

TechTopics No. 24

Checking integrity of vacuum interrupters

Recently, one of our customers asked us to explain why we recommend the use of a dielectric (power-frequency) test to check for the integrity of the vacuum in a vacuum interrupter. The customer asked what standard dictated that a dielectric (power-frequency) test be used.

A dielectric (power-frequency) test is appropriate for any electrical equipment, but this issue is a matter of practicality, not of standards. For old technologies, such as, air-magnetic circuit breakers, the user could visually examine the arc chutes for integrity, and could also examine the contacts. However, for any circuit breaker with sealed interrupters (such as, vacuum or SF₆), it is not possible to visually determine the internal condition of the arc interrupting structure or examine the contacts. Therefore, another means is needed to determine the dielectric condition of these vital elements.

Vacuum interrupter contacts are designed so they practically never wear out. Our circuit breakers (typically) are capable of 10,000 interruptions at full-load current, which is also the typical mechanical endurance of the operating mechanism. Depending on the interrupting rating, the vacuum interrupters are capable of 20 to 100 full-fault current interruptions. Compared to the endurance of the old technologies, the contact life of vacuum circuit breakers is nearly unlimited. By comparison, air-magnetic circuit breakers were only required to endure four full-fault current operations before rebuild or replacement.

What about dielectric integrity? Since the inside of the vacuum interrupter cannot be visually examined, the only practical means to check vacuum integrity is a dielectric test across the open contacts. This is recognized in a variety of standards, but the major ANSI/IEEE standard is C37.09-1999.

Clause 5.8 of this standard has this to say on the subject:

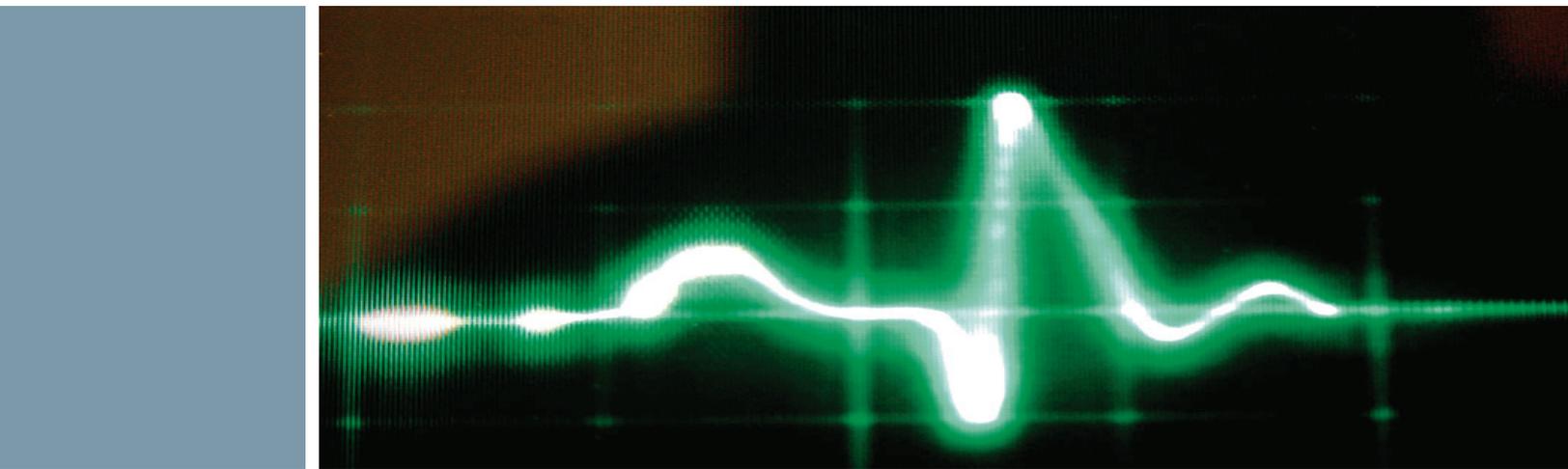
5.8 Vacuum integrity tests

The purpose of vacuum integrity tests is to demonstrate that the pressure on the vacuum interrupter is still below the maximum level required for the acceptable performance of the switching and insulating functions. The vacuum level will have been checked by the vacuum interrupter manufacturer before shipping the unit to the circuit breaker manufacturer. Therefore, the tests identified in this standard are to demonstrate that the assembly of the vacuum interrupter into the circuit breaker and the operation of the circuit breaker do not affect the vacuum integrity of the interrupters.

Measuring the pressure inside of a vacuum interrupter is a very difficult task and those measurements can only be performed on a vacuum interrupter by itself, not when installed in a circuit breaker. Therefore, the requirements of this standard are limited to the use of a voltage withstand test to verify that the vacuum pressure is still within the acceptable limits.

After assembly, the vacuum circuit breaker shall be subjected to a dielectric withstand test to demonstrate its integrity. The test voltage shall be stated by the manufacturer and the final dielectric test shall be carried out after the routine mechanical production tests. These tests may be combined with the requirements of 5.16.

This basically says that vacuum integrity is checked by means of a dielectric test across the open contacts. On a new 15 kV circuit breaker, this is performed at 36 kV ac. For a used circuit breaker, the test voltage should be 75 percent of the new test voltage, or 27 kV for this example. The 75 percent level for field dielectric tests is established in ANSI/IEEE C37.010, clause 5.5.1, and provides a margin for normal deterioration, minor contamination, and the like.



The use of a dielectric (power-frequency) test to check vacuum integrity is also incorporated in ANSI C37.85-2002. This document is entitled "Power Vacuum Interrupters — Safety Requirements For X-Radiation Limits," and clause 6 is as follows:

6. Dielectric withstand voltage tests on used interrupters

Dielectric withstand voltage tests should be performed by users of switchgear devices to prove the ability of insulating materials and spacings to withstand specified over-voltages for specified times without dielectric breakdown or puncture. The test voltage levels used for field tests are typically 75 or 80 percent of the levels used on new equipment by the suppliers. Such tests should be conducted as commissioning tests before new equipment is placed into service, as tests before recently maintained equipment is returned to service, and in general, as part of a comprehensive preventive maintenance program.

Power-frequency withstand voltage tests may also be used to establish the vacuum integrity of vacuum interrupters. Suppliers shall prescribe the test procedures, including gap settings and test voltages, for conducting power-frequency withstand voltage tests on used vacuum interrupters or switchgear utilizing vacuum interrupters.

When power-frequency withstand voltage tests are performed on used vacuum interrupters, or on switchgear components utilizing vacuum interrupters (including contactors, switches, circuit breakers and the like), precautions shall be taken for the safety of test personnel. If distances normally required for electrical safety are maintained, X-radiation exposure to test personnel generally does not exceed established dose limits (refer to ANSI N43.3-1993). Nevertheless, adequate precautions such as shielding or distance should be used to protect personnel against possible higher X-radiation occurrences due, for example, to incorrect contact spacing, or to the inadvertent application of voltages in excess of the values prescribed in Column 3 of Table 1.

For "clean" applications (environments that meet the "usual service conditions" in ANSI IIEEE C37.20.2), we recommend a vacuum integrity test at normal maintenance (for the type GMI circuit breaker, five years or the number of operations appropriate to the rating as shown in the instruction manual). For environments that are more severe, the dielectric (power-frequency) test should be performed more frequently to detect contamination of the external surfaces of the vacuum interrupter (the inside of the vacuum interrupter is not affected by the environmental conditions).

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