DOBLE MATERIALS LABORATORY

APPLICATION NOTE: COVERED CONDUCTOR DEPOSITION TESTS (CCD)

INTRODUCTION

Covered conductor deposition or CCD tests as they are commonly known started to be developed in 2004. The purpose of the CCD test was to determine if copper sulfide deposition would occur either on the conductor or in the paper insulation surrounding it. There are several variations of which two are briefly discussed below.

DOBLE CCD TEST

The Doble CCD test is performed in 2 different ways in order to cover many operating conditions. Vials with oil and a Kraft paper covered copper rod are used. In one vial, a needle is inserted to allow a moderate amount of oxygen to enter the vial over the duration of the test. In another vial, the cap is completely closed and the only oxygen available is that which was present at the beginning of the experiment. The vials are housed in an aluminum block to maintain a constant temperature. They are aged for 4 days at 140°C. After the test, the paper covered copper rods are removed, cleaned of oil and both the copper and the paper are inspected. The evaluation of the copper rods is done using the ASTM D 1275B/D 130 standards for definition of corrosivity and tarnish level. The paper is inspected for the presence of a deposit. The result "deposition" whether heavy, moderate or light means that there was a visible deposit on the paper but does not characterize this as good or bad. The interaction of the copper, oil, and oxygen with the paper insulation over the duration of the test can result in the formation of deposits of copper sulfide, or copper, or oil/paper degradation byproducts. Many oils form some sort of deposit but some do not pose any risk in service. It is the paper deposits with a metallic sheen that reduce the dielectric strength of the paper that are considered a “fail” from corrosive sulfur and are considered to pose a risk. Other deposits that do not form a metallic sheen are considered a “pass”.

CIGRE WG A2.32 CCD TEST (PROPOSED IEC METHOD 62535)

Vials with oil and a Kraft paper covered copper rod are used. The test is performed in duplicate. The oil is air saturated first before being placed in the vial and then capped. Thus the only oxygen available is that which was present at the beginning of the experiment. The samples are aged for 3 days at 150°C. After the test, the paper covered copper rods are removed, cleaned and both the copper and the paper are inspected. The evaluation of the copper rods is done using the ASTM D 1275B/D 130 standards for

definition of corrosivity and tarnish level. The paper is inspected for the presence of a deposit. The same types of deposits in the paper are looked for as in the Doble CCD test.

WHY THE DIFFERENCE BETWEEN THE TESTS?

Through much research Doble found that both an air breathing vial and sealed vial were needed to adequately test for all aspects of the copper deposition phenomenon. This was due to the fact that most of the deposition found in the paper was in air breathing vials and not sealed vials. On occasion, copper sulfide deposition was found in the sealed vials and not the air breathing vials so in this regard this was the reason to have both vials used in the testing. Also, we found that in a majority of the cases, the sealed vials pushed the deposition towards the copper instead of the paper and in the air breathing vials the opposite was true in which more of the copper sulfide deposition was pushed towards the paper insulation. We also found that aging the samples at 150°C also pushed the copper sulfide deposition towards the copper and not the paper. By lowering the temperature to 140°C and extending the aging from 3 days to 4 days, it was found that the deposition was pushed more towards the paper.

Since the ASTM D 1275B test already served as a good indicator of corrosive sulfur attack on copper, the Doble CCD test is used primarily as the indicator for copper sulfide deposition in the paper insulation. We also still examine the copper conductor because not all corrosive sulfur mechanisms are the same and this is recognized in the Doble CCD test.

In both CCD tests, Doble and the IEC proposed test, the pass/fail criteria is the same for the copper conductor and the paper insulation.

In addition and if so desired, Doble also offers confirmatory tests on the paper insulation after the qualitative inspection. These include dielectric strength, resistivity and/or SEM/EDX analysis on the paper insulation used in the test.

The table below provides information on the pass/fail criteria on each of the CCD tests described in this application note.

TABLE 1
Pass/Fail Criteria for CCD Tests

Copper	D 130 Tarnish Level	Result
Non-corrosive	1a through 3b	Pass
Corrosive	4a, 4b, 4c	Fail

Paper Deposition	Result
No deposition	Pass
Heavy deposition, dull in color	Pass
Moderate deposition, dull in color	Pass
Light deposition, dull in color	Pass
Heavy deposition, metallic sheen	Fail
Moderate deposition, metallic sheen	Fail
Light deposition, metallic sheen	Fail

In the Doble CCD test, if the copper rod is considered to be corrosive and/or any of the two paper samples (from the air breathing or sealed vials) has a metallic sheen deposit then the oil is considered to have failed the test.

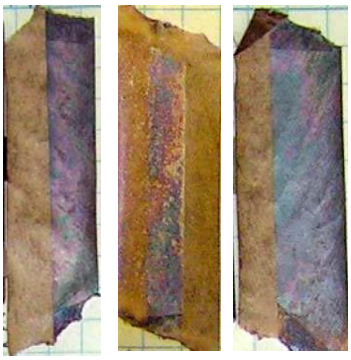
In the CIGRE test (proposed IEC 62535), failure of the test is considered to have occurred when the copper rod tarnishes to a corrosive condition (D 130, tarnish levels 4a, 4b, or 4c) or when there is a metallic type deposition in the paper.

EXAMPLES OF COPPER RODS AND KRAFT PAPER INSULATION AFTER TESTING

Considered to be Non-corrosive
PASS

Considered to be corrosive
FAIL

Paper with no or dull deposits
From left to right:
No deposit, heavy dull deposit, and moderate dull deposit
PASS



Paper with metallic sheen
From left to right:
Heavy, moderate, heavy
FAIL