Qualitrol Iris Power

IRIS POWER
A QUALITROL Company

DIAGNOSTIC NEWS

September 2011

Vibration Sparking Analysis Using Neutral-End Couplers

By: Vicki Warren

Inside this issue:

UPCOMING EVENTS 2011

PCIC 2011	Toronto, Canada Sept 19-21
Hydro Vision Brazil	Rio de Janeiro, Brazil Sept 20-22
CMDM	Bucharest, Romania Sept 19-23
IEEE IAS Annual Meeting	Orlando, Florida Oct 9-13
Hydro 2011	Prague, Czech Republic Oct 17-19
GE 7EA User Group	San Antonio, TX Nov 1-3

Vibration sparking (VS) is similar looking but is actually a completely different deterioration process from classic slot partial discharge (PD). The VS mechanism is driven by the magnetic flux in the core and can occur at any point of the winding [2]; whereas PD can only occur on higher voltage bars [1]. The first instance of vibration sparking occurred during the late 1950s in hydrogen-cooled turbine generators, when hard (polyester and epoxy) insulation systems were first introduced. It seems to occur rarely, but there have been several instances since the 1960s on both motors and generators.

The root cause of VS is too low a resistance of the slot conductive coating, together with vibration of the stator coil or bar. The energy to drive the VS mechanism is substantial since it is driven by the main magnetic flux in the stator core. A comprehensive description of the physics involved has been made by Liese [3]. Liese has estimated that the resistance of the slot conductive coating should not be lower than 300 to 2000 ohms per square to prevent VS.

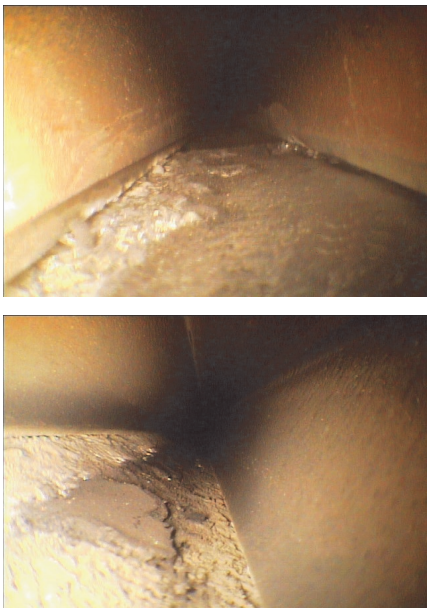
There are several somewhat unpredictable factors involved in the rate of deterioration resulting from slot partial discharge (PD) and from vibration sparking. As a result it is not possible to define clear rules for predicting deterioration rates. Well-made mica insulation systems have proven to be highly resistant to PD and high frequency pulses. Significant levels, without any extraneous influences, seem not to penetrate the mica tapes even after 20 or 30 years of service. However, vibration sparking and slot discharge due to loose coils can be very aggressive.

It may be difficult to distinguish the evidence of VS and slot discharge PD. If a bar is operating at high voltage, there may be no way to be certain, but if a deteriorated bar is from a low-voltage portion of the winding, it is certain to be VS. The slot portion can be difficult to inspect. If there are radial ventilation ducts, a good inspection can be made via boroscope. Some indication may be observable at the ends of the slots.

In a typical motor or generator, three to six capacitive-type sensors are installed at the high voltage end of the winding. Because vibration sparking (VS) can occur anywhere in the winding, including the neutral end, it is advisable that a 7th coupler be installed at the neutral end of machines where VS is expected. At the neutral end, there is insufficient voltage to have PD, so pulses detected by the neutral end sensor are either cross-coupled from other sources, or may be indications of VS.

Unlike with sensors connected at the high voltage end [5], as of yet no verified statistical database exists for evaluating the magnitude of pulse activity detected by the sensors installed at the neutral end, but it is possible to trend the results. Increases in the activity are presumed to be indicative of changes in the winding condition related to vibration sparking.

Continued on page 2..



Borescope Vibration Sparking Damage to Bar Insulation

IRIS POWER
A QUALITROL Company

Qualitrol-Iris Power—3110 American Dr.—Mississauga—Ontario—Canada—L4V 1T2
Telephone: 905-677-4824; Fax: 905-677-8498; Email: sales.iris@qualitrolcorp.com; www.irispower.com—www.qualitrolcorp.com

Vibration Sparking Analysis Using Neutral-End Couplers

- *continued from page 1* -

Table 1, below, displays the statistical breakdown for all data collected from the neutral end sensors on air-cooled machines. Since there is no electrical stress at the neutral end, then the presence of any activity is either from VS, noise or cross-coupling. When data suspected to be from these external sources are removed from the database, the remaining statistical results are different, as shown in Table 1 below. These tables may provide some guidance for analysis; however, it is the comparison of patterns from the line-end and neutral sensors that provide the most information.

...comparison of patterns from the line-end and neutral sensors provide the most information...

Failure processes have unique pulse characteristics that can be used to determine the likelihood that a specific process is occurring. Though these characteristics can be used to evaluate pulse plots to determine the possibility that a process is occurring within a winding, it should be noted that not all characteristics may be observable for any one generator or testing cycle. Table 2 below compares the expected pulse characteristic patterns for the two slot-based failure processes: slot discharge and vibration sparking,

Table 1. Distribution of Qm for air-cooled Turbine Generators with neutral end sensors

Disclaimer: please be advised that the sample size for Table 1 is small, and therefore, wide fluctuations in the tabulated data from year to year may occur.

	13-15kV Neutral couplers		16-18kV Neutral couplers	
Oper kV	All	Without ext	All	Without ext
25%	28	25	44	39
50%	42	40	134	59
75%	121	60	514	317
90%	202	122	943	777
95%	222	159	1013	930

Table 2. Comparison of Pulse Characteristics

Pulse Characteristic	Slot Discharge	Vibration Sparking
Neutral coupler activity	No – confined to high voltage bars/coils	Yes – widespread activity
Trend	Yes – the magnitude of the PD will increase as the deterioration worsens	Unknown – but likely the magnitudes at the neutral coupler would increase as the deterioration worsens
Position relative to AC cycle	Classic positions of 45° and 225°	Zero crossings of 0° and 180° at both the neutral and line-end
Polarity predominance	Positive due to the surface activity	None – similar materials
Load dependence	Yes, direct – if bars are loose No – if problem is due to poor contact to ground	Yes, direct – bars will be loose
Temperature dependence	Yes – but can be either direct or inverse due to the impact of temperature on the conductivity of the carbon-based material and thermal expansion of materials	

Continued on page 4...

Brad Spacinsky—Manager, Field Service

Brad Spacinsky joined Iris in the fall of 2005 and has been working as an Applications Engineer and International Project Manager since. He has had great success managing territories in both North American and Europe.

He completed his Bachelor degree in Electrical Engineering at McMaster University and became a registered professional engineer in 2010. He also holds a certificate from Ryerson University in Project Management and holds a certification as a *Certified Associate in Project Management* with the Project Management Institute.

For the past year Brad has been working with the IEEE, Industrial Applications Society, Petroleum and Chemical Industry Conference as part of the organizing team for the 2011 conference which is taking place in Toronto, Canada.

Brad has now been appointed manager of the Iris Field Services group, working with specialists around the world including Canada, India, UK, USA, China, Egypt and Switzerland. He brings a great perspective to the Field Service department with both his technical expertise and commercial savvy. His past experience in Sales will bridge the gap between Field Service and Sales and compliment the Field Service Specialist's front line role as the Qualitrol-Iris Power face to our customers.

The Field Service team will continue to expand the group and increase its success in driving business for Iris Power. This includes expansion of services offered, increased marketing presence and continuing to train world class field service engineers who will grow our presence at customer sites around the world.

So you think you tested your software, eh?

By Blake Lloyd

Software quality management is an ever growing issue for Iris Power and other vendors of Windows™ applications. As operating system versions flourish, delivering robust and reliable software is a very complex exercise. The normal testing regime for new software includes Unit testing, Functional testing, Integration testing, Usability testing, Performance testing and Load testing. Added to this is a whole series of Installer testing and Operating System compatibility testing. Just because a program installs and operates perfectly on Windows 7 – 32 bit – Service Pack 1, there is no guarantee that the exact same code will not misbehave within different environments. Users of our software have the whole gambit of operating systems and service pack versions, operating system languages, and in addition have a broad range of 3rd party software installed on their systems. The goal of our testing is to ensure our software applications function properly under all circumstances and operating systems.

One invaluable tool which makes this task even manageable was the introduction of Virtual Machines. A Virtual machine allows you to run one version of an operating system in a window in another version. These applications have been offered over the years by many vendors and made to support more than just Windows virtualization. Windows 7 comes with Virtual PC software built in for use by anyone. Using virtual machines you can very quickly change operating systems – and if something crashes or misbehaves, you can just reload, and return to a "clean" system. This allows our Developers and Technical Support team to verify our software in many environments, without actually having to install/re-install the operating system. A virtual machine will re-load in seconds as opposed to a 2 hour Windows 7 fresh install. All Iris applications go through testing in the full range of Operating Systems which we support (XP and above) including alternate language versions like Korean and Spanish. We don't always get it right, but we go to great lengths to ensure your software is robust and reliable

As a side note, some other great uses for virtualization are to use a Virtual PC when browsing the web. If for some reason you get cyber attacked, you can just close the virtual machine and reopen it, with no damage to your primary operating system. Another common use is when you have a software program that for example was only able to run on Windows XP, you can quickly launch an XP Virtual PC in Windows 7 and execute the software on the XP operating system. For those with Windows 7 who are interested in learning more see **http://www.microsoft.com/windows/virtual-pc.**

Qualitrol-Iris Power Continues International Expansion

By Joseph Mbuyi

As a consequence of the acquisition of Iris Power by Qualitrol in 2011, we are embarking on an aggressive expansion of our business outside of our traditional bases of North America and Europe. To this end, we have hired new staff in China, Brazil, India and the Middle East. We now have 5 project managers and field service specialists based in China alone, and will be adding more this year. The aim is to bring the benefits of on-line monitoring and diagnostic tools to the whole world, while providing a local presence in each region so that customers can talk to Qualitrol-Iris Power sales associates and access our installation expertise easily. Although we are establishing local offices in most regions, we continue to work with our local commercial partners to provide these products and services.

One other aspect of this expansion is our desire to have conferences in each region. Our vehicle for this will be the Qualitrol Condition Monitoring Conference (QCMC). These events will be much like the Iris Rotating Machine Conference, which we have been running in North America for 14 years, but the focus is broadened. Instead of just topics on motors and generators, the QCMC will include sessions on other electrical apparatus, such as transformers and switchgear. The first QCMC will be held in Dubai in late November (see http://irispower.com/qcmc.aspx). I hope you will be able to join us in Dubai. If not, we expect to expand the QCMCs to other regions in 2012.

QCMC 2011

Qualitrol Condition Monitoring Conference will be held in Dubai, UAE, November 28-29, 2011.

Visit www.irispower.com for more information or email resi.zarb@qualitrolcorp.com

2011 Training Courses

- ◊ Hydrogenerator Maintenance Course, Portland, OR, October 11-13
- ◊ Partial Discharge Seminar, November 24-25, Singapore
- ◊ Partial Discharge Course, Orlando, FL, December 6-8
- ◊ Partial Discharge Course, Gothenburg, Sweden, December 13-15

For more information, contact: khoward@qualitrolcorp.com

International Generator Technical Community

By: Jane Hutt, National Electric Coil

On any given day, online at the International Generator Technical Community (IGTC) Forum, you will find member engineers, worldwide, young, old and in between, with all levels of experience, discussing the operation and maintenance of their generators. The conversations are familiar and sometimes ordinary, as conversations about generators go, but unique because they often span borders and times zones. This worldwide, online community of engineers can be found at **www.generatortechnicalcommunity.org**.

What began in March, 2010, as a trial, without foreseeable or guaranteed results, has given way to a vibrant community of friends and mentors, nearly 750 of them in more than 54 countries. The IGTC Forum is unique among other industry forums and roundtables. Generator-related issues don't stand second or third in technical priority to turbines, switchgear, boilers and other assorted balance of plant equipment and site management issues. The Forum is simply "in-depth generator" for both thermal and hydro units – hands-on and practical in focus.

The site rules require members to curb any inclination toward commercially-motivated interactions and stick only to technical issues. An atmosphere of genuine problem-solving prevails. In the last three months, there have been posts asking questions and speaking to issues related to:

- ◊ When, what intervals and how to do inspections on a generator and its components
- ◊ Getting the opinion of others as to accepted industry standards and practices for maintenance and operation
- ◊ Explaining unexpected test results found during scheduled maintenance
- ◊ Concerns about partial discharge (PD), in general, as well as PD unique to specific machine makes/models
- ◊ Continuing operation if a unit is experiencing issues such as hotspots, vibration, PD
- ◊ Assessing remaining life impacts resulting from two-shifting (cycling) generator units
- ◊ Maintenance issues unique to globally VPI'd stators
- ◊ Understanding factory test results and quality reports received from a winding manufacturer
- ◊ Resolving chronic end winding vibration problems

The IGTC Forum is actually multiple forums with various categories of generator-related issues, each with its own volunteer moderator. A special section of the forum is reserved for Round Table discussions on topics that span more than one category and address multiple, but related issues. Like other online forum sites, the work of monitoring and maintaining the forum is carried out by volunteers, including Iris's own Greg Stone, who monitors the Air-Cooled Generator forum.

The IGTC is proud of the contributions of time and technical knowledge provided by all of its moderators. The footer on the site's web pages, not only thanks the forum moderators for contributing their time, it also reminds IGTC members that the site works because their participation is part of their contribution to the good of the engineering community.

Vibration Sparking Analysis Using Neutral-End Couplers

- continued from page 2 -

Summary: For years, monitoring of the partial discharge activity has proven beneficial for detection of stator winding failure processes that affect the high voltage coils/bars in windings, including slot discharge. It is also possible that similar test configurations that use an additional sensor at the neutral end can provide insight as to the presence or absence of vibration sparking. Based on data collected to date, it is not the overall magnitude of the activity of the line-end sensors and/or the neutral end sensors, but the patterns of the detected pulses that are more relevant. Therefore, interpretation of neutral end data should also include comparison of the patterns to the line-end machine and system couplers, identifying pattern location relative to the AC cycle, and analysis of the impact of load and temperature changes to the pulse activity. From this analysis of data collected online, hypotheses regarding the likelihood of the presence of vibration sparking can be made. The neutral end coupler is a single-ended installation, as such, the configuration does not allow for direction-of-arrival discrimination of pulses that are originating from outside the winding from the system. Therefore, it is possible that some of the activity detected by the neutral end sensor is not originating from within the winding, but from external sources, noise or from cross-coupling.

References

[1] P. Lonseth, V.R. Mulhall, "High Intensity Slot Spark Discharge – Its Causes And Cure", IEEE International Symposium on Electrical Insulation, Montreal, June 1976, Paper C4.

[2] IEEE 1434-2000 "IEEE Guide to the Measurement of Partial Discharges in Rotating Machinery."

[3] M. Liese, M. Brown, "Design-Dependent Slot Discharge and Vibration Sparking on High Voltage Windings", to be published, IEEE Trans DEI, August 2008.

[4] J.F. Lyles, T.E. Goodeve, and G.C. Stone, "Using Diagnostic Technology for Identifying Generator Winding Maintenance Needs," Hydro Review Magazine, June 1993, pp. 59-67.

[5] V. Warren, "Partial Discharge Testing – A Progress Report" Proc. Iris Rotating Machine Conference, San Antonio, June 2011.