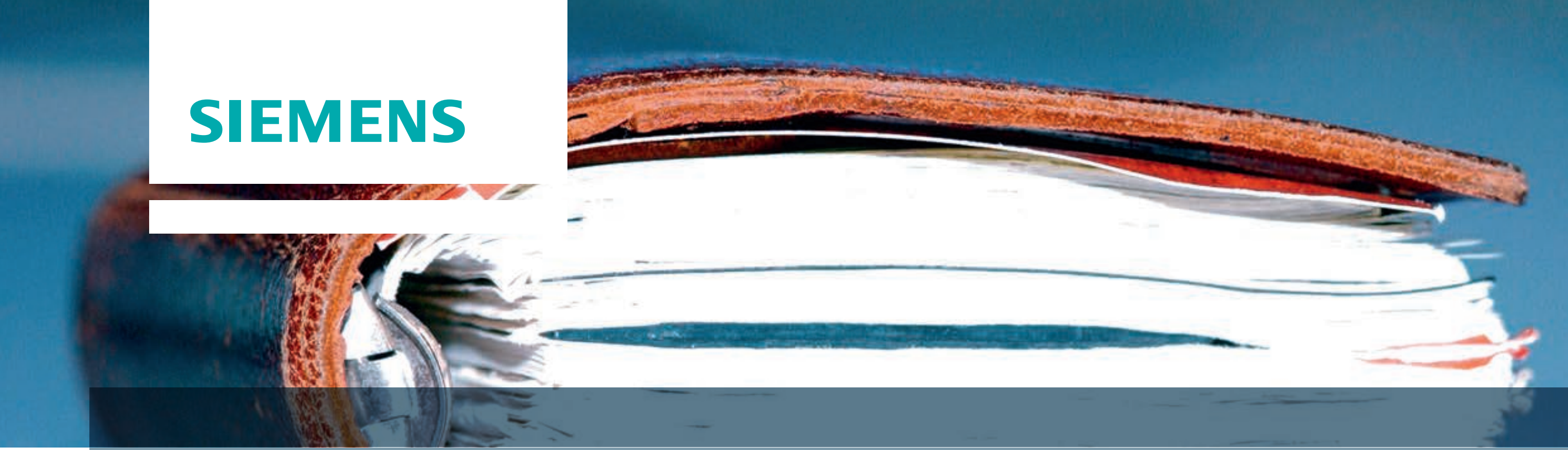


SIEMENS

TechTopics No. 120

High-potential testing – current doesn't matter!

Siemens often receives questions from testing firms and users about high-potential testing, particularly with low-energy dc hi-pot test sets used to conduct tests of vacuum integrity on circuit breakers. These test sets are designed to be compact and highly portable, and therefore, have relatively limited output capabilities, and particularly of current.

In most commercial test laboratories and in our factory, ac high-potential test sets are used that are relatively large, and hence not readily portable, which have adequate voltage and current output to allow maintenance of the required test voltage without tripping the test set on current.

For high-potential withstand-voltage testing, it is the voltage level and the time duration that matter – the leakage current during the test does not matter.

In high-potential testing (referred to as power-frequency withstand testing in IEEE standards), the test voltage is applied to each conductor in turn with all other conductors and the equipment frame grounded. To be considered a passed test, the test voltage must be held successfully for 60 seconds. The test voltage is far above the normal service voltage, for example, the test voltage for typical switchgear rated 15 kV is 36 kV ac. In contrast, in normal service, the line-ground voltage would only be 15 kV / 1.732 = 8.7 kV.

For medium-voltage switchgear products, the required test voltages are:

Rated maximum voltage	Rated power-frequency withstand	Field test voltage	Field test voltage
kV (rms)	kV (rms)	kV (rms)	kV dc
4.76	19	14.25	20.2
8.25	36	27	38.2
15.0	36	27	38.2
15.0 generator circuit breaker	38	28.5	40.3
27.6	60	45	64
38.0	80	60	85

At these test voltages, the equipment experiences partial discharges and significant capacitive-charging current, so the test set must be able to support the current required at the test voltage. Even if the testing is performed with dc test voltage, the most common means of testing in actual installations, the test set must still be able to support the current required for the duration of the test.

When vacuum interrupters are tested for vacuum integrity, the test voltage is applied across the open contacts of the vacuum interrupter.

The various possible current paths from one side of the interrupter to the other (and to ground) include the gap between the open contacts inside the interrupter, the exterior (ceramic) surfaces of the vacuum interrupter, the insulators from each side of the vacuum interrupter to ground, the insulating pushrods between the interrupter and operating mechanism and the tension struts from one side of the interrupter to the other.

These paths are illustrated in the photo in Figure 1 of the circuit breaker operating mechanism used in a type GMSG circuit breaker. Thus, there are multiple parallel paths for current flow. In addition, the ambient humidity when the test is conducted can influence the current demanded significantly. This even influences testing in the factory and design testing, as there can be adverse atmospheric conditions that prevent us from conducting design tests in accordance with the standards until such conditions abate.

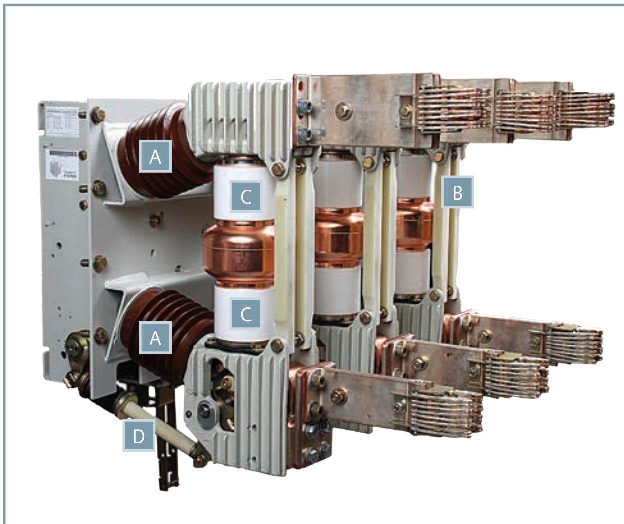
When conducting high-potential tests on any equipment, special care must be exercised to clean the exterior insulation surfaces, to reduce the surface currents that flow across contaminated insulation. Especially in the case of testing for vacuum integrity, the objective is to determine if the vacuum interrupter has maintained its vacuum integrity, and therefore, the exterior of the interrupter and other insulating surfaces must be as clean as possible.

Because of the variability encountered in high-potential testing, the current during the test can vary considerably, but the current level is not relevant to the test. For a high-potential test, the criterion for pass/fail is whether the test specimen, in this case the vacuum interrupter, sustain the test voltage for at least one minute without breakdown.

IEEE standard 4, the standard for high-voltage test techniques, recognizes this limitation and states that when relative humidity exceeds about 80 percent, the disruptive discharge voltage during the test becomes irregular, especially when a disruptive discharge occurs over an insulating surface, and because of this test results can be inconsistent.

Another aspect to remember about high-potential testing is that the leakage current increases as the size of the test specimen increases. In our factory, Siemens has no difficulty testing normal shipping groups consisting of up to five sections of switchgear, but if we attempt to increase the number of sections tested simultaneously, the leakage current from many parallel paths between the test leads overwhelms even the rather large test sets that used in the factory. In a jobsite test situation, when the high-potential test equipment is likely of lower capacity than used in the factory, this becomes a more prevalent problem.

For high-potential withstand-voltage testing, it is the voltage level and the time duration that matter – the leakage current during the test does not matter.



Item	Description
A	Standoff support insulators
B	Tension struts
C	Interrupter ceramic insulators
D	Operating pushrods

Figure 1: Type 3AH3 operating mechanism

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Siemens Industry
7000 Siemens Road
Wendell, North Carolina 27591

For more information, please contact our Customer Support Center.
Phone: +1 (800) 347-6659

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