

IEEE Guide for Insulation Maintenance for Rotating Electric Machinery (5 hp to less than 10 000 hp)

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Abstract: Information necessary to permit an effective evaluation of the insulation systems of medium and small rotating electric machines is presented. The guide is intended to apply in general to industrial air-cooled machines rated from 5 hp to 10 000 hp. However, the procedures may be found useful for other types of machines.

Keywords: industrial power system maintenance, power system maintenance, rotating-machine insulation

The Institute of Electrical and Electronics Engineers, Inc.

345 East 47th Street, New York, NY 10017-2394, USA

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Foreword

[This foreword is not a part of IEEE Std 432-1992, IEEE Guide for Insulation Maintenance for Rotating Electric Machinery (5 hp to less than 10 000 hp.)]

The purpose of this guide is to present information necessary to permit an effective evaluation of the insulation systems of medium and small rotating electric machines. Such an evaluation should serve as a guide to the degree of maintenance or replacement that might be deemed necessary and also offer some indication of the future service reliability of the equipment under consideration.

To fulfill these functions, the following should be reviewed:

- 1) Service conditions reducing insulation life
- 2) Insulation systems in general use
- 3) Visual inspection methods
- 4) Insulation maintenance testing principles
- 5) Electrical insulation tests
- 6) Methods for cleaning insulation structures

This revision of IEEE Std 432-1976 was prepared by Working Group P432, which had the following membership at the time this standard was completed:

R. L. Balke, *Chair*

D. K. Arndt
W. B. Penn

R. F. Sharrow
R. H. Yerke

This publication was originally prepared by a working group of the Rotating Machinery Committee of the IEEE Power Engineering Society. The working group membership was as follows:

W. A. Weddendorf, *Chair*

D. A. Addison
D. Bartos
E. A. Boulter
J. M. Brown
A. W. W. Cameron
E. B. Curdts
W. H. Farrell

C. J. Herman
P. W. Hernick
J. S. Johnson
J. L. Kuehlthau
V. S. McFerlin
W. B. Penn
S. Rowntree

E. R. Scattergood
F. R. Schleif
C. C. Sergeant
R. F. Sharrow
E. C. Starr
H. P. Walker
E. S. Yates

The following persons were on the Insulation (now Materials) Subcommittee that approved this guide for submission to the Electric Machinery Committee:

E. J. Adolpson
P. E. Alexander
D. Arndt
R. L. Balke
W. H. Bentley, Jr.
E. A. Boulter
L. E. Braswell, III
L. W. Buchanan
A. W. W. Cameron
J. L. Cohon
R. J. Flaherty
E. M. Fort

B. K. Gupta
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D. E. Schump
R. F. Sharrow
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W. G. Stiffler
G. C. Stone
J. E. Timperly
R. F. Weddleton
J. J. Wilkes
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1. Introduction

1.1 Scope

This insulation maintenance guide is applicable to industrial air-cooled rotating electric machines rated from 5 hp to 10 000 hp. The procedures detailed herein may also be useful for other types of machines.

1.2 References

This guide should be used in conjunction with the following publications. When the standards are superseded by an approved revision, the revision should apply.

[1] IEEE Std 4-1978, IEEE Standard Techniques for High Voltage Testing (ANSI).¹

[2] IEEE Std 43-1974 (Reaff 1991), IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery (ANSI).

[3] IEEE Std 56-1977 (Reaff 1991), IEEE Guide for Insulation Maintenance of Large AC Rotating Machinery (10 000 kVA and Larger) (ANSI).

[4] IEEE Std 62-1978, IEEE Guide for Field Testing Power Apparatus Insulation.

[5] IEEE Std 67-1990, IEEE Guide for Operation and Maintenance of Turbine Generators (ANSI).

[6] IEEE Std 95-1977 (Reaff 1991), IEEE Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage (ANSI).

[7] IEEE Std 100-1988, IEEE Standard Dictionary of Electrical and Electronics Terms—4th ed. (ANSI).

¹IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P. O. Box 1331, Piscataway, NJ 08855-1331, USA.

[8] IEEE Std 433-1974 (Reaff 1991), IEEE Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Voltage at Very Low Frequency (ANSI).

[9] IEEE Std 492-1974 (Reaff 1986), IEEE Guide for Operation and Maintenance of Hydro-Generators (ANSI).

[10] IEEE Std 522-1992, IEEE Guide for Testing Turn-to-Turn Insulation on Form-Wound Stator Coils for Alternating-Current Rotating Electric Machines.

2. The Significance of Maintenance

Rotating electric machines are complex structures that are subjected to mechanical, electrical, thermal, and environmental stresses of varying magnitude. Of the various components, the insulation systems are the most susceptible to aging or damage due to these stresses. The service life of an electric machine will, therefore, largely depend on the serviceability of the insulation systems.

Where reliability is of concern, adequate inspection and testing programs are advocated to assure that the equipment is maintained in satisfactory condition to minimize the possibility of in-service failure.

The experience and data obtained from regular maintenance inspection and testing programs can, in addition to providing an evaluation of the present condition of the equipment, give some indication of long-term trends and probable need for future repair or replacement.

The extent to which a maintenance program is pursued will depend largely on the operator's own experience and philosophy, but should also take into account the importance of service reliability for the equipment. Where high service reliability is required, a regular maintenance program involving periodic disassembly and knowledgeable visual examination of the equipment, together with the application of electrical tests of proven significance, is strongly recommended.

It should be recognized that overpotential tests can damage insulation that is contaminated or in marginal condition. Where there is uncertainty, consultation with the manufacturer is recommended. This is implicit in setting up an appropriate maintenance testing program.

3. Service Conditions Reducing Insulation Life

As has been stated, electric machines and their insulation systems are subjected to mechanical, electrical, thermal and environmental stresses that give rise to many deteriorating influences. The most significant of these are the following:

- 1) *Thermal aging*. This is the normal service temperature deteriorating influence on insulation.
- 2) *Overtemperature*. This is the unusually high temperature of operation caused by conditions such as overload, high ambient temperature, restricted ventilation, foreign materials deposited on windings, or winding faults.
- 3) *Overvoltage*. This is an abnormal voltage higher than the service voltage such as caused by switching, lightning surges, or certain power supplies.
- 4) *Contamination*. This deteriorates electrical insulation by conducting current over insulated surfaces, or by attacking the material reducing electrical insulating quality or physical strength, or by thermally insulating the material that causes the material to operate at higher than normal temperatures. Such contaminants include the following:
 - a) Water or extreme humidity
 - b) Oil or grease, including unstable antiwear and extreme pressure lubricants
 - c) Conducting dusts and particles
 - d) Nonconducting dusts and particles
 - e) Chemicals of industry

- 5) *Physical damage.* This contributes to electrical insulation failure by opening leakage paths through the insulation. Physical damages includes the following:
 - a) Physical shock
 - b) Vibration
 - c) Overspeed
 - d) Short-circuit forces or line starting
 - e) Erosion by foreign matter
 - f) Damage by foreign objects
 - g) Thermal cycling
- 6) *Ionization effects.* Ionization (corona), which may occur at higher operating voltages, is accompanied by several undesirable effects such as chemical action, heating, and erosion (see Appendix A).

4. Insulation Systems in General Use

4.1 Insulated Parts

Insulation is present in various machine components, but the complexity of the structures is such that no attempt will be made to describe such components in detail. However, such detailed information as well as knowledge of modes of insulation failure are important to permit more meaningful evaluation. Principal components are generally described as follows.

4.1.1 Armature Winding

For the purpose of this guide, the armature winding can be considered to be the main current-carrying winding, usually the stator in ac machines and the rotor in dc machines, including associated leads where applicable. The armature coils usually have wire, turn, and ground insulation. Band insulation is also required for wire-banded armatures (see 4.2.)

DC armatures have commutator insulation, while insulated wedges, blocks, and insulated mechanical supports are common to both ac and dc machines. Shrink rings on commutators require micaceous insulation between the rings and commutator.

4.1.2 Field Windings

The fields of ac machines are either salient pole or cylindrical type, while in dc machines they comprise stationary coils. In all cases, they have turn and ground insulation, insulated mechanical supports, and lead insulation. AC machines, in addition, may have collector ring insulation, retaining ring insulation, and banding insulation.

4.1.3 Brush Rigging

Both ac and dc machines typically have insulated brush riggings.

4.1.4 Core and Frame Assembly

The principal insulation components in this assembly are the insulation between laminations in the core and insulation on through bolts in some designs.

4.1.5 Other Parts

Insulation is sometimes used on bearings to eliminate shaft currents. Insulation is also used to isolate temperature-measuring devices such as thermocouples, resistance temperature detectors, thermistors, etc.