

TEV, One of the Most Misunderstood and Undervalued Partial Discharge Measurement Methods

Ultrasonic activity is easily understood as during a scan there is either an undesirable sound present or there isn't, while the highly directional nature of the signal means identification is often relatively straightforward. This type of discharge is almost always found on the surface of insulation meaning the defect can be readily spotted during a subsequent inspection.

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Furthermore, provided an air pathway exists for signal transmission we are directly measuring the sound pressure produced from the discharge site, dependent upon aperture size and proximity to the source.

Transient Earth Voltage or TEV on the other hand is somewhat more abstract in that the signal being measured is more an approximation of the energy generated. Originally developed in the 1970's to detect discharge from internal voids within solid insulation the technique has matured with the advent of Phase Resolved data to include other defect types such as contact/gap discharge or poor earthing/floating metalwork issues; in fact anything with the potential to generate small Arcs / sparks with rising system Volts.

So what are we actually measuring with the TEV sensor on the exterior of the asset? Well by using a capacitively coupled probe and a typical bandwidth of around 3-80MHz the PD instrument can detect the tiny voltages (in mV) induced from the electromagnetic wave that is generated internally from these micro-Arcs. The wave, a fast-moving transient with a rise time of nanoseconds propagates away in all directions and finding its way outside at joints or gaps in the Metalwork can travel great distances along the Metalwork, through Air or in other earthed equipment. The closer to the source the greater the Amplitude (in dBmV) available for measurement while time of flight comparison of signal arrival times between two probes (or more in the case of a permanent Monitor) allows for accurate pin-pointing. Discharge Pulse rate, ie. the number of discrete events per one cycle of the mains can be helpful in distinguishing genuine activity from external interference, and together with Amplitude gives rise to the Severity rating useful in ranking defects in order of priority. Finally, the PRPD plot has become an essential part of interpretation and can further help determine signal authenticity, whether single or multiple phases are involved and even the type of defect likely responsible.

CASE STUDY

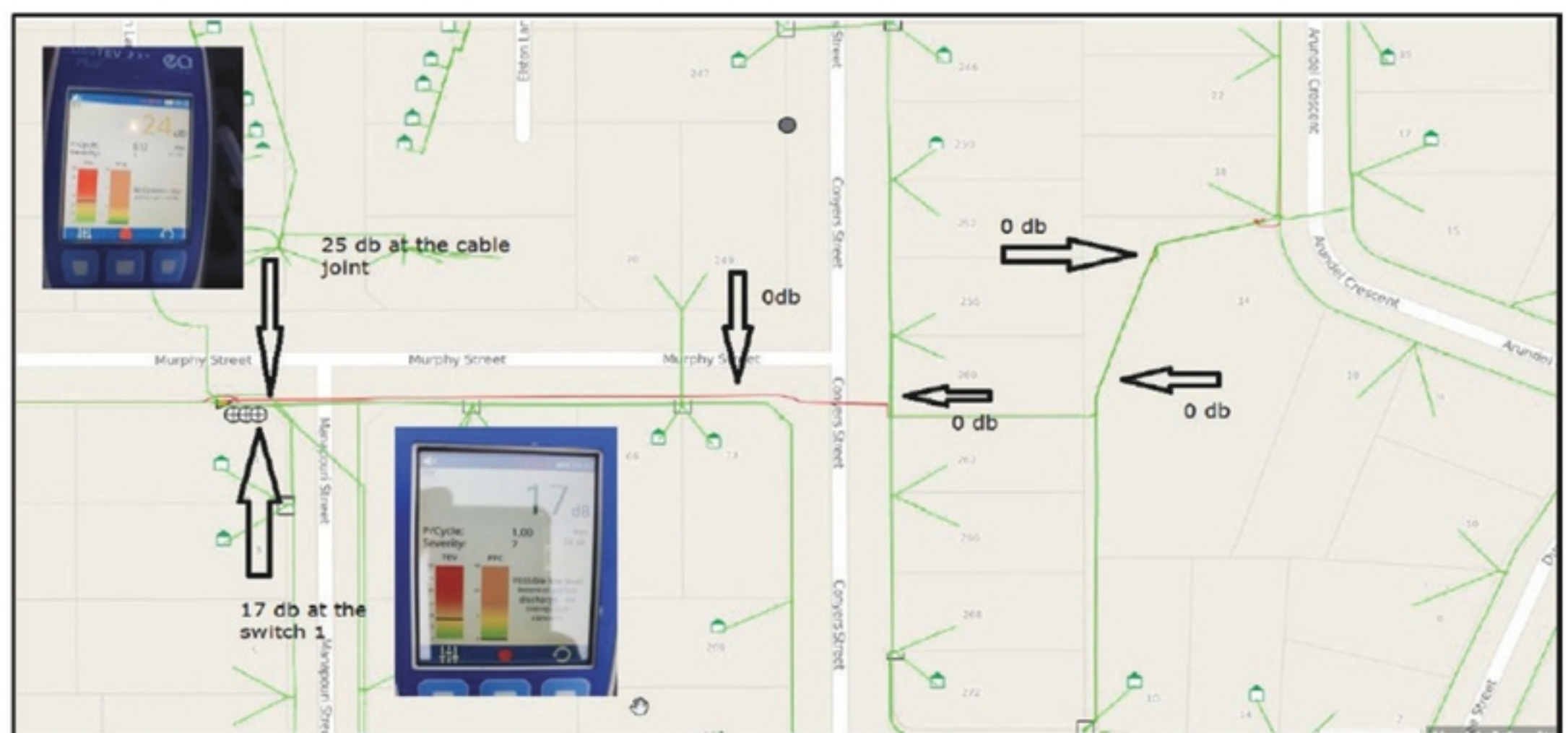
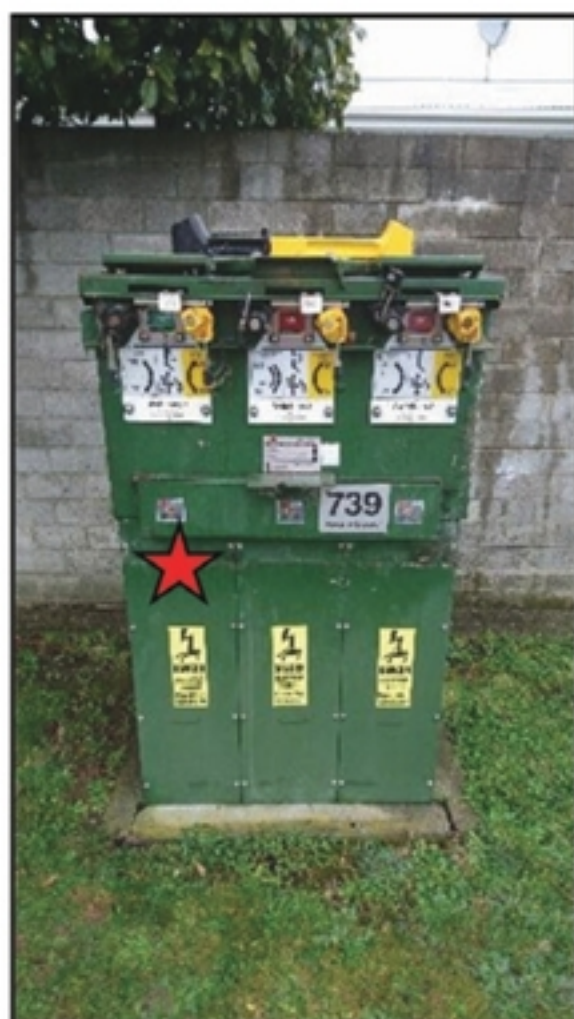
Here we examine a real world example from a New Zealand Network whereby TEV on an Oil filled RMU together with a resourceful experiment confirmed genuine activity allowing for remediation of a developing fault and avoiding a future outage from contributing to failure statistics.

Annual TEV readings on this particular unit were very high from 2019 through 2022 compared to the general switch population and the PRPD strongly suggesting internal void activity from an Air spaced Termination Box. While this seemed unlikely (though not impossible) we'd speculated a close-in cable joint could in fact be responsible and further information was sought with the client undertaking additional measurement / investigation using their own UltraTEV Plus² instrument.

As suggested, Earth stakes were driven into the ground approximately 300mm at known joint locations which has the effect of physically moving our sensor closer to the subject under test and a reading obtained at the first joint out was 8dBmV higher on the day than the adjacent switch providing confidence that we were on the right track (diagram as received from Asset owner).

This joint, an original 3 core Paper Lead was exposed and further online PD measurement conducted on both this and the Termination Box. The joint was then replaced, three Core PILC to XLPE single Core x 3 Transition Joint and new singles terminated at the switch, the RMU was also serviced at the same time. Further 'in-house' testing indicated some PD still present at the joint which might suggest the existing aged PILC cable, but that the PD at the Cable Box had improved. Note there is no Ultrasonic activity present / nor able to be detected here while a lack of access to the cable screen 'energized' means using a HFCT sensor is not an option.

HVDS return visit in 2023 revealed a vast improvement in all switch readings, while the 2020 PRPD plot displays a text-book void

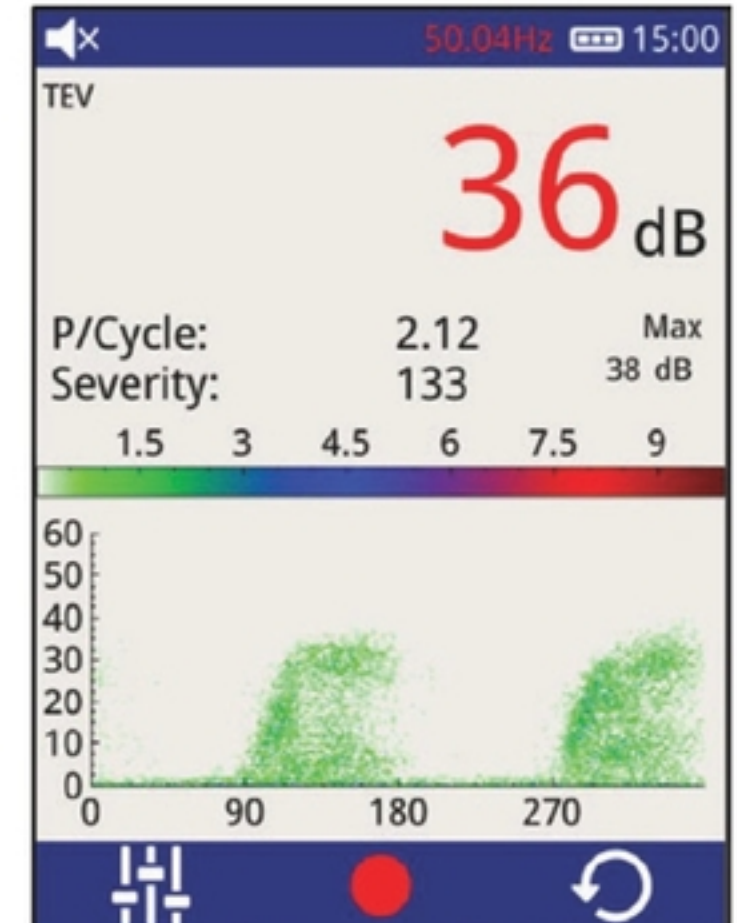


PANEL NAME	SWITCH POSITION (OPEN, CLOSED, EARTHED, ABSENT)	BUSBAR 1 UPPERFRONT	BUSBAR 2 LOWER/REAR	SWITCH TANK	CT CHAMBER	VOLTAGE TRANSFORMER	TERMINATION BOX
Sw No.1 to Sw2 @ 7433	O						33
Sw No.3 to Tx 739	C			36			34
Sw No.2 to Sw1 @ 725	C						36

Above: 2020 TEV readings
Below: 2023 following maintenance

Right: 2020 PRPD
Sw No.1 to Sw2 @ 7433

PANEL NAME	SWITCH POSITION (OPEN, CLOSED, EARTHED, ABSENT)	BUSBAR 1 UPPERFRONT	BUSBAR 2 LOWER/REAR	SWITCH TANK	CT CHAMBER	VOLTAGE TRANSFORMER	TERMINATION BOX
Sw No.1 to Sw2 @ 7433	O						5
Sw No.3 to Tx 739	C			5			5
Sw No.2 to Sw1 @ 725	C						6



discharge pattern by virtue of the two clusters spaced 180° and discharge active for what looks like most of each half cycle of the sine wave, and from a low inception Voltage. In this example an Amplitude of 36dBmV and Pulse rate of 2.12ppc gives rise to a Severity of 133, exceeding the threshold for investigation. The removed joint may not itself have been investigated but public safety has been improved at this berm site with the client later commenting 'But getting on top of these potential faults is good, We have had a lot of bad PR in that part of the network through 2021 and 2022'.

TEV has evolved into a truly versatile technique that finds application both indoors and out, on screened Cables and earthed Switchgear alike. The recent proliferation of Acoustic imaging devices promoted on the likes of networking platform LinkedIn boldly claim their ability to detect PD which is half right if we are only talking about 'surface' discharge and provided there is direct line of site, such as an overhead HV Network outdoors. These imaging devices cannot, and will not find any internal anomalies at their tuned 40kHz frequency and in an enclosed cabinet

reveal only the largest aperture through which sound can escape offering no real advantage over the traditional Ultrasonic Detector. The operator's ability, often with a Thermal imaging background to confirm legitimate surface discharge over other noise sources can also be questionable given a report recently shared with HVDS by a client.

The final takeaway is that a solitary test method is inadequate to fully cover off a comprehensive Partial Discharge assessment while an experienced services company can save you time and money, improve reliability stats and reduce downtime by targeting your maintenance to exactly where it is needed.

Contact HV Diagnostic Services or EA Technology for more information
www.hvds.co.nz
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Your partners in Partial Discharge detection because history matters & experience counts

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Discharge from CT Bushing to support board (removed for photograph) April 2015.