SERVICES EXPLAINED

# REFCL Options Explained

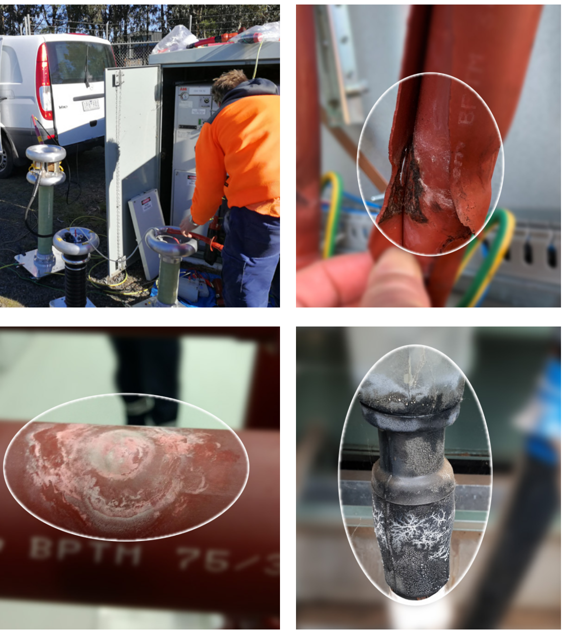
## HARDENING AT A GLANCE

### PRIMARY BENEFITS

- REFCL compliance
- Condition report of HV network
- Identify underlying HV issues

### SECONDARY BENEFITS

- Confidence in HV network condition
- Prevent unexpected outages
- Excellent baseline to monitor HV asset performance
- Extend/maximise asset lifetime



*REFCL Testing and issues identified*

To prepare private HV networks to withstand REFCL overvoltage's there is a choice, segregate from the grid with an isolation transformer or perform HV testing and harden the network where required. Each site should be examined on a case-by-case basis and in some situations an isolation transformer may be the preferred option, however, in many situations huge economic and operational advantages are obtained by testing and hardening your network. This article looks at those advantages and provides case studies where testing and hardening has been performed.

## ISOLATION TRANSFORMER INSTALLATION

An isolation transformer is used to transfer electrical power to a customer's HV network, while isolating it from the source, protecting the network from REFCL overvoltage's. The installation costs upwards of $500,000 while adding a further HV asset which must be maintained during its lifespan. There is no improvement or benefit to the existing assets under regular service conditions.

## TESTING AND HARDENING EXISTING ASSETS

Hardening involves assessing and testing a HV network to determine if the assets can operate safely at REFCL overvoltage's and identifying any components on the HV network that require upgrading. As a by-product of this, the HV assets performance is also assessed at regular service conditions. Testing costs from $15,000 for a simple network comprising Ring Main Unit, feeder cable and transformer, providing REFCL compliance and importantly an HV asset condition assessment.

Most HV assets which are in good condition and have been installed by a competent HV specialist can easily withstand the REFCL overvoltage's for the short duration required. Customarily assets that require replacement are inexpensive items that are not REFCL rated, such as voltage transformers and surge arrestors.

HV assets which are tested and deemed not REFCL compliant often underperform at service voltage. In these cases, an isolation transformer will not protect the assets from regular operating conditions and it will not halt the deterioration, leading to impending failure. Testing identifies issues pursuant to REFCL and highlights issues at service voltage, enabling maintenance planning to fix faults before they lead to critical, costly failures. The issues featured here, which were identified during REFCL testing, would fail regardless of REFCL or an isolation transformer.

Both options ensure regulated REFCL compliance, the primary difference is testing/hardening provides a reliable HV condition assessment, ensuring plant reliability in all conditions and has a cost benefit. This fact was highlighted in the Marxsen Report on High Voltage Customers when considering the risk of REFCL related faults; "To manage this risk, the report recommends that distribution businesses commence working with their HV customers now to discover suitable network hardening technical mitigations."

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CASE STUDIES

# High Voltage Testing Services
## Gas Plant

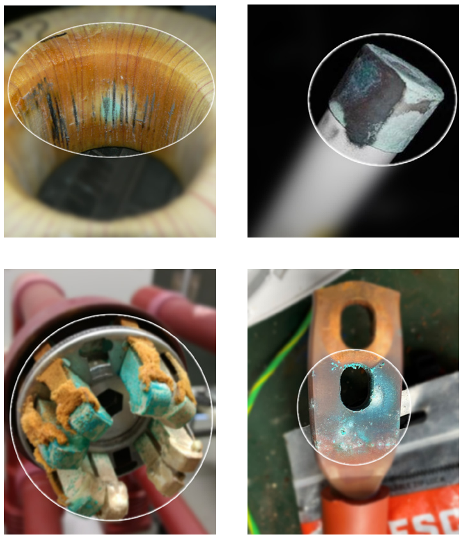
## HV COMPONENT REPLACEMENT

In many cases larger HV assets fail testing requirements, or more critically break down in service conditions, due to faulty minor components. These components often include Voltage Transformers, Current Transformers, cable terminations and joints. With effective testing faulty components can be identified prior to failure. This allows replacement items to be sourced and installed at a relatively low cost during a scheduled shutdown, maximising the lifespan and performance of the asset.

## PROJECT DESCRIPTION

To determine REFCL compliance and provide a condition assessment for all site HV assets, high voltage testing was performed for a private high voltage network customer. Like many private network customers, the site included an incoming cable, metering cubicle, feeder cable and transformer.

In addition to a detailed inspection, Partial Discharge (PD), Dielectric Dissipation Factor (DDF) and monitored withstand testing was performed on all HV assets in isolation. Dependent upon the capacitance of the item being tested, 50 Hz or VLF (0.1 Hz) test sets were used for energisation of the assets.



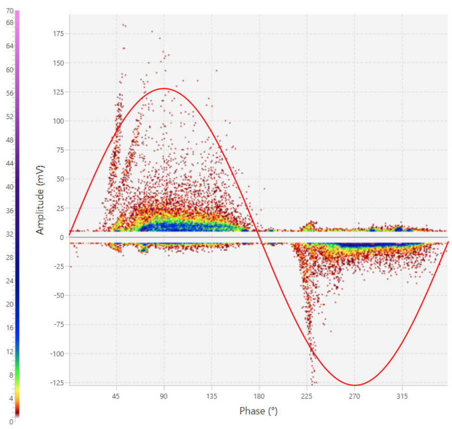
*Corrosion & Oxidisation*

## SWITCHGEAR FINDINGS

During the initial isolation and inspection of the site assets, corrosion and oxidisation were observed and noted on several components inside the switchgear cubicle. A by-product of Partial Discharge is the release of ozone and nitrous oxide, this commonly results in visible corrosion and oxidisation on the surface of HV components.

High Voltage PD testing confirmed significant discharge was occurring from multiple locations in the switchgear. Using a combination of PD time-of-flight techniques, including electromagnetic and acoustic sensors, the offending components were successfully pinpointed. It was determined that the remainder of the switchgear was in good condition with no PD evident.

The root cause of this PD was likely high precipitation and faulty cubicle heater.




*PD Phase Pattern from discharging switchgear*

## THE OUTCOMES

- Entire site's condition assessed in 1 day utilising concurrent testing
- Discharging CT's and VT's identified
- Switchgear cubicle heater repaired
- Follow-up testing completed with the site deemed REFCL compliant
- Functionality of the HV network ultimately upgraded

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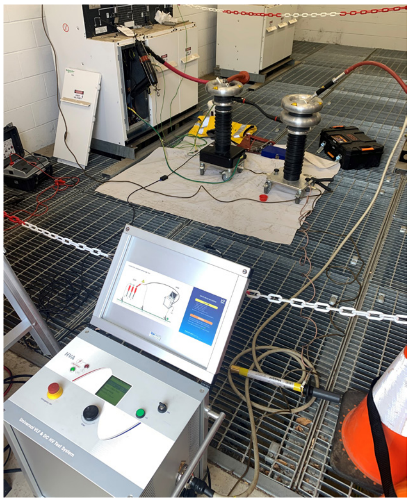
## CASE STUDIES

# High Voltage Testing Services
Water Treatment Plant

## CABLE JOINT ISSUES

When discovered, pinpointing the location of PD on a cable is imperative. LIVE HV's extensive cable database has proven tolerance levels for mid-cable are far lower than PD detected from a joint or termination and must be remedied with greater urgency. Following repair, it is important to retest the cable to confirm its conditional integrity.



*Cable Test Setup*

## PROJECT DESCRIPTION

During REFCL high voltage compliance testing the resilience of an essential 22 kV cable required confirmation. Proving the ability of this cable to maintain regular service conditions and sustain REFCL overvoltage's involved the application of Insulation Resistance (IR), Partial Discharge (PD), Tan Delta (TD) and monitored withstand testing.

Records indicated that there were no joints on the cable, so any failure points were likely to emanate from the terminations.

## CABLE FINDINGS

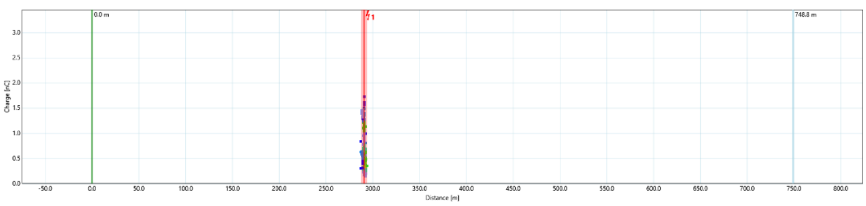
PD and TD testing was performed concurrently so either diagnostic measurement indicating an issue would result in the test being aborted to prevent damage to the cable. The TD test results were acceptable however the PD indicated discharge emanating from within the cable.

TD measures the overall dielectric properties of a cable whereas PD measurements detect a localised breakdown. It could therefore be concluded that the overall condition of the cable was healthy however there was an area of localised breakdown that required attention.

Using time domain reflectometry techniques, it was possible to calculate the location of the discharge. The PD was determined to be midway along the cable and pinpointed with a tolerance of less than 1 metre over a 500-metre cable. Generally, this would indicate a joint at the location, however the customer was unable to confirm a joint due to incorrect schematics. As no joint could be confirmed the testing was stopped due to the high risk of accelerated failure that mid cable PD can pose to a cable. An excavation of the cable was recommended.

Upon excavation a joint was revealed at the precise location PD had been identified.

*Excavated Joint*




*PD Location*

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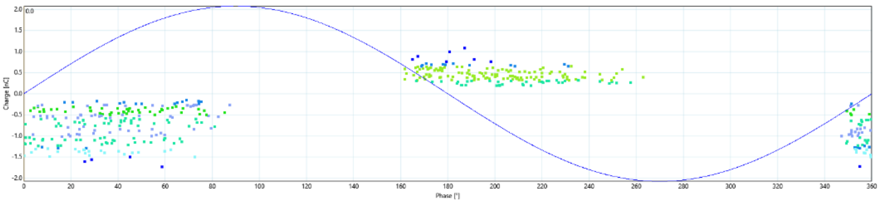
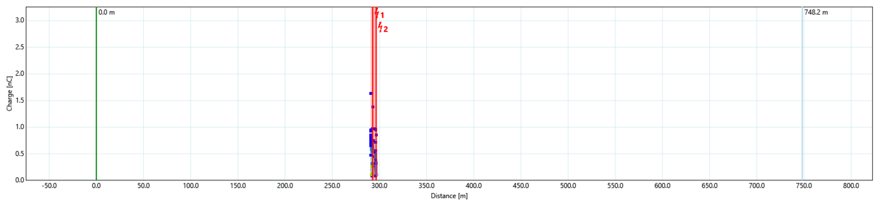
**CASE STUDIES**

# High Voltage Testing Services
## Water Treatment Plant




*PD Phase Pattern*



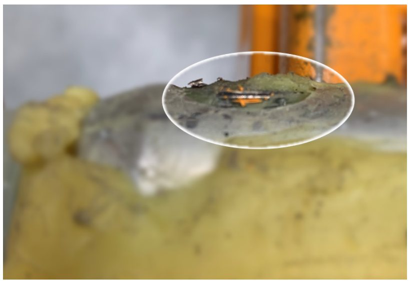

*PD Location of First Replacement Joints*

*Semi Conductive Layer Cut*

## FOLLOW UP

The discharging joint and a small section of cable was removed and replaced with two new joints. Upon testing both of these new joints also had unacceptable levels of PD! As such they were also replaced, and repeat testing showed the cable was now 'healthy'.

An investigation was performed on the replacement joints and found that the semi conductive layer was not cut level and the shear bolt from the cable joint was protruding above the joint sleeve.



*Protruding Shear Bolt*

## THE OUTCOMES

- Partial Discharge was diagnosed and accurately located to a previously unknown joint
- Repairing required cutting a small section of cable and replacing with two new joints
- Repeat testing discovered both new joints were discharging and also had to be replaced!
- An investigation determined that the semi conductive layer cut was not level
- This highlights the importance of performing PD testing when commissioning assets or making alterations

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CASE STUDIES

# High Voltage Testing Services Quarry

## CRITICAL ASSET REPLACEMENT

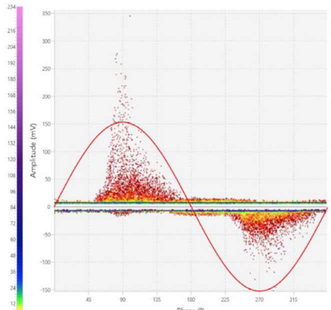
Condition assessments of critical assets are integral to maximising their performance and lifespan. Assets such as switchgear, transformers and motors are expensive to replace and operational losses caused by unplanned shutdowns can be catastrophic.

## PROJECT DESCRIPTION

As part of site wide REFCL high voltage compliance testing, the integrity of a critical 22 kV switchboard was assessed with offline Partial Discharge (PD) testing. PD testing is one of the best tools for assessing HV switchgear as the insulation performance can be accurately measured without placing unnecessary stress on the asset.

## SWITCHBOARD FINDINGS

PD was detected from the switchboard which was high in magnitude and incepting below service voltage. Using time-of-flight techniques, the PD was identified as emanating from the bus section. Withstand testing on the switchgear was not performed as it was considered likely to fail during this procedure.



*Discharging Switchgear*

Along with high magnitude PD, the critical factors here are the inception voltage and location. Having PD inception below regular service voltage shows that the asset will be discharging during regular service conditions and be continually deteriorating. The location was also critical, being the bus section of a sealed unit the best option in this case was full replacement of the asset.

The switchgear was placed back into service with a recommendation that it be replaced as soon as a new asset could be sourced. Remote online PD monitoring was set up to continuously trend the asset's rate of degradation so the customer could be alerted if any significant rise in PD was detected. The customer was able to plan for contingencies should the equipment have failed in the interim.


*Remote Monitoring*

## THE OUTCOMES

- Destructive PD identified below service voltage drastically shortening the switchgear's lifespan
- Remote online PD solution installed to monitor the asset while a replacement was sourced
- Contingencies planned for should asset failure occur during 6-month replacement lead time
- Following commissioning and required testing, the site was deemed acceptable to place into service with an active REFCL system
- As a result of testing the customer obtained new equipment which is easier to maintain with an extended lifespan
- Unforeseen, costly shutdown prevented, REFCL compliance obtained at a lower cost than alternative options

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