Shop Tech Talk September 2010

Surge Testing and HiPot Testing of Electric Motors

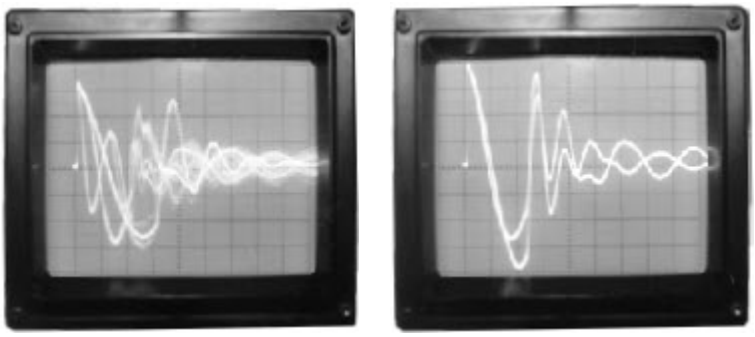
Surge Comparison Testing of Electric Motor Windings is carried out using a Surge Tester made by companies like Baker/SKF, PJ Electronics, Hipotronics and others and the test is performed to determine the winding insulation condition. This test detects turn-to-turn, coil-to-coil and phase-to-phase insulation defects that are hard to discover by other methods. For a 3 phase electric motor each of the motor leads is connected to each of the 3 leads from the surge tester and the motor ground is connected to the tester ground lead.

The surge tester imposes brief voltage surges (or pulses) to the coils during a Surge Test to create a voltage gradient (or potential) across the length of the wire in the winding. This gradient produces a momentary voltage stress between turns. The coil will respond, in the time periods between pulses, with a ringing or damped sinusoidal waveform pattern. Each coil has its own unique signature ringing or wave pattern which can be displayed on a CRT display screen.

When the wave pattern of two equal voltage Surge Tests are displayed simultaneously, if a single wave pattern is seen, the phases being tested are equal in their inductance. In other words the windings have the same number of turns, insulation, orientation, etc. and are considered to be good.

When the wave patterns of two equal voltage Surge Tests are displayed simultaneously, and two distinct wave patterns are seen, the phases being tested are not equal in their inductance. There probably is a fault in one of the windings or there is some other cause for the differing inductance. For example, the faulted winding may have shorted turns compared to the complete phase, reducing the inductance, and thus altering the wave pattern.

Good Comparison Pattern. Only one wave appears on the surge tester screen when two tests are displayed simultaneously. (The wave patterns being compared are superimposed exactly.)



Faulty Comparison Patterns. Waveforms are erratic during the test (left) or separated throughout the entire trace (right).

See next page for Hi Pot Testing →

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High Potential (HiPot) Testing.

A Dielectric Voltage Withstand test is another name for a HiPot test.
Insulation resistance can be measured and dielectric strength assured with a DC HiPot Test.
The resistance is determined by dividing the voltage impressed on the coil by the leakage current measured. Both are monitored with the DC HiPot test.
The key to DC HiPot testing is to look for leakage current that is rising faster than the increase in voltage that is applied to the winding. ***The test can then be stopped before the insulation is damaged.***

A recommended value for DC High Potential (HiPot) and Surge voltage to test a new motor, generator, or transformer in service is twice the line voltage plus 1000 volts for one minute. This test voltage value is consistent with NEMA MG-1, ANSI/IEEE 95-1977 (test voltages greater than 5000V) and IEEE 43-1974 (test voltages less than 5000V).

Examples **for 460 and 4160 volts motors are as follows:**
2 x 460 V = 920 V + 1000 V = 1920 V
2 x 4160 V = 8320 V + 1000 V = 9320 V

For windings of motors that have been running for some time I would advise using a value based on 75% of that used at the factory when motor was new.

The HiPot test is considered the mainstay of motor testing. HiPot tests can be performed in one of two ways, AC or DC.
Although the Surge test will test for grounds, it does not uniformly test all the ground wall insulation as thoroughly as the HiPot test. Nor does the Surge test give a quantitative value of the leakage current to ground. The HiPot brings the entire motor winding up to the same potential. Since all the windings are at the same potential, there is no turn-to-turn, or phase-to-phase insulation stress.
There is uniform voltage stress applied between the winding insulation and the ground wall.

During a typical DC HiPot test, all motor output leads are tied together and connected to test lead #1 of the DC HiPot tester. The tester ground lead is connected to the motor frame. The output voltage is raised to some predetermined test voltage and a current reading is measured. The lower the leakage current reading for the given voltage, the better the ground wall insulation.
Some Surge Comparison Testers provide the DC HiPot test as a separate and added function to the Surge Testing Unit.

The principle behind a HiPot test is that weakened insulation will puncture if it is subjected to a high enough voltage. The test voltage is selected such that good insulation will survive the test , whereas damaged insulation will break down during the test.In principle,insulation that fails a HiPot test could be expected to fail in a relatively short period of time if placed in service. The electric stress distribution within the insulation during a DC test is different from that in normal AC operation, since the DC electric field is determined by resistances rather than capacitances.Thus some users prefer to do AC HiPot tests, since AC stress is experienced during normal operation.

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