Power Frequency Withstand Testing of 38kV Switchgear

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To accomplish the dielectric requirements of 27kV and 38kV class equipment in the 40 inch footprint of Powell PV27, PV38, PV27-AR and PV38-AR equipment, capacitance graded bushings are used for the primary disconnecting devices. This allows the use of smaller, 600V rated current transformers on the primary disconnect spouts within the circuit breaker compartment rather than fully rated bar type transformers mounted in the cable compartment. While capacitance grading provides enhanced dielectric capability in a smaller space, the same characteristics that reduce the voltage stresses create some issues when performing dielectric testing.

The capacitance grading creates layers of equipotential voltage with the proper spacing of conductive foil and insulation. This makes a smooth transition from line voltage inside the bushing to ground on the outside of the bushing. Applying voltage to the primary conductor charges each layer. The current required to charge the foils is negligible during normal operation, but is seen as leakage current during dielectric testing and can easily push the capabilities of a field High Potential (Hipot) test set beyond its limits.

The capacitance graded bushings draw about 6mA each at line voltage. The charging current goes up nearly linearly as the voltage is increased. This means at the factory test level of 80kV for a 38kV bushing, each bushing is drawing approximately 18mA. At the field test level of 60kV, the bushing is drawing approximately 12mA. For 27kV equipment the factory test level is 60kV, so at the field test level of 45kV, each bushing will draw approximately 8mA.

A large AC Hipot, typical of those found in switchgear factories and test labs, will be limited to a 100-200mA output and the trip/failure point will often be set to a lower value. Portable field Hipot units may have even lower output current of 50ma or less. It is easy to see that it does not take many vertical sections of switchgear to have the charging current for the capacitance graded bushings higher than the test supply is capable of producing. The result is a failure indication on the test set with no actual insulation failure in the equipment.

Field testing using a Megger is also problematic. It is difficult to charge the capacitive bushing using a typical Megger test device and because the charging current for the bushing is seen as leakage current in the calculated resistance result, the test results are not accurate.

There is no ANSI recommended DC test for 27kV or 38kV equipment. The reason is DC testing of AC rated equipment also produces inaccurate results. The DC test does not evaluate the capacitive coupling of components within the insulation system. It also tends to over stress the insulating materials.

Therefore, Powell recommends the equipment be AC tested. This can be accomplished in several ways. The equipment can be separated into smaller sections to reduce the charging current requirements of the bushings. Restricting the number of bushings in the test circuit to draw about 75% of the test equipment output is a reasonable rule of thumb to avoid false tripping due to the charging current on the bushings.
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A second alternative method uses a very low frequency power supply. This delivers an AC signal, but the reduction in frequency reduces the charging current draw; giving you the benefits of an AC test with the low current of a DC test.

When the goal of testing is simply to validate the insulation system was not damaged during maintenance or installation, Powell recommends reduced voltage testing with DC. Applying a 50kV DC signal to the circuit for 1 minute will confirm insulation and interrupter integrity. While this is not a full dielectric test, it serves to confirm the system is good for operating voltage.

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