

IEEE Test Procedure for Evaluation and Classification of Insulation Systems for Direct-Current Machines

Sponsor
Rotating Machinery Committee
of the
IEEE Power Engineering Society

Approved September 9, 1976
Reaffirmed September 26, 1991

IEEE Standards Board

Approved July 17, 1981
Reaffirmed May 6, 1992

American National Standards Institute

Copyright © 1977 by

The Institute of Electrical and Electronics Engineers, Inc.

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Approved September 9, 1976

IEEE Standards Board

William R. Kruesi, Chair
Irvin N. Howell, Jr., Vice Chair
Ivan G. Easton, Secretary

William E. Andrus
Jean Jacques Archambault
Dale R. Cochran
Warren H. Cook
Louis Costrell
Jay Forster
Joseph L. Koepfinger
Irving Kolodny

Benjamin J. Leon
Anthony C. Lordi
John P. Markey
Thomas J. Martin
Donald T. Michael
Voss A. Moore
William S. Morgan
William J. Neiswender

Gustave Shapiro
Ralph M. Showers
Robert A. Soderman
Leonard W. Thomas, Sr.
Charles L. Wagner
William T. Wintringham†

†Deceased

Foreword

[This foreword is not a part of IEEE Std 304-1977, Test Procedure for Evaluation and Classification of Insulation Systems for Direct-Current Machines.]

The activity that culminated in this standard was initiated with work that was first presented in an appendix to IEEE Std 117-1974 , Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery.

Now, years later, incorporating the findings and the experience of a number of workers on the direct-current task force, a test procedure for trial use, completely divorced from IEEE Std 117-1974 , is herewith presented. Because it is an initial presentation and because it includes the work of several individuals, the proposed test procedure is not a precisely ritualized test procedure but presents alternative schemes for effecting the desired results.

However, the philosophy of functional testing presented is in accord with similar test procedures issued by the IEEE and accepted by the National Electrical Manufacturers Association and the American National Standards Institute, and it is to be hoped and expected, as further work is done in this area by people and companies interested, that the alternative schemes can be merged so that a more unified approach will evolve in subsequent revisions of this proposed test procedure.

This publication was prepared by the Working Group on Insulation for Direct-Current Machines of the Insulation Subcommittee of the Rotating Machinery Committee of the IEEE Power Engineering Society. The membership of the Working Group was:

*W. B. Penn, Chair

J. S. Askey
*J. C. Botts
G. P. Gibson
W. H. Gottung

L. M. Johnson
J. L. Kuehlthian
L. P. Mahon
*G. L. Moses

C. L. Sidway
*W. G. Stiffler
H. P. Walker
*E. S. Yates

*Task force members participating in the tests.

This standard was revised in 1976 and the revision group consisted of the following members.

W. G. Stiffler, Chair

W. B. Penn

F. Cook

CLAUSE	PAGE
1. Introduction	1
1.1 Purpose	1
1.2 Methods of Evaluation	2
1.3 Summary	3
2. Insulation Test Models for Direct-Current Machines	3
2.1 Field Coils (Random or Mush Wound)	3
2.2 Field Coils (Precision, Layer, Flat Wound)	6
2.3 Armatures, Random-Wound Coils, Test Models	7
2.4 Armatures, Form-Wound Coils, Test Models	9
2.5 Other Test Fixtures	10
2.6 Actual Machines	10
3. Test Exposures	11
3.1 Temperature and Time of Exposure	11
3.2 Mechanical Stress (Vibration)	13
3.3 Moisture Exposure	13
3.4 Voltage Checks	14
4. Procedure for Analysis and Reporting of Thermal Life Test Data	15
5. References	15

IEEE Test Procedure for Evaluation and Classification of Insulation Systems for Direct-Current Machines

1. Introduction

1.1 Purpose

The purpose of this test procedure is to classify insulation systems for direct-current machines in accordance with their limiting temperatures as determined by test rather than by chemical composition, in accordance with IEEE Std 1-1969, General Principles for Temperature Limits in the Rating of Electric Equipment.

The intention is to classify according to the recognized A, B, F, and H categories by determining thermal capability in accordance with machine temperature-rise standards. However, no standard hot-spot allowances have yet been established for direct-current machines, at least for integral-horsepower motors. These would, of course, vary with the ventilation, enclosure, etc.

Insulation systems may be shown by experience to have suitable thermal endurance when operated in a machine at the limiting temperature rise specified in the standard for the machine under consideration or by accepted test wherein the thermal, electric, and other stresses occurring in the operation of a machine are simulated and the deleterious effects accelerated in a manner affording correlation with service conditions.

Other insulation systems may then be compared to service-proven systems under similar test conditions. If a comparison is made on a system of a given insulation class, the new system must have equal or longer thermal life under the same test conditions to be considered in that temperature class. Data from such tests may be used to establish the temperature classification of new insulation systems before they are service proven. The concepts implemented herein are based on IEEE Std 1-1969.

A wide and increasing variety of synthetic electrical insulating materials is available for application in electric machinery and apparatus. Included in these materials are wire enamels, films, papers, felts, elastomers, resins, and varnishes. As there is a growing tendency either to rely solely on these materials as electrical insulation or to employ them with the old familiar materials in novel combinations, there is a corresponding increase in the problems associated with the selection and evaluation of insulations. An insulation system or combination of insulation materials must be evaluated rather than one insulating material.

Many of the specifications regulating the use of insulation materials were written before the advent of the newer synthetics and were based upon experience gained with the old materials over a long period of time. Difficulties arise, therefore, when an effort is made to classify these new insulation materials or combinations under the various standards as Class A, Class B, Class F, or Class H insulations.

This test procedure has been prepared to indicate accepted tests for the evaluation and classification of insulation systems for direct-current electric machines. It is expected that the various insulating materials or components making up the insulation system to be tested will first have been screened in accordance with specific material test procedures, such as ASTM D2307¹ for magnet wire, to establish their probable success.

This procedure is intended to evaluate insulation systems for use in usual service conditions.

It does not cover special requirements such as for machines in gas atmospheres being subjected to strong chemicals, to metal dusts, or to submersion in liquids.

1.2 Methods of Evaluation

Components, fixtures, and models suitable for use in insulation evaluation tests are described, and a series of exposures to heat, vibration, moisture, and electric stress to which the models may be subjected to represent cumulative effects of long service under accelerated conditions is recommended. The end point of insulation life is established by periodic voltage checks.

It is also recommended that for each particular system to be evaluated, a suitable type of specimen be selected and that an adequate number of these be subjected to repeated cycles of heat, vibration, moisture, and electric stress as outlined in this procedure.

An adequate number of samples to obtain a good statistical average for each chosen temperature of heat exposure should be carried through the test procedure until failure occurs. The tests should be carried through on the indicated number of specimens for at least three different test temperatures for each insulation system to be evaluated. To promote uniformity in the results, there are given seven alternative ranges of temperature, requiring from 1 to 49 days per cycle, that are appropriate for making these tests.

The number of cycles, converted to total number of hours of heat aging to the end of life, is averaged for each group of samples at each of the test temperatures and is then reported in the final results of the tests. The ratios of these hours of life for the new insulation system to those for the old established insulation system provide a rough measure of the ratio of the service life expectancy of the new system to that of the old system but are not an absolute evaluation of service life. The combined effects of the heat, vibration, moisture, and electric stresses imposed on the insulation during these tests are intentionally made more severe than those normally found in service at the same temperature. Therefore, the life of any given insulation system in these tests will be shorter than that to be expected in actual service at a comparable temperature.

This procedure will permit approximate comparisons only and cannot be relied upon to determine completely the merits of any particular insulation. Such information can only be obtained from extended service experience. In the course of time, however, it is expected that enough data may be obtained from tests of this kind to establish a normal number of hours of heat aging before failure that will be representative of each of the standard temperature classes of insulation systems A, B, F, and H for each type of specimen. It may also be feasible in machine standards to specify the number of hours before failure that will be appropriate as indications of satisfactory performance under special service conditions, such as short-time or intermittent and high-temperature exposures. Following the general procedures outlined above, the temperature classification in which any new insulating system belongs may be determined.

¹ASTM Standards can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.