So, You Have Found PD – What Next?

So, you have carried out an annual partial discharge (PD) survey of your HV plant and the readings suggest you have a problem, what next? That quickly becomes a matter of potential consequence and risk; but if you decide it is time to act, have you got all the available information on the actual location of the defect?

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When testing HV plant for PD using handheld equipment one of the most obvious and useful places to test is at the cable box / terminations. Terminations are the interface between the plant and cable systems. They must be installed correctly with a smooth stress profile in the transition from the screened cable to the connection of the conductor onto the HV bushings. Unfortunately, this is an area where mistakes happen; defects can be introduced for a whole raft of reasons. This can be lack of knowledge or training of people, difficult working conditions, inadequate spacing and just small jointing mistakes made in unforgiving high stress points can cause PD.

The result is that cable terminations are invariably the most common cause of insulation breakdown and failure of HV plant and equipment. So, it makes perfect sense to test at the cables / terminations for this reason alone. When carrying out PD surveys on air insulated switchgear, you should always, as a minimum, use the combination of both Transient Earth Voltage (TEV) and Ultrasonic techniques.

Testing for surface discharge on an air insulated cable box e.g. caused by crossed phases is best carried out using airborne ultrasonic microphones where the operator scans all air gaps into the chamber whilst listening for the tell-tale crackle of partial discharge. This is complemented by testing for TEV activity and where you have access to the screened cable (e.g. underneath the cable box) the TEV sensor is ideally placed on the cable as well as the metal cladding.

When testing for PD, you should always be aware that you will have instances where both techniques will detect the same issue and others where only one of the techniques will. Which method(s) find the problem helps in the diagnosis and the assessment of the defect type and its location. For example, if there is low level surface PD happening, with little component to earth, such as when there is inadequate clearance between two phases once the screen has been removed,

Figure 1 *PD Detected on the cable box / cable of an RMU*

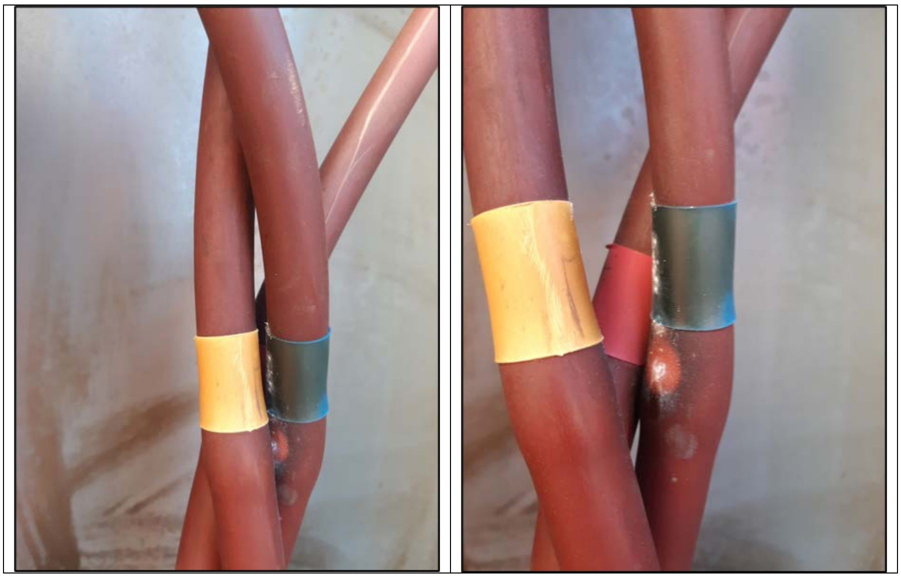

Figure 2 *PD Activity caused by incorrect installation of cable termination*

then you may only get ultrasonic activity and no TEV. If the surface discharge is of a high amplitude or is tracking towards earth, then the TEV signals can also be elevated and both ultrasonic and TEV can be detected.

CASE STUDY 1

One recent example found in New Zealand is shown in Figure 1 where a defect was found on an air insulated cable box of an aged Long & Crawford T4GF3 RMU using both TEV and ultrasonic techniques. The TEV measurement taken on the cable just below the cable box showed a high level of activity. The fact that this was coupled with high ultrasonic activity (although intermittent in nature) points to the source being inside that cable box.

Airborne ultrasonic activity relies on an air path from the source of the PD to the microphone. If the phase resolved partial discharge (PRPD) pattern and classification algorithm are consistent with PD, then locating the defect is a straightforward matter

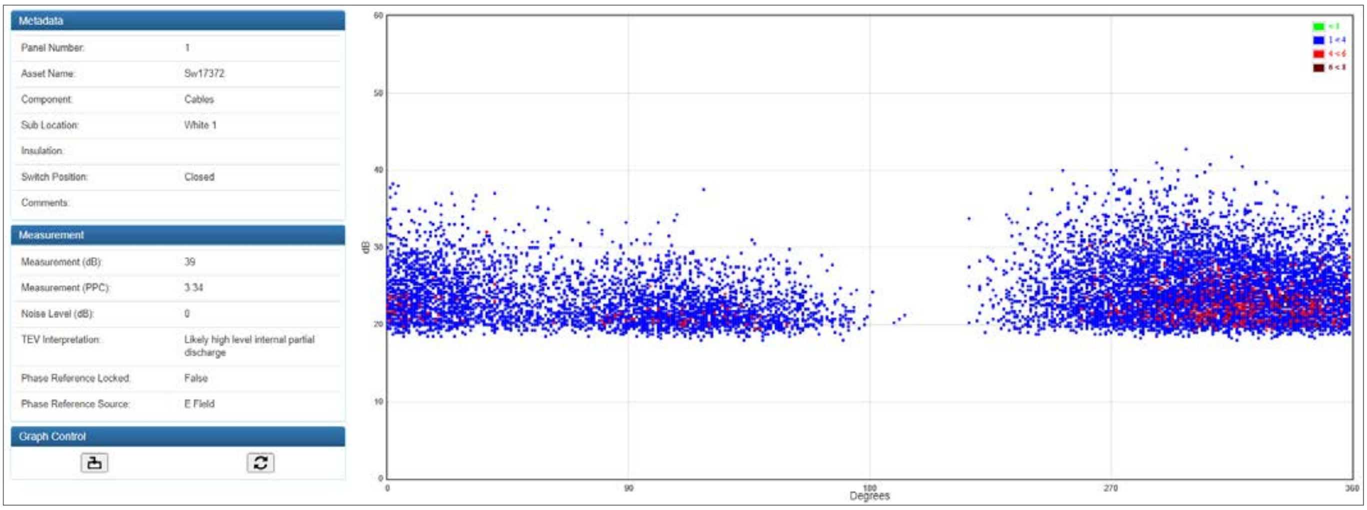

Figure 3 *High TEV Signals detected by UltraTEV Plus² PD instrument*

of opening the chamber and undertaking a thorough visual examination. Ultrasonic activity will always be occurring on the surface of insulation and unless it is at the very early stage of evolution will have left some visible evidence. In many cases the underlying cause, such as inadequate spacing is also obvious to trained and experienced personnel. It certainly was in this case (Figure 2).

DEALING WITH INTERNAL PD DEFECTS

When PD is detected only by the TEV method, the defect is more likely to be internal to insulation and things may not always be quite so straightforward to pinpoint the source of the problem. A repeated mistake we come across is people finding PD at the cable termination area and concluding, with some justification due to failure statistics, that the termination is defective. Taking an outage and replacing the termination only to find the PD is still present once the asset is re-energised, however, is a less than ideal situation.

It is therefore good to know that when you have found internal type PD there are additional tests that can help you further determine the location and the best course of action to take.

CASE STUDY 2

High TEV signals were detected at the cable terminations of a kiosk substation in Australia, see Figure 3. The PRPD plot is consistent with internal void discharge. No evidence of ultrasonic activity was recorded. The first technique we use to help with the location is to use a time of flight measurement to determine the direction of travel of the PD pulses. The UltraTEV Plus² Locator probe measures at a resolution of 0.3ns (approx. 10cm). From this we can determine which phases are discharging and from which direction signals are arriving at the sensors. In this case we determined

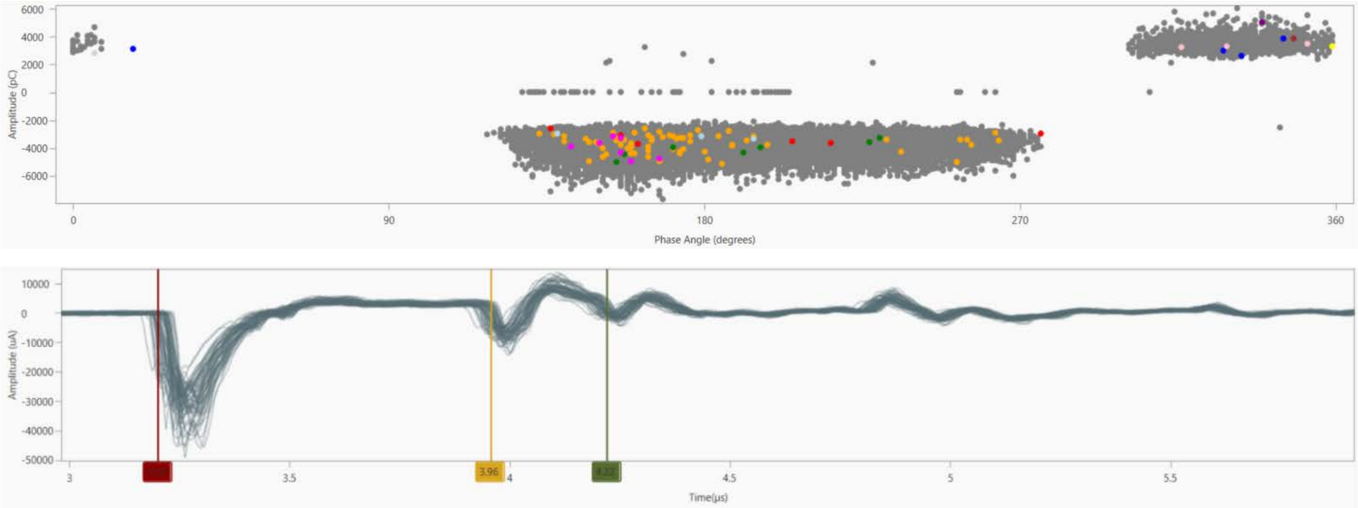

Figure 4 *Cable PD activity captured using the CableData Collector*

that the signals were travelling up from the cable rather than from the termination or the switchgear.

Therefore, the next technique we used was to capture signals on the earth sheath of the cable using an HFCT. This can also be done using an UltraTEV Plus^2 accessory, however in this instance we had the more sophisticated CableData Collector available at site. The captured PRPD and waveform plots are shown in Figure 4 and they indicated that the PD source was at a position of approximately 20m from the kiosk, which looking at cable records tied in with a joint position.

So, in this instance focussing on the termination, or indeed the switchgear, would have been the wrong call. However, proactive replacement of the nearby joint in a planned manner will prevent a future unexpected outage, improve the performance of the network and save money.

When PD has been detected, you must always be mindful that high frequency TEV signals travel, and cables act as good waveguides for the signals: from the switchgear, from nearby joints or from connected plant. The location of the problem will vary from case to case and we have many examples of all the different situations; it actually is in the termination, it is imported from nearby joints, it is in the switchgear, it is being imported from connected plant, e.g. PD in a transformer cable box with signals travelling to the switchgear via the cable.

SUMMARY

A lot of effort continues in the development of handheld PD instruments and today they are smarter and much more capable than ever. However, to get the best value, you always must be conscious of more than just the numbers on an instrument and apply sound engineering judgement.

The approach we undertake at EA Technology and HV Diagnostic Services is to consider as much as we can before remedial action is planned such as:

- What technique finds the issue?
- What is the TEV and ultrasonic PRPD pattern?
  - o surface PD
  - o internal void
  - o contact problem
  - o PD in oil
- What is the trend of the PD?
- What does time of flight measurements indicate?
- Can we use HFCT / cable PD measurements and what do they indicate?
- What type of switchgear is it, is there a history of failure or known defects?

At EA Technology and HVDS we have led the way in the use of non-intrusive PD testing for decades and are here to support our customers with experienced and practical advice which is a key factor when embarking on a programme of PD testing.

UltraTEV Plus^2 with Locator probe

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