IRIS POWER
A QUALITROL Company

Diagnostic News

November 2016

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Partial Discharge Testing of Stator Bars and Coils as a Quality Assurance Test

By: Greg Stone

Partial discharge (PD) testing is one of the most widely used methods to assess the quality of electrical insulation in new high voltage equipment such as power cables, transformers and switchgear. IEEE and IEC standards specify how to perform the PD test, identify what magnitude of PD (in picoCoulombs) is permitted, and what the test voltage is for each of these types of equipment. Stator windings in motors and generators are different. To date, IEEE 1434 and IEC 60034-27 identify how to perform the PD test on coils/bars as well as windings, but there is no standard that recommends the PD magnitude that is acceptable nor the test voltage, either for bars/coils or for complete windings. It seems reasonable that a standardized PD test for new stators is not available since each brand of PD detector will produce significantly different levels of PD, making it hard to obtain consistent results. However, recently there has been some investigation on developing a PD quality assurance (QA) test for stator bars and coils.

In power cables, transformers and switchgear, PD can occur if small voids are created within the insulation during manufacture, or air gaps occur between conductors at different voltage levels. The primarily-organic insulation in these types of equipment deteriorates when exposed to prolonged PD, growing "electrical trees" or developing surface tracking. Eventually, the organic insulation (polyethylene, oil, paper or epoxy) will puncture, causing failure in as short a time as a few months. The PD quality assurance test ensures that no such voids or gaps are created during manufacturing, that would result in premature failure of the equipment.

Voids within the groundwall insulation of new bars and coils rated 3 kV and above can occur for a variety of reasons, such as by wrinkling of the mica paper tapes, poor control of the liquid epoxy chemistry and viscosity (VPI process), insufficient time for epoxy impregnation (VPI process), inadequate pressure for resin rich

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New Portable Instruments for On-Line Measurement of Stator Winding PD

The Iris Power PDA-IV, TGA-B and TGA-S have been completely redesigned. Customers have told us that they wanted a TGA/PDA that was easier to carry and had the ability to do a test using battery power, thus eliminating the need to get 120/240 V to the motor or generator being tested. The new design was introduced at the 2016 Iris Rotating Machine Conference, and is now in regular production. It has a much more rugged design and is in a self-contained case similar to what has proved popular with the Iris Power RFA line. Talk to your local application engineer to get a demo of the PDA-IV^{RP} or TGA^{RP}.

UPCOMING EVENTS 2017

EPRI –TGUG Users Group	Jan 16-20 Memphis, TN
EPRI—LEMUG	Jan 29-30 Miramar Beach, FL
501 F&G User Group Meeting/ Vendors Fair	Feb 19-23 Reno, NV
IEEE EIC	June 10-15 Baltimore, MD

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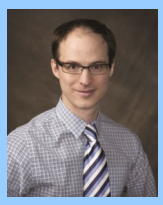
Iris Co-Author Receives Best Paper Award



John Letal of the Qualitrol-Iris Power RMTS group helped to author a paper entitled "Vibration Diagnostics and Overhaul Procedures at Jajce Generating Station". This paper was presented at the 2016 HydroVision conference in Minneapolis, USA. Co-authored with Ozren Huznjak of Veski, the paper was voted the third best paper at this conference. Congratulations Ozren and John!

Using Partial Discharge Testing of Stator Bars and Coils as a QA Test

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tapes, etc. If these voids are within the groundwall (see Figure) and the coil is connected to the high voltage terminal of the motor or generator, then PD may occur within the voids. Because almost all machines rated 3 kV and above are made with mica paper tapes, which are very resistant to PD attack, it may take years or even decades for a failure to occur in service. Thus PD is not as catastrophic for a motor or generator as it is for other types of high voltage equipment. But there is still interest in an objective, non-destructive test that can assess if severe voids are present.

One such test for voids is the dissipation factor tip-up test (IEEE 286 and IEC 60034-27-3). The tip-up is an indirect method of measuring the PD activity. However, the tip-up test cannot distinguish between one large void and many small voids in a coil or bar since it measures the average condition of the coil or bar. The other way to detect voids is directly with a PD Quality Assurance test. The advantage of the PD QA test is that a modern digital PD test can measure the severity of the largest voids (the peak PD magnitude), and give an indication of the number of voids (from the PD pulse repetition rate). Another advantage of the PD test is that the phase-resolved PD pattern can be used to determine where the voids are located within the groundwall (i.e. near the coil/bar surface, or closer to the copper conductors, as is the case in the figure).

One of the technical problems with a factory PD test on coils and bars is that different brands of PD instruments seem to detect different levels of PD on the same coils/bars. Recently GE and EDF have published IEEE papers where PD was measured on the same coil using 3 different brands of PD test instrument [1,2]. The tests were done with instruments using the IEC 60270 frequency range (< 1MHz). The PD levels differed by as much as three to one. That is, 100 pC might be measured with detector 1, but detector 2 might yield 300 pC, on the same coil. This variation means that a coil might pass using one instrument, but fail using another. The reason for the variation between brands is unknown, but it could be caused by:

- Each brand of detector tends to use slightly different PD detection frequencies, yet still be within the IEC 60270 range.
- The meaning of peak PD magnitude that is used in ASTM D1868 and IEC 60270 is based on an analog concept that does translate easily for modern digital PD detectors. It seems different PD equipment manufacturers calculate the peak PD magnitude differently in their modern digital PD detectors.

Until these two issues are resolved, it will be difficult to obtain a consistent PD magnitude between brands. So, although IEEE Electrical Machines Committee/Materials subcommittee is now attempting to draft a PD test standard for coils and bars, progress will probably have to wait for consensus on specific frequencies and a digital method of calculating peak PD magnitude.

References

1. *A. Petit, "Temperature effect on insulation resistance of generator stator bar affected by water ingress", IEEE Electrical Insulation Conference, June 2015.*
2. *S. Ul Haq, et al, "Comparative Study of IEC 60270 Compliant Instruments for PD Pattern Acquisition, IEEE Petrochemical Industry Conference, September 2016.*§

Iris Rotating Machine Conference
June 19-22, 2017
CALL for PAPERS

We invite you to attend the 20th Annual Iris Rotating Machine Conference in Orlando, Florida. Take advantage of the opportunity to join large motor and generator experts from around the world to discuss best practices and innovations in equipment design, operations, monitoring, diagnostics and maintenance.

We are now looking for relevant papers for the rotating machine technical program. Preferred subjects include:

- Recent stator or rotor winding failures
- New winding repair methods
- Experience with machine testing and condition monitoring
- Advances in motor and generator design
- Machine maintenance procedures

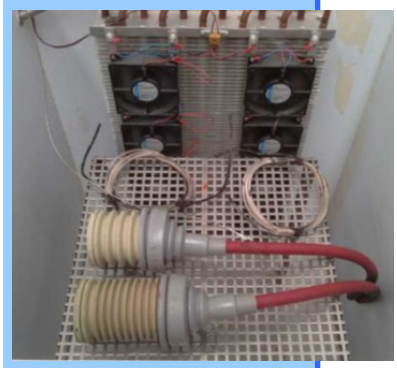
Please submit a short abstract to Karen Howard (khoward@qualitrolcorp.com).

Schedule of Submission

- Abstract submittal deadline February 28th, 2017
- Authors notified of acceptance March 20th, 2017
- Paper submittal deadline April 28, 2017

The conference will take place at the Holiday Inn & Suites, 5905 Kirkman Road, Orlando, FL, 407-351-3333. We have negotiated a room rate of $99 US—book early!§

Capactive PD Couplers now ATEX Certified



Iris Power continuously expands its products and certifications to satisfy customer and standards needs world wide. One of latest market requirements was specific hazardous location certification, known as ATEX, for the Iris Power Epoxy Mica Capacitor(EMC). The EMC certification provides additional support and easier system certification (rotating machine, motor or termination box) because the installed component is already ATEX certified.

The EMC is designed to operate continuously in a wide temperature range of -50°C to +130°C (-58°F to +266°F) for the life of a rotating machine. Based on the temperature range and IEC 60079-0 standard, 6.9 kV and 16 kV EMCs have been exposed for numerous hours at +95°C, RH 90% followed by +150°C, dry and finally followed by -55°C. For this type of certification, the main concern was thermomechanical endurance and safety, as well as dielectric strength.

All required tests were successful and comply with the Essential Health and Safety requirements relating to the design and construction of products intended for use in potentially explosive atmosphere given in Annex II to the Directive 2014/34/EU-ATEX of the European Parliament and of the Council, dated February 26, 2014. Compliance with the Essential Health and Safety requirements has been assured by compliance with EN 60079-0:2012/A11:2013 and EN 60079-7:2015.

Valid markings of the certified components are:

II2G Ex e IIC T6 Gb Tamb = -50°C to +130°C

2017 Training Courses

Partial Discharge Course
March 28-30
New Orleans, LA
and
October 17-19
Seattle, WA

Hydrogenerator Maintenance Course
April 25-27
Toronto, Canada

EL CID Training Seminar
June 6-8
Toronto, Canada

For more information, contact:
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New IEC Technical Specification on PD Measurements

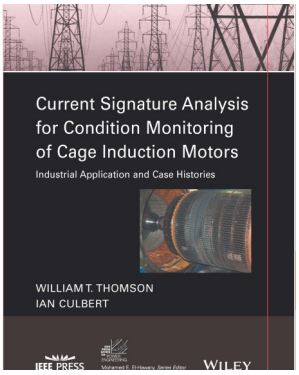
IEC TS 62478:2016 "High voltage test techniques - Measurement of partial discharges by electromagnetic and acoustic methods" has just been published. This new standard is a complement to IEC 60270 which covers PD measurement in the low frequency range (<3 MHz), and outlines how to calibrate mV into picoCoulombs for capacitive test objects. IEC 62478 covers measurements in three other frequency bands:

- High Frequency (3-30 MHz)
- Very High Frequency (30-300 MHz)
- Ultra High Frequency (300-3000 MHz)

The new document discusses why PD measurement can be useful at frequencies higher than those used in IEC 60270 (and ASTM D1868), describes many detection methods, outlines why PD cannot be measured in pC at higher frequencies, and gives several examples of VHF and UHF PD detection in transformers, gas insulated switchgear and rotating machines. These applications have become very important since on-line PD testing at the VHF and UHF frequencies is usually more reliable (i.e. there are fewer false indications) due to the greater immunity to electrical noise at the higher frequencies.

With IEC 62478 now published, IEC will embark on a complete revision of the IEC 60270.§

New Book on Current Signature Analysis to Detect Induction Motor Rotor Winding Problems



Professor Bill Thomson and Ian Culbert have written a book called "Current Signature Analysis for Condition Monitoring of Cage Induction Motors – Industrial Applications and Case Studies". It is published by Wiley – IEEE Press. The book is being printed now and will be available shortly. It can be ordered directly from Wiley, at the URL www.wiley.com/buy/9781119029595. The list price of the book is $140 US, but with the promotion code ENGN4, there is a 25% discount.

In the early 1980s, Bill Thomson was one of the inventors of motor current signature analysis (MCSA) while a professor at Robert Gordon University in Aberdeen, Scotland. Since retiring, he has been an active consultant to owners of motors in utility and petrochemical companies, diagnosing the root causes of failures. It was from this experience that Bill collected dozens of case studies on the application of MCSA. Bill has been a frequent presenter of papers at the Iris Rotating Machine Conference, and contributed many of the algorithms that are in the Iris Power MDSP3 current signature instrument. Ian Culbert, who died last year, provided some of the material on the design and failure of squirrel cage induction rotors. Ian worked for two motor manufacturers before joining Ontario Hydro and then Iris Power.§