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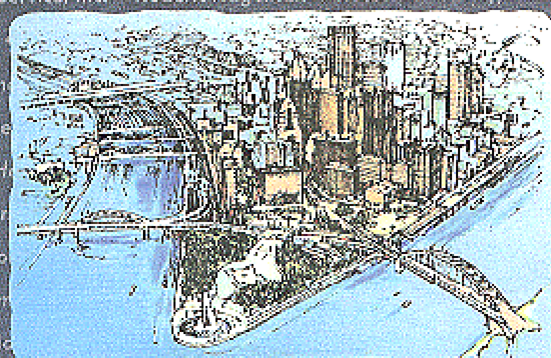

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Electrical Insulating Material Testing

by Don A. Genutis
Hampton Tedder Technical Services

A wide variety of materials has been utilized over the years for electrical insulation applications. This article examines various methods adopted for electrical testing of materials and provides insight to considerations that should be made when contemplating material substitution during apparatus repair.

Material Properties

The American Society for Testing and Materials (ASTM) is the principal organization that develops test procedures for the evaluation of electrical materials in the United States. The procedures that have been developed range from simple insulation resistance tests that are performed on equipment in the field to elaborate laboratory tests that accelerate insulation degradation by varying voltage stresses and environmental conditions.

Prior to summarizing the most common ASTM tests, sample conditioning should be mentioned. Before testing is conducted insulation samples are machined to specified sizes and then placed in an environmental simulation chamber. Depending on the insulation's intended application, conditioning subjects the material to thermal stress, high humidity, or surface contamination.

Resistivity

Material volume and surface resistivity is measured by applying a dc voltage and measuring the insulation leakage current. Volume resistivity is measured by "guarding" surface currents as shown in Figure 1. This removes the surface leakage component from the measurement circuit so that only true volume resistance results are obtained.

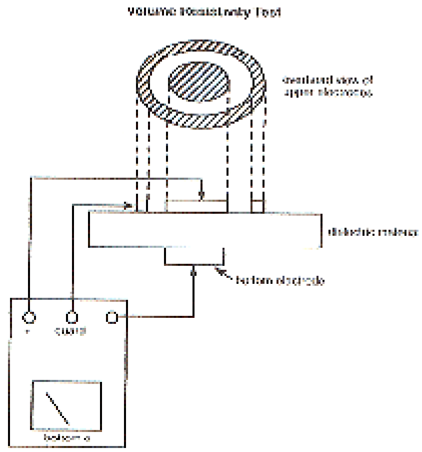

Figure 1

Dielectric Strength

Usually measured in volts/mil, this property is the voltage at which breakdown occurs. Dielectric strength varies as a function of thickness as shown in Figure 2; therefore, sample thickness is an important factor when comparing materials.

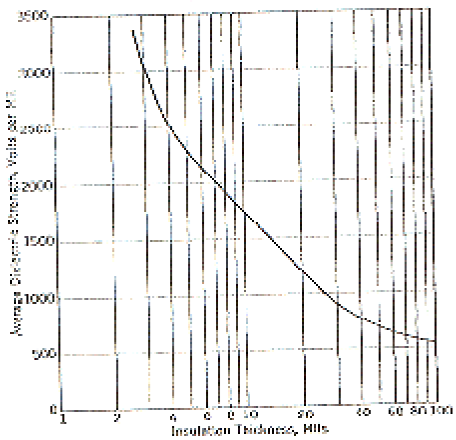

Figure 2

Dissipation Factor

Dissipation factor, also known as power factor, is the angle between the voltage and current vectors when ac voltage is applied to the sample. This test applies high voltage to stress the insulation in a manner similar to actual operating conditions.

Track Resistance Tests

These evaluations determine the material's ability to resist surface tracking. In Figure 3, a photograph of the incline plane tracking test is shown. This test applies high voltage ac to the sample while a liquid contaminate flows across the surface to ultimately cause failure by tracking or erosion. In just a matter of hours, this test can simulate years of actual operating conditions.

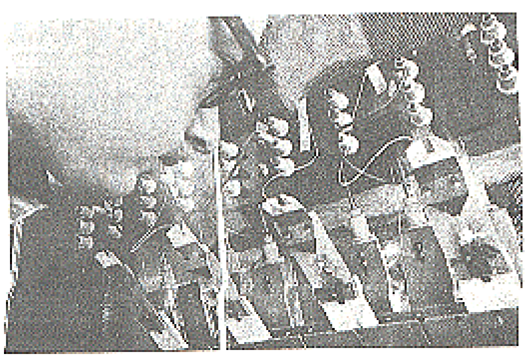

Figure 3

Arc Resistance

This test evaluates the material's capability to resist damage when a high intensity electric discharge (arc) is applied to the surface. Arc resistant materials are often used in arc interruption components.

Other Significant Properties

Based upon the application, several other material properties may be important for electrical insulation evaluation, including the following:

Chemical — Capability to withstand water, high humidity, oil, acid, and sunlight may be significant properties. Flammability may also be an important factor.

Thermal — Maximum operating temperature, brittle point, softening point, and thermal resistivity may be important properties for certain applications, such as machines.

Mechanical — Elongation, compressive strength, hardness, and impact strength are other important material properties.

Sources such as *The Electrical Engineers Handbook* provides a helpful summary of various electrical insulation material properties.

Examples of Incorrect Material Substitution

1. Field inspections of a 13.8 kV, 100 MW generator stator determined that rewedging was necessary. Original equipment manufacturer's (OEM) representatives insisted that the fiberglass reinforced polyester wedges must be treated with an OEM Teflon coating to inhibit abrasion from vibration. Even after being forewarned of this potential problem, the customer selected the low-bid generator service shop's recommendation to use uncoated wedges, which will likely reduce equipment life.

2. A major electrical equipment manufacturer applies a clear antitracking varnish to the green fiberglass-reinforced polyester lift rods used in 550 kV SF_6 circuit breakers as a part of the manufacturing process. The application of this varnish cannot be detected by visual examination and could lead to equipment failure should a noncoated substitute be used.

   Another manufacturer applies a similar *antitracking* coating from the supports that insulate the poles to the frame of 15 kV class vacuum circuit breakers.

3. Many problems have occurred when using gasketing material that is not compatible with mineral oil or silicone liquid used in transformers.

4. Moisture absorption of the fibrous insulation stacks used in oil circuit breaker interrupter grid assemblies have led to grid stack warpage and breaker failure upon fault interruption in some cases due to contact operation impairment. This has led to OEM redesigned replacement grid stack assemblies. In this case, even repairing the original interrupters with the same material does not address the design change and will not prevent future moisture absorption problems.

Summary

Due to a wide variation of properties, one should take great care in regard to material substitution in electrical equipment. The future consequences of misapplied insulation could be disastrous. Whenever damaged insulation is to be replaced during repairs, the technician should adhere to the following procedures:

- Always contact the OEM to purchase the direct replacement part. Occasionally, the manufacturer will have an upgraded part with improved material characteristics for the given application.

- If the manufacturer can no longer provide the part, then one should consider using the equipment surplus market. Some surplus equipment may have been dormant for a long time or subjected to heavy duty, so careful testing and examination of the part for insulation degradation should be made.

- After exhausting all sources, very careful consideration should be made before attempting substitution. Depending on the application, it may be wise to consult an outside laboratory to identify the original material before proceeding.

Bibliography

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Don A. Genutis acquired the former Westinghouse East Pittsburgh electrical insulation testing laboratory in 1983 and operated the facility for several years before concentrating on field testing. Don is presently Managing Director of Hampton Tedder Technical Services, a NETA full member company with offices in Southern California and Las Vegas.

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