

**ANSI C50.32-1976 and
IEEE Std 117-1974**
(reaffirmed 1984)
(Revision of IEEE Std 117-1956)

An American National Standard

IEEE Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery

Sponsor
**Rotating Machinery Committee
of the
IEEE Power Engineering Society**

Approved May 24, 1973
Reaffirmed December 13, 1984
Reaffirmed September 26, 1991

IEEE Standards Board

Approved September 7, 1976
Reaffirmed April 20, 1992

American National Standards Institute

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Approved May 24, 1973

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Foreword

(This foreword is not part of IEEE Std 117-1974, Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery.)

The Institute wishes to acknowledge its indebtedness to those who have so freely given of their time and knowledge, and have conducted experimental work on which many of the IEEE publications are based.

Early work with random-wound models of coil and slot assemblies (motorettes) indicated that a wide range of life expectancy with a given insulation system could be obtained. In 1958, as a result of an industry round robin, the Committee did not consider the data reported to be sufficiently consistent to warrant standards being based upon the figures. Accordingly a new test program using motorettes was initiated.

The Working Group delved deeply into each element of the 1956 version of this standard. The result was a specific written set of instructions regarding the preparation of the motorette, and the testing procedure itself. In the latter case, it was found that a special humidity environmental chamber had to be designed to reduce variation due to lack of humidity control. These features are discussed and referenced in the procedure itself.

The general conclusion of the second round robin was that test results indicated that the IEEE Std 117-1974 Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery must be rigidly adhered to in all testing details, if uniform results between different testing locations are to be achieved.

This Test Procedure has been prepared by a Working Group of the Insulation Subcommittee of the Rotating Machinery Committee of the IEEE Power Engineering Society. Members who participated in the preparation of this Test Procedure are as follows:

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1. Introduction

1.1 Purpose

The chief purpose of this test procedure is to classify insulation systems in accordance with their temperature limits by test, rather than by chemical composition. The intention is, first to classify according to the recognized thermal classification A, B, F, H, and above H categories as referenced in the Appendix. The motorette procedure is intended to be used as an Industry Standard for insulation systems in that data obtained in accordance with this standard can be correlated between testing laboratories.

A wide variety of synthetic electrical insulation materials is available for application in electric machinery and apparatus. 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. Consequently a complete insulation system must be evaluated rather than testing only individual insulating materials.

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 materials or combinations for insulation purposes under IEEE Std 1-1969 General Principles for Temperature Limits in the Rating of Electric Machinery and supplementary documents IEEE Std 98-1972, Guide for the Preparation of Test Procedures for the Thermal Evaluation and Establishment of Temperature Indices of Solid Electric Insulating Materials, and IEEE Std 99-1970. Guide for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment.

A wide range of properties is available in current synthetic materials, so that it is not feasible to classify them on the basis of their chemical composition alone. Secondly, it is not desirable to wait and acquire the knowledge required to classify them solely on the basis of experience. In the third place, composite systems of insulation, in which materials of different temperature classes are used in different parts of the structure, may give satisfactory service at temperatures higher than normally permitted for the lowest temperature component; and, conversely, compatibility or other problems may arise whereby the highest temperature component is rendered unsuitable for use at its classified temperature.

This test procedure has been prepared to outline useful methods for the evaluation of systems of insulation for random-wound stators of rotating electric machines. It is expected that the several insulating materials, or components, making up any insulation system to be tested will first be screened in accordance with specific test procedures for each type of material. Normally materials that have given acceptable performance in these separate screening tests would be included in the system evaluation tests outlined in this procedure.

This procedure is intended to evaluate insulation systems for use in "usual service conditions" with air cooling. It has also been a useful tool for evaluating systems for special requirements where machines are enclosed in gas atmospheres, subjected to strong chemicals, to metal dusts, or submersion in liquids. However, these special requirements are beyond the scope of this test procedure.

1.2 Methods of Evaluation

The test procedure includes two principal sections.

- 1) Section 2. describes motorettes (models suitable for use in insulation evaluation tests) and recommends a series of exposures to heat, vibration, and moisture to which the motorettes may be subjected to represent cumulative effects of long service, under accelerated conditions. Procedures for applying periodic voltage checks, to establish the end point of insulation life, are also given
- 2) Section 3. describes similar procedures when actual motors are used as the test specimens

It is recommended that for each particular system to be evaluated, a suitable type of a specimen, namely a motorette or a complete motor be selected; and then an adequate number of these be subjected to repeated cycles of heat, vibration, moisture, and electrical stress as outlined in Sections 2. and 3. of this procedure.

An adequate number of samples to obtain a good statistical average, in no case less than ten motorettes or five motors, should be carried through the test procedure until failure occurs, for each chosen temperature of heat exposure. It is recommended that the tests 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 six possible ranges of exposure requiring from 1 day to 32 days per given temperature, that are appropriate for making these tests.

The number of cycles and the total number of hours of heat aging, to the end of life for the average of each group of samples and for each of the test temperatures, are then reported as the final results of the tests. The extrapolated regression line obtained for a new insulation system is determined from these data according to the procedure in IEEE Std 101-1972, Guide for Statistical Analysis of Thermal Life Test Data. (The motorette or motor life from an *accepted standard* must be used as the criterion to determine the new insulation systems thermal rating from the plot. A control set of test units using an established insulation system should be used so that a comparison of the new system to the old system can be made.) As indicated in Section 2. the combined effects of the heat, vibration, moisture, and electrical 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.

At present 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.

2. Motorettes

2.1 Insulation Test Specimens

2.1.1 Scope

This section suggests appropriate test specimens for evaluating insulating systems, which may be usefully subjected to the exposures outlined in Section 2.2, to simulate their behavior in service. It is considered that one type of motorette, as defined in the following, will adequately represent random-wound machines, both fractional and integral, of 600 V rating or less. Other types of specimens will be required to represent machines with more than 600 V and with other than random-wound insulation systems. Procedures for evaluating such other types of insulation not covered elsewhere [21, 22] are under study, and will be included in future revisions of this procedure.

2.1.2 Motorettes

The model shall be made to embody all of the elements and should be as nearly as possible representative of a complete winding insulation system.

Specifically, it is recommended that for the purposes of testing random-wound motor insulation, a motorette be employed, as shown in Figs 1, 2, and 3. At least ten motorettes shall be subjected to each of a series of test exposures, as outlined in the following:

Fig 1 shows typical components of a motorette before final assembly. Each of these components should be subjected to separate screening tests, to establish uniformity and normality before they are assembled. For example, a number of representative samples of the wire, slot cells, phase insulation, and so forth, may be broken down by 60 Hz high-potential tests, or other means. It should be recognized that the number of tests required to establish the acceptable temperature limit in service will increase greatly, if the performance of individual components varies over a wide range. Therefore, everything possible should be done to assure that the individual components are uniform and representative of the materials used in actual service.

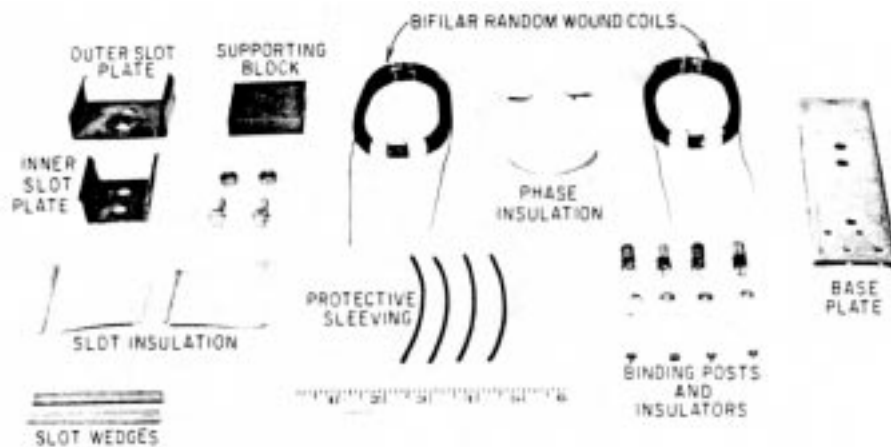


Figure 1—Components of Motorette Before Final Assembly

The finished motorette consists of a rigid supporting metal stand with four suitable stand-off porcelain insulators bolted to one end and with a slot portion, made from an inner and outer plate, bolted to the other end. The supporting stand has holes for mounting the fixture during vibration testing. The slot sections are fabricated from U S Standard no 16 gauge (0.060 in [1.52 mm]) steel sheets such as AISI 1010 cold rolled steel. The assembled slot portion contains

two coils insulated from ground by slot cells, insulated from each other by phase insulation and held in place with slot wedges. These components are typical parts used in actual motors. The coils are each wound with two parallel wires so that conductor-to-conductor electrical tests may be made. They can be machine wound on pins or forms, as in ordinary shop practice. In special cases the construction and processing procedures may be modified to simulate the intended use.

2.1.3 Preparation of Motorettes

The following is a detailed description of the preparation of the motorettes for the industry wide round robin and is presented as a guide to those who have need to build them. As noted above, modifications may be made to simulate more clearly the intended use.

2.1.3.1

Components used:

- 1) Wire—AWG no 18 magnet wire. heavy film coated
- 2) Slot Liner—10 rail (0.25 mm) sheet insulation slit into rolls of 2 3/4 in (70 mm) width. The material was cuffed [frac18] in (3.2 mm) on each side making a final width of 2 1/2 in (64 mm). This allowed 3/16 in (4.8 mm) to project from each end of the slot
- 3) Phase Insulation—10 rail (0.25 mm) sheet insulation cut into pieces, two pieces for each motorette, 1/2 in (13 mm) by 3 in (76 mm) strips and one circular piece 2 1/2 in (64 mm) diameter with a hole 1 1/2 in (38 mm) in diameter in center. This allowed 1/4 in (6.4 mm) overlap on the rectangular pieces. The circular pieces were cut in half and the two halves placed in the end turns
- 4) Slot Wedges—the wedges were cut from preformed U-shaped stock. The wedges were 3/8 in (9.5 mm) wide at the base and 3 in (76 mm) long. One end of the wedge is rounded to insure easy passage through the slot

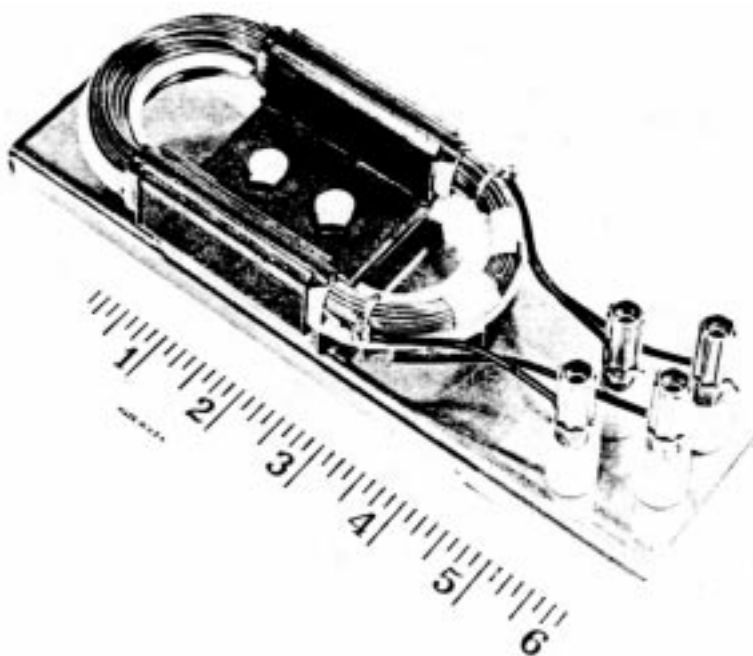


Figure 2—Completely Assembled and Varnished Motorette

- 5) Tubing—insulated tubing of sufficient size to go over lead and sufficient length to cover lead from the center of slot portion of coil to terminal
- 6) Tie Cord—this was of sufficient length to tie coil and leads together