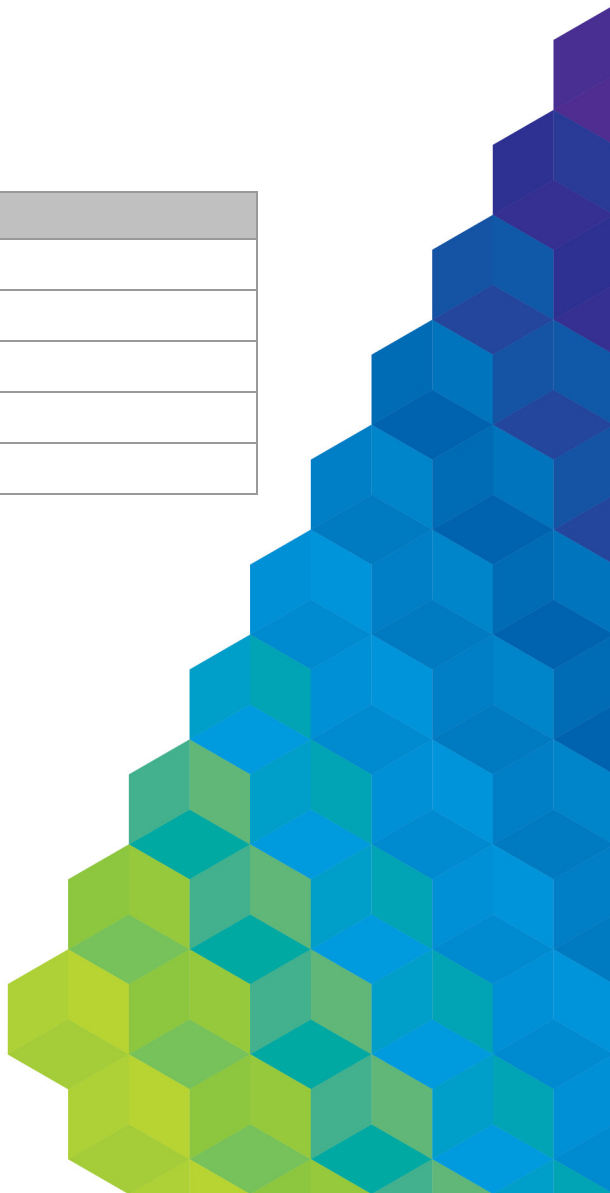
Rapid Earth Fault Current Limiter (REFCL) Program

Operating Modes

Document Details	
Document Number:	REF 20-17
Version number:	2
Status:	Approved
Approver:	Mike Carter
Date of approval	18/04/2018



REVISION HISTORY

Issue Number	Date	Description	Author
1	28/06/2017	First Issue	J Dyer
2	18/04/2018	Minor updates	J Bernardo

1 PURPOSE AND BACKGOUND

1.1 Purpose

The purpose of this supporting document is to explain the operating modes that AusNet Services' intends to use for Rapid Earth Fault Current Limiters (REFCL) installed on the network.

REFCLs are to be installed on AusNet Services' network in response to new bushfire mitigation regulations. The REFCLs will be operated in several modes dependent on the current fire risk. The mode of operation will have an impact on several factors including the extent to which fire ignition risk is mitigated, network reliability and ease of network operation.

1.2 Background

AusNet Services' network operates in a unique geographical location, which is exposed to extreme bushfire risk. These conditions warrant significant investment to mitigate the bushfire risk.

The 2009 Victorian Bushfire Royal Commission made several recommendations with respect to fires initiated from distribution electricity networks. Subsequently, the Victorian Government established the Powerline Bushfire Safety Program to research the optimal way to deploy REFCLs for bushfire prevention. This research led the Government to introduce Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

For AusNet Services, the regulations require each polyphase electric line originating from 22 selected zone substations to comply with mandated voltage reduction performance standards by 1 May 2023. In the timeframes specified in the regulations, the installation of REFCLs is the only feasible technological solution.

The REFCL installation program will be managed in three Tranches. This document outlines the operating modes for REFCLs installed in all tranches. As REFCL operating experience is obtained and REFCL compatible equipment is further developed the operating modes may change as the REFCL Program evolves. As such, any change to operating modes will be updated in this document.

1.3 Objective

The objective of this operating modes document is to:

- describe the REFCL operating modes;
- describe the linkage between operating modes and fire ignition risk; and
- describe the impact on network reliability arising from each operating mode.

2 Drivers

The Electricity Safety (Bushfire Mitigation) Amendment Regulations (2016) specify the installation and operation of the voltage reduction required on a polyphase line when a phase-to-ground fault occurs, and the fault current limits that must be achieved. These limits are termed the 'required capacity' in the regulations.

Application of the 'required capacity' protection setting will be applied to REFCLs operating on supply networks within areas where a Total Fire Ban or Code Red Day is declared. Application of the setting applies from midnight to midnight. Furthermore, the configuration of the supply network that has been demonstrated to achieve the 'required capacity' will be in place on Total Fire Ban or Code Red Days

Operating Modes

The installation and operation of REFCLs is complex and expensive. However, the technology has proven, during trials, to reduce the risk of fire starts arising from phase to ground faults on the 22 kV network. As the REFCLs do reduce the risk of fire starts, AusNet Services intends to operate the REFCLs outside of Total Fire Ban or Code Red Days albeit at reduced levels of sensitivity. Initially three modes of operation will be utilised:

- Fire Risk Mode – applicable on Total Fire Ban and Code Red Days (maximum sensitivity)
- Standard Mode – applicable during periods of the declared bushfire season that are not Total Fire Ban or Code Red Days. (Reduced Sensitivity?)
- REFCL-NER Mode – applicable during periods of lower bushfire risk e.q. days that fall outside the declared bushfire season (REFCL

3 Selection of Operating Mode

Each of the three operating modes will result in different reliability and fire ignition risk outcomes.

In the most sensitive mode, **Fire Risk Mode**, the risk of fire ignition from a phase to ground fault is minimised however, the impact on customer reliability is the greatest. i.e. a permanent phase to ground fault will result in an interruption to all customers on the affected feeder as compared to the existing arrangement where automatic circuit reclosers limit the number of customers affected. Extended restoration time is also expected as manual fault finding processes will be applied to locate the high impedance fault. Further, because of the sensitivity of the settings, interruptions to supply (feeder trips) may arise from other factors such as normal network switching operations to undertake maintenance and connection works.

In **Standard Mode**, AusNet Services is seeking to balance fire ignition risk, network reliability and network operability. When a phase to ground fault occurs, the REFCL may compensate for up to 20 secs allowing any transient fault to clear. Where the fault remains permanent, the feeder circuit breaker will interrupt supply to all customers on the feeder leading to a momentary outage. The REFCL settings in this mode should allow normal network maintenance and connection activities to be completed without leading to spurious REFCL operations.

In **REFCL-NER** mode, the REFCL may compensate for up to 20 secs allowing any transient fault to clear. If the fault remains (low impedance faults) after this initial period, the protection system will automatically revert to the pre-REFCL earthing protection system (the majority of zone substation sites are low impedance earthed via a resistor i.e. NER). This may minimise the number of customers impacted by a fault and may minimise the time taken to locate a fault, as the increased fault current is likely to cause fuses to operate. In this mode, the risk of fire start is higher than the other operating modes hence why it is only used during periods of low bushfire risk.

The existing DFA scheme is currently not REFCL compatible, works are under development (refer to Distributed Feeder Automation Strategy) to modify the scheme and its field devices that the DFA algorithm relies on to identify the faulted zone. Until this work is complete the existing DFA will not be in service on REFCL protected networks. Once the REFCL compatible DFA (DFA 2) is installed, this scheme will be utilised as far as practicably possible under all operating modes.

The following operating modes are only possible after ACRs and sectionalisers are updated to detect low fault currents and directional power flows.

Operating Modes

	C-I-C	C-I-C	C-I-C
C-I-C			
C-I-C	C-I-C		
C-I-C	C-I-C		
C-I-C	C-I-C		
C-I-C			
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C	C-I-C

Operating Modes

	C-I-C	C-I-C	C-I-C
C-I-C			
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C			
C-I-C	C-I-C	C-I-C	C-I-C

Operating Modes

	C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C			
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C	C-I-C

Definitions:

Transient Fault – A fault that self clears after a short period of time

Permanent Fault – A fault that persists and needs to be rectified by personnel in the field

Momentary Outage – An outage experienced by the customer that lasts less than 1 minute (occurs when a CB or ACR successfully closes after a fault occurs or DFA restores supply to customers)

Sustained Outage – An outage experienced by the customer that lasts more than 1 minute

4 Summary

Three operating modes will be used initially for REFCL operation. The mode of operation will be dependent on bushfire ignition risk and seek to provide a balance between risk reduction, network reliability and network operability.

The three modes have not yet been developed and tested on a full zone substation at the required capacity. It is probable that some refinement to the mode of operation will result during the development and testing process and as REFCL operating experience increases. The result of development and testing will lead to defined criteria that will determine the duration of operation in each of the Standard and REFCL-NER modes.