

Vol.21 Issue 4



Feature



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Annual Conference of Doble Clients-- “The Boston Marathon of Maintenance and Test Conferences”

On April 9-14, 2006 a distinct group of approximately 1,000 engineers will gather for the 73rd Annual International Conference of Doble Clients in Boston, Massachusetts. Most would agree that this distinct group represents some of the most knowledgeable engineers in the maintenance and testing of high-voltage apparatus. The Boston Marathon is the world's oldest annual marathon and ranks as one of the world's most prestigious road racing events. It attracts some of the world's best runners; and is the marathon against which all others are measured. Like the Boston Marathon, the Doble Client Conference is one of tradition and prestige now in its 73rd year attracting some of the world's best engineers. FYI -This year's Marathon will be held on Monday, April 17th—immediately following the Doble Conference.

For a complete program, and registration information [Click here](#).

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Technical Briefing

[Doble Collaborative Study on Corrosive Sulfur](#)

Power Trends

Surge arresters are often “overlooked” when performing Power Factor Tests on transformers, breakers, and other apparatus in the substation. Often times, the testers are aware of how a transformer or a breaker functions, but are not aware of the intended purpose of the surge arresters. Since there are no “moving” parts to maintain or an oil sample to pull, it is often their policy not perform any testing on the arrester. This paper outlines the general design of arresters, polymer vs. porcelain arresters, testing of arresters, and a check list on arrester test result analysis. For more information of this paper, [click here](#).

Doble Tested





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Doble Collaborative Study on Corrosive Sulfur

Paul J. Griffin and Lance R. Lewand

Doble Engineering Company

There is still time to join! The Collaborative Study on Corrosive Sulfur is moving along quickly, but new members are still welcome.

Why? The problem of corrosive sulfur has reappeared after not being a significant issue for decades. In the past few years there have been a number of failures of very large power transformers and shunt reactors due to corrosive sulfur. This has occurred even though the electrical insulating mineral oils passed international standard test methods including ASTM D 1275 and DIN 51353. The problem occurs because the corrosive sulfur reacts with copper conductors and silver contacts to form metal sulfides that contaminate the insulating paper. Since metal sulfides are conductive, the dielectric breakdown strength of the paper is reduced. Under some conditions, a breakdown occurs through the insulation between conductor strands on a disk or between disks. Figure 1 shows the evidence of discharge activity on the paper-wrapped conductor strands facing the center axis of this four year old transformer winding. This discharge activity ultimately leads to apparatus failure. Although the number of failures has been small, the value of assets lost have been substantial. Problems have been reported from many countries. Doble has organized a research program to investigate this problem. The details are available using this link:

http://www.doble.com/content/services/IM_03_Investigating_Copper_Sulfide_Contamination_Lewand_Paper.pdf



Figure 2: Evidence of Discharge Activity on a Disk From a Failed Transformer

Who Has Joined? Over 25 companies have joined the collaborative study including transformer oil refiners, apparatus manufacturers, utilities, and an insurance company. This is an industry problem that needs to be resolved through improved specifications, a better understanding of the corrosion process, and methods for detection and mitigation. Although copper sulfide cannot be removed there are methods that might greatly reduce further formation of conductive metal-sulfur compounds in problem units. Researching this problem as a group, representing a cross-section of the industry, provides substance and can help accelerate changes required to detect and mitigate.

What Transformers and Reactors are Most Susceptible? Transformers with oils that do not meet the Doble

modified corrosive sulfur tests are more susceptible to this problem. The most recent revision of the Doble Transformer Oil Purchase Specification includes important details. The problem with corrosive sulfur is both time and temperature dependent. The longer an apparatus operates at higher temperatures with an oil containing excessive amounts of corrosive sulfur, the greater the corrosion and formation of metal sulfides. Sealed transformers are more susceptible to the corrosive sulfur problem as oxygen reacts with copper and organo-metallic compounds which compete for reaction sites with the corrosive sulfur. This slows down the formation of the conductive metal sulfides but does not stop their formation. Lower voltage apparatus have can have an advantage if the copper conductors are coated with enamel insulation. The enamel creates a barrier preventing reaction with the corrosive sulfur. The various factors that can influence copper sulfide formation will be investigated in the collaborative study.

How Can the Problem be Prevented? Standards organizations need to revise present specifications for a more rigorous evaluation for corrosive sulfur. At Doble Engineering Company, we have revised our insulating mineral oil specification requirements for corrosive sulfur by modifying the present ASTM method D 1275. The modifications include extending the duration of the test from 19 to 48 hours and increasing the test temperature from 140°C to 150°C. Some added precautions are taken to minimize the oxygen content in the test oil. In testing to date, we have found that the oils from failed transformers with evidence of copper sulfide formation did not pass this modified test, but did pass the present ASTM method. As additional research is performed it is likely that new methods will be developed. Part of the collaborative study is to evaluate test methods for detecting the corrosive sulfur. However, to help prevent this problem from becoming widespread immediate use of Doble more rigorous test method is recommended. See the Doble Transformer Oil Purchase Specification as revised January 1, 2006 for details. TOPS can be download from the following link:

http://www.doble.com/services/lab_services_transformer_oil_specs.html

How can the Problem be Detected in Existing Equipment? All failures have occurred without prior evidence of an incipient fault. This makes the problem difficult to detect and manage. The failures have occurred after from one to several years of apparatus being in service. The corrosion process appears to take this time to form critical amounts of conductive sulfides. Dissolved gas-in-oil tests are routinely used to detect developing problems from overheating, partial discharge activity, or arcing. To date dissolved gas-in-oil has not given any indication of partial discharge activity or arcing in these units, even when a sample was taken one day before the failure. Although there can be an increase in the insulation power factor, this test has not been found to routinely detect this problem when performed in the standard fashion. Some laboratory investigations using power factor have been shown to detect copper sulfide in paper under some conditions. More research is needed to determine if this can be applied to apparatus in the field. As part of the collaborative study electrical tests will be evaluated to see which might be able to detect significant contamination of the cellulosic insulation.

Research Efforts and Potential Solutions - It is likely that there is a substantial amount of oil in service in large power transformers that can cause the sulfur corrosion problems. Although these oils with excessive amounts of corrosive sulfur represent a very small percentage of the total oil volume in service, it is still important as copper corrosion and sulfide formation cannot be reversed. It is possible to mitigate against further significant corrosion. Possible methods include removal of the corrosive sulfur compounds, oil replacement, partial oil replacement, and passivation using metal deactivators. No simple means for removing corrosive sulfur compounds from the oil has been developed. Depending on the size of the problem this may be an area for future research. Preliminary studies at the Doble Laboratory have shown that mineral oils can have considerable differences in the temperatures at which they will begin to form copper sulfide under test conditions. Further studies will be performed. Mixing higher corrosive sulfur content oils with those having very low sulfur content can significantly improve the former's characteristics well beyond acceptable limits. Another method that has been employed is the use of a passivator that binds up some of the active sites on the metal surface retarding reactions with corrosive sulfur. More research is need and will be performed as part of the collaborative study, to better understand how well these methods will work and the long-term benefits. For the immediate future these methods appear to be promising and could help mitigate developing problems. Some companies have already started using these approaches; and we will be monitoring and evaluating the effectiveness as part of our study.

How do I Join? Contact Paul Griffin by emailing him: pgriffin@doble.com



Please don't hesitate to share your thoughts on this article. Send your opinions and comments to: DobleExchange@doble.com. We are always interested in **Doble-Tested** case studies and field photographs from the Client Community. Please send these to DobleExchange@doble.com.

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Doble Test Assistant Data Structure

In this issue of Doble Tested, we give clients an update on the new Doble Test Assistant (DTA) data structure, and some of the great improvements of the latest version.

Safety Matters

A Client Utility shared this at the recent Fall Committee Meetings. The utility had a fuseless capacitor bank failure while performing acceptance tests on the bank. It was requested to have the remaining units that were not ruptured to be delivered to their lab for testing and dissection.

When handling these capacitors a couple of items to note are 1) to effectively remove trapped charges from fuseless capacitors, the two bushings need to be shorted and grounded to the case because the fuseless capacitors internal series capacitor packets are insulated from the case, and 2) when performing dissection on the capacitors, be sure to short individual packs to their neighbors before contacting the packets.

They found that even though the bushings were shorted and grounded to the case and the internal discharge resistors were in place, trapped charges still remained in the series capacitor packets. Shorting the packets to their neighbors removed these charges.

Power Talk

Editorial

*Our Transformers are not the only aging utility resources. As growing numbers of utility workers reach retirement age, not only are utilities in danger of losing the "explicit knowledge" of those retiring workers -- that is, the type of knowledge that can be gleaned from books and manuals -- but also more importantly, their "tacit knowledge". This refers to be underwritten tricks of the trade that workers gain over the course of their utility career. These are things that can't be found in a job/policy manual. It's more frequently, and very aptly, called "experience". An industry magazine recently summarized the problem by saying "**When that 25-year old transformer, fails, you want to be sure your 25-year-young substation engineer knows how to handle the problem.**"*

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New DTA Data Structure

Why did Doble implement a new data structure? There were two reasons that drove the decision to move to a new file format: 1) The desire to implement additional tests in the DTA Field system such as Leakage Reactance and 2) the request for a more open data structure that would facilitate using the data contained in a DTA file by other software applications. The original file format, Compressed Data Set (CDS) was developed by Doble at a time when there existed no standard for compressing files. It was an era when files sizes needed to be kept to a minimum being the principal means for transferring files was the floppy disk. Being a proprietary file format it could not be read by other application and some type of update/conversion would be required if the format were to be modified. The decision to move to XML (extended markup language) was based on widespread acceptance. Microsoft offers a number of tools and applications that work with the XML format. The file is basic text, which will facilitate moving the record over the web and through firewalls.

What happens to the CDS file once it is converted to XML? The CDS filename format used a random number with file extension of "A" and two numbers, the numbers represented the type of apparatus for example; A13 was a two winding transformer, A21 was an oil circuit breaker (a complete list is provided below). When a file was deleted through the DTA Data Manager the A was converted to X and the record was removed from the list, but the file still resided in the directory until it was Purged or Recovered. When a CDS is opened and saved with DTA Field V5 it's automatically converted to the XML format the old file is renamed with an X (instead of A) extension, thus it still exists, but will not appear in the data list of the DTA Data Manager. Any changes made in the record using DTA Field V5 will not be saved in the CDS version of the data set.

New File Names

Since we were going to the trouble of developing a new data structure it made sense to implement a name convention that was more descriptive. All files will now have an XML extension. The file name will consist of the apparatus serial number, or other apparatus unique information (user configurable from the Data Manager, select Tools then Configure), followed by an underscore "_" and two alphanumeric characters that represents the apparatus type.

The table below shows the old and new file name extensions:

Apparatus	Old File Name	New File Name
Autotransformer w/o Tertiary	#####.A11	s/n_XA.XML
Autotransformer w/ Tertiary	#####.A12	s/n_AT.XML
Two-Winding Transformer	#####.A13	s/n_X2.XML
Three-Winding Transformer	#####.A14	s/n_X3.XML

Voltage Regulator	#####.A15	/n_VR.XML
Oil Circuit Breaker	#####.A21	s/n_BO.XML
Live Tank Breaker	#####.A23	s/n_BX.XML
Air-magnetic Breaker	#####.A25	s/n_BA.XML
Vacuum Breaker	#####.A27	s/n_BV.XML



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From the Editor

Dear Clients:

Recently, I published an article in Utility Automation Engineering T&D that addressed a major problem in our industry-- **Knowledge Loss**. According to the Bureau of Labor Statistics, electric power industry workers are already older than the national average. The average utility employee is 43.7 years old, and the median age will continue to increase over the next 25 years. For utilities as a whole, more than 148,000 employees fall in the 55-to-64 year old range, with another 26,000 employees over age 65. Even more significant, approximately half of the Baby Boomer group will reach retirement in the next five years. We have seen firsthand at Doble Client Conferences, that our fellow utility engineers have taken early retirement and others have taken advantage of the so-called "golden parachute" due to mergers and acquisitions. The result is that those engineers who are left are forced to "do more with less", with much of their workforce "green." Basically, our industry has a major case of "brain drain."

That being said, there are many industry events being planned in 2006 that you should urge your newer engineers to attend to help fill this knowledge loss. The recent **4th Annual Life of a Transformer Seminar** in Clearwater, Florida was one such example. This event was jam packed with everything you need to know about a transformer from the design phase to manufacturing, testing, maintenance, aging, and retirement. I attended the seminar and was particularly impressed by the superb speakers. Their presentations were extremely educational, interesting, and kept me on the edge of my chair the entire time. Whether you are an experienced engineer or new to the industry, you will gain a great deal by attending Doble's Life of a Transformer Seminar in February, 2007. Additional information about the 2007 Transformer Seminar will be posted on the Doble website soon.

The **7th Annual Latin American Doble Client Conference** is being held on February 28- March 4, 2006 in Mexico City . The preliminary program includes papers with the following topics:

- On-site Repair of a 85 kV Gas Insulated Substation
- Acceptance Testing of Mobile Substations
- Reliability Evaluation of Gas Insulated Substations from 23 to 230 kV
- Replacement of 23 kV Circuit Breakers on 12.6 KVAR Capacitor Banks
- Protection Coordination for Simultaneous Faults on Distribution Circuits
- Importance of Statistical References on Electrical Test Results
- Failure Analysis of 400 kV Gas Insulated Substation
- Proposal for Purchase Specification for 420 kV, 1,600 Amps Oil-SF6 Bushings
- Wedge Replacement on 58 MVA, 13.8 kV Generator
- Summary of Integral Maintenance Program on 20 Hydro Generators
- Repair of Hydrogen Leaks on 350 MW, 20 kV, H2-H2O Cooled Generator
- Condition Based Maintenance
- Transformer Diagnostics with SFRA Using Poles and Zeroes Analysis.

Also on our busy schedule is the premier event for our industry-- the **73rd International Conference of**

Doble Clients on April 9-14, 2006 . Since 1934, the Doble Conference has been regarded as the leading forum in the world for the exchange of information on maintenance and condition assessment of high voltage apparatus . Besides the presentations, tutorials, formal discussions, and the industry expo, this event also provides the opportunity for **networking** with your peers. What's more, you can also earn valuable Continuing Education Units (CEUs). The Doble Client Conference is truly an **international** conference with more than 30 countries expected to attend. It is this "international flavor" that makes the Conference discussions so interesting. The exchange of information and ideas on a "user-level" is why so many engineers regard this to be THE industry conference.

By attending and participating in these events, and urging your "green employees" to do the same, we can all work together and solve one of our industry's biggest problems, the "brain drain"!

Be sure also to check out the all-new Doble Web Site. www.doble.com. It has been completely re-designed with a new look and easier navigation. The new Doble Knowledge base and Portal was also recently launched. Clients attending the Fall Meetings in Salt Lake City were given a preview of this new client resource. On the portal, Doble Clients are able to view past Conference Papers, Tutorials, Manufacturer Services Advisories, Reference Books and Guides, and a historic archive of e-mail responses to the ASK DOBLE Maintenance Engineer Discussion Forum. All of this information is provided as part of the Doble Services Program to those clients under an annual contract with Doble.

We look forward to seeing you at a Doble Event soon.

Sincerely,

Wayne A. Bishop Jr.
Managing Editor, Doble Exchange



Please don't hesitate to share your thoughts on this article. Send your opinions and comments to: DobleExchange@doble.com. We are always interested in **Doble-Tested** case studies and field photographs from the Client Community. Please send these to DobleExchange@doble.com.

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