

## Engineer's Notebook

In March 2000, the IEEE-SA Standards Board approved a revision of IEEE Std 43-1974 by the Electric Machinery Committee of the IEEE Power Engineering Society. This revision is IEEE Std 43-2000, the "IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery". Changes made to the types of insulation used in electric rotating machines have resulted in different insulation resistance characteristics, and therefore, required a substantial revision to the IEEE standard. According to the IEEE, the standard is intended for:

- **Individuals/organizations that manufacture rotating machines.**
- **Individuals/organizations that are responsible for the acceptance of new rotating machines.**
- **Individuals/organizations that test and maintain rotating machines.**
- **Individuals/organizations that operate rotating machines.**

**Megger** recommends that anyone involved in testing and/or maintaining rotating machinery review this standard in detail. This article will provide some of the highlights.

IEEE Std 43-2000 recommends a procedure for measuring insulation resistance of armature and field windings in rotating machines rated 1 hp, 750 W or greater and applies to synchronous machines, induction machines, dc machines and synchronous condensers. It does not apply to fractional horsepower machines. It also recommends the insulation test voltage (based on winding rating) and minimum acceptable values of insulation resistance for ac and dc rotating machine windings.

## IEEE Recommended Practice for Insulation Testing



### Test Voltage

The following chart provides guidelines for the DC voltage to be applied during an insulation resistance test. Note that voltages up to 10 kV are recommended for windings rated at greater than 12 kV.

*Winding Rated Voltage (V)	Insulation Resistance Test Direct Voltage (V)
<1000	500
1000-2500	500-1000
2501-5000	1000-2500
5001-12,000	2500-5000
>12,000	5000-10,000

\* Rated line-to-line voltage for three-phase ac machines, line-to-ground voltage for single-phase machines, and rated direct voltage for dc machines or field windings.

The standard recommends that each phase be isolated and tested separately (if feasible) as this approach allows comparisons to be made between phases. The two phases not being tested should be grounded to the same ground as the stator core or rotor body. When all phases are tested simultaneously, only the insulation to ground is tested. Insulation resistance measurements should be made with all external equipment (cables, capacitors, surge arresters, etc.) disconnected and grounded as these items may influence the resistance reading. A common ground should be used to prevent stray losses in the ground circuit that could effect the test results.

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## Types of Tests/Minimum Acceptable Values

The standard calls out both the insulation resistance test and the polarization index test (PI), and recommends that both tests be made (if possible). It indicates that testing history should be used to track changes. If history is not available, the standard provides minimum values for both tests that can be used to estimate the suitability of the winding. These are the lowest values at which a winding is recommended for an overvoltage test or for operation.

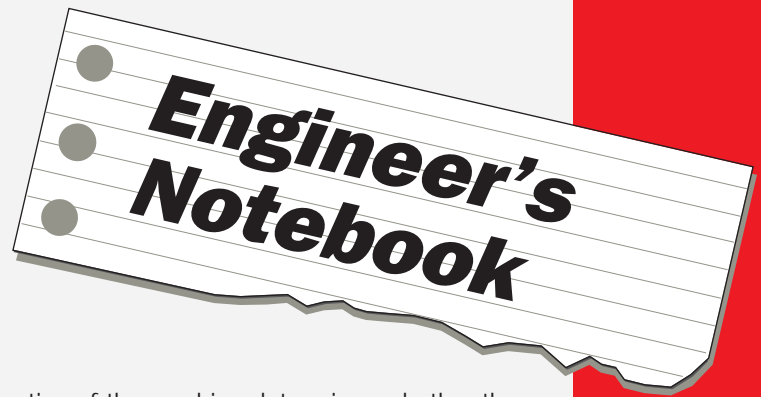
The recommended minimum values for PI are based on the thermal class of the insulating materials and apply to all insulating materials regardless of application per IEC 60085-01: 1984. The PI test is not applicable to noninsulated field windings. Be aware that a very high PI (greater than 8) for varnished cambric, shellac mica-folium, or asphaltic stator windings may indicate that the insulation has been thermally aged and may be at risk of failure. Physical inspection can be used to confirm if the insulation is dry and brittle.

Thermal Class Rating	Minimum PI Value
Class A	1.5
Class B	2.0
Class F	2.0
Class H	2.0

The recommended minimum insulation resistance after one minute at 40 °C can be determined from the following chart. The minimum resistance of one phase of a three-phase armature winding tested with the other two grounded should be approximately twice that of the entire winding. If each phase is tested separately (with guard circuits being used on the phases not under test), the observed minimum resistance should be three times the entire winding.

Minimum Insulation Resistance (MΩ)	Test Specimen
kV* + 1	For most windings made before about 1970, all field windings, and others not described below.
100	For most dc armature and AC windings built after about 1970 (form-wound coils).
5	For most machines with random-wound stator coils and form-wound coils rated below 1 kV.

\* kV is the rated machine terminal voltage in rms kV



The rating of the machine determines whether the motor windings must achieve the minimum value for either the insulation resistance test or PI test, or must achieve the minimum for both tests.

Machine Rating	Evaluation Criteria
10,000 kVA or less	Should have EITHER a value of the PI test or a value of the insulation resistance test (at 40 °C) above the minimum recommended values.
Above 10,000 kVA	Should have BOTH a value of the PI test or a value of the insulation resistance test (at 40 °C) above the minimum recommended values.

### Summary

Following is a brief summary of the highlights of IEEE std 43-2000:

- **Test voltages up to 10 kV are recommended for windings rated greater than 12 kV.**
- **Both the insulation resistance test and the Polarization Index test are recommended.**
- **Test results should be compared to historical values to identify changes.**
- **In lieu of historical records, minimum acceptable values (based on the type of equipment) for both tests are indicated.**
- **Depending on the machine rating, the readings for one or both tests should exceed the minimum acceptable values.**
- **If the readings are below the minimum acceptable values, the winding is not recommended for an over voltage test or for operation.**

Content for this article was provided by Megger

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