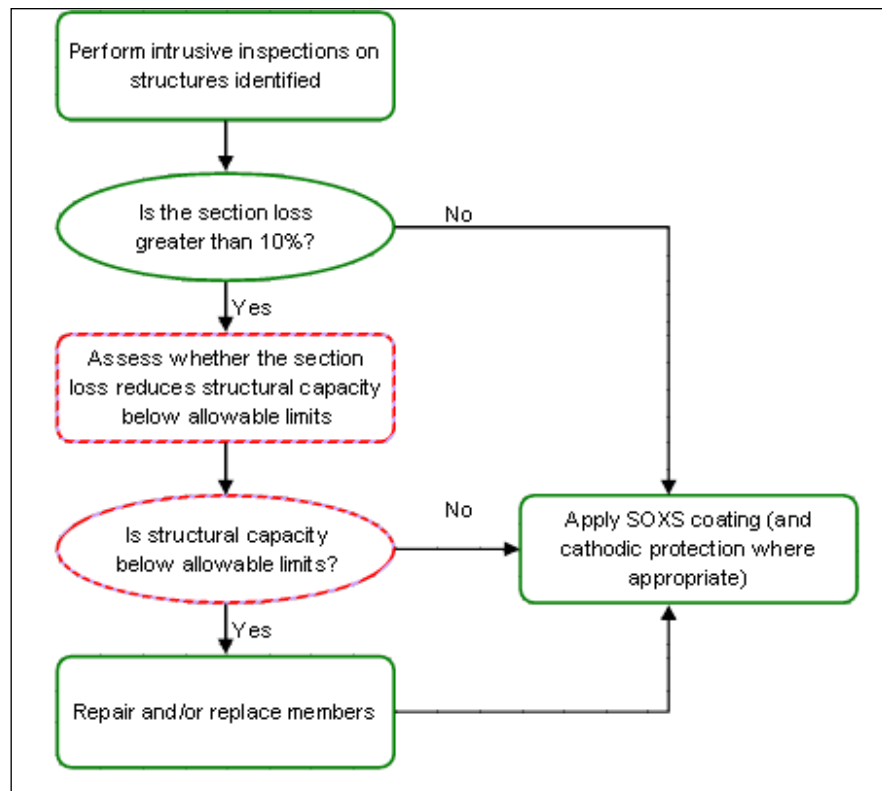


Figure 15 – Intrusive inspection of structure foundations decision-making process

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The first key decision in the process relates to the need to perform a structural capacity assessment, this decision is made based on the amount of metal section loss measured on the structure foundation members.

Risk assessments performed with close consideration of existing design standards⁷, and design standards used in the construction of existing structures, highlight that section losses above ten per cent present unacceptable risks due to reduction of steels inherent material strength over time. Structures with more than ten per cent section loss may or may not be suitable for the application of protective painting to strengthen the structure.

Reductions of inherent material strength coupled with section losses greater than ten per cent reduce the structural capacity of the foundation to levels close to the structural load. When the structural load exceeds the structural capacity the structure will fail. Risk assessment outcomes therefore indicate that foundations with section loss greater than ten per cent may not be suitable for cleaning and painting (SOXS) alone and firstly require a structural capacity investigation.

The second risk assessment is performed as part of the structural capacity investigation. The objective of this risk assessment is to quantify the level of risk and determine the optimum corrective action required. This secondary risk assessment is more detailed than the first and is performed as part of technical engineering assessment. Consideration is given to key factors such as soil types, soil corrosivity, rates of metal corrosion, typical wind loads, local topology, structure orientation, structure and foundation design, proximity of structure to roads/railways and criticality of transmission line in terms of financial incentive scheme performance. The outcome of this risk assessment informs asset managers on the extent of remedial actions which include whether to clean and paint (SOXS), repair or replace members, reinforce foundation or replace foundations.

4.1.2 Drivers

As discussed in section 3.4.3, foundation failures can have significant financial impact on AusNet Services through outage penalties imposed and the cost of emergency rectification works. Although the possible consequences are high there have been no incidents of foundation failure since 1957 indicating that the probability of foundation failure is not high. Although this may be the case, a significant benefit of the SOXS program is the avoidance of costly foundation strengthening works which can be achieved through timely application of protective paint.

A review conducted in FY2015 on the results of the intrusive inspections undertaken since 2009 showed that the number of footings suffering from corrosion attack below ground has declined significantly. This is an indication that tower footings which are most at risk of suffering corrosion have been addressed and it is pragmatic to decrease the SOXS program going forward. This decision is supported by the condition assessment survey which identifies more than 99% of the tower footings' above-ground condition between C1 and C2.

4.2 Structure Electrical Earth Testing

Overhead transmission lines can be struck by lightning during storms triggering line fault events. Under fault conditions fault currents may discharge through the tower foundation and create Earth Potential Rise (EPR) at the tower legs and in soil surrounding the structure foundations. EPR can cause property damage and presents health and safety risks. Poor earthing of structures can lead to line outages following lightning strikes as high resistance drives up structure voltage rise to cause insulator flashover. The subsequent circuit power arc discharge is identified by the electrical protection systems which de-energises the phase conductors.

The electrical resistance of the tower foundations to the general mass of earth are measured during tower construction to verify that the foundation resistances are within accepted limits leading to reliable protection operations and ensuring EPR is within safe limits. The performance requirements of the earthing system may need to change over time for the following reasons:

- changes in ground conditions;
- damage to the earthing system;
- A lower earth resistance may be required due to increased line fault current;
- A lower earth resistance may be required due to changes in the environment surrounding the structures location (e.g. land usage, public access frequency and bushfire risk).

⁷ AS/NZS 7000:2010 Overhead Line Design – Detailed Procedures.

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Analysis of line outage data assists in identifying transmission lines with possible earthing issues. Lines with high outage frequency due to lightning are targeted for structure earth testing. Findings from the resistance tests inform risk assessments and determine the priority and scope of rectifications works.

The earth resistance of the foundations along the HWPS-ROTS 220kV Nos. 1 and 2 lines, which suffered a double outage in February 2010, have been tested and specific towers have been identified for earthing improvement – to be undertaken as a project. The MBTS-DDTS 220kV Nos. 1 and 2 lines will likewise be tested so the line's foundation resistance can be determined and, if necessary, improved.

It is likely that other lines will have to be included in the future test program as the earthing resistance worsens (i.e. becomes higher) as the soil properties change and the foundations deteriorate due to corrosion or natural degradation.

4.3 Cathodic Protection Systems

Sacrificial Cathodic Protection (CP) and Impressed Current Cathodic Protection (ICCP) systems inhibit metal loss by changing the DC voltage relationship between the structure and surrounding soil. CP does this by promoting corrosion of a sacrificial anode. It is far more cost effective than attempting to protect deep exposed steel with SOXS type coatings. ICCP units are installed where towers are bonded to substation earth grids and the current required to prevent corrosion of the galvanized steel is outside the voltage and current range that can be delivered by sacrificial anodes.

There are currently 12 CP sites and 24 ICCP sites in service, the majority of which are connected to structure foundations next to terminal stations. Cathodic protection was first used on the transmission network in 1970 to protect structure foundations close to West Melbourne Terminal Station (WMTS). These units were required to mitigate the adverse effects of stray current on the structure foundation steel work. CP and ICCP units have been installed progressively between 1970 and 2005.

Regular inspections of these installations include bimonthly current readings for ICCP units, and surveys of anodes on CP and ICCP units every 2 years. These inspections have identified that on some installations the sacrificial anodes will have to be replenished as well as the replacement of the transformer rectifier units on some ICCP installations.

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5 Strategic Factors

5.1 Increasing Conductor Replacements

An increase in transmission line conductor replacements is anticipated over the next 10 – 20 years as conductors installed in more aggressive environmental conditions in the 1950s approach the end of their economic life. Conductor replacement and possible augmentation is a major investment and as such the structural integrity of all associated assets, such as insulators, tower members and foundations, must be accurately assessed and forecast to ensure that the scope of replacement and augmentation works is economically based. Foundation strengthening works may be required to ensure an economic service life of replacement conductors can be realised.

5.2 Resources

As the replacement of transmission line assets is expected to accelerate over the next 20 years, a corresponding increase in demand for line replacement resources is expected over the same period. This demand is expected to increase replacement cost rates and allowances will need to be made for this as part of long term capital budget forecasting.

5.3 Foundation Issues

Transmission line structure foundations can face a number of issues. These issues are typically identified through line patrols conducting condition assessments on the transmission elements and/or easement patrol assessing the status of the transmission easements.

Concrete pedestals have been identified as damaged during line patrols. If remedial action is not taken, moisture can enter the structural element which will cause the steel reinforcing bars and legs to develop further corrosion, which in turn decreases the strength of the foundation. The deterioration will eventually require extensive repairs or foundation replacement.

Additionally, soil erosion can occur on tower sites due to environmental factors such as wind, removal of vegetation or changes in water levels, as demonstrated by three 220 kV tower foundations located outside Hazelwood Power Station. Lack of remedial action introduces a risk of tower foundation failure which reduces overhead line reliability. Backfilling with rock has been the soil erosion mitigation method used in the past however this has been unsuccessful. Moving forward, it is recommended to install permanent sheet piling retaining walls and then backfilling.

Furthermore, widespread flooding of structure foundations and wombat holes on the foundations are known issues. Widespread flooding has occurred in recent years due to wetter than average climatic conditions. Flooding events are expected to become more frequent in future years as one of the widely accepted adverse effects of global warming. Wombat holes have also been found to be an issue which requires the relocation of the wombats and then the backfilling of the holes with either concrete or densely compacted fill.

Transmission Line Structure Foundations

6 Key Issues

The key issues associated with transmission line structure foundations are as follows:

- Structure footings corrode at ground line due to a mix of air and moisture.
- Structure foundations can be compromised by flooding due to wet weather events.
- Corrosion of direct buried steel footings is accelerated by electrical currents circulating between structure earths and a nearby terminal station earth grid or from stray currents from DC traction supplies. Cathodic protection systems are necessary to mitigate this effect in selected locations.
- Electrical fault currents may discharge through the tower foundations and create earth potential rise (EPR) at the tower legs and in soil surrounding the structure foundations and drive increased line trip events.
- Structure footing legs can be damaged by vehicles or farming machinery.
- Data records for structure foundations in the asset information system lack sufficient technical detail for future targeting of economic remedial works.

Transmission Line Structure Foundations

7 Strategies

Implementation of the following strategies is required for prudent and efficient management of transmission line structure foundations:

- Continue to perform visual inspection of structure footings as part of the routine inspection cycle.
- Continue to monitor the status of the tower site and foundation for flooding, vegetation and erosion to assure the safe performance of all structures.
- Continue to perform life extension works on damaged or corroded footings identified as part of the SOXS program.
- Continue the program of inspections for cathodic protection systems. The effectiveness of cathodic protection systems is maintained by inspecting and replenishing anodes.
- Implement the use of Field Mobile Inspection (FMI) technologies to automatically update the asset information system with condition assessment data.