Use Polarization Index Test To Determine Condition/Health Of Motor Insulation

By Chuck Yung
EASA Technical Support Specialist

Insulation resistance is affected by several variables: the type of insulation, age of the material, surface area, moisture and contamination. Insulation resistance can be described as being made up of four components: Leakage, capacitance, conduction and absorption. Capacitance normally only affects the first few seconds of the **Polarization Index** (PI) test; conduction should be essentially zero if the windings are dry; and leakage current is constant over time. The PI test is useful because the remaining variable – absorption current – indicates the health of the insulation.

The PI test is used to determine the condition of motor insulation to ground. The ratio of 1-minute to 10-minute resistance is recorded.

10 minute resistance / 1-minute resistance = PI ratio

The PI measures the time required for molecules of insulation to polarize to resist the flow of current. Insulation molecules at rest are randomly oriented (see Figure, top). When current is applied to the windings, the molecules align themselves (see Figure, bottom) to resist the flow of current. How quickly this happens tells us a lot about the condition of the insulation.

Because the PI measures insulation resistance between the conductors and ground, this test is only useful for taped/sealed coils. The purpose of the PI test is to gauge the condition of the insulation, so a large amount of conductor surface exposed to air (air is an insulator) skews the results. Humidity and surface contamination would greatly affect the values obtained. That makes the PI test ineffective for random windings, most fields and any winding with "appreciable amounts of exposed conductors."

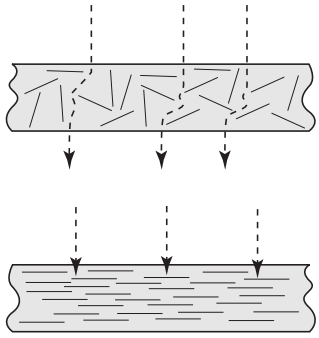

Figure – The upper sketch shows the insulation molecules at rest. The PI test measures the time required for the molecules to align (polarize) from their random orientation to resist the flow of current. In the lower sketch, molecules align themselves to resist the flow of currents.

The ratio should be between 2 and 5, normally. A ratio below 2 indicates a dirty or moist winding. A ratio above 5 may indicate a very dry, brittle insulation system. There are exceptions to the above guidelines. High-voltage VPI and pressed-coil insulation systems may yield a PI between 1 and 2, for a perfectly good winding. Newer epoxy insulation systems have such a fast reaction time that the molecules polarize almost insantly. According to IEEE 43-2000, when the "1-minute insulation resistance is over 5000 meg-ohms, the calculated PI may not be meaningful."

When a winding is energized — by megger or hipot or in service – the insulation molecules polarize. Because it takes time for the insulation molecules to return to their "at rest" position, the windings must be de-energized long enough to return to rest. If the molecules are not fully at rest, it will take less time for them to polarize and the PI ratio will be

IEEE 43-2000 clarified minimum insulation resistance as follows:

Min. M Ω	Winding under test
kV+1	Most windings made before (about) 1970.
100	Most form coil DC armatures and AC windings built after 1970.
5	Most random-wound stator coils, and form coils rated below 1 kV.

Use Polarization Index *. . . Continued*

misleading. Megging a motor before the PI test will artificially lower the PI ratio.

To ensure a valid PI test, ground the motor leads to the frame for 20-30+ minutes before doing the PI test. Doing a PI test immediately after the windings are energized *for any reason* will skew the results of the PI test.