

DIAGNOSTIC NEWS

Iris Power LP
SUMMER 2007

IN THIS ISSUE:

- Acceptable Contact Resistance Value *Pg. 2*
- Iris Adwel Merger *Pg. 3*
- Digital Winding Resistance *Pg. 4*
- Product Upgrades *Pg. 4*

Your Source For Monitoring the Reliability of Electrical Equipment

STATOR WINDING HIPOT TESTING – PART 2

Greg Stone

In the last issue, I listed some of the important issues surrounding AC and DC hipot (high potential) testing, including:

- Should hipot testing be done on machines that have seen service – i.e. maintenance hipot testing?
- Does hipot testing shorten the life of a winding?
- What are the pros and cons of AC vs. DC testing?
- What about 0.1 Hz (or very low frequency – VLF) hipot testing?
- What about DC Ramp testing, where the DC voltage is automatically but slowly raised to the maximum test voltage, at the same time as the current is monitored?

The first two topics were discussed in the Feb 2007 issue of Diagnostic News (go to www.irispower.com/ to download a copy). In this issue I address the last three topics.

AC vs. DC

In the vast majority of cases, a commissioning hipot test on a new stator is with AC voltage, rather than DC. In a past survey conducted by EPRI, and in my personal experience, machine owners in North America normally use DC for maintenance hipot testing, whereas those outside of North America tend to use AC. The reasons for this dichotomy are not clear, but perhaps it is because AC hipot units are so large and heavy compared to a DC hipot testers, making transport of the AC tester only possible by road. Since the US, Canada and Mexico are so physically large, the transportation costs and associated effort may not be considered realistic for AC hipot test sets.

However, the evidence suggests that an AC hipot is more sensitive to significant insulation flaws in the slot portion of the coils/bars than DC, especially with modern polyester and modern epoxy mica insulation systems. This is because the large air pockets within the insulation will have little or no voltage across them when subjected to DC stress. In contrast, a large capacitive voltage will develop across voids during an AC hipot, resulting in PD that can cause failure. In the endwindings, serious insulation problems far from the core are usually more easily detected with DC than AC, since there is little voltage across the insulation beyond the stress relief coatings under AC stress.

Since problems in the slot are usually not obvious during a visual inspection (as compared to problems in the endwinding), the preference for AC hipot exists because it can best detect problems in the slot.

continued on page 3

EVENTS

EPRI Workshop	Aug. 13-14, 2007 Phoenix, AZ
PCIC	Sept. 17-19, 2007 Calgary, AB
Motor Maintenance Course	Nov. 6-8, 2007 Hotel Monteleone New Orleans, LA
Partial Discharge Course	Nov. 13-15, 2007 Sheraton Safari Hotel & Suites Orlando, FL



STATOR WINDING HIPOT TESTING – PART 2 CONTINUED...

VLF Test

The superior ability of the AC hipot test to find significant problems that may not be visually observed easily, is offset by the bulk and power requirements of the required AC hipot test set. One way of overcoming this limitation is to use a 50 or 60 Hz resonant test set, which is much more compact. Regrettably this is usually not feasible since as the voltage is raised to near the hipot test level, the stator PD activity is usually so intense that the test set loses resonance and can not reach the required test voltage. An alternative to this is to use a much lower AC test frequency, usually 0.1 Hz. This is referred to as a very low frequency (VLF) test. Modern VLF test sets are almost as compact as a DC hipot unit, yet can provide a reasonably good AC waveform. Even with the low 0.1 Hz AC, it seems that the VLF test behaves closer to an AC test than a DC hipot test. Since the capacitive current at 0.1 Hz is 1/600th the current at 60 Hz, the test set can be supplied from a wall outlet. VLF testing has become popular for testing power cables, and the test set created for such cable testing can be used for stator windings. IEEE 433 describes the test in more detail. This document has just been extensively revised and should be re-published soon.

DC RAMP TEST

To some machine owners, one of the disadvantages of hipot testing is that the insulation can fail during the test, necessitating a repair or replacement of some sort, that extends a machine outage. The DC ramp test is an alternative to the DC hipot test that may provide warning of an impending hipot failure, which allows a knowledgeable user to sometimes abort the hipot test before a complete insulation system breakdown occurs. In this test, the DC voltage is increased at a constant rate (typically 1 or 2 kV per minute) while the DC supply current is measured. If there is a sudden increase in current, it may indicate imminent breakdown, and the test can be aborted. In my experience, aborting the test before failure is most likely to be successful when the insulation problem is in the endwinding. A further advantage of the Ramp test is that some researchers have found some leakage current patterns are characteristic of specific insulation problems. This version of the hipot test is described in IEEE 95, and the test instrument is available from Adwel/Iris.



In summary, hipot tests are the most objective and effective way to determine if there are serious insulation system problems in a stator winding that may result in in-service failures. However they should be performed with care. Whether the hipot test is done or not is a management decision weighing the risks of a hipot test failure versus the consequence of an in-service failure.

ACCEPTABLE CONTACT RESISTANCE VALUES

What is an acceptable contact resistance value?

A low-voltage 4000-amp circuit breaker may have a resistance in the range of 20 to 50 micro-ohms, while a high-voltage circuit breaker rated at 2000 amps may have a resistance in the range of 200 to 500 micro-ohms. Both would be acceptable values. There is no published standard that gives numeric pass/fail values.

Following are a few guidelines noted over 25 years of testing:

- 1) Consult the manufacturer. Often circuit breakers are tested in the factory and the results are provided with the factory test data. A comparison to these values will allow the test operator to detect and evaluate any deterioration. Unfortunately, this information is rarely available in the field, especially during the hectic maintenance period.
- 2) Compare to similar devices. Generally a transformer station will have a number of circuit breakers of the same model and ratings. While making the reasonable assumption that they won't all be defective, the test operator can compare results to other results. Resistance values that deviate from the lowest value recorded for the other circuit breakers by a sizeable margin (20%, for instance) could be investigated.
- 3) Compare the phases. This technique is similar to the one mentioned above. If a group of similar circuit breakers is not available, look for differences among each of the three phases.

IRMC 2007

Iris celebrated the 10th anniversary of the IRMC this past June, in San Antonio, Texas. During the event Iris Power LP formally announced the acquisition of Adwel International Inc.; the result of which is an expanded line of off-line testing and diagnostic tools for rotating machines, as well as instruments targeted at the Transmission and Distribution market.

The conference was a great success, with over one hundred attendees from twenty countries including China,

continued on page 3...



IRMC 2007
Continued from page 2

India, Japan, Australia, Brazil and Denmark. In addition to the usual tutorials, workshops and user groups, there were also twenty technical papers on various aspects of repair, maintenance, testing and monitoring of electrical apparatus, a unique compilation of knowledge and experience across many powerplants and utilities.

Iris would like to extend our thanks to all attendees. We look forward to seeing you next year in Santa Monica. Please keep visiting our website at www.irispower.com for details.

216 EXAMPLES OF WHERE ON-LINE PD IDENTIFIED MOTOR AND GENERATOR PROBLEMS

Clyde Maughan (cmaughan@nycap.rr.com) is a well-known consultant and former GE expert who provides consultation services including training of generator service specialists, writing of maintenance procedures, failure investigations & analysis, design & manufacturing consultation, insurance claim resolution, and expert trial testimony. A project he has been recently engaged in is to evaluate the effectiveness of on-line partial discharge (PD) testing for stator windings.

Mr. Maughan wrote the paper "Partial Discharge - A Valuable Stator Winding Evaluation Tool", which was presented at the 2006 IEEE International Symposium on Electrical Insulation. The paper refers to 216 incidents, where on-line PD detected problems. These 216 "incidents" were drawn from a list of case studies that customers of the Iris technology have published during the past 20 years. The Table below shows a summary of the incidents, classified by Mr. Maughan according to the root cause.

Contamination	10
Vibration	54
Design/Manufacturing	127
Operation/Maintenance	12
Non-Generator	13
Total	216

The following is an excerpt of the paper: "...users of PD monitoring have been left with uncertainty as to just how valuable PD measurement might be in assessing the condition of the stator winding of a specific generator or motor. In an attempt to address this concern, the 'success rate' of one vendor's database has been analyzed. The PD technology this vendor uses has been installed on a large number of generators and motors and data have been received from about 3600 of these machines. In 216 cases, investigation of high PD readings has been conducted and the equipment owner has provided the vendor with the results of the investigations...PD monitoring systems appear to be finding conditions of concern on about 6% of generators where the equipment is installed. Probably no other generator monitoring system exceeds this rate of problem detect. Because of the high capability of PD monitoring, as illustrated in this paper, continued rapid growth in the installation of PD monitoring instrumentation should be encouraged and expected... PD monitoring has identified many pending service problems, prevented a significant number of generator service failures, and has resulted in a major cost saving to the power generation industry..."

IRIS ADWEL MERGER

IRIS Power and ADWEL International have combined forces to better serve a broad spectrum of the global electrical testing & measurement market. Through merging the IRIS leadership in Partial Discharge Analysis (PDA) testing with the ADWEL expertise in Stator Core testing of generators & motors, clients will now have direct access to the widest selection of on-line and off-line insulation, stator core and T&D testing products and services in the electric power industry.

Test equipment & services now include the following:

- Partial Discharge Analysis (PDA)
- Electromagnetic Core Imperfection Detector (EL CID)
- Wedge Tightness Detection
- Signature Analysis
- Motor and Generator Rotor Flux Monitoring
- DC Ramp Insulation Tester

Test equipment available for the Transmission & Distribution industry includes the following:

- Winding Resistance Tester
- Contact Resistance Tester
- Current Transformer Tester
- Transformer Ratiometer

The two companies will operate under IRIS Power LP once amalgamated.



UPCOMING EVENTS

Please join us for the Motor Maintenance Course (November 6-8) in New Orleans, and the Partial Discharge Course (November 13-15) in Orlando, Florida. Space is limited, so register now.

For more information, or to register, please contact Michelle Mathias at 416-620-5600 Ext. 231, or by email at mmathias@irispower.com.

Motor Maintenance

Cost: \$1250 USD
Hotel Monteleone
214 Royal Street
New Orleans, LA

Partial Discharge

Cost: \$1050 USD
Sheraton Safari Hotel &
Suites Lake Beuna Vista
12205 Apopka-Vineland
Rd.
Orlando, FL

NEW PRODUCTS & SERVICES

DIGITAL WINDING RESISTANCE



Adwel has been manufacturing and selling transformer winding resistance measuring instruments for over fifteen years. Three years ago we introduced the Digital Winding Resistance tester model DWR-10, a micro-processor based product which makes very accurate measurements of winding

resistance in record time. The product features a 10-amp power supply, two high resolution channels, memory for data storage, and a built in printer. All housed in a rugged case making the DWR an excellent product for field testing.

This product is also available as model DWR-10t. This allows transformer manufacturers to automatically record resistance and time as the transformer windings cool after a heat run.

In September, a new model, the DWR-10-TC will be available. This model will include a unique feature that will automatically advance the on-load tap-changer while making measurements and saving the results, with little or no human intervention. This will significantly reduce the labor associated with testing transformers with a large number of taps.

To address your inquiries or obtain more information please contact your sales representative, phone us at 416-321-1988 (Toll free 1-800-463-1988), or visit us at www.adwel.com/winding.html.

UPGRADES FOR PDVIEW3 & PDLITE PRO NOW AVAILABLE

If you are using PDLitePro with a TGA or PDA-IV analyzer we strongly recommend upgrading PDLitePro and PDView3 applications in order to avoid compatibility issues in future. The upgrades are free of charge and are in line with our policy of continuously improving our products.

The upgrades are a result of a recent change in the database structure of files used by these applications. The latest versions now have the following changes:

- PDLitePro is now capable of using low frequency couplers for off-line testing compliant with IEC 60034-27.
- PDView is now capable of viewing data from low frequency tests.
- Minor bugs relating to some reporting templates have been fixed in PDView.

Both PDView and PDLitePro now have the capability to view results in pC (pico coulombs) if normalization has been carried out and the conversion factor is known. A scaling factor (k factor) used with external attenuators can now be employed.

If you have purchased a license for, and are using PDView Advanced Edition please contact your sales representative or advise us at upgrade@irispower.com before upgrading PDView3.

Although the new applications have been thoroughly tested before release, you are encouraged to archive a copy of your existing database(s) before upgrade to avoid possible loss of data should you encounter installation or conversion difficulties.

