# Program of Works

# 2017 – 2022

## Circuit Breaker Online Monitoring

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| **Document number** | N/A |
| **Issue number** | 1 |
| **Status** | Approved |
| **Approver** | S. Owens |
| **Date of approval** | 14/07/2015 |

# ISSUE/AMENDMENT STATUS

| Issue No | Date | Description | Author | Approved |
|---|---|---|---|---|
| 1 | 14/07/15 | Initial document | C. Yates | S. Owens |
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# Table of Contents

# 1 Summary

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| **PROGRAM** | CB On Line Monitor Installation |
| **SERVICE DATE** | On-going throughout period 2017/18 – 2021/22. |
| **LOCATION** | 2 Urban Terminal Stations |
| **VALUE** | $170 k |

Table 1 – Program overview

## 1.1 Program Scope

Install locally accessed online CB monitors (OLM) on five live tank CBs and five dead tank circuit breakers at two metropolitan terminal stations. The scope includes:

- Retrofitting transducers;
- Re-terminating existing transducers and inputs;
- Specifying and procuring OLMs;
- Install Monitor;
- Developing OLM procedure.

## 1.2 Program Expenditure Forecast

| 2017/18 ($k) | 2018/19 ($k) | 2019/20 ($k) | 2020/21 ($k) | 2021/22 ($k) | Total ($k) |
|---|---|---|---|---|---|
| 70 | 100 | - | - | - | 170 |

Table 2 – Proposed cash flow summary

# 2 Program Drivers

- Network reliability, quality and security of supply:
  - The failure of these CBs will result in unplanned extended outages of the failed CB and may cause adjacent circuit outages due to collateral damage caused by the failure.
- Safety and Environment:
  - Failure of bulk oil CBs can result in explosions and fires. The large volume of oil within the CB (CB) tank may spill oil and spread oil fires. Further, failure of porcelain bushings on these CBs can result in projectiles. All of these will present a safety risk to people working in the switch yard. Spillage of oil also poses environmental hazards as bulk oil CBs are not positioned within a bunded area.

Financial Impacts:

- Failure of the CBs may result in market impact costs;[1]
- The 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.

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.

[1] Market Impact Parameter Scheme (MIPS).

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

# 4 Overview

Interrupters of dead tank SF6 circuit breakers are not designed to be maintained in situ as opening SF6 chambers in open air is problematic - instead they require a workshop overhaul. Furthermore the interrupting chambers are not designed be routinely maintained like a bulk oil or minimum oil CBs.

The mean time to failure (MTTF) for electronic equipment – particularly within an outdoor enclosure – is around 15 years. The corresponding lifespan for primary electrical assets is notionally 45 years. Furthermore, CBs are subject to a random failure profile for up to the first 20 years of service. As a result no value is gained by installing electronic monitoring equipment for the first 15 years of service – the monitor is likely to fail at the point that the information becomes useful. Figure 1 shows the notional intended life cycle of a dead tank circuit breaker:

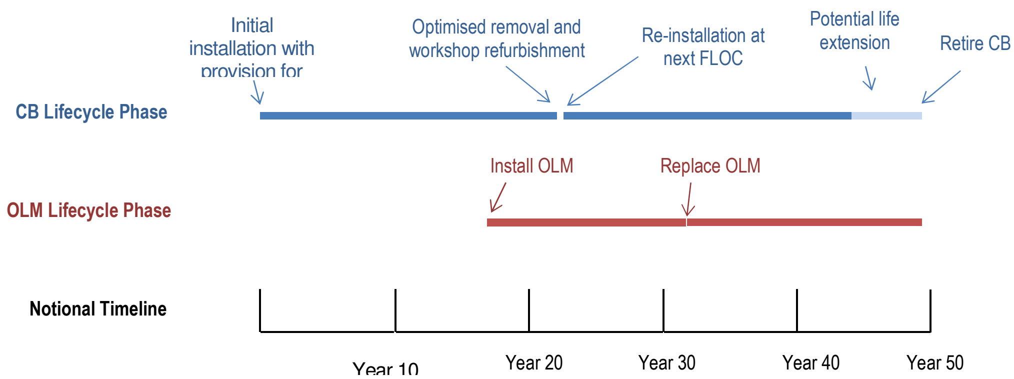


Figure 1 – CB and OLM Lifecycle

The CB itself has two life phases – initial installation and half-life refurbishment re-installation. The CB is initially installed with provision for monitoring; however the monitor is not installed nor even purchased. The monitor will then be installed after around 15 years to provide detailed condition information and allow the half-life refurbishment time to be optimised. The monitor is intended to be modular (plug and play) so that it can be installed and replaced without requiring an outage. The CB is replaced - with a previously refurbished CB - and transported to a workshop for complete refurbishment. Once refurbished it is swapped into service for the next refurbishment in a different functional location. The monitor is then used to trend condition and optimise the decommissioning of the CB – in many cases having an accurate picture of condition can be used to extend the life of the asset by delaying CB retirement.

In the absence of detailed condition information the half-life refurbishment is based on time, operations, or condition as of a class 2 overhaul, which is inherently time based.

The program aims to install on-line monitors on SF6 live tank and dead tank circuit breakers that will have reached 15 years of service during the 2017-22 regulatory period. The intention is to begin monitoring the condition of the CBs before their notional 20 year half-life refurbishment. Knowing the condition and the performance trends of the circuit breaker will allow the half-life refurbishment time to be optimised.

Once the monitor deems a CB requires a refurbishment, the CB will be swapped out and transported to a workshop to be refurbished as a rotable spare. After the workshop overhaul, the same theory can be applied in optimising the replacement time. Knowing the trending condition of CBs will allow asset replacement to be optimised and potentially delayed.

The advantage of using an electronic monitor is that outages are not required unless condition dictates otherwise. This reduces the maintenance time increasing the overall availability. All CBs at a station with OLMs can be downloaded periodically in a single visit without outages. The conceptual condition based maintenance sequence is being developed in line with Figure 2:

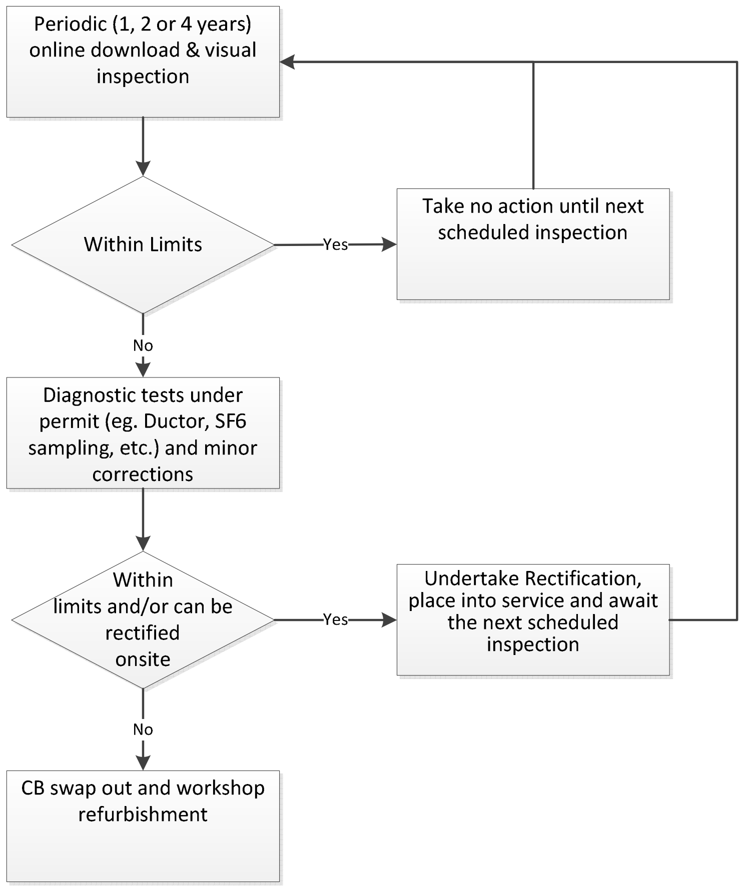


Figure 2 – Proposed Condition Based Maintenance Sequence

The process considers local download via a USB device. In time it is envisaged that the monitors would be telemetered back to the control room with alarm set points instigating further diagnostic testing and/or rectification.

# 5 Risk Matrix

Installation of monitors allows a finer level of condition knowledge and allows CBs to be refurbished or replaced prior to a failure. Adding OLMs reduces the likelihood that a CB will fail preventing:

- adverse environmental egress;
- network unavailability;
- unplanned capital expenditure.

Risk of injury to personnel is unchanged for dead tank CBs as they are designed to fail in a safe manner.

| Consequence | | | | | | |
|---|---|---|---|---|---|---|
| | 5 | II | II | I | I | I |
| | 4 | III | II | II | I | I |
| | 3 | X | X | II | II | I |
| | 2 | IV | III | III | II | II |
| | 1 | IV | IV | III | III | III |
| | | A | B | C | D | E |
| | | Likelihood | | | | |

Figure 3 – Risk Matrix

# 6 Options

This section describes the four options that have been considered.

## 6.1 Option 1 – Do nothing

The 'do nothing' option means AusNet Services retains the current maintenance treatment of SF6 CBs. Maintenance remains purely time-based with class 1 overhauls undertaken every 4 years requiring an outage and labour and a class 2 overhaul is undertaken every 16 years regardless of condition. Half-life refurbishment is based on operations or time and may or may not be required – if not required it is an expensive and time consuming exercise to undertake a workshop overhaul and opening the SF6 chamber inherently increases the instantaneous likelihood of failure once re-commissioned, ie it creates a second period of infant mortality.

Assessing condition once every four years provides coarse detail. It is not recommended that current maintenance be undertaken more often. There is an opportunity with an on-line monitor to gather finer detail with minimal effort, ie a USB download every 12 or 24 months may prevent the need for an outage for much more than four years.

This option involves the least cost; however it won't save any money in the future.

## 6.2 Option 2 – Install remotely Accessed Online monitors on 51 Circuit breakers

Install 51 OLMs over 2017-22 period on all circuit breakers that have been in service for 15 years or more and telemeter via SCADA.

This option provides the opportunity to delay outages, refurbishments and replacements. It also removes the need to visit site as the condition of CBs can be assed from the office. The visual condition can be assessed during periodic station inspections.

This would offer the least ongoing OPEX expenses; however the installation of wiring back to the station control room and the telemetry required would significantly dominate the cost of the OLM and would likely dissolve the benefit. This option is considered beneficial for greenfield sites or major switchyard rebuilds.

Rolling out to all 51 CBs identified places emphasis on quantity rather than quality. There is a risk that a partially specified system will be installed on a large number of CBs without realising the full benefits.

### 6.3 Option 3 – Install locally Accessed online monitors on 51 Circuit breakers

Install 51 OLMs over 2017-22 period on all circuit breakers that have been in service for 15 years or more. Like option 2, this option provides all the functionality to obtain fine detailed condition information without the need for routine outages. The difference is that downloads are required to be undertaken at site.

This is the most cost effective option to assess condition of CBs that will have been in service for 15 years or more during the 2017-22 period. The main drawback is that rolling out to all 51 CBs identified places emphasis on quantity rather than quality. There is a risk that a partially specified system will be installed on a large number of CBs without realising the full benefits.

### 6.4 Option 4 – Install locally Accessed Online monitors on 10 Circuit breakers

Install OLMs on ten circuit breakers at two different sites – five dead tank CBs at ATS and five live tank CBs at TSTS.

This is the same as option 3 except that the OLMs will only be installed on ten CBs in the period. This allows time to properly develop the functionality of the OLM, the analysis of the data, the procedures for turning the data into action, and realise the benefits. By 2022 OLMs can be retrofitted on the remaining 41 CBs and established as a business as usual process.

The benefits for optimising the half-life refurbishment of the remaining 41 will be limited by 2022 - however benefits can still be obtained for the optimisation for the retirement by installing the OLMs or retrofitting the provision. The timing of the refreshment can be established with existing methods and the OLM provision can be retrofitted during the workshop overhaul. The next generation (CBs reaching 15 years of service after 2022) can have the OLMs installed on site with benefits realised for refurbishment and replacement.

Learnings of the initial installations will be incorporated into the CB specification so that the full CB lifecycle can follow Figure 1.

## 7 Recommended Action

Install OLMs on 10 CBs at two stations with local access in line with option 4.

## 8 Reference Documents

| | |
|---|---|
| AHR 10-54 | Victorian Electricity Transmission Network Asset Health Report – CBs. |
| AMS 10-54 | CB Asset Management Strategy. |