

IEEE Recommended Practice— General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation

Sponsor

IEEE Standards Coordinating Committee 4, Insulation Systems
of the
IEEE Power Engineering Society

Reaffirmed 22 September 2005

Approved 7 December 2000

IEEE-SA Standards Board

Abstract: This recommended practice is intended to serve in the preparation of standards that are principally concerned with the thermal endurance of EIM and simple combinations of such materials, with the establishment of limiting temperatures of EIS, and with the provision of general principles for thermal classification of EIS.

Keywords: aging factors, EIM, EIS, electrical insulating material, electrical insulating system, electrical properties, electrical stress, environmental stress, factor of influence, hottest-spot temperature, mechanical properties, mechanical stress, observable temperature rise, relative temperature index, temperature index, temperature limits, thermal aging, thermal evaluation, voltage stress

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Print: ISBN 0-7381-2716-7 SH94898
PDF: ISBN 0-7381-2717-5 SS94898

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Introduction

(This introduction is not a part of IEEE Std 1-2000, IEEE Recommended Practice—General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation.)

There is general agreement from experience that a number of service stresses influence the service life of electrical insulation in electric equipment. The purpose of IEEE Std 1-2000 is to provide guidance for the preparation of thermal-aging test procedures to determine the temperature index (TI) of electrical insulating materials (EIM) and the thermal class of electrical insulation systems (EIS).

The main changes from IEEE Std 1-1986 are as follows:

- a) The title was changed from a “Standard” to a “Recommended Practice” to be consistent with the predominant verb used in the text, “should.”
- b) The table of thermal classification, now Table 3, was modified to include both numerical and letter designations and all currently recognized temperature classes.
- c) The multifactor testing portion of Clause 8 has been deleted because it is beyond the scope of this recommended practice, which covers temperature limits.

This revision has been made with the intent of harmonization with IEC 60085-1984, Thermal evaluation and classification of electrical insulation, and IEC 60505-1999, Evaluation and qualification of electrical insulation systems. This work was done by a working group of IEEE Standards Coordinating Committee 4 (SCC4), Insulation Systems. The members of the SCC4 working group are also technical experts of IEC TC 98, Electrical Insulation Systems. TC 98 plans to draft a revision to IEC 60085-1984.

At the time this revision was completed, the SCC4 working group had the following membership:

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Contents

1.	Overview	1
1.1	Scope	1
1.2	Purpose	2
2.	References	2
3.	Definitions	2
3.1	General definitions	2
3.2	Definitions related to electric equipment	3
3.3	Definitions related to the evaluation of thermal capability	4
4.	General concepts	5
4.1	Temperature measurement	5
4.2	Additional aging factors	5
4.3	Limits of temperature	6
5.	Basic considerations in the preparation of standards	7
5.1	Service experience	7
5.2	General principles for temperature limits	8
5.3	Purpose of life testing	8
6.	Evaluation of the thermal capability of EIM	8
6.1	Thermal aging	9
6.2	TI and relative temperature index (RTI) of an EIM	10
6.3	Determination of TI for EIM by test	11
6.4	Determination of material TI by experience	12
7.	Limiting temperatures and their measurement for EIS	12
7.1	Derivation of temperature rise	12
7.2	Methods of temperature determination	15
7.3	Effects of altitude	16
8.	Thermal evaluation of EIS	17
8.1	Temperature classification of EIS	17
8.2	EIS classes	18
8.3	Thermal evaluation test procedures for EIS	18
	Annex A (informative) Illustration of thermal endurance graph, TI, RTI, and HIC	21
	Annex B (informative) Bibliography	23

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1. Overview

These principles are intended to serve in the preparation of IEEE and other standards that deal with the selection of temperature limits and the measurement of temperature for specific types of electric equipment. They include an outline of the fundamental considerations and a review of the elements to be considered in applying the principles to specific cases.

1.1 Scope

Guiding principles are included for the development of test procedures for

- Thermal evaluation of electrical insulating materials (EIM)
- Thermal evaluation of electrical insulation systems (EIS)
- Thermal classification¹ of EIS for rating electric equipment

The principles are presented in the following order:

- Clause 4, General concepts
- Clause 6, Evaluation of the thermal capability of EIM
- Clause 7, Limiting temperatures and their measurement for EIS
- Clause 8, Thermal evaluation of EIS

In the application of these principles, variations are necessary to suit the widely different types of equipment and service conditions that are considered in equipment standards. When specific equipment, IEEE, or other

¹Historically, the term *thermal classification* has been used in reference to both insulation systems and to electric equipment. Therefore, for clarity, thermal classification should always be used in combination with the word *system* or *equipment*, for example, Class 155 System.

recognized standards based on these principles are available, they should take precedence over this recommended practice.

1.2 Purpose

This recommended practice is intended to serve in the preparation of standards that are principally concerned with the thermal endurance of EIM and simple combinations thereof, with the establishment of limiting temperatures of EIS, and with the provision of general principles for thermal classification of EIS.

2. References

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

IEC 60085-1984, Thermal evaluation and classification of electrical insulation.²

IEEE Std 98-1984 (Reaff 1993), IEEE Standard for the Preparation of Test Procedures for the Thermal Evaluation of Solid Electrical Insulating Materials.³

IEEE Std 99-1980 (Reaff 2000), IEEE Recommended Practice for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electrical Equipment.

IEEE Std 101-1987 (Reaff 1995), IEEE Guide for the Statistical Analysis of Thermal Life Test Data.

IEEE Std 943-1986 (Reaff 1992), IEEE Guide for Aging Mechanisms and Diagnostic Procedures in Evaluating Electrical Insulation Systems.

3. Definitions

For this recommended practice, the following terms and definitions apply. *The Authoritative Dictionary of the IEEE Standards Terms* [B3]⁴ should be referenced for terms not defined in this clause.

3.1 General definitions

3.1.1 aging: The irreversible change of the properties of an electrical insulating material (EIM) or electrical insulation system (EIS) due to action of one or more factors of influence.

3.1.2 aging factor: A factor of influence that causes aging.

3.1.3 electrical insulating material(s) (EIM): Material suitable for providing electrical isolation between parts at different voltages. It may be a solid, liquid, or gas.

²IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

³IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

⁴The numbers in brackets correspond to those of the bibliography in Annex B.

3.1.4 electrical insulation system(s) (EIS): An insulating structure containing one or more electrical insulating materials (EIM) together with associated conducting parts employed in electric equipment (an electromechanical device).

3.1.5 estimated life (performance): The expected service life derived from either service experience or the results of tests performed in accordance with appropriate evaluation procedures or both, as established by the responsible technical committee.

3.1.6 factor of influence: A stress imposed by conditions of operation, environment, or test that affects the life of an electrical insulating material (EIM) or electrical insulation system (EIS).

3.1.7 service condition: A combination of factors of influence and duty that are to be expected in a specific application of an electric device.

3.1.8 service requirement: Specified factors of influence, intended performance, and duty of an electric device.

3.1.9 simple combination of [electrical] insulating materials (EIM): A number of insulating materials, which together make possible the evaluation of any interaction between them. Magnet (winding) wire insulation and varnish are illustrative.

3.1.10 thermal aging: The aging that takes place at an elevated temperature due to chemical reactions.

3.1.11 useful service life: The length of time (usually in hours) for which an electrical insulating material (EIM), electrical insulation system (EIS), or electric equipment performs in an adequate or specified fashion.

3.2 Definitions related to electric equipment

3.2.1 ambient: The medium (for example, air, gas, liquid, or earth) in which electric equipment operates.

3.2.2 ambient temperature: The temperature of the ambient medium.

3.2.3 hottest-spot temperature (hot spot): The highest temperature attained in any part of the electrical insulation system (EIS) of electric equipment. (Difficulties in its determination are encountered. See Clause 4.)

3.2.4 hottest-spot temperature allowance: The designated difference between the hottest-spot temperature and the observable insulation temperature. Suggested values are commonly used in standards. (The value depends on many factors, such as size and design of the equipment, and should be determined by thermal analysis and/or calculations based on fundamental loss and heat transfer principles and substantiated by testing on prototype equipment or full-size models).

3.2.5 limiting ambient temperature: The highest (or lowest) ambient temperature at which electric equipment is expected to give specified performance under specified conditions, for example, rated load.

3.2.6 limiting hottest-spot temperature: The highest temperature attained in any part of the electrical insulation system (EIS) of electric equipment, which is operating under specified conditions, usually at maximum rating and the upper limiting ambient temperature.

3.2.7 observable insulation temperature: The temperature of the electrical insulation system (EIS) in electric equipment, which is measured in a specified way, for example, with a thermometer, embedded thermocouple, or resistance detector or by winding resistance or other suitable procedure.