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PD measurement saves refinery millions

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With a Megger Centrix cable test van, Koopmann Energie und Elektrotechnik, a service company that specialises in handling emergencies in the energy supply sector, was able to prevent losses amounting to millions of Euros at an oil refinery in Germany. The emergency arose when a medium voltage cable failed, causing a circuit breaker to trip and stopping the oil transport pumps. Not only did this halt production, but if the situation had not been remedied rapidly, very costly damage to the plant would have resulted.

Background

Network operators responsible for supply reliability usually want cable test vans that are perfectly tailored to suit their own infrastructure. Before a test van is purchased however, the question often arises whether it should be used exclusively to deal with urgent incidents, or whether it would be more beneficial to use its diagnostic systems for status-oriented servicing to help ensure that cable faults do not occur in the first place.

Today, many sophisticated cable diagnostic techniques are available, including tan delta measurements as well as PD measurements using VLF test voltages with 50 Hz slope technology or damped AC (DAC) voltages, which can be used to test underground cables in a gentle, nondestructive manner. These methods have become widely known and accepted.

What is less well known is that these tried-and-tested techniques also significantly improve the ability to respond effectively to emergencies, as well as making it much easier to determine the location of a cable fault. This means that from the perspective of a service company like Koopmann, the question of whether or not a cable test van should incorporate diagnostic tools is completely redundant. The answer, unequivocally, has to be yes.

In fact, status-oriented servicing is now well established as the best and most efficient servicing strategy for network operators. This is the only servicing strategy that Koopmann recommends to its customers, as it demonstrably offers the best balance between economic efficiency and supply reliability.

This is because the network operator only needs to take action if the cable diagnostic tests indicate that problems exist, rather than acting purely on suspicion by replacing cables for no better reason than their age or, even worse, waiting until cable faults occur and cause damage, meaning that costly rectification work is carried out far too late.

Of all available servicing strategies, this last one –waiting until a fault occurs – is the most expensive and the least efficient, but unfortunately it is still the strategy most frequently adopted.

This can have serious consequences, as is clearly shown by the following report, which describes a situation where, by using Megger DAC diagnostic systems, Koopmann saved an oil refinery from the threat of millions of Euros worth of damage.

It is worth mentioning, however, that had the diagnostic tests been carried out earlier, even the limited damage that did occur could have been avoided.

The incident

The Koopmann 24-hour service team was called to an incident in an oil refinery. A 20 kV medium voltage cable had appeared to fail suddenly, with the result that the circuit breaker supplying power to a high-pressure tank had tripped. For the refinery, the consequence was devastating – all of the pumps failed. Operations came to a complete standstill because the oil being supplied via the pipelines could no longer be processed.

The refinery was facing enormously costly damage that would be almost impossible to rectify, and the immediate challenge was to contain this damage within tolerable limits.

Insulation measurement

The first action taken by the emergency team was to switch the power supply to another cable to put at least some of the pumps back into operation. But where was the original fault? As a first step to answering this question, the team used its Centrix cable test van to carry out a standard DC insulation measurement at 1000 V, along with capacitance measurements on the 20 kV cable.

This preliminary insulation measurement usually determines whether the fault is solely the result of a short circuit, whether it is a high impedance fault or indeed whether there is any fault at all. Comparing the insulation resistances and capacitance values of all phases often gives an indication of the type of cable fault. This was not the case here, however. There was no short circuit and no significant differences in the insulation resistances of the phases.

Reflection measurement

The service team then carried out a traditional reflection measurement using a Megger Teleflex VX test set. It proved very easy to recognise the end of the cable, thanks to the lenght-dependent amplitude compensation. There were no significant variations between the phases, which reliably indicated that there were no particular issues anywhere between the measuring poing and the end of the cable. Neither was any problem found at the end of the cable.

VLF test

Next, the team enhanced protection and connected its VLF system. A voltage of 3 x V_0 36 kV was used, with the intention of causing a breakdown. As service provider, Koopmann needs to be prepared for all possible incidents that can occur on site. That's why the company relies on the most powerful VLF testing systems with cosine-square technology from Megger, which are integrated into all of its test vans.

These systems are the only way of testing extremely long cable routes in a way that complies with the applicable standards, a feature that the Koopmann engineers find particularly valuable.
Contrary to expectations, however, no breakdown occurred; the cable at the refinery withstood this high stress without any problems. Apart from slightly increased leakage current, yet again no abnormalities were discovered. The cable fault, which certainly seemed to exist, was proving elusive!

An air of tension admittedly started to spread slowly among the members of the experienced Koopmann team. All of the standard methods that had always been so successful did not seem to be yielding results this time.

The circuit breaker

For safety reasons, it was then decided to check contact resistances at the circuit breaker, as the pumps would stop only if this breaker tripped. The Koopmann team routinely carries a Megger MOM2 micro-ohmmeter in its emergency kit for situations of this type. Its compact dimensions and convenient weight of just 1 kg means that it is easily stored in any test van and, despite its small size, the MOM2 provides a test current of 200 A.

But even the contact resistance measurements at the circuit breaker did not yield any explanation. In fact, all of the tests performed indicated that the supply network was essentially in tip-top condition. The decision was therefore taken that it was safe to re-energise the cable. When this was done, everything worked perfectly; the problem appeared to have been resolved. The refinery was once again running at full output, much to the satisfaction of the client. But still no one knew why the problem had occurred.

The second event

Three days later, Koopmann received another call from the refinery. The section had tripped again. Once again, the standard tests described above were carried out without success, raising suspicions that this was a periodically occurring fault that would continue to elude all traditional fault location methods, unless someone happened to be testing the cable section at exactly the right time.

Luckily for the refinery, the Koopmann team on site that day had a Megger Centrix 1 80 PD partial discharge analysis system, which incorporates sophisticated diagnostic functions for DAC testing. The team recommended to the refinery that a partial discharge (PD) measurement be carried out.
Koopmann has been using DAC test equipment from Megger for PD measurements for years, as it is still to this day the only non-destructive PD measurement device on the market. When this equipment is used, even critical cables can be put back into service following PD diagnostics.

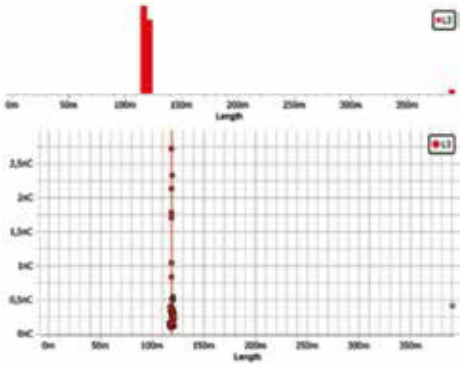
The central Centrix control unit means that tests can be carried out in quick succession

The fault is found!

It was precisely this test that ended up paying off in this situation, as it revealed increased PD levels at a coupling, which were indicative of a serious abnormality.

The accompanying image clearly shows partial discharges at a coupling 120 metres away (the x-axis is the cable length, the y-axis the PD level). In Koopmann's experience, it is the PD frequency rather than its level that is the decisive factor in intermittent faults. As there was only this one PD weak point in this particular case, it was easy to work out what had caused this intermittent fault.

Using the refinery's exemplary documentation, the Koopmann team was immediately able to work out exactly where the faulty coupling was located, and what type of coupling it was – an oilfilled coupling sleeve. Without further delay, the team found and replaced the coupling. A repeated VLF test, as prescribed by VDE Standard 0726 (HDXY) and additional PD measurements showed no further abnormalities. The partial discharges at the coupling were no longer there. Full operation was immediately resumed, and the cable section has not failed since.



Mapping for V <= Vmax (L1, L2, and L3)

Summary

A cable fault location system with a non-destructive PD measurement function, as is currently offered only by Megger's DAC technology, is undoubtedly the best cable fault location system. Without this technology or with another cable fault location system from other manufacturers, the Koopmann team would not have been able to finally locate this elusive cable fault. The refinery's exemplary documentation also played an important role, as it allowed the correct coupling to be located quickly and accurately.