ESV Guidance for HV Customers

Including demonstrating REFCL readiness to ESV

Purpose

This document contains guidance for high voltage customers (HVC) that will be supplied from a Rapid Earth Fault Current Limiter (REFCL) protected network in regard to:

- Determining their legislative obligations
- Ensuring that their installation can continue to operate reliably and safely when supplied from a REFCL protected network
- Demonstrating to Energy Safe Victoria (ESV) that their electrical installation is REFCL ready.

Disclaimer

Context

Following the devastating bushfires of Black Saturday in 2009, the Victorian Government established the Victorian Bushfires Royal Commission to consider how the likelihood and consequence of bushfire ignitions could be reduced. The Commission observed that powerlines and electricity infrastructure caused many of the major bushfires in 2009.

In response to the Commission's report the Victorian Government established the Powerline Bushfire Safety Program (PBSP). Following extensive research, development and trials, the PBSP developed several initiatives to address the Commission's findings. One initiative included the targeted upgrade of certain zone substations to REFCL protection.

The Electricity Safety (Bushfire Mitigation) Regulations 2013 were amended on 1 May 2016, requiring affected Distribution Businesses (DB) to deploy the '*required capacity*' at 45 zone substations supplying the highest bushfire consequence areas of Victoria, which is delivered by the deployment of the REFCL technology.

A REFCL provides protection to the 22 kV multi-wire powerlines that originate from one of the 45 REFCL protected zone substations. It does not provide protection to low-voltage or single wire earth return (SWER) powerlines, as these powerlines are isolated via a power transformer that a REFCL cannot 'see' past. Therefore only the 22 kV electrical assets owned by DBs and directly connected High Voltage Customers (HVC) are affected.

A REFCL protects against single-phase to earth faults, which have been found to be the most common fault type. It is not currently optimised to protect against other fault types, in which case existing protection systems will operate.

When a REFCL unit responds to a single phase-to-earth fault, the voltage on the faulted line rapidly collapses to near zero, such that there is unlikely to be sufficient energy to initiate a fire. In response, the voltage on the remaining two unfaulted phases rises to approximately full phase to phase voltage, i.e. an increase from approx. 12.7 kV to a maximum of 24.2 kV. This provides the benefit of appropriately treating the fault, without customers experiencing a loss of electricity supply, i.e. *'keeping the lights on'*. However both the extent and duration of the voltage excursion on the unfaulted phases may exceed the design limits of the HVC's electrical infrastructure.

On 20 August 2018 the Essential Services Commission published amendments to the Electricity Distribution Code (version 9A). Essentially, clause 16 of the amended Code clearly place the obligation on HVCs to ensure their installation is REFCL ready such that it can continue to operate reliably and safely.

Recognising that HVCs may incur significant costs to become REFCL ready, the Victorian Government established a $10 million High Voltage Customer Assistance Program (HCAP) to provide some financial relief to HVCs obliged to assess and make changes to their electrical assets in order to be ready to operate in over-voltage conditions that may be associated with REFCL operation. In order to obtain funding through HCAP, a HVC must demonstrate to ESV that their installation is REFCL ready, among other activities.

Cross-Country Faults

If your assets are not appropriately hardened or isolated, they may fail when exposed to the over-voltages that occur when a REFCL is responding to a fault and cause what is known as a cross country fault (a second earth fault on the network, on a different phase to the first one and located randomly elsewhere on the network where there is a weak asset). A REFCL can only compensate for one fault at a time. Therefore in the case of two concurrent faults on a single REFCL protected network the bushfire risk reduction may no longer be achieved.

Obligations

REFCL

Cross-Country Faults

As per clause 3.2.2 (a) of the Electricity Distribution Code Version 9A:

> *A **customer** must use best endeavours to ensure that the **distribution system** and the **reliability** and **quality of supply** to other **customers** are not adversely affected by the **customer's** actions or equipment;*

As per clause 16 (c) of the Electricity Distribution Code Version 9A:

> *A **business customer** must take reasonable precautions to minimise the risk of loss or damage to any equipment, premises or business of the **business customer** which may result from poor quality or reliability of electricity **supply** or the **distribution system** operating under the **REFCL condition** in accordance with clause 4.2.2A.*

This means that as a customer you have an obligation to use best endeavours to ensure that your installation does not adversely affect the DB's network or other customer installations, including causing cross country faults.

Specified Operators

Section 83A of the Electricity Safety Act 1998 (the Act): defines an at-risk electric line as:

- any electric line (other than a private electric line) that is above the surface of land; and
- in a hazardous bushfire risk area (HBRA).

In cases where a High Voltage Customer operates an *at-risk electric line*, the legislation deems them to be a *Specified Operator* with specific duties, including requirements to:

- Submit a Bushfire Mitigation Plan (BMP[1]) to ESV by 30 June each year for acceptance, and
- Ensure an Electric Line Clearance Management Plan (ELCMP[2]) is prepared before 31 March each year, for the next financial year, and published on their internet site and available for inspection at the responsible person's principal office.

Bushfire Mitigation Plan / Electric Line Clearance Management Plan

For ESV to determine whether your installation requires a BMP or ELCMP you will need to provide ESV with:

- The site address/s for the properties where your electrical installation(s) are located.
- A map of the site where your electrical installation(s) are located that shows where the installations are located within the site and system diagram (this may be on one plan or separate drawings over a Google map or aerial photo/image) showing the details of the electricity supplies into the site/s, including:
  - All High Voltage (HV) lines and cables (Overhead and Underground) on the property,
  - Any Low Voltage (LV) bare overhead lines on the property,
  - The location of the point of supply (this is where the distribution business ownership of electrical assets ceases and the HV Customer's responsibility commences),
  - Any HV switches and isolation points, and
  - Any HV Substation/transformer locations, including any proposed isolation transformer installations (if applicable).

Demonstrating REFCL readiness:

In order to demonstrate to ESV that your installation(s) is/are REFCL ready, ESV requires you to provide a letter signed by the company CEO or relevant director that states that you have completed all necessary studies, tests and works that confirm your installation(s) is/are compatible with a REFCL protected network. The studies, tests and works that will need to be undertaken will depend on the solution(s) you have chosen to implement and the condition/arrangement of your installation(s). The Government's High Voltage Customer Assistance Program (HCAP) *step-by-step guide* provides an overview of the typical process that should be followed.

Initially you will need to undertake, or have undertaken for you, an engineering assessment of your installation(s) to determine if it is compatible with a REFCL protected network. In most cases some work will need to be performed to ensure compatibility. This assessment should include, but not be limited to:

- A complete audit of the ratings, condition and age of all high voltage electrical assets that will be supplied from the REFCL protected network(s)
- Tests to determine if the assets can withstand full phase to phase voltage (as per Table 1A of the Electricity Distribution Code version 9A, typically 24.2 kV) across each phase to earth for a period that aligns with the testing that will be undertaken by your DB
- Consideration of whether any changes are required to your protection and control system(s)
- Consideration of how REFCL protection will impact your business needs.

If your assessment determines that some or all of your assets are not rated for, or not in a condition that is expected to withstand elevated phase to earth voltages, or are otherwise incompatible with a REFCL

[1] Means a plan referred to in section 83BA(1) of the Act

[2] Means a plan referred to in Regulation 9(2) of the Electricity Safety (Electric Line Clearance) Regulations 2015, as required to be prepared by a person responsible under section 84D of the Act for keeping the whole or any part of a tree clear of an electric line the person owns or operates.

protected network, you will need to develop a solution to ensure that your installation(s) can continue to operate reliably and safely.

There are three general solutions that have been identified by the industry (voltage conversion, hardening and isolation). In any case you should consult with ESV directly before committing to a particular solution to confirm any safety requirements. As part of this process, ESV will assess whether you are obligated to have an approved Bushfire Mitigation Plan (BMP) and/or an Electric Line Clearance Management Plan (ELCMP), refer to the REFCL

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Specified Operators

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- any electric line (other than a private electric line) that is above the surface of land; and
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In cases where a High Voltage Customer operates an *at-risk electric line*, the legislation deems them to be a *Specified Operator* with specific duties, including requirements to:

- Submit a Bushfire Mitigation Plan (BMP) to ESV by 30 June each year for acceptance, and
- Ensure an Electric Line Clearance Management Plan (ELCMP) is prepared before 31 March each year, for the next financial year, and published on their internet site and available for inspection at the responsible person's principal office.

Bushfire Mitigation Plan / Electric Line Clearance Management Plan section for further detail.

ESV has previously provided a *Position Paper – Installing Isolating Transformer(s) on Polyphase Electric Lines with Required Capacity* that describes ESV's expectations for isolation solutions. The following is intended to provide more practical guidance to assist you with determining what you need to do in each scenario.

Voltage Conversion

In some cases your installation(s) may draw sufficiently low power to make low voltage conversion of your installation(s) viable. In this case you will need to work with your DB to organise this change in your connection arrangement. If your installation(s) is/are converted to low voltage, it/they will not be affected by REFCL operation.

If you do convert to low voltage supply, any new or substantially replaced low voltage overhead lines may be required to be placed underground.

Isolation

Isolation involves installing an isolation transformer(s) that is/are separately earthed on the secondary (HV customer) side. This serves to isolate your installation(s) from the effect of a REFCL and will allow your installation(s) to function in much the same manner as it has prior to REFCL implementation.

If you elect to 'isolate your installation', ESV will evaluate the residual safety risks that may be present by any bare HV powerlines downstream/beyond the isolation device, and ESV may direct further treatment such as a requirement to cover or underground these powerlines, as outlined in the *ESV position paper – Installing Isolating Transformer(s) on Polyphase Electric Lines with Required Capacity*. In this case you should consult with ESV and your DB as early as possible to confirm what additional regulatory obligations or technical requirements you may have.

You will also need to provide ESV with:

- The details of the isolation devices (transformer) installed (or to be installed) including the name of the manufacturer, and the size and specifications of the isolation transformer; and
- Provide a site map, system diagram and any photographs showing the detail of the incoming HV supplies into the site/s, including:
  - The location where the isolation device(s) (transformer) was, or is to be, installed on the property,
  - All High Voltage (HV) lines and cables (Overhead and Underground) on the property,
  - Any Low Voltage (LV) bare overhead lines on the property,
  - Point of supply (this is where the distribution business ownership ceases and the HV Customer's responsibility commences),
  - Any HV switches and isolation points, and
  - HV Substation/transformer locations, including any proposed isolation transformer installations (if applicable).
- Once the works have been completed, written confirmation, signed by a company Director or the CEO, that the isolation devices (transformer) installation and commissioning works have been fully completed.

The Government's High Voltage Customer Assistance Program (HCAP) *step-by-step guide* provides an overview of the typical process that should be followed, and the timing for providing this information. A copy of this guide was emailed to HVCs in mid-August and can be found on DELWP's website under the Network Assets Regulation section here.

Additionally, please note that your local DB will likely require the above information and additional details to be provided separately to them for evaluation prior to installation. Please contact/liaise directly with your DB in that regard.

Powercor has provided its standards to ESV for their installed isolation transformers. These are appended for information and guidance only, and are provided on a no liability basis. These standards include:

- Distribution Construction Standard - Isolating Kiosk Assembly – 6MVA & 3MVA
- Isolation Transformer – General information
- Functional Specification for Isolating Substations for use on REFCL Systems
- Schematic of Isolation Transformers.

AusNet Services will share similar information with its customers upon request.

Hardening

Hardening involves the detailed assessment, testing and rectification (where required) of all of your electrical assets that will be protected by a REFCL. If you elect to 'harden your installation', such that it is compatible with a REFCL protected network, ESV requires you to provide:

- A detailed technical assessment of your electrical equipment for REFCL readiness, and

- Written confirmation, signed by a company Director or the CEO, that all identified REFCL readiness works have been completed.

The Government's High Voltage Customer Assistance Program (HCAP) *step-by-step guide* provides an overview of the typical process that should be followed, and the timing for providing this information. A copy of this guide was emailed to HVCs in mid-August and is available on DELWP's website under the Network Assets Regulation section here.

Before committing to harden your electrical assets there are some important factors that should be taken into consideration as per the Technical Guidance section below.

Technical Guidance

The following technical guidance should be considered when determining the solution(s) that will ensure your installation(s) are REFCL ready.

Operation

Your distribution business (DB) has flexibility in how it chooses to operate its REFCL(s). This is likely to vary from business to business and at different times of the year. A REFCL provides benefits in regard to bushfire mitigation and reductions in power outages due to certain intermittent faults (increased reliability). However, a REFCL only works for single phase to earth faults (the most common fault type), and REFCL faults can be difficult to locate (discrimination/selectivity). This means that when a REFCL is operating in a High Fire Risk or Normal mode there may be a reduction in the reliability of supply and outages when faults occur, as they may be prolonged (decrease in supply availability) whilst the DB isolates the feeder and locates the fault.

Because of this difficulty in discriminating for and locating faults, your DB may choose to switch back to a resistively or solidly earthed system to improve reliability/availability of supply from time to time where the bushfire risk is lower or due to technical issues/during maintenance associated with the REFCL. It is likely that your DB will operate its REFCLs in four different modes as follows (further explanation is provided in the Protection & Control Systems section below):

- High Fire Risk Mode:
  - Normally reserved for days of extreme bushfire risk (e.g. total fire ban days).
  - The REFCL will detect a fault and determine if it is intermittent or permanent.
  - For most intermittent faults, your installation will generally not experience any loss of power (except for some three-phase equipment that is directly connected at 22 kV, if applicable).
  - For permanent faults the entire feeder will likely be tripped at the DB's zone substation. This is because a REFCL limits the fault current below the threshold of traditional current-based protection devices; hence it won't be able to detect the fault location. Power will not be restored until the line has been patrolled, the fault identified and manually isolated/rectified. This may lead to prolonged outages.
  - It is also likely that any fault passage detection and identification, as well as any automatic fault isolation/restoration systems that may be installed within your installation(s) will no longer work. Note that this will generally only be applicable to large, complex installations. In this case they may also need to be rectified to be REFCL compatible.
- Normal Mode:
  - Will be used over the summer period and throughout the rest of the year with possible varying levels of sensitivity
  - The REFCL will detect a fault and determine if it is intermittent or permanent.
  - For most intermittent faults, your installation will generally not experience any loss of power (except for some three-phase equipment that is directly connected at 22 kV, if applicable).

  - For permanent faults the entire feeder will likely be tripped at the DB's zone substation. This is because a REFCL limits the fault current below the threshold of traditional current-based protection devices; hence they won't be able to detect the fault location.
  - Following detection of a permanent fault your DB will attempt to isolate the fault to a small section of the faulted feeder (as they currently do with traditional protection systems) to limit the impact to customers and allow power to be restored to healthy parts of the feeder, where possible.
  - If the fault cannot be located by the REFCL system, your DB may switch to Bypass Mode, thus allowing traditional current based protection to operate and isolate the faulted section.
  - This mode is expected to improve supply reliability for single phase to earth intermittent faults and provide equivalent supply reliability/availability for all other fault types when compared to a non-REFCL protected network.
  - It is also likely that any fault passage detection and identification, as well as any automatic fault isolation/restoration systems that may be installed within your installation(s) will no longer work. Note that this will generally only be applicable to large, complex installations. In this case they may also need to be rectified to be REFCL compatible.

- Bypass Mode:
  - Normally only used when the REFCL cannot locate the fault and on days of lower bushfire risk.
  - The REFCL will detect a fault and determine if it is intermittent or permanent.
  - For most intermittent faults, your installation will generally not experience any loss of power (except for some three-phase equipment that is directly connected at 22 kV, if applicable).
  - For permanent faults the DB may switch to a resistively (typically low impedance) or directly earthed system to allow downstream current-based protection devices to operate.
  - This will enable the fault to be better located and minimise the impact on upstream unfaulted sections of the network.
  - This mode is expected to improve supply reliability for single phase to earth intermittent faults and provide equivalent supply reliability/availability for all other fault types when compared to a non-REFCL protected network.
- Out of service:
  - The REFCL will not be in service (normally due to technical issues or for maintenance) and the system will either be directly or resistively (typically low impedance) earthed. Traditional current based protection systems will operate as normal.

Your installation must therefore be compatible with the different operating modes that the DB may choose to apply. Note that these modes are subject to change from DB to DB and over time. There are also varying levels of sensitivity that your DB may choose to operate at that may affect your installation(s) in different ways. However, once the REFCLs are in operation, any changes made by the DB to operating modes and sensitivity will be communicated with HV Customers. You should consult with your DB to confirm what its specific operating modes will be.

Protection & Control Systems

In general there are three possible earthing arrangements (solidly/directly earthed, resistively earthed and resonantly (REFCL) earthed) that your installation may need to be compatible with. In all cases you will need to confirm with your DB which earthing arrangements are applicable to your installation and the associated parameters that you will need to design to. Each system will impact your protection and control systems differently and it is important that you understand the implications and take action where required.

In all cases you will need to work with your DB to:

- Understand the technical challenges that REFCL implementation will impose on your installation
- Understand when and how your installation will be impacted by REFCL protection

- Develop solutions to maintain an equivalent or improved level of supply reliability and availability, and/or accept reductions and/or improvements in reliability and availability (depending on the operating conditions) in these parameters.

It is recommended that you complete a protection study to ensure your Protection and Control Systems coordinate with the DB and operate as intended.

Solidly Earthed

At some times the neutral of the power transformer(s) that supplies(y) your installation(s) will be solidly or directly connected to earth. You will need to check with your DB to confirm if this is the case. In this case the fault current will generally be high.

In this scenario protection systems typically operate by detecting fault current (current based). Protection devices closer to the customer load are generally more sensitive/faster so that they operate first, before the upstream protection devices (known as discrimination or selectivity). This network configuration serves to isolate the fault locally while limiting the impact on the rest of the network.

Resistively Earthed

At some times the neutral of the power transformer(s) that supplies(y) your installation(s) will be connected to a resistor before being connected to earth. You will need to check with your DB to confirm if this is the case. This system serves to limit the fault current, and has historically been installed for this purpose.

In this scenario current based protection is typically used in much the same way as a solidly or directly earthed systems; however the protection device settings will often need to be more sensitive, as the fault current is typically reduced.

Resonantly Earthed (REFCL)

At other times the neutral of the power transformer(s) that supplies(y) your installation(s) will be connected to a REFCL before being connected to earth. REFCL protected networks have very low fault currents (that's why they're able to reduce the risk of bushfires) that traditional current based protection systems cannot reliably detect.

At this time it is expected that your DB will operate with the REFCL in service (under Normal or High Fire Risk mode) at all times, with the level of sensitivity increased on days of heightened bushfire risk, as discussed in the Operation section above. However you should confirm the details of this with your DB.

Possible protection systems that may be compatible with a REFCL protected network include, but are not limited to: Wattmetric, Admittance, Neutral Voltage Displacement and Broken Conductor Protection techniques. These systems generally work by detecting changes in the circuit power, resistance and voltage instead of current. At this stage these protection techniques are still considered specialised and there are limited devices commercially available.

The REFCL protection system at the DB's zone substation is also expected to operate quickly, thus making it difficult for any compatible protection devices to discriminate (operate before the feeder circuit-breaker). Therefore it is unlikely that there will be an immediate need to upgrade your protection and control systems; however this could change in the future as protection techniques and products evolve.

Depending on your business needs, you may accept a potential reduction in supply availability, or take action to address this risk. This may include installing REFCL compatible protection devices (if commercially available), privately owned backup generation or backup utility supplies.

Equipment

Cables

From the experience of the distribution businesses (DB), it is understood that cables can be a significant risk for REFCL implementation. This is largely due to the critical nature of these assets, as well as the cost and time involved in their replacement. From local DB and international experience, certain types of cables have been found to present a higher risk of failure during REFCL operation than others, including:

- Older cables, due to natural deterioration
- First generation XLPE cables (generally pre-1990) manufactured using steam curing have been found to contain microscopic water-filled voids in the insulation, leading to progressive insulation deterioration and shortened service lives
- Water-logged cables (cables improperly installed under the water table or in areas subject to flooding)
- Cables with manufacturing defects or poorly made joints or terminations.

If your installation contains cables of these types, it is likely they will need to be replaced.

All HV cables should be subject to tests to confirm their compatibility with REFCL protection. Depending on the test results, you should arrange for remedial action on vulnerable cables. The appended *Guideline for REFCL Asset Resilience Testing* provides details of testing that is recommended to confirm the compatibility of cables with REFCL protection. Also refer the Distribution Business Experience section below for further information.

Transformers & Other Plant

Dissolved Gas analysis (DGA) tests of transformers should be performed to identify the extent of any insulation deterioration, which can be contributed to by the presence of water in the oil or low oil levels. In some cases you may already be performing these tests as part of your asset maintenance activities. Where insulation deterioration is advanced, you should consider bringing forward replacement or refurbishment.

For all HV plant (including transformers, circuit breakers, ring main units and kiosk substations) it is recommended that offline partial discharge and voltage withstand testing be performed to confirm compatibility with REFCL protection. The appended *Guideline for REFCL Asset Resilience Testing* provides details of these tests.

Surge Arrestors/Diverters

Distribution business experience has shown surge arrestors to be significantly susceptible during REFCL operation. The DBs have found certain classes of surge arrestors to be more likely to fail when exposed to REFCL related over-voltages and other types to be more resilient. The GHD Review of Powercor surge arrestor replacement strategy (available on the AER's website, accessible here) provides a list of surge arrestors installed on Powercor's network that were tested for REFCL compatibility and the recommendations Powercor adopted for retention or replacement. Also refer to the Distribution Business Experience section below for further information.

Earthing Systems

The DBs have advised ESV that they will revert to solidly or resistively (typical low impedance) earthed systems from time to time. This means that you should maintain your existing earthing systems to their current design standards and design all future earthing systems based on these worst case earth fault currents.

Furthermore, as currently optimised a REFCL can only compensate for single-phase to earth faults, fault current may not be reduced to the same magnitude for multi-phase to earth faults. Therefore even if your DB chooses to operate REFCL(s) at all times, there will still be significant fault current in a worst case scenario

that your earthing system will need to safely conduct to earth in order to limit the safety risk associated with step and touch potential.

You should confirm with your DB what worst-case fault levels your installation's earthing system(s) will need to be designed to accommodate. Alternatively you can design your earthing system to accommodate the maximum allowable fault levels which are set out in Table 5 of the Electricity Distribution Code, version 9A.

Distribution Business Experience

The following has been provided to ESV by affected Distribution Businesses on a no liability basis to assist HV customers in assessing if their installation(s) is/are REFCL ready.

Powercor

Powercor has compiled this information based on its experience gained with REFCLs on its own network. In 2016, Powercor commissioned its first REFCL at Gisborne (GSB) zone substation, followed in 2017 by Woodend (WND) zone substation. In 2018 Powercor commissioned a further five zone substations with a sixth due in early 2019.

To ensure Powercor's distribution network is compatible with REFCL operation, Powercor has undertaken network hardening and compatibility works. Powercor has replaced some of the following assets which may be found on high voltage customer networks:

- Surge arrestors; and
- Underground cables.

Surge arrestors

Powercor reviewed all surge arrestors on its network to identify which surge arrestors needed to be replaced as they were not compatible with REFCL-related over-voltages. The review confirmed that a majority of surge arrestors needed to be replaced due to the need to withstand the higher phase-to-earth voltages from REFCL operation. Powercor's preferred surge arrestor for REFCL-protected portions of its supply network is the Type W ABB POLIM K22-80. A technical report on their surge arrestor strategy, including testing and analysis, is available on the AER's website, accessible here.

Underground cables

The ability of underground cables to withstand REFCL operation is linked to their age and condition. The common technical issues that affect cables are water 'trees'[3], water ingress and insulation defects. The quality of the installation of the cables and accessories (such as joints and elbows) is also a factor. To identify if a cable is suitable, a conservative approach would be to online test all cables and offline test all critical cables. Online testing indicates whether a cable has been installed well and whether the insulation is in good condition. Offline testing is the only way to determine if moisture is present in the cable.

Powercor's experience is that special focus should be paid to paper lead sheath cables (typically pre 1990), XLPE cables from pre 1990 and all cables with straight joints and outdoor terminations as this increases moisture ingress likelihood.

For further details please refer to Powercor's XLPE cable review which is available on the AER's website, accessible here.

[3] 'Treeing' is an electrical pre-breakdown phenomenon in solid insulation which causes partial discharges and progresses through the stressed dielectric insulation. The formation of water 'trees' is a common breakdown mechanism and source of electrical faults in underground cables.

Other assets

Powercor has not proactively replaced the following assets:

- Distribution switchgear (with the exception of Felten and Guilleaume (FG) switchgear)
- Distribution transformers
- Insulators.

Powercor's experience is that the switchgear and transformers installed on its network are largely resilient to REFCL operation. Apart from the FG switchgear, there are no models that it is proactively replacing as part of its network hardening works. However, all plant should be in good condition (free of water ingress) with correct insulation-medium levels (oil or gas) to withstand REFCL operation in the short-to-medium term. Offline testing of these assets should be conducted to ensure satisfactory long-term operation.

AusNet Services

AusNet Services has also compiled this information based on experience with REFCLs gained on its own network. In 2015 AusNet Services commissioned its first REFCL at Kilmore South (KMS) zone substation, followed in 2017 by Woori Yallock (WYK) zone substation. In 2018 AusNet Services has commissioned a further three zone substations with a fourth due in late 2018 and a further two in early 2019.

To ensure AusNet Services' distribution network is compatible with REFCL operation, AusNet Services has undertaken network hardening and compatibility works. AusNet Services has replaced some of the following assets which may be found on high voltage customer networks:

- Surge arrestors
- Underground cables
- Some zone substation voltage transformers (VTs).

Surge arrestors

AusNet Services reviewed all surge arrestors on its network to identify which surge arrestors needed to be replaced. The review confirmed that a majority of surge arrestors should be replaced due to the need to withstand the higher phase-to-earth voltages from REFCL operation. As part of the process HV testing was completed on suspect Surge Arrestors with the results dictating whether a type of Surge Arrestor can withstand the elevated voltages.

AusNet Services has three approved surge arrestors for REFCL areas which are the Eaton Cooper Ultrasil (UHS2710Z0015), Hubbell Power Systems Ohio Brass Arrestor (294822) and ABB POLIM D22-10.

Underground cables

AusNet Services found the ability of underground cables to withstand REFCL operation is linked to their age and condition. To identify if a cable is suitable, AusNet Services performs both online and offline testing. Online testing indicates the cable condition at nominal system voltage. Offline testing is the only way to determine the cables true condition and how it is expected to behave under REFCL condition. These tests also found that the common technical issues that affect cables are water trees, water ingress and insulation defects.

Other assets

AusNet Services has also not proactively replaced the following assets:

- Distribution switchgear
- Distribution transformers
- Insulators

AusNet Services experience is that the switchgear and transformers installed on its network are largely resilient to REFCL operation. There are no models that it is proactively replacing as part of its network hardening works. However, all plant should be in good condition with correct insulation-medium levels (oil or gas) to withstand REFCL operation in the short-to-medium term. Offline testing should be conducted to ensure satisfactory long-term operation.

Although it is unlikely your installation will include this type of asset, AusNet Services has also targeted replacement of their Non-Metallic Screen High Voltage Aerial Bundled Cable (NMS HV ABC) due to its unpredictable deterioration rate.

Attachments

- REFCL Asset Resilience Testing Guideline
- GHD Review of Powercor surge arrestor replacement strategy

Powercor isolation transformer information:

- Distribution Construction Standard - Isolating Kiosk Assembly – 6MVA & 3MVA
- Isolation Transformer – General information
- Functional Specification for Isolating Substations for use on REFCL Systems
- Schematic of Isolation Transformers.