Power Diagnostix announces the new Division "Power Diagnostix Service"

Recently, the Power Diagnostix group founded his service division called Power Diagnostix Service GmbH. Since early 1993, over 3000 digital partial detectors have been sold worldwide. The past 22 years, the company has built a solid reputation in the field of special measurement and monitoring devices for the high voltage and power engineering sector. Due to the increasing demand for on-site testing, assistance, and expertise during factory acceptance testing, founding this new service department was a logical next step in order to provide full on-site support during various partial discharge tests.

Power Diagnostix Service offers on-site high voltage insulation condition measurements on motor and generators, power and distribution transformers, medium and high voltage class cables, and gas/air insulated switchgear (GIS). Additionally, technical support can be offered during factory and site acceptance tests, and we act as independent consultants as well to locate partial discharge sources within different high voltage insulation systems. Our measurements reports with detailed summary and recommendations can often be very valuable when taking important decisions concerning required maintenance actions or design modifications in order to improve the reliability of the various high voltage equipment as mentioned above. Service measurements or PD localization can be offered worldwide. Measurements can be performed via both the off-line and online principles.

Fig. 1: 1.3 MW converter based test system

For off-line testing, we are equipped with two mobile test systems and portable equipment. With the large test set, a 2 MVA converter based system, embedded into a 40 feat standard container, we can offer both induced (up to 90 kV) and applied voltage testing (up to 500 kV). The test system is self-contained for on-site tests requiring up to 100 kVA by using a generator mounted to the auxiliary tap axle. When operating the system in resonance mode we only need to inject the losses, and, hence, a couple of kW´ is sufficient to cover a 500 kV applied voltage test, for instance. When more input power is needed, the test system can be supplied by diesel generator.

Fig. 2: Control room of the truck

The medium voltage test system comes with a 100 kV/11 kVA AC dielectric for testing dry type transformers, medium voltage switchgear or short cable jumpers, for instance. In case of larger capacitive loads, the van can be extended with a trailer, providing a 500 kVA/50 kV resonant test system. Similar to the large test set, this system is also self-contained for power requirements up to 16 kVA.

Fig. 3: Medium voltage test van

As alternative for the power frequency sources, several portable very low frequency (VLF) sources are available as well for on-site testing of medium voltage equipment up to 60 kV.

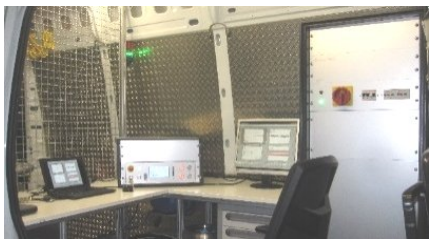

Fig. 4: Control room of the van

Based on our long term experiences with partial discharge analysis and development of application related test equipment, PD Service is the perfect partner for complicated root cause analysis and partial discharge fault localization. Beside

on-site measurement surveys, service measurement contracts can be offered as well, even remote reporting is possible. Our team of experienced service engineers is prepared to assist you with any testing inquiry.

Testing of Rotating Machines

Although the current epoxy mica insulation system widely tolerates partial discharge activity, insulation condition monitoring becomes more and more a standard in this branch and is strongly recommended in order to detect possible dielectric problems in an early stage. Both motors and generators can be tested off-line with our medium voltage test set. The 50 kV/500 kVA allows energizing of small motors up to large windings of hydro generators.

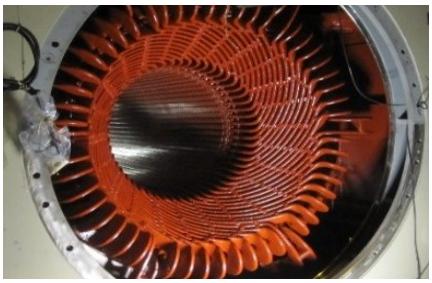

Fig. 5: Stator winding of a turbo generator

Fig. 6: On-site test on a 4500 MVA pump motor with the resonant test system

Mostly, off-line tests are carried out during maintenance outages or online by using permanently or provisionally installed coupling units during regularly surveys. With the communication techniques of today, even remote monitoring can be offered as a service.

Fig. 7: On-site PD and TD test on a 150 MVA turbo generator

As mentioned above, the testing will be performed according to the relevant standards such as the IEC 60034, IEC 60034-27 part 1-3, IEEE 400.3, and others, or by special agreements made with the owner of the equipment.

Fig. 8: Test setup on 250 kW asynchronous motor with the MV test van

In addition to the off-line PD and tan delta testing, we can also offer the common additional dielectric tests such as:

- Winding resistance
- Insulation resistance
- Polarization index
- Step-voltage tests
- Dielectric absorption and re-absorption
- Hi-pot testing
- Rotor reflectometer tests (for synchronous machines)

In case of pre-installed coupling capacitors, PD measurements can be performed during normal operational conditions. Existing calibration data can be used to conduct the readings. Alternatively, an online sensitivity estimation can be performed or a fresh off-line calibration.

Fig. 9: Calibration of couplers for online PD measurements

Besides testing of entire windings, Power Diagnostix Service can provide expertise as well on QA testing of stator bars according to standards such as the IEC 60034-27 part 3 and IEEE 286-200. Fundamental design problems can be unveiled by dedicated testing and resolved by well-considered corrective actions.

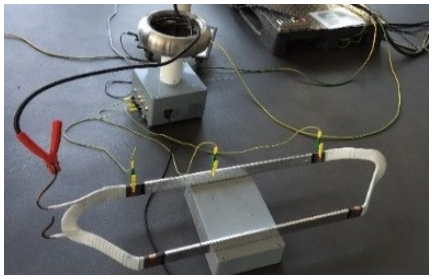

Fig. 10: Test setup for stator bars in the laboratory

Usually, up to 10% of an entire batch needs to be examined, but, prior to the production process, VPI or resin rich dummies can be provided to Power Diagnostix for advanced testing in our laboratory in Aachen. Alternatively, a service engineer can perform testing at the customer's laboratory as well.

Testing of Medium and High Voltage Class Cables

Partial discharges may appear in power cables and accessories as a result of insulation defects. Very often the problem is not present in the solid insulation material, e. g. in the extruded polyethylene (XLPE), but can be more frequently related to dielectric problems within the accessories such as end terminations and joints. Occasionally, internal cavities are detected in new cables caused imperfect by production processes.

Fig. 11: PD calibration prior to an off-line PD test

Partial discharge measurements during so called after laying or after installation tests can unveil dielectric problems caused by un-careful fitting of accessories such as end terminations and joints. Although they are strongly recommended, relevant standards such as IEC 60502 and IEC 62067 are not defining partial discharge measurements as a standard test after installation, and, hence, no limits or criteria are given. The partial discharge test procedures have been recently updated and extended in the new edition of the IEC 60885-3 that was released last April. Currently, we experience an increasing demand for on-site PD testing as part of the after installation test (SAT) and we expect that this demand will show an increasing tendency since several Cigré (CIGRE WG D1.33 and IEEE (400.3) working groups are proceeding on required procedures for on-site testing of medium and high voltage class cables. Re-testing the cable's main insulation with a certain sensitivity, but, mainly verifying the performance of the accessories fitted are very important and can offer installation companies a certain guarantee on their work. It stands to reason that re-testing the cable according to standards is not feasible with typical on-site sensitivities from a few tens up to 100 pC. Comparing the shielded environment with the often noisy substation backgrounds, sometimes require to measure into frequencies exceeding the IEC 60270's limits, which can influence the signal properties of the high frequency partial discharge pulses along the cables length. However, in such cases the global measurement circuit using a regular coupling capacitors can then be extended by using portable PD detectors and near field sensors such as

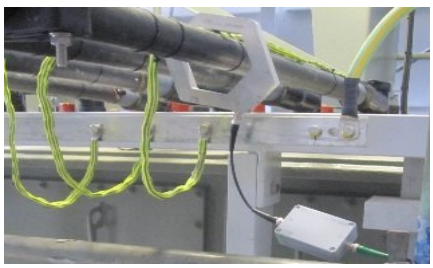

Fig. 12: Near field PD test with HFCT and portable PD detector

acoustic sensors, high frequency current transformers (HFCTs) in the cross link boxes or at the end terminations itself, in order to improve the coverage of mainly the cable accessories.

Testing of high voltage cables with or without partial discharge measurements can be performed with voltages up to 500 kV using our large mobile test system.

Fig. 13: Site acceptance test (SAT) on 220 kV cables according to IEC 60267

Besides the regular one hour test at the rated voltage applied between the core and sheath, according to standards such as the IEC 62067, our large system is also available for 24 h soak tests in single or three phases regimes by injecting through the GIS and transformers, respectively.

Fig. 14: 24h soak test on the HV cables of an offshore wind turbine substation

For medium voltage class cables we make use of a 50 kV/ 500 kVA resonant test set embedded into a trailer. With the three different voltage taps we have full power (500 kVA) available at every bushing and, hence, we can cover a wide

capacitance range from short jumper cables up to lengths of a few kilometers.

Besides using our power frequency sources, we can assess medium voltage cables using very low frequency (VLF) hi-pots up to 60 kV_{peak}.

Fig. 15: On-site PD and TD test on medium voltage cables using VLF (0.1 Hz)

In addition to the regular PD measurement, tan delta (dissipation factor) and capacitance measurements can be performed as well. In case it is required to perform a partial discharge localization along the cables trace, we can make use of equipment offering the well-known time domain reflectometry technique.

Power and Distribution Transformers

On-site partial discharge testing on power and distribution transformers shows currently an increasing demand. A trigger for such on-site surveys may be an online monitoring system for dissolved gas analysis (DGA) or a permanently installed PD monitor, a Bucholz relay, for a general insulation condition assessment as part of condition based maintenance programs. Besides this, retesting to standards after on-site repairs is nowadays more common than before, since provision of powerful light weighted mobile test sets can significantly reduce transportation costs for large power units and smaller transformers that are difficult to be accessed, e. g. the dry type units on top of wind turbines.

Our 2 MVA mobile power source is specially designed for on-site transformer testing. We can offer induced voltage tests in single or three phase mode with frequencies from 20 to 200 Hz and applied voltage tests using a reactor with fixed inductance. Besides the partial discharge testing to standards such as IEC 60076-3 and IEEE C57.12.00, additional tests such as the load and no load losses and heat run tests can be performed as well.

Fig. 16: On-site high voltage test on 500 MVA current limiting reactors

Test capabilities of the AC mobile test system:

- Rated power 1.3 MW
- Induced voltage testing up to 90 kV
- Applied voltage testing up to 500 kV
- No load loss test
- Load loss test
- Heat run test (up to 1.3 MW)
- Electrical and acoustic PD detection

Fig. 17: Preparation for a 3-phase induced and voltage test

When a full site acceptance test (SAT) or re-commissioning is needed, the high voltage tests can be extended with electrical routine and dielectric tests such as:

- Transformer ratio measurements
- Winding resistance test
- Insulation resistance test
- Polarity and excitation current test
- Frequency response analysis (SFRA)
- Oil analysis
- Tan delta and capacitance

Fig. 18: Preparation for a 500 kV on-site applied voltage test

When online testing is the only alternative, transformers can be equipped with temporary installed sensors such as quadrupoles to the test taps and or UHF sensors in the drain valves

or flanges. After completing calibrations and sensitivity checks the transformer can be energized by back feeding through the grid. Such measurements might be more prone to external disturbances such as coronas, but give generally good results by applying noise cancellation techniques and appropriate corona shielding.

Fig. 19: On-site investigation setup

When the electrical PD measurements show evidence of partial discharge activity within the tank or bushings, a dedicated fault analysis and localization can be performed using phase, time, and frequency domain measurements.

Fig. 20: Online acoustic detection on a transformer oil bushing

Besides these well-known troubleshooting techniques, Power Diagnostix has more than 25 years of experience in using the acoustic triangulation method which has been proven to be very effective for more than hundred cases with new built transformers. Acoustic measurements have been performed successfully online and off-line. However, preferably, acoustic testing shall be performed with an external power source as the insulating media is not homogenous under online conditions.

Fig. 21: 3-phase induced PD measurement on a dry type transformer

Besides on-site testing of larger power units we offer service measurements on dry type units as well. Support can be offered in the workshop or laboratory with acceptance testing to standards such as the IEC 60076-11 and the IEEE C57.12.01. Onsite testing as a general insulation condition assesment, fault anlysis, or re-acceptance testing is possible as well. However, ambient noise conditions must be considered, and, hence, filtering and special setup modifications become very important. Testing via the applied and induced principles is possible. A local power source or our mobile sets can be used. For units that are difficult to access, e. g. wind turbine transformers, for instance, a small portable hi-pot can be brought on-site to test the cast resin coils one by one in applied mode. The electrical routine and dieletric tests as mentioned above can be performed as well, prior to the partial discharge test.

Testing of Switchgear

High voltage testing on a new air or gas insulated switchgear is a standard test to be completed during the commissioning stage. PD service can support with on-site applied voltage tests up to 500 kV using the large mobile test system. For medium voltage GIS or AIS installations, our Van or smaller portable instruments can be used. In case UHF PD sensors are embedded into the GIS, we can make use of them to monitor the partial discharge activity within the GIS system during the high voltage test, in addition to the PD signals captured by the coupling capacitor. With systems that are online we can install external sensors on isolated non shielded flanges or fix acoustic sensors onto the wall of the gas chambers. With the last method, we can use the time of flight measurements principle to locate hopping particles, for instance.

Your Inquiry

In case of service measurement inquiries, please approach us by e-mail to:

services@pdix.com.

In order to provide a fast response on specific testing inquiries, following general information is very helpful:

- Number of objects to be tested
- Equipment characteristics / rating plate
- Picture or outline drawing
- Testing site and date
- Reason for the test (e.g. FAT/SAT or diagnostic test)
- Desired testing standards

After having evaluated the inquiry, we will contact you to discuss all related details concerning the on-site tests and provide a project related budget quotation.

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