



HIGHLIGHTS FROM THE 2007 DOBLE CLIENT COMMITTEE MEETINGS & USER GROUP MEETING

Held September 23 – 28, 2007 in Philadelphia, Pennsylvania, USA

Following is a brief report of highlights from the recent Doble Client Committee Meetings and User Group Meetings. Detailed Committee Minutes will be posted on the Doble Knowledgebase in November. If you have questions or would like additional information on any of the following subjects, please contact your Doble Client Service Engineer or Regional Sales Manager for assistance.

Arresters, Capacitors, Cables and Accessories Committee

Capacitors

Action: What are our experiences regarding capacitor failures? What is the failure rate and is it increasing or decreasing? Has my company investigated a failure that we would like to share?

During the September 2007 conference, Mr. Dave Lemmerman, PECO, was the keynote speaker. Mr. Lemmerman addressed many concerns about capacitors in his keynote address to the conference attendees. The speaker agreed that the utility companies must address such items as grounding, switching, how to control the transient currents that are caused by the capacitors and what are the concerns with single bank or back to back banks, reactors, protective devices and many other integrated items. In the address, various types of failures and some possible causes for the failures were reviewed with the attendees.

In the committee meeting one member suggested that the ACCA committee perform a survey in an attempt to identify capacitor failures. Defective capacitors may not be the root cause of the failure so every item must be reviewed as a possible cause. One committee guest mentioned trapped charges, the type of switching used, and the importance of not focusing on just one item. Some of the items suggested as primary topics on the survey are: Mode of Failure Detection, Capacitor Can Data, Bank Design, Switching Method and Switching Frequency. These topics will be broken down into subtopics to provide more detailed information on the survey.

After hearing some of the concerns, the committee officers thought that the types of switching and protective devices should be part of a capacitor tutorial that is planned to be presented in the future.

Surge Arresters

Action Item: Do we have a surge arrester IR inspection program? Maybe we need one? What are the inspector's criteria for determining good verses bad surge arresters?

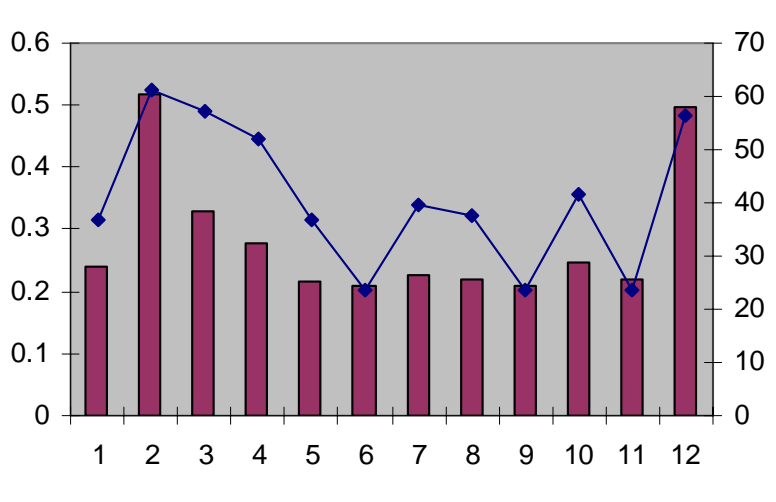
The use of infrared technology is a common tool used to detect defective equipment in substations. Surge arrester manufacturers have recommended to this committee that performing an IR scan, to detect any abnormal temperature rise above ambient, will help identify defective arresters. The manufacturers also recommended performing a watts-loss test to verify that the arrester has an abnormal condition. The manufacturers suggested not to rely only on an increase in operating temperature to detect a defect because different types of arresters may have different operating temperatures. A committee member shared some of his finding that verify that IR and



watts-loss testing are a reliable method of identifying problems with metal oxide surge arresters. Figure 1 and Table 1 indicate that arresters with the higher temperatures have higher watts-loss results.

Watts

Temperature °C



Watts and Temperature Comparison of the Individual Surge Arresters
Figure 1

Table 1 Surge Arrester Tests

Location	Test Mode	Test kV	mA	Watts	IR _{auto}	Temp °C	Temp °F
A Phase BL	GND RB	10.003	0.1910	0.2390	G	36.8	98.24
B Phase BL	GND RB	10.002	0.1990	0.5170	I	61.3	142.34
C Phase BL	GND RB	10.003	0.1960	0.3280	I	57.3	135.14
A Phase SM	GND RB	10.002	0.1920	0.2790	I	51.9	125.42
B Phase SM	GND RB	10.003	0.1900	0.2160	G	36.9	98.42
C Phase SM	GND RB	10.003	0.1910	0.2100	G	23.8	74.84
A Phase SS	GND RB	10.002	0.1910	0.2250	G	39.6	103.28
B Phase SS	GND RB	10.002	0.1910	0.2190	G	37.8	100.04
C Phase SS	GND RB	10.003	0.1900	0.2100	G	23.8	74.84
A Phase LH	GND RB	10.003	0.1960	0.2480	G	41.5	106.7
B Phase LH	GND RB	10.002	0.1950	0.2180	G	23.8	74.84
C Phase LH	GND RB	10.003	0.2000	0.4970	I	56.4	133.52

The Joslyn ZIP0054 MOV 42 kV arrester has a lower limit of 0.060 watts and the upper limit is 0.250 watts.

One utility member reported using 3-5 degree C as a limit while another member reported using 5 degrees C as trouble and anything over 20 degrees C as urgent. It appears from the various comments that there are no



standards for temperature limitations on surge arresters. Some members reported using temperature rise compared to other like arresters while some use ambient temperature as the reference. A paper offered for the 2008 April Client Conference will address many of these issues and will identify common mistakes made by the thermographer when performing a scan.

Asset and Maintenance Management Committee

Action Item: Make sure we are budgeted to attend this tutorial.

April 2008 Doble Conference Tutorial: Asset Health Indices

The Asset and Maintenance Management Committee will offer a tutorial at the April 2008 Doble Conference in Boston. The tutorial will include a discussion of the methods being used to assign weights to equipment inputs to establish overall equipment / system / station health indexes. The tutorial may also include aging of substation assets, methods for assessing life including transformer life assessment and end of life determination. Examples of end of life teardowns including the knowledge gained through the teardown process will be discussed.

The proposed speakers include:

Tom Kydd, Hydro One
John Stead, Altalink
Dr. Charles Feinstein, Santa Clara University

Maintenance Strategies

Action item: Do we have to fine tune our proactive apparatus condition assessment program?

A discussion was held on maintenance strategies including an overview of the dominant strategies used by utilities today including Reliability Centered Maintenance (RCM), Condition Based Maintenance (CBM), Risk Based Maintenance (RBM) and Performance Focused Maintenance (PFM).

RCM is a process for determining what maintenance should be performed but it doesn't give too much insight into when to perform the maintenance. RBM tries to answer the "when question" by looking at and quantifying the effects of failure and assigning a risk value to each task and potentially to each piece of equipment. The probability of failure and the cost of maintenance changes as the maintenance frequency varies. At the end, what is left is either a list of prioritized tasks with the highest risk tasks on top or the practice of changing the frequency so that the risk for all tasks is the same. In the later case, the maintenance frequency differs for all device/task combinations but must be performed. There is no room for adjusting the maintenance schedule.

PFM is Performance Focused Maintenance. PFM extends RCM, RBM and CBM and incorporates maintenance program management. Its goal is to perform the right tasks at the right intervals at the equipment level and definitively demonstrate at the executive level the value of maintenance and the linkage to overall utility goals and objectives. It ties maintenance into a comprehensive corporate strategy that is defensible and is more resilient to blind corporate cost cutting activities.



The committee discussions also raised the question of whether time based maintenance has been completely eliminated from utility practices. It seems as though a shift has taken place not necessarily from time based triggers for maintenance but rather what is performed during those intervals. Intrusive maintenance practices have often been replaced by less intrusive tasks such as diagnostic testing and inspections. These tasks have led to a condition assessment approach with an asset scoring system. This asset health review can then be used for planning for further required maintenance or timing of capital replacements.

Long Lead Times

Action Item: Do we need to reduce apparatus purchasing lead times?

The Asset Management Committee held a discussion involving how utilities are dealing with long lead times from manufacturers of various types of equipment. Many utilities are reaching out to secure long lead materials “off shore” to their normal business avenues. The vendor community is utilizing both assembly and manufacturing plants remote from the main offices, typically various countries dispersed worldwide. Combine these two facts and the material acquisition marketplace is now truly global.

Today, utilities are recognizing the need and justifying the replacement of aging (end of life) assets and in addition many are now seeing load growths that were indicative of the late 1980’s. The number of manufacturers in North America has declined and there appears to be a consolidation of facilities around the globe. The end result is utilities are competing for production slots and shop floor time resulting in longer lead times to secure key assets.

New purchase practices are changing. They may involve placing an order with a global OEM who uses a rationalized design but manufactured in a factory where the capability is unknown to the purchaser. Alternatively, the vendor may be offering both a design and factory location unfamiliar to the purchaser. As a consequence, Asset Managers need to have competent processes in order to buy suitable equipment in this global market place.

Some of the strategies utilities are using to cope with the lead times are using “blanket purchase orders” over longer periods of time (2-5 years) thereby securing price and manufacturer commitment, strategic partnerships with manufacturers, sharing agreements with other utilities and stronger long-term planning techniques including proactively replacing transformers before failure with the use of asset health reviews.

Human Resources

Action Item: Do we have enough trained employees? What about in 5 years? Are development plans being considered?

The development of human capital is a very important issue in the utility industry today. Recent statistics show that up to 50% of workers in the electrical utility industry may be eligible to retire by 2010. With this loss of expertise also comes the issue of how to develop employees and how to limit human errors. Many programs were discussed at the meeting including four year apprentice programs, centralized training facilities, mentoring programs and error reduction programs. In addition, qualified employees first have to be identified before hiring. Some utilities have started using skills assessment techniques along with a verbal interview to employ the most well rounded candidates.



Also, utilities are beginning to partner with local universities and technical schools to gain access to employees. As for the limitation of human errors, whether it is by the newer, inexperienced employee or the veteran employee, the committee members discussed that communication techniques are key. Written job procedures which require employees to think of how tasks will be performed before work begins were discussed.

These procedures are meant to identify not only job tasks but safety issues such as isolation points, grounding and potential hazards. Meetings between departments that will be working together can be held to identify what areas each will be working upon and what risks will be involved. The development of electrical industry workers will continue to be of great interest over the coming years as our workforce ages and expertise is lost.

Bushings, Insulators, and Instrument Transformers

Field Experience With 800 kV Gas-Insulated Freestanding Voltage Transformers (GIF-VT)

Action Item: Do we use silicone insulated apparatus?

Since 1995 Hydro Quebec has installed 33 gas-insulated free-standing voltage transformers type GIF-VT which are rated 800 kV. Each unit features two silicone section insulators and provides an extended accuracy for 765 kV shunt reactors control switching. After seven years in service, one unit failed on October 25, 2002 at the Hydro Quebec substation. The peak current value of the short-circuit current was 29 kA and the fault duration 43 ms. The GIF-VT withstood the internal arc. The repair cost was about 40 % of the initial GIF-VT price. A paper was proposed to document Hydro Quebec's experiences with the gas insulated voltage transformers including details of the failure investigation.

Catastrophic Failure of Trench COTA Bushings rated 230kV, 2000A

Action Item: How many of these type bushings do we have?

Duke Energy experienced a catastrophic failure of a Trench Type COTA, 900 kV BIL bushing manufactured in France in 2003. The bushing was mounted on a 480 MVA autotransformer in the H3 position and in service since August of 2006. The bushing had a copper center conductor. The transformer was historically lightly loaded. The load at the time of the failure was about 52% (233 MVA). The bushing failed on April 24, 2007 at 7:15 pm on the air side of the bushing. It was noted that there was a small arc trace approximately 190 cm down from the top of the bushing. Duke Energy's relay targets indicated a phase to phase fault. The bushing C1 power factor and capacitance tests in 2005 and 2006 had compared well with nameplate values. Trench has been very involved with the investigation and the root cause is still unknown. However, Trench according to their initial report, didn't believe the problem was due to corrosive sulfur, based on the time the unit was in service and the operating conditions during its service life. The two sister units will be torn down at the Trench facility at France in October.

Catastrophic Failures of Trench COTA Bushings

Action Item: How many of these type bushings do we have?

Pacific Gas and Electric has had three failures of Trench Type COTA bushings within the last year. The bushings were a draw lead type with an aluminum conductor tube. The bushings were rated 230 kV, 1600 Amps and 900



BIL. The first failure occurred at the Brentwood Plant. This bushing was manufactured in Canada in the year 2001. Power factor tests were performed on December 11, 2006. The C1 and C2 power factor and capacitance tests compared well with the nameplate values. The H3 bushing failed catastrophically on August 5, 2007 at 2:14 AM. The H3 bushing's aluminum center tube was melted off. The upper porcelain was shattered and the paper and foil was burned off. Trench was involved in the analysis of the failure. The analysis showed no signs of overheating with the seals and o-rings were intact. At the lower end of the bushing, a puncture was found that went through the outer one third of the condenser layers and was four inches below the voltage tap. It is believed that there was a partial shorting of the internal two thirds of the conductive layers. The outer one third of the condenser layer was exposed to full voltage, which then lead to the fault. The upper half of the bushing was completely destroyed, therefore could not be analyzed. Most likely the cause of the failure was a defect in the insulation right above the flange, however it is hard to analyze due to the damage. It was noted that radial stresses in this area are the highest. There is a possibility that the failure was due to vandalism, for instance a gun shot. However there have been no reports of gun shots in the area. The failure caused collateral damage to the H1 and H2 bushing. The other two bushing failures were similar to this failure. The bushing failures are still under investigation with Trench. Trench has been diligently working with PG&E to determine the root cause of the problem.

Also, Progress Energy experienced three failures of Trench type COTA bushings. Two of the bushings were 161 kV rated at 750 BIL and the third bushing was 230 kV rated 900 BIL. These bushings were also manufactured in Canada, and have the aluminum center tube. These failed bushings are presently under investigation by Trench.

Circuit Breaker Committee

Safety Items

- **Maintenance Practices While Working on Breakers**

Action Item: Review our policy for working and testing on top of circuit breakers.

A lengthy discussion took place regarding safety associated with working on circuit breakers. This discussion began many years ago with respect to the dangers of working around air blast breakers pressurized to 400 up to 2000 psi in many substations. Now it has continued with lower pressure breakers such as SF6 and oil breakers. Some companies are allowing workers to climb onto the breakers while others use ladders or man-lifts. Some require fall protection which in most cases requires the use of man-lifts or bucket trucks. This is because there is no provisions provided by the circuit breaker manufacturer to tie a safety system on these breakers. The bushing should NOT be used for safety support. The bushing are NOT built to mechanically break the fall of an employee who uses it as a tie point for a harness.

The issue is particularly important when making micro-ohm measurements. Contact resistance requires careful placement of leads and hence the employee must often be lifted up to bushing head level to place the measurement leads.

- **Safety Working Around "Swing Handle Disconnects"**

Action Item: Discuss with switching crews the potential of pinching fingers when operating disconnect switches.



There were three cases reported where workers pinched their fingers while closing disconnects. One Utility reported a problem with pinched fingers while operating a disconnect switch without gloves on, but actually the gloves would not have stopped the pinching. It was a matter of switch handle design and operator training which allowed the injury.

- **Working Around Pressurized Equipment**

Action Item: Do we have a policy related to working around pressurized equipment?

This problem has been around for a long time and goes back to the days of high pressure air blast breakers, sudden and unexpected porcelain failures, chances of hitting the breaker with a bucket truck or applying an undue load on the bushing and having mechanical breakage. As those problems were dealt with, breaker designs changed from high pressure air to SF6 gas at lower but still dangerous pressures. SF6 breakers have their own issues, but some of the prevalent ones are working around the breaker, where to stand when connecting test leads, how to approach the breaker, where to place ladders, lift devices and what fall protection cautions to use. Some utility members offered solutions which included using step ladders, not leaning on the equipment, lift devices that would not interfere with the equipment and staying off equipment that did not have safe foot holds on which to stand to perform work.

Problems Confirming SF6 Gas Decomposition

Action Item: What is our success with the Drager test?

Dominion Technical Solutions experienced Drager tube testing which indicated the presence of decomposition byproducts, however a gas sample sent to the laboratory didn't identify any problem. It was stated that possibly the laboratories are not measuring to the sensitivity needed to detect the decomposition products. The decomposition byproducts of SF6 are very reactive and will not remain unchanged in the sample container for very long. Getting the byproducts into a sample cylinder without having them react with the tubing to the cylinder is an issue also. One client commented that in his efforts to investigate SF6 sampling with knowledgeable people, it was determined that the industry must go to a parts per billion technology before such testing will be practical. In the Insulation Committee it was reported that IEEE or ASTM may start working on these issues by developing standards for SF6 gas sampling. On the other hand, at SaskPower they have been successfully measuring the SF6 byproducts.

General Electric Type U Bushings on Oil Circuit Breakers

Action Item: What is our testing and replacement program for breaker mounted GE Type U bushings?

Many utilities have replaced their transformer mounted General Electric type U bushing however failures are being reported on breaker mounted type U bushings. What are clients doing to manage type U's on breakers? Most attendees did not seem to have any special maintenance plan for these bushings. It seems like there are more failures occurring and some clients are finding higher than normal power factor results.

SF6 Circuit Breaker Failures During Initial Energization



Action Item: Have we experience breaker failures upon energization? Look at Safety procedures associated with initial energization.

Tri-State G&T has experienced some failures during initial energization which has driven them to make changes in their energization switching procedures. American Electric Power gave a presentation during the meeting of two failures that occurred during initial energization. In both cases that bushings were not aligned properly in the breaker. High potential and Doble tests were both questionable in one of the circuit breaker's initial tests.

Service Advisories

Action Item: Do we have this equipment on our system? If so, circulate these Service Advisories to the maintenance crews.

These service advisories are available through Doble's knowledgebase.

- **Powells Service Advisory SA010**

This service advisory concerns the PowlVac Mechanism "Tolerance Stack Up". The problem indicated in the service advisory is a possible operating condition on certain PowlVac® circuit breakers which requires inspection by qualified personnel and possible component replacement. If this condition exists, the BREAKER MAY NOT RESPOND PROPERLY TO AN "OPEN" COMMAND.

- **Mitsubishi Electric Power Products Service Advisory 06001**

This service advisory deals with an issue on the cabinet heaters which are causing damage to the back of the cabinet, the wiring and wiring duct for type 100/120-SFMT-40SE circuit breakers.

- **Mitsubishi Solenoid Clip Prevention Assembly Advisory 05001**

This advisory applies to all Mitsubishi gas circuit breakers with BH-3 and BH-3.1 mechanisms used on breaker types 70-SFMT-32F, 100-SFMT-40SE and 120-SFMT-40SE. The trip prevention pin installed may not be fully engaged, allowing the trigger to release the latch when the plunger is pushed. This could be a safety concern when performing inspections or making adjustments during installation or maintenance.

- **S+C Circuit Switcher Service Advisory on Leaking, 1992 to 1995**

The fix is to change out the support column. While the service advisory is old, circuit switchers are still having this problem which can be identified by visual checks.

Insulating Materials Committee

Changes to the Doble Transformers Oil Purchase Specification

Action Item: Review our company's Oil Purchase Specifications. Should we modify it to include CCD and DBDS test?



The Transformers Oil Purchase Specification (TOPS) will be changed in the next year to include the use of the Doble CCD tests and analysis for certain passivators such as BTA and Irgamet 39 and possibly the analysis for DBDS (dibenzyl disulfide). Additives other than oxidation inhibitors are only allowed when it is agreed upon between the buyer and the seller. The CCD tests and DBDS testing are being added to aid in determining if the oil is susceptible to forming corrosive sulfur compounds in the oil and on copper surfaces.

Doble Working with ASTM to Define Standard Methods for SF6 Sampling

Action Item: Do we have a written procedure for sampling SF6 gas?

The technical representative from Doble to ASTM has been in contact with Honeywell to aid in developing more SF6 practices and standards within ASTM committee D 27. To date there is only one SF6 document within ASTM and that is the specification for new SF6 gas. There are no practices for sampling or testing for degradation byproducts. Since SF6 has been used in breakers since the 1960s and many gas insulated electrical apparatus exist in a utilities' substation, it was thought prudent to try to standardize the current practices for sampling and testing so that results are comparable.

Laboratory Standards

Action Item: What method does our lab use to assure the accuracy of DGA measurements?

Laboratory analysis of transformer oils to measure dissolved fault gases is the single most important test available to transformer owners for assessing the condition of their equipment. As critical asset management decisions are made based on these analyses, the laboratory must ensure proper control of its analytical processes. A proposed paper outlines how dissolved gas in oil standards can be used to demonstrate process precision and accuracy and help in solving analysis problems that would not be noticed otherwise. It also will discuss how dissolved gas in oil standards can be used to evaluate the uncertainty of laboratory measurements and what laboratory quality control data should be available to asset managers to help them understand the scope of validity of their laboratory data.

ASTM D 923

Action Item: Circulate copies of the new ASTM Oil sampling procedure to the test crews.

ASTM has just approved D 923 which contains oil sampling practices (released week of September 10th, 2007). The new practice should be consulted prior to sampling as there are significant changes that have been incorporated. The ASTM sampling practice D 923 had been withdrawn for about a year and a half while being revised. D923 has incorporated ASTM D 3613 so D 3613 will no longer exist.

Thermally Upgraded Paper NOT Used in Some 65 Degree C Rise Transformers

Action Item: Check our transformer purchase specification to confirm that thermally upgraded paper is required.

In the discussions at the last Insulating Materials meeting in Boston questions were raised about the type of paper used in 65° C rise transformers. In some transformer failure investigations Doble has found that some newer



transformers rated for 65° C rise over ambient had Kraft paper present and not thermally upgraded Kraft paper. During discussions at this meeting it was determined that many clients did not know that thermally upgraded paper was not used in 65° C rise transformers of some manufacturers. One client brought to the committee's attention that this information is very important as some utilities specify ambient of 40° C as opposed to 30° C. Therefore, clients should check their purchase specification to confirm that thermally upgraded paper is specified or that the thermal design of the transformer is such that thermally upgraded paper is not needed and complies with IEEE specifications. In addition, there are test methods to determine if the paper has been thermally upgraded or that the paper passes the requirement of IEEE C57.100, Annex A.

PACC Committee

The PACC Committee Meeting

The meeting was very productive which included these main features:

- The result of the Maintenance Survey was very well received. The members expressed a desire to participate in future surveys.
- The next survey will be on application of sudden pressure and Buchholz relays that are applied on transformers. There have been many mis-operations of these two relays and the survey is intended to gauge the application of these relays.
- The Protection Portal generated significant interest and attendees expressed a desire to be able to post questions regarding relay testing.
- There were several new members participating in the meeting.
- There will be some form of survey or a tutorial on relay replacement strategies that are prevalent in the utilities
- Some attendees brought to the floor the issues with EMAX relays and a discussion ensued regarding the issues related to these relays.
- Some wiring issues pertaining to GE relays G30 and G60 was brought up. This is more of an issue with the Instruction Manual not being clear on some changes that need to be done when one is applying G30 instead of a G60 relay.
- A presentation was given underscoring the need for paying attention to over-frequency relay settings in a system. A lack of careful consideration for the frequency relay settings led to a cascading failure in one of the regions in Canada. This was a very well received presentation.
- The SEL Accelerator program has some unique features that can lead to incorrect version of settings to be downloaded into the relays.
- There was a lot of interest in future papers on transformer protection—commissioning and testing.



- A presentation on Protective grounding organized under the auspices of PACC was a well attended program.
- A great interest was shown for a future tutorial on Power System Harmonics

Protection Testing User Group (PTUG)

Technical Presentations and Training

Two days of technical presentations were given in Philadelphia and an additional three days of training sessions which included Introduction to ProTesT, Basic Protective Relaying and ProTesT Advanced Settings Features. All three tutorials attracted at least 50 attendees. A link to the PTUG presentations is being mailed out to all PTUG members.

PTUG Sessions

The sessions for the PTUG were chaired by Craig Munro of BC Hydro, Dan Anderson of Northeast Utilities and Donna Williams of Ameren. They all did a very good job of keeping everybody entertained and also to keep all presentations on schedule. There were 12 different presentations given during the two day PTUG session. The session was started with Jay Gosalia providing an overall program agenda, followed by Ed Khan who provided the logistical details of the PTUG conference. The main program started with a keynote address by Dr. Damir Novosel of InfraSource. One very interesting feature of the PTUG presentation was the two live demonstrations on end-to-end testing of relay schemes.

Rotating Machinery Committee

Action Item: Forward these items to the plant engineers.

New Class H (180°C) Insulation System

There has been a push for higher temperature classes of insulation in both the high and low voltage systems. Today, variable speed drives (VSD's) are being installed in various motor applications. VSD's generate higher frequencies, which heat the insulation. The new generations of air-cooled, combustion turbine generators operate very hot and with high voltage stresses are causing premature failures of the insulation systems. A Class H insulation system with high corona resistance is desperately needed in these two situations.

A 2008 Conference paper will discuss the development of a new Class H insulation system and compare it to the original Class H system (PEI) and the traditional Epoxy system. The characteristics, such as bond strength and viscosity will be discussed and compared. Lastly, the electrical testing is to be provided and compared amongst the three systems.

Thermal Imaging of Brush Rigging as a Maintenance Tool

American Electric Power performed experimentation on thermal imaging of carbon brushes in one of their power plants. It is difficult to determine whether the brushes are making contact to the collector ring or if the brush



grades are incorrect or even mixed without taking the unit offline. While the unit was online, thermal images were taken of the brushes which were making good contact with the collector ring. One brush was then lifted and the thermal scan was repeated after 30 minutes of wait time. It was very obvious from the thermal images that the lifted brush was much cooler than those that were making contact. In addition, brush grades were mixed and thermal images were taken. It was clear that the brushes were not carrying the current evenly due to the variation in heating. Brush grades should never be mixed on the same slip ring or commutator due to the current being carried unevenly.

Previous methods of detecting problems with commutation involved studying the markings on the commutator, and inspecting brush wear. This typically requires the unit to be offline. One individual's experience with thermal imaging prevented flashovers which they were encountering due to overheating. They employed this technique, were able to determine when a flashover was beginning to manifest and were able to prevent it. They used this technique until they were able to solve the problem which occurred due to a rough environment and incorrect brush grade.

Pole Drop Testing Using the M4000 and the Leakage Reactance Module

For those companies already equipped with a Doble Insulation Analyzer (M4000) and a Leakage Reactance Module (M4110) an AC Pole drop test can be performed. Measured power factor, watts, voltage and inductance are recorded. A faulty pole will display a change in inductance, and the adjacent poles will not be affected. This is unlike the traditional AC Pole drop test in which the voltage will drop on the faulty pole as well as the two adjacent poles.

Condition Assessment in Power Plants using Electromagnetic Interference (EMI)

If there is a defect in the system that causes corona, partial discharge or arcing, various elements are produced, such as heat, gasses, sound and radio noise. Thermal scanning will detect the heat component, acoustic testing will detect the sound, DGA will detect gases and EMI will detect the radio noise. EMI diagnostics will detect problems with motors, generators, cables, switchgear, transformers, etc. The test is performed online and the data is collected and analyzed in the time domain. A paper titled "High Voltage Equipment Condition Assessment with EMI Diagnostics" providing case studies of electrical and mechanical problems found on large motors will be presented at the 2008 Doble Client Conference by James Timperley.

Transformers Committee

Understanding Transformer Factory Testing Tutorial

Action Item: Distribute copies of the tutorial presentation to the engineering staff. Next month, schedule a meeting to replay the tutorial for interested staff.

This tutorial was moderated by the Transformers Committee Chair Terry C. Troop, FirstEnergy and concentrated on two of the more significant groups of tests commonly performed: the dielectric tests and the temperature tests.

The purpose of the dielectric tests in the factory is to demonstrate that the transformer has been designed and constructed to withstand the specified insulation levels. Loren Wagenaar, of WagenTrans Consulting and Domenico Corsi of Doble Engineering, noted experts in the field of factory testing, provided the presentations for



this group of tests. Mr. Wagenaar has been Chair of the Dielectric Test Subcommittee since 1995 and Mr. Corsi's expertise is well exercised during the many factory tests that he has witnessed. The explanation of lightning impulse, switching surge, applied potential and the induced potential tests were covered in this section. The discussions included the test methods, the equipment used to perform the test and the analysis of the results.

The temperature test, often referred to as the heat run, verifies a transformer's guaranteed temperature rise and consequently its ultimate capacity. Bruce Broweleit, employed with Grant County PUD provided an in depth description of the temperature tests. This section discussed how the transformer oil rises and winding gradients are calculated to establish the average winding and hottest spot rises for the unit under test. Loren Wagenaar, who consults on many transformer issues, provided an example of a transformer that failed the heat run.

Persons attending this tutorial left with the basic knowledge required to witness these types of factory tests and make rudimentary decisions on the suitability of the test methods and procedures utilized during the factory testing.

The tutorial can be viewed on the Doble website at <http://www.doble.com/>

Dissolved Gas Analysis of Load Tap Changers (DGA of LTC's)

Action Item: Review our company's policy and budget for performing routine DGA of LTC oil.

This subcommittee met on Wednesday, September 26, 2007 and in part covered the following items:

- **Progress on Establishing Limits for LTC Types**

The study of the Maloney type MA/MB and General Electric type LR load tap changers continued. Feedback from the group will aid in providing the limits for the revised guide.

- **Dissolved Gas Data on the DTAWeb**

The DTAWeb system is ready to collect LTC DGA sample data. It was noted that TOA databases can be loaded into the DTAWeb by using a part of the program included in the DTAWeb software called "Loading CSV Data".

- **Three Cases of LTC Saves**

An overview of Hydro One's saves for the period since January 1, 2007 was given. The first slide noted that *"The ULTC DGA analysis and subsequent proactive repairs have become so routine to us we forget to celebrate our successes. Another good year of success stories with only **one surprise failure** and yes it was one where the ULTC DGA sample was missed."* The program was able to save 13 load tap changers from failure so far this year.

Southern California Edison has recently started using DGA to detect impending LTC failures and provided a presentation on three FPE TC-546 and one FPE TC-525 saves.

American Electric Power was able to save a Reinhausen type UMV-II load tap changer. The LTC was first noticed to be in trouble because it was 13 degrees hotter than the main tank. The gasses were



significantly high. When the load tap changer was entered it was found that the connection of “N” lead to the tap board was overheating. The tap board needed to be replaced due to cracking and heat damage. This condition, if gone undetected, would have caused a catastrophic failure of the unit.

Transformer Manufacturers Survey

Action Item: Contact our Principal Engineer to get a copy of the transformer manufacturers list.

This survey has been issued to the committee and helps identify where to buy transformers.

- Lists transformer manufacturers and locations.
- Allows utility’s to report their use of each of the manufacturers for purchasing transformers.
- Last sent out in June 2007. The document is available from your Principal Engineer.
- Document has 278 manufacturers listed and 100 lines of input from the clients.
- Client input continues to be encouraged.

Mobile Transformer Procurement

Action Item: Are we ordering mobiles? If yes, submit a list of questions to Doble to make sure they get covered in the conference paper or symposium.

There was interest in obtaining a panel discussion on the subject of Mobile Transformer procurement experiences because the requirement for compact design and large MVA ratings provides many design challenges. The Clients offered the following experiences:

- The results of a recent AskDoble question on bidding for mobile transformers were discussed in the meeting. This question posed by New York State Electric and Gas had 9 respondents.
- AltaLink, during the early stages of the mobile transformer project, took a protection expert and the trucker to speak with the manufacturer to get the design right.
- Keep the relay circuits simple.
- LCRA requires a system to be provided with the mobile to handle the SF₆ gas which removes the gas in about 45 minutes.
- Public Service Electric and Gas opted for vacuum breakers so that the SF₆ considerations were not a factor but vacuum breakers have their own issues as they must be in the right position for transportation.
- A SaskPower representative suggested that the strength of the frame be considered and hooks be installed to help with extraction when the unit gets stuck.
- Four manufacturers of mobile transformers were identified in the survey list including Pauwels, EFECAC, Transformer Networks and Delta-Star. More manufacturers may be available.
- Specific procedures are recommended to set up the mobile transformers at each station which reduces the set-up time and errors.
- FirstEnergy just received two 230kV mobile transformers sized at 30 MVA and 70 MVA. The larger unit requires a jeep, a three axle tractor and when assembled for transportation is 110 feet long.



It was noted that there had been two recent papers on mobile transformers which are located on the Doble Website.

- UTILITY EXPERIENCE BUILDING A MOBILE TRANSFORMER, 2004 Doble Client Conference, Jeffery M. Wright, Vermont Electric Power Company, Inc., Documents the process of purchasing a transportable transformer, upgrading it to a truly mobile unit.
- MOBILE UNIT SUBSTATION USE AND REFURBISHMENT PROGRAMS, 2004 Doble Client Conference, Tom Kydd, HydroOne, Describes how a utility has applied mobile transformer technology through the years.

Low Frequency Heating Field Dry-Out of a 750MVA 500kV Autotransformer

Action Item: Look at our test results to see if we have wet units. Are they critical to get dried?

HydroOne determined that there were moisture issues within a large group of 750 MVA autotransformers. These units were very critical for power delivery so a quick dry-out was necessary. The use of the low frequency heating technique shortened the processing time significantly. HydroOne and ABB plan to provide a paper on this subject for the 2008 Conference.

Power Factor Research of Transformers Filled with Natural Ester Fluid

Action Item: Send our test data to Doble for natural ester filled transformers.

Doble Engineering Company is continuing a study of power factor test results of transformers filled with natural ester (Such as Envirotemp®FR3™) insulating fluid. The focus of the study is to establish power factor limits for new transformers, understand how the power factor changes over several years of in-service use and establish a power factor versus temperature correction curve for transformers filled with ester based fluids.

Assessing Transformer Insulation Dryness Using Dew Point Measurements Below Freezing

Action Item: Are we receiving any transformers this winter? We may need to process them to get the true moisture level!

A concern was described that assessing the dryness of transformer insulation may be difficult when the temperature of the transformer is below 0 degrees C. There was data displayed from Waukesha Electric Systems for two transformers relating to cold weather dew point measurement. The data suggested that at cold temperatures the dew point measurement may falsely indicate a wet transformer. A paper on a study by National Grid US and Waukesha Electric on this subject has been proposed for the Conference.

Shipping Damage of Transformers

Action Item: Are we buying transformers that are shipped across the ocean? If yes, look at the paper listed below.



Eskom in South Africa has offered a paper for the 2008 Doble Conference to share their experiences with damage of large transformers shipped over large distances, focusing on the overseas leg of the journey and will summarize lessons learned. Are manufacturers designing transformers to sustain ocean shipment? What is to be included in the transformer specification? What are the concerns with impact recorder reliability and the use of vibration dampers. A must-read paper for anyone considering shipping transformers overseas is a 1992 Doble Conference paper titled, "Sea Transport of Transformer" by Smit Transformatoren B.V., which presents an analysis of the forces to which power transformers are subjected to during transport at sea. The measures that may be taken by a transformer manufacturer to internally and/or externally strengthen the core, which is most susceptible to transport forces, are discussed. It was recollected, at this meeting, that discussions following this 1992 paper called out rail shipment as being far worse in G-Forces than anything on the open sea, as documented – not by popular opinion.

SFRA for Fault Detection in Power Transformers

Action Item: Are we establishing factory and field SFRA benchmark fingerprints?

Comision Federal de Electricidad (CFE), a large utility in Mexico, in collaboration with the University of Michoacana, are offering a paper for the 2008 Doble Conference to share their laboratory experiences with SFRA testing as a tool with which one can differentiate and identify bad connections, residual core flux, the effects of tap positions, and faults that they deliberately created in a transformer. Doble conference papers pertaining to frequency response analysis and time domain analysis date back to 1976.

Effects of Stray Leakage Flux on the tank of a 420 MVA, 20 /230 kV GSU at a Generating Station

Action Item: Have we done IR scans on our GSU's to see if we have a heating problem?

This is another offered paper from Comision Federal de Electricidad about a complicated issue that took almost 3 years to resolve. A 1995 vintage GSU took years to develop localized hot spots on the tank, reaching temperatures in some areas upwards of 181 degrees C. The paper will describe operating events along the way and will provide a technical explanation of the phenomenon that developed. The manufacturer's solution required replacement of the bolts and washers that held together the two-section tank as well as the addition of copper straps, bridging across the bolts, to bond the two sections together. Interestingly, the manufacturer, having consulted and satisfying themselves of its viability, implemented different materials in the design of the tank, the tank cover and the bolts, allegedly to reduce costs.

Transformer Testing Case Studies

Doble PowerTest has offered a paper for the 2008 Doble Conference that will include several case studies in which a comprehensive treatment of gas results and electrical test results are provided, and complemented with teardown findings. These include a dielectric failure, a thermal failure and a mechanical failure. The third of these studies provides an excellent case whereby the DGA did not provide evidence of an incipient failure but the problem was detected in the electrical test results.

SFRA User Group

Action Item: Need to download and get the passwords for this software.



Doble SFRA V5.0 is Released

The new version of Doble Engineering's SFRA V5.0 software now includes impedance and admittance graphing and inter-operability with Doble's DTAWeb software. Five new languages are also integrated; Chinese, Spanish, Portuguese, Czech, and Polish.

DTAWeb V1.1 Supports Doble SFRA

DTAWeb allows utilities to store and SFRA data in a master database. DTAWeb can now import, export and review SFRA data. DTAWeb allows utilities to quickly sort through their SFRA data, locate and quickly view SFRA data. Up to nine traces from the database can be overlaid to help identify sister units or conduct quick comparisons. If advanced analysis is required the data can now be exported back to Doble SFRA 5.0.

SFRA Presentations

Action Item: Do we have any cases where SFRA found a problem?

Nebraska Public Utilities and FirstEnergy presented case studies of how SFRA successfully found and confirmed transformer damage. The Nebraska Public Utilities case showed that SFRA was a critical test in noticing a loose high voltage connecting link. FirstEnergy presented a case where burnt crossover links led to significant low frequency impedance variation in both the SFRA open circuit and short circuit test results. Both case studies used supporting transformer condition data such as power factor, leakage reactance, TTR, exciting current and DGA oil results.

Circuit Breaker Timing User Group

Action Item: Need to download and get the passwords for this software.

T-Doble V1.2a is Released

Doble Engineering Company announced the release of T-Doble V1.2a. T-Doble V1.2a provides new features and general maintenance updates for latest circuit breaker timing instrument, the TDR900. T-Doble now performs an advanced analysis of trip command coil waveforms and allows for the advanced configuration of the Doble probe and user scaling.

T-Doble Integration to the TDR9000

Doble Engineering Company announced the T-Doble software platform will be applied to the TDR9000 instrument. This change will eliminate TRX, TRX Field, and the dependency on SyBase. The user will only have to manage one software platform, simplifying training requirement and data management.