Together We Power The World SM
Apparatus Maintenance and Power Management For Energy Delivery

Testing for Corrosive Sulfur in Transformer Oil

Recently there have been a number of failures of power transformers and reactors where there are indicators of copper corrosion and formation of copper sulfides on conductors and insulating materials. The conductive copper sulfide reduces the dielectric breakdown voltage of the solid insulation. This can result in a dielectric puncture through the paper insulation. The failures have occurred after the apparatus have been in service for a year or more, often several years. At normal operating temperatures the corrosion process appears to take this time to form critical amounts of conductive sulfides. To date the failures have occurred without prior evidence of abnormal gassing behavior and therefore it appears that this problem is difficult to detect and manage.

Which Transformers and Reactors to Test

1) Critical units to your system
2) Units that have the following characteristics
   a) Manufactured from 1999 to present
   b) Have oils that failed the corrosive sulfur tests (ASTM D 1275B and CCD tests)
   c) Operate at high temperatures over long periods time such as generator step-up transformers
   d) Are either gas blanketed or have a sealed conservator system (a few failures have occurred with free-breathing conservators)
3) Corrosive sulfur problems have been known to occur in units older than 1999, but to a much lesser extent. Test the ones that are most critical to your system first. The lowest voltage class transformer known to have failed due to corrosive sulfur is 35 kV but most failures have been above distribution voltages.
4) Those unit that do not have completely enameled or varnished conductors

Suggested Testing

Doble now recommends two primary tests to be performed and several optional tests:

1. ASTM D1275B, Corrosive Sulfur in Oil, required volume is at least 250 mL
2. Doble Covered Conductor Deposition (CCD) Test, required volume is at least 60 mL, the test is performed in two vessels, one sealed and one that has restricted breathing , or,
3. Doble Covered Conductor Deposition (CCD+DT) Test with dielectric breakdown voltage testing of the paper after aging, required volume is at least 60 mL, the test is performed in two vessels, one sealed and one that has restricted breathing. The dielectric breakdown voltage test is performed to determine if any deposits produced in the paper significantly impact the dielectric strength of the paper
4. Dibenzyl disulfide (DBDS in Oil) – this is a new test that can help identify one of the sources of corrosive sulfur. It is not needed on all samples but should be tested to see if it is in the oils on your system.
5. Passivator in Oil – whether in the oil originally or after it has been added, this test provides information on the amount of passivator present in the oil. Doble is able to detect benzotriazole (BTA) and Irgamet 39 along with similar type products. This test does not determine if there is corrosive sulfur. Passivators are used to retard the formation of copper sulfide.

The D1275B test provides information on how corrosive the oil is to some metals such as the copper conductor and if sulfide deposits are likely to occur on the conductor. The second test provides information on the propensity of the corrosive sulfur to produce copper sulfide deposits on the paper, which can significantly reduce its dielectric strength. Copper sulfide deposition in the paper appears to be the main failure mode for this phenomenon. There is one sulfur compound that has been found that has the potential to create some of the corrosive sulfur problems in transformers and reactors. Doble has developed a test to determine the concentration of DBDS by gas chromatography. The test is listed as follows: Dibenzyl disulfide in oil, Doble Method, required volume is 10 mL.

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Possible actions for oil that fails the D 1275B or Doble CCD (+DT) test

There is not enough information at this time to make strong recommendations at this time. Doble has a collaborative research project underway to better understand the problem and methods of mitigation. Failure of an oil to pass either or the other tests is troublesome. The D 1275B test aids the user in determining if copper sulfide will build up on the conductor. Given enough time, the copper sulfide buildup may become so significant that is starts to flake off into the bulk oil and solid insulation where, because of its conductivity, it can cause a dielectric failure (This has been shown to occur in LTCs and bushings). The Doble CCD test aids in determining if the copper sulfide deposition in the paper is likely to occur. Copper sulfide in the paper reduces its dielectric strength. Practically speaking, the deposition of copper sulfide in the paper is the bigger problem in transformers. There are several approaches that have been used to try and reduce the risk of failure for transformers and reactors that have been operating with oil that fails the corrosive sulfur tests:

1. Replace the oil with one that passes these tests. A significant amount of oil will remain in the solid insulation that will then mix with the replacement oil. The characteristics of the blend will determine how much the risk has been reduced.
2. Partial oil replacement is another possibility. Depending on the characteristics of blended products it might be possible to dilute out the problem to reduce the risk.
3. Adding a passivator can reduce the reaction between metals such as copper and silver and corrosive sulfur. The passivator can also reduce deposition in the paper insulation. It must be noted, that the passivator does not completely stop the reactions and the long-term benefits need to be determined. The passivator content needs to be monitored.
4. Combinations of action 1 or 2 with 3 can be used.
5. Removal of dibenzyl disulfide from the oil. Other corrosive sulfur compounds may not be removed. However, laboratory testing can determine this.

All of these remedial actions are under study. It is important to note that none of these remedial actions will remove copper sulfide that has deposited or correct damage that has already occurred. Oil replacement and passivation and combinations of these have already been used with in-service transformers.

To determine if deposition has occurred in the cellulosic materials such as paper and pressboard Doble has developed a high-voltage power factor tip-up test. Preliminary results have been promising for this indicator test and it is now being offered as a service.

Prepared by: March 16, 2007

For More Information, Please Contact:

Lance R. Lewand
Materials Laboratory Manager
Doble Engineering Company
85 Walnut Street
Watertown, MA 02472 USA
Pone: 617-393-2981
E-mail: llewand@doble.com

Or

Paul J. Griffin
Vice-President, Laboratory Services
Doble Engineering Company
85 Walnut Street
Watertown, MA 02472 USA
Phone: 617-393-2902
E-mail: pgriffin@doble.com