Pole Top Capacitors

AMS – Electricity Distribution Network

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Disclaimer

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1 Executive Summary

This document is part of the suite of Asset Management Strategies relating to AusNet Services' electricity distribution network. The purpose of this strategy is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of Pole Top Capacitors.

This strategy applies to the 86 pole top capacitors installed on 22kV distribution feeders. Each Pole Top Capacitor consist of capacitors, a switch with integral sensors and controller.

Condition assessment shows that most are in good/average operating condition (C1 to C3) and approximately 13% of the population were found to be either in "Poor" condition (C4) or "Very Poor" condition (C5). Failure analysis for 2015-2018 period show capacitor controller failures contribute to 50% of the total failures.

A risk assessment indicates that failure risk cost is low compared to cost of replacement and does not warrant a proactive risk based replacement program at this time. However certain pole top capacitors can become important under N-1 feeder operating conditions and the present pole top capacitors are not able to be connected to SCADA or remotely monitored in real time. Investigation and development of SCADA connected pole top capacitor controller is a strategic development. The summary of proposed asset strategies is listed below.

1.1 Asset Strategies

1.1.1 New Assets

- Continue to procure pole-top capacitors in accordance with DES 10-03;
- Update controller specification to include SCADA facility for remote monitoring

1.1.2 Inspection

- Continue with routine visual inspection program and conduct thermo-vision scans where required
- Update and document the inspection criteria in the Asset Inspection Manual;

1.1.3 Maintenance

- Review the capacitor control method (permanently ON, current or voltage controlled) periodically with distribution network modifications

1.1.4 Spares

- Maintain strategic spares holding of one complete unit of pole top capacitor assembly with controller, vacuum switches and associated instrument transformers per region

1.1.5 Replacement

- Continue Reactive replacement based on inspection and monitor controller failure rates
- Investigate economics of providing SCADA indication and control for summer critical pole top capacitor units, when available

2 Introduction

2.1 Purpose

The purpose of this document is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of pole top capacitors in AusNet Services' Victorian electricity distribution network. This document is intended to be used to inform asset management decisions and communicate the basis for activities.

In addition, this document forms part of our Asset Management System for compliance with relevant standards and regulatory requirements. It is intended to demonstrate responsible asset management practices by outlining economically justified outcomes.

2.2 Scope

This asset management strategy applies to all medium voltage pole-top capacitors associated with the AusNet Services electricity distribution network.

Medium Voltage Capacitor Banks installed in zone substations are covered under AMS 20 -53.

2.3 Asset Management Objectives

As stated in *AMS 01-01 Asset Management System Overview*, the high-level asset management objectives are:

- Comply with legal and contractual obligations;
- Maintain safety;
- Be future ready;
- Maintain network performance at the lowest sustainable cost; and
- Meet customer needs.

As stated in *AMS 20-01 Electricity Distribution Network Asset Management Strategy*, the electricity distribution network objectives are:

- Improve efficiency of network investments;
- Maintain long-term network reliability;
- Implement REFCL's within prescribed timeframes;
- Reduce risks in highest bushfire risk areas;
- Achieve top quartile operational efficiency; and
- Prepare for changing network usage.

3 Asset Description

3.1 Asset Function

Pole–top capacitors are used to provide reactive power at selected locations in medium voltage feeders to improve the energy transfer efficiency of the immediate and upstream network.

In the long radial sections of the medium voltage network, the pole-top capacitors produce a “leading” current that offsets or reduces the “lagging” load current. Compensating the lagging current reduces the network’s electrical losses. Pole-top capacitors are strategically positioned closer to the loads causing the “lagging” current to achieve this performance.

The pole-top capacitor installation consists of three capacitor cans, a voltage transformer, three single phase switches, current sensors, surge arresters and three single phase MV fuse switches to protect and as required isolate each phase. These pole-top capacitors are operated by controllers and are either permanently on, voltage controlled or current controlled depending on the requirement at the location.

Appendix1 shows a typical Three-Phase Pole-Top Capacitor with one capacitor can per phase.

3.2 Asset Population

AusNet Services has a total of 86 pole top capacitors installed in 22kV distribution feeders. The population of pole top capacitors and the capacitor controller by manufacturer are shown in Figure 1 & 2.

C.I.C

C.I.C

AusNet Services is using mainly two types of pole-top capacitor banks, [C.I.C]. Pole top capacitor assemblies are generally supplied as a complete package including the Capacitor cans, Vacuum switches and Controller.

Key manufacturer types of pole top capacitor assemblies, vacuum switches and capacitor controllers are shown in Table 1.

Table 1: Key manufacturers of Pole top capacitor components

Pole Top capacitor assembly	Vacuum Switches	Capacitor Controller
C.I.C		

3.3 Asset Age Profile

The service age profile of the pole-top capacitors as of 2018 is shown in Figure 3 below. Average age of pole top capacitors and controllers is about 9 years oldest being 17 years. It is noted that 71% of the controllers are older than 10 years and 12% of the capacitor units are older than 10 years.

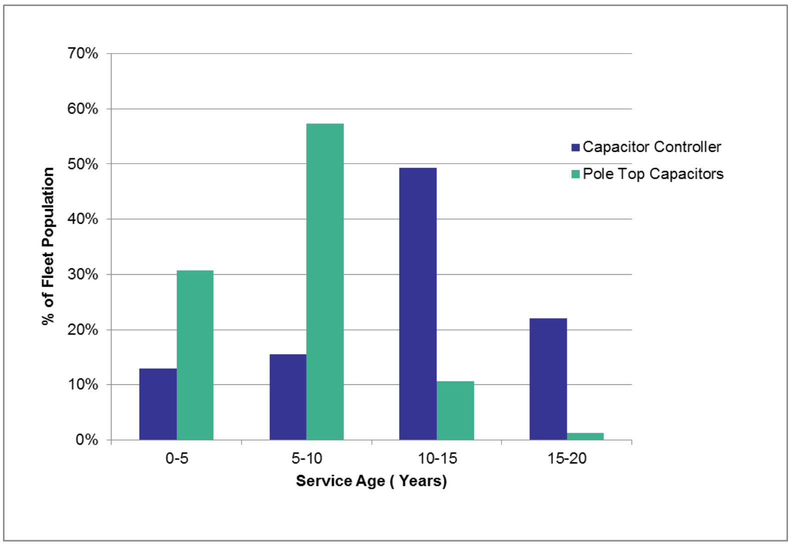

Figure 3 – Pole top capacitor and Capacitor Controller population by Service Age

3.4 Asset Condition

Table 2 provides the condition assessment criteria of distribution Pole-Top Capacitors.

Table 2 – Condition Assessment Criteria

Score	Condition	Condition Description
C1	Very Good	· Incorporates the new pole-top capacitors that are generally new. · Are in an acceptable visual condition with no signs of corrosion, tracking or defects/ damage · Have no historical problems with capacitors ,vacuum switches, or VTs or capacitor controllers · continue to perform visual inspection and conduct thermo-vision scans
C2	Good	· Are in an acceptable visual condition with no signs of corrosion, tracking or damage · Their controller technology is up to date for its service age · Have very few minor problems which does not require immediate intervention or show any trend of deterioration of condition of performance · continue to perform visual inspection and conduct thermo-vision scans
C3	Average	· Are in an acceptable visual condition with minor signs of corrosion, tracking or damage · They are in an average condition for its service age and older technology type · Have no more than one historical intervention : fuse failures, issues with vacuum switches or controllers · continue to perform visual inspection and conduct thermo-vision scans
C4	Poor	· Developing signs of deterioration and or corrosion ,cap can leaks, occasional fuse failures · Have no more than two historical interventions due to fuse failures ,cap can leaks /defects , issues with vacuum switch operations or controller interventions. Controllers becoming obsolete /unsupported · Maintenance of these pole top caps becoming uneconomical and becoming unreliable and poor performance
C5	Very Poor	· Are showing signs of significant deterioration and or corrosion ,capacitor can failures ,recurrent fuse blowing and it does not provide required VAR support when required. · These PTCs are approaching end of economic life and technical life. · Have historical problems and causing customer outages and they are unreliable. Their controller technology is obsolete and cause frequent malfunction · Maintenance of these pole tops capacitors are uneconomical compared to asset replacement

Condition profile of Pole top capacitors and capacitor controllers are shown in Figure 4.

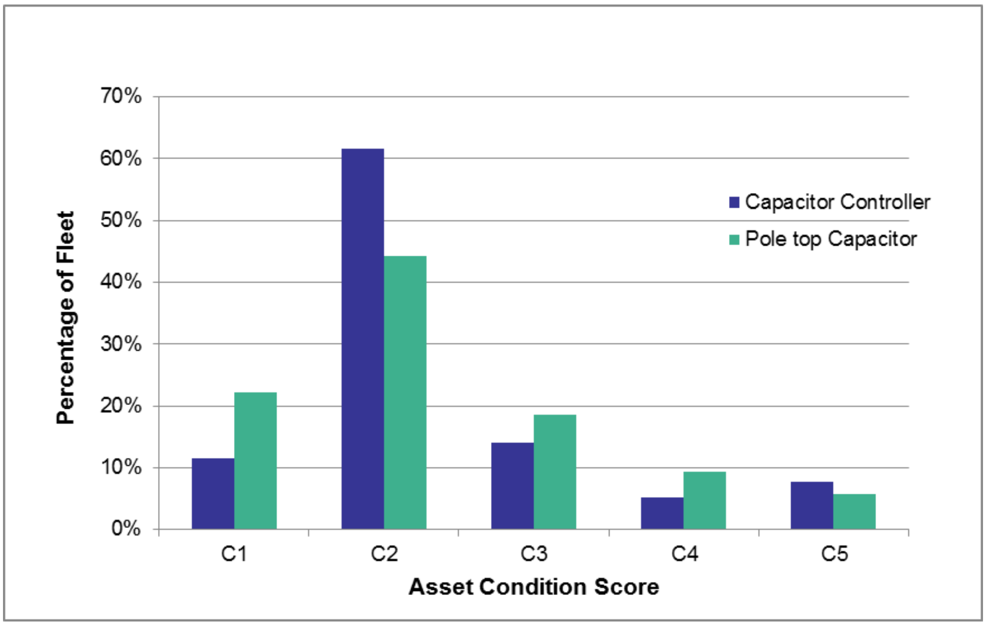

Figure 4 – Condition Profile of Pole Top Capacitors and Capacitor Controllers

All pole top capacitors are below 20 years old, yet some have developed issues in them mainly due to capacitor controller failures, CT & VT failures, vacuum switch failures leaving the pole top capacitor becoming non-functional, malfunction or defective.

Pole top capacitors are not connected to SCADA real time system and hence not able to monitor them remotely. Defects in primary equipment associated with capacitor units are found during visual inspections but controller failures are not detected always unless tested. Hence the condition of controllers cannot be properly assessed. Approximately 13% of the pole top capacitor units (with controllers) were assessed as C4 or C5 asset condition.

3.5 Asset Criticality

Asset criticality that is the consequence of functional failure, of pole top capacitors is low due to lower safety impact, collateral damage impact and community impact. Malfunction or non-functioning of a pole top capacitor affects mainly customer power quality and increase in power losses of the network. Certain pole top capacitors become important during load transfers in the event of feeder failures during certain time of the year to maintain the voltage quality of customers but their criticality level is expected to be low during majority of the year.

3.6 Asset Performance

AusNet Services routinely analyses the root cause of unplanned work undertaken on pole top capacitors and investigates all major failures and tracks their effects on power quality to the customers.

3.6.1 Planned Inspections

All pole mounted capacitors are subjected to regular condition inspections in conjunction with line asset inspections in accordance with the Asset Inspection Manual (4111-1).

Pole-mounted capacitors are visually inspected together with their support structure every 37 months in the Hazardous Bushfire Risk Areas (HBRA) while pole-mounted capacitors in non-HBRA regions are inspected every 61 months.

A small portion of pole-top capacitors are inspected annually as a business requirement under the summer preparation regime. The operation of these pole-top capacitors is important during the peak loading period each summer to ensure that voltage profiles are maintained and for the network to perform efficiently.

Periodic inspection of pole-top capacitors includes:

- Visual examination of the pole-top capacitors looking for foreign materials and damaged or excessively dirty components;
- Visual examination of all capacitor units looking for damaged or excessively dirty bushings, leakage or unusual swelling;
- Visual examination of all electrical connections for signs of overheating. A thermal scan may also be performed on all electrical connections to check for overheated electrical joints;
- Examination of all metal parts for signs of corrosion.

3.6.2 Corrective Maintenance

Records of unplanned maintenance work undertaken on pole top capacitors are based on proactive and reactive works performed on them and are maintained in SAP.

Figure 5 below shows the number of inspection based reactive based work orders in 2015 -2018 period.

All pole top capacitors are less than 20 years old and relatively new. It is observed the failure rate of pole top capacitors have decreased over the last four years due to the inspection based maintenance carried out in them. Failures reported are mostly random in nature mainly due to fuse failures, vacuum switch failures, capacitor cans failures, current or voltage transformer failures while controller failure being the most common type of failure.

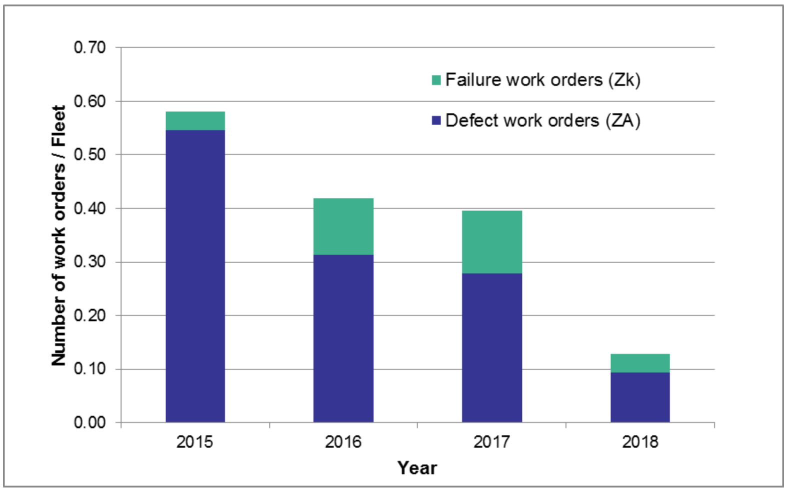

Figure 5 – Number of Work orders/fleet 2015-2018

3.6.3 Major Asset Failures

Number of major defects and failures associated with pole top capacitors and controllers during the 2015- 2018 period is shown in Appendix 2.

14 defective pole top capacitor assemblies were found during the 2015-2018 period (see Appendix 2) due to numerous defects. This is equivalent to about a 4% pole top capacitor functional failure per year.

It was observed that 50% of the failures are due to capacitor controller failures, 21% due to instrument transformer issues and about 14 % due to capacitor units. Re-programming of controller and unknown causes contributed to about 14%. It is observed that 86 % of the controller failures had controller service age over 11years.

4 Other Issues

4.1 Non availability of Remote Monitoring

Pole top capacitors are not connected to SCADA system and their functioning will not be known unless there is visual damage of primary equipment visible to the naked eye. Capacitor Controller failure is the common mode of failure and will not be known unless it is tested on site. As no on-line monitoring facilities are available, it is possible that a pole-top capacitor failure may go undetected until annual inspection is done for summer preparedness that again checked only on fraction of pole top capacitors. It is expected that random controller failures may increase with age after 10 years and hence managing pole top capacitor fleet without remote monitoring could become challenging.

5 Risk and Option Analysis

The consequential risk is currently low compared to cost of replacement t and hence does not warrant proactive risk based replacement program. Inspection and condition based repair or replacement on end of life is the continued option for pole top capacitors and their controllers.

6 Asset Strategies

6.1 New Assets

- Continue to procure pole-top capacitors in accordance with DES 10-03;
- Update controller specification to include SCADA facility for remote monitoring

6.2 Inspection

- Continue with routine visual inspection program and conduct thermo-vision scans where required
- Update and document the inspection criteria in the Asset Inspection Manual;

6.3 Maintenance

- Review the capacitor control method (permanently ON, current or voltage controlled) periodically with distribution network modifications

6.4 Spares

- Maintain strategic spares holding of one complete unit of pole top capacitor assembly with controller, vacuum switches and associated instrument transformers per region

6.5 Replacement

- Continue Reactive replacement based on inspection and monitor controller failure rates
- Investigate economics of providing SCADA indication and control for summer critical pole top capacitor units, when available

Appendix 1 – Typical Three-Phase Pole Top Capacitor Assembly

Appendix 2 – Defects/Failures of Pole Top Capacitors and Capacitor Controllers 2015–2018

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