Program of Works

2017 – 2022

Transformer Bushing Online Monitoring

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1 Summary

PROGRAM	Transformer Bushing On Line Monitor Installation
SERVICE DATE	On-going throughout period 2017/18 – 2021/22
LOCATION	3 Terminal Stations
VALUE	$500k

Table 1 – Program overview

1.1 Program Scope

Install locally accessed online monitors (OLM) on the bushings of six of the main interconnector transformers at three terminal stations. The scope includes:

- retrofitting transducers to bushing capacitive taps and terminating them at ground level;
- coupling alarms to existing transformer protection system;
- specifying and procuring monitors; and
- installing monitors.

1.2 Program Expenditure Forecast

2017/18 ($k)	2018/19 ($k)	2019/20 ($k)	2020/21 ($k)	2021/22 ($k)	Total ($k)
100	100	100	100	100	500

Table 2 – Program timing and expenditure summary

2 Program Drivers

- Network reliability, quality and security of supply:
  - To mitigate the need for offline testing of bushings – therefore increase the availability of the transformers while reducing the risk of bushing and transformer failure.
- Safety and Environment:
  - Prevent explosive failure of bushings that pose a safety risk.
  - Reduce the need for high voltage testing.
  - Reduce the need to work at heights.
  - Reduce the need to perform testing under time constraints.

- Financial Impacts:
    - Failure of transformer bushings and resultant transformer outages may result in market impact costs[1].
    - The prevention of financial penalties from incentive schemes[2].
    - Increased costs associated with emergency replacements following major failures.
    - Costs associated with collateral damage to the adjacent plant caused as a result of oil fires and projectiles.
    - Costs associated with injuries / fatalities arisen to staff and contractors working on site as a result of fires and projectiles.
- Regulatory Compliance:
    - To comply with all applicable obligations or requirements associated with the provision of transmission services including capital expenditure objectives as described in National Electricity Rule 6A.6.7a and obligations set out in the Electricity safety Act. Rule 6A.6.7a requires the Transmission Network Service Provider (TNSP) to propose capital expenditure forecasts which meet the expected demand, comply with applicable regulatory requirements, and maintain the quality, reliability and security of supply of both prescribed transmission services and the transmission network. Under the Electricity Safety Act the TNSP must design, construct, operate, maintain and decommission its supply network to minimise as far as practicable the hazards and risks to the safety of any persons or damage to any person's property arising from the supply network.
- Corporate Image:
    - To maintain good corporate image as a prudent asset manager by managing risk as low as practicable.

3 Obligations

The National Electricity Rules (clauses 6A.6.6 and 6A.6.7) require AusNet Services to forecast operating and capital expenditures to, amongst other objectives, *comply with all applicable regulatory obligations or requirements associated with the provision of prescribed transmission services.*

The Electricity Safety Act (clause 98) requires a major electricity company, such as AusNet Services to design, construct, operate, maintain and decommission its supply network to minimise as far as practicable—

(a) the hazards and risks to the safety of any person arising from the supply network; and

(b) the hazards and risks of damage to the property of any person arising from the supply network; and

(c) the bushfire danger arising from the supply network.

[1] Market Impact Parameter Scheme (MIPS).

[2] Availability Incentive Scheme (AIS) and AER Performance Incentive (PI) Scheme.

In the definitions of this Act, the term 'practicable', means having regard to—

(a) the severity of the hazard or risk in question; and

(b) the state of knowledge about the hazard or risk and any ways of removing or mitigating the hazard or risk; and

(c) the availability and suitability of ways to remove or mitigate the hazard or risk; and

(d) the cost of removing or mitigating the hazard or risk;

This means "as low as reasonably practicable" which has been interpreted as until the safety related costs are (grossly) disproportionate to the safety related benefit.

The Occupational Health and Safety Act requires AusNet Services to provide and maintain so far as is reasonably practicable for employees a working environment that is safe and without risks to health.

4 Overview

Bushings are a key component of power transformers – unfortunately a bushing failure more often than not also damages the transformer. Bushings have a very concentrated insulation system that is subject to deterioration. Regular measurement of the insulation condition is currently done by off line testing to record and trend the insulation deterioration.

On line monitoring will provide a more complete understanding of the deterioration of the bushing insulation condition especially for those bushings that have reached a stage in their life where deterioration and age are related. With more data available, trends can be established without taking outages or running the risk of outages being cancelled due to network requirements. It also allows outages to be planned based on condition rather than time, and allows outages to coincide with other planned outages offering increased flexibility in managing network availability.

The transformers chosen for the installation of online bushing monitoring have network and interconnection significance. These transformers constrain the network when they are not available and their bushing conditions are at the turning point in their life. The intended plan is to make connections to the capacitive taps of the identified bushings that will allow on-line measurement of dielectric dissipation factor (DDF) and capacitance. Monitors will most cost effectively be located at ground level adjacent to the transformer for on-site interrogation allowing the periodic downloading of measurement history for trending analysis and diagnostics. In addition to local monitoring, some alarm points can be coupled with other transformer alarm signals allowing downloading to be undertaken as a result of an alarm.

Ultimately, this plan will improve the planning and scheduling of outages and or replacements potentially extending bushing life beyond what was possible without online monitoring. Ideally WAN / SCADA viewings of the data would be the installed solution, but this solution is not economic and less practical to implement in these older terminal stations. Table 3 shows the transformers proposed to have on-line monitoring installed.

Station	Transformer	Configuration
HWTS	A1 – 500/220kV	3 phase
HYTS	M1 – 500/275kV	3 phase
	M2 – 500/275kV	3 phase
SMTS	F2 – 500/330kV	3 x single phase

Table 3 – Selected Monitor Installations

5 Risk

Installation of monitors allows a finer level of condition knowledge and allows bushings to be refurbished or replaced prior to a failure. Adding OLM reduces the likelihood that a bushing will fail resulting by reducing:

- safety risk to people and network unavailability;
- unplanned capital expenditure;
- environmental impact and associated poor public image.

6 Options

6.1 Option 1 – Do nothing

The 'do nothing' option means AusNet Services continues with the current program of time-based (typically six-yearly) offline bushing inspections and testing. Difficulties obtaining outages presents the risk that maintenance will be deferred and the condition of the bushings will not be understood. This has the potential consequence of a failure that may have otherwise have been prevented, reducing the chance of extended transformer outages and costly repairs.

6.2 Option 2 – Install monitors for local access

Option 2 entails installing bushing monitors on four 500kV main system transformers stipulated in Table 3.

The installation involves:

- installing transducers to bushing capacitive taps;
- terminating transducers into monitoring system at the ground level;
- wiring alarms to existing transformer protection systems; and
- interrogation of monitoring system locally with transformers remaining in service.

The benefits of this option are that the transformer remains in service requiring removal from service only if the online condition dictates as such. Bushings can be interrogated at any time and more frequently, providing more data for trending and correlation with load and temperature.

This option is considered the most cost effective means of online bushing monitoring as it does not require extra infrastructure to provide the data remotely. This option is estimated to cost $500k for the four transformers.

This is the preferred option.

6.3 Option 3 – Install monitors for remote access

Option 3 expands on option 2 by installing the infrastructure necessary to interrogate the monitors remotely in SCADA and engineering systems.

The cost is estimated at $980k with the only additional functionality being the reduced requirement to drive to site to retrieve data.

This option is not recommended for the brown field installations such as those stipulated in Table 3.

7 Recommended Action

Install transformer bushing monitors as per Option 2.

8 Reference Documents

AMS 10-67 Power Transformer and Shunt reactors.