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IEEE Standard General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation

Sponsor

IEEE Standards Coordinating Committee 4, Thermal Rating

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Foreword

(This Foreword is not a part of ANSI/IEEE Std 1-1986, IEEE Standard General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.)

Technical progress since 1969 revision of this standard has resulted in general agreement that a number of service stresses or factors, influence the life of electrical insulation, in materials tests and in systems used in electric equipment. While earlier editions of this standard made note of this fact, no guidance was provided to equipment committees who found a need to incorporate these additional factors into specific test guides.

With the text of the newly revised 1969 version of this standard as a starting point, the first meeting of International Electrotechnical Commission Technical Committee No 63, Insulation Systems, began the development of IEC Publication 505, Guide for the Evaluation and Identification of Insulation Systems of Electrical Equipment, which was published in 1974. This standard provides a guide for equipment committees to use in devising test procedures for insulation systems exposed in service to aging caused by thermal, electrical, environmental, and mechanical stresses.

During the revision process of IEEE Std 1 international attention was focused on a much needed revision of IEC Publication 85, Thermal Evaluation and Classification of Electrical Insulation. The available 1957 edition of this IEC document was similar to the 1954 revision of IEEE No 1. The contributions of experts from the United States to the revision of IEC Publication 85, who were also members of the Standards Coordinating Committee No 4, delayed work on the current revision of IEEE Std 1. However, the experience gained by this diversion has been utilized to make this edition of ANSI/IEEE Std 1-1986 a better standard and in harmony with the IEC publications.

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CLAUSE	PAGE
Part I General	1
1. Purpose and Scope	1
2. Definitions.....	2
2.1 General Definitions	2
2.2 Definitions Related to Electric Equipment	2
2.3 Definitions Related to the Evaluation of Thermal Capability.....	3
3. References.....	4
4. General Concepts	4
4.1	5
4.2	5
4.3	5
4.4	6
4.5	6
4.6	6
4.7	6
4.8	6
5. Basic Considerations in the Preparation of Standards	7
Part II Evaluation of the Thermal Capability of Insulating Materials	8
1. Purpose and Scope	8
2. Thermal Aging	8
3. Temperature Designation of Insulating Materials.....	9
4. Determination of Temperature Index by Test.....	11
4.1 General	11
4.2 Statistical Criteria	11
4.3 Acceleration of Thermal-Aging Tests	11
5. Determination of Material Temperature Class by Experience.....	12
5.1 General	12
5.2 Service Experience Data	12
Part III Limiting Temperatures and Their Measurement for Electrical Insulation Systems.....	13
1. Purpose and Scope	13
2. Derivation of Temperature Rise.....	13
3. Methods of Temperature Determination.....	15
4. Effects of Altitude	17

CLAUSE	PAGE
Part IV Evaluation of Electrical Insulation Systems.....	18
1. Purpose and Scope	18
2. Temperature Classification of Insulation Systems.....	18
2.1 General	18
2.2 Insulation System Classes.....	19
2.3 Thermal Evaluation Functional Test Procedures for Insulation Systems	19
3. Multifactor Functional Evaluation of Insulation Systems	20
3.1 General Principles	20
3.2 Procedures for Multifactor Functional Evaluation	21
Annex A Illustration of Thermal Endurance Graph, Temperature Index, Relative Temperature Index, and Halving Interval (Informative).....	23
Annex B List of Some Important Factors of Influence and Duty Relevant to Insulation in Electrical Equipment (Informative).....	24
Annex C Bibliography (Informative).....	27

IEEE Standard General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation

Part I General

1. Purpose and Scope

These principles are intended to serve as a guide 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. Guiding principles are included for the development of test procedures for

- 1) Thermal evaluation of electrical insulating materials
- 2) Thermal evaluation of insulation systems
- 3) Thermal classification¹ of insulation systems for use in rating electric equipment.

For many types of equipment proper evaluation of their electrical insulation for service conditions requires controlled exposure to a range of aging stresses which may or may not include thermal aging. The aging factors of influence may include thermal, electric, ambient (environmental), and mechanical stresses. Thermal aging has been widely used as a single factor test method. The other factors may also be evaluated by single factor tests or they may be combined with or without thermal aging into a multifactor test. Guiding principles for developing insulation systems test procedures for single and multifactor aging are included in this standard.

Insulating materials, as referred to herein, are substances in which the electric conductivity is very small (approaching zero) and provide electric isolation.

Insulation systems, as referred to herein, include an insulating material or a suitable combination of insulating materials specifically designed to perform the functions needed in electric and electronic equipment.

Other definitions necessary for the use of these principles are listed in Section 1..

The Principles are presented in the following order:

¹Historically, the term *thermal classification* has been used in reference to both insulation systems and to electric equipment. Thermal classification should always be used in combination with the words *system* or *equipment* to clearly denote to which the term applies. For example, Class 155 System.

<i>Part I.</i>	General
<i>Part II.</i>	Evaluation of Thermal Capability of Insulating Materials
<i>Part III.</i>	Limiting Temperatures and Their Measurement for Electrical Insulation Systems
<i>Part IV.</i>	Evaluation of Electrical Insulation Systems

In the application of these principles, variations will be necessary to suit the widely different types of equipment and service conditions that are considered in equipment standards. The temperature limits and other provisions given herein are not intended to be used for rating or testing equipment for which specific IEEE, or other recognized standards based on these principles, are available.

2. Definitions

2.1 General Definitions

2.1.1 electrical insulating material: A substance in which the electrical conductivity is very small (approaching zero) and provides electric isolation.

2.1.2 electrical insulation system: An insulating material or a suitable combination of insulating materials specifically designed to perform the functions needed in electric and electronic equipment.

2.1.3 simple combination of insulating materials: A number of insulating materials, which together make possible the evaluation of any interaction between them.

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

2.1.5 estimated life (performance): The expected useful service life based upon service experience or the results of tests performed in accordance with appropriate evaluation procedures established by the responsible technical committee, or both.

2.1.6 aging: The irreversible change (usually degradation) that takes place with time.

2.1.7 thermal aging: The aging that takes place at an elevated temperature.

2.1.8 factor of influence: A specific physical stress imposed by operation, environment, or test that influences the performance of an insulating material, insulation system, or electric equipment (Appendix B.1).

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

2.1.10 service condition: A combination of factors of influence, which are to be expected in a specific application of electric equipment.

2.1.11 service requirement: The specified performance to be expected in a specific application under a specified service condition.

2.2 Definitions Related to Electric Equipment

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

2.2.2 ambient temperature: The temperature of the ambient medium.

2.2.3 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.

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

2.2.5 observable temperature rise: The difference between the observable insulation temperature and the ambient temperature.

2.2.6 hottest-spot temperature (*hot spot*): The highest temperature attained in any part of the insulation of electric equipment. (Difficulties in its determination are encountered. See Section 4.).

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

2.2.8 hottest-spot temperature allowance: The designated difference between the hottest-spot temperature and the observable insulation temperature. (The value is arbitrary, difficult to determine, and depends on many factors, such as size and design of the equipment).

2.3 Definitions Related to the Evaluation of Thermal Capability

2.3.1 functional test: A means of evaluation in which an insulating material, insulation system, or electric equipment is exposed to factors of influence, which simulate or are characteristic of actual service conditions.

2.3.2 test model: A representation of equipment, a component or part of equipment, or the equipment itself, that is suitable for use in a functional test.

2.3.3 accelerated test: A functional test in which one or more factors of influence are increased in magnitude or frequency of application so as to decrease the time needed for the test.

2.3.4 diagnostic factor: A variable or fixed stress, which can be applied periodically or continuously during an accelerated test, to measure the degree of aging without in itself influencing the aging process.

2.3.5 end-point criterion: A value of property or property degradation (either absolute or percentage change) which defines failure in a functional test.

2.3.6 proof test: A means of evaluation in which an arbitrary fixed level of a diagnostic factor is applied periodically. In this case, the number of failures among multiple test specimens (rather than the magnitude of the diagnostic factor, see 2.3.4) defines the end-point of the test.

2.3.7 thermal endurance relationship: The expression of aging time to failure as a function of test temperature in an aging test.

2.3.8 thermal endurance graph: The graphical expression of the thermal endurance relationship in which time to failure is plotted against the reciprocal of the absolute test temperature. See Fig. A.1.

2.3.9 temperature index (TI): The number that corresponds to the temperature in °C, derived mathematically or graphically from the thermal endurance relationship at a specified time (often 20 000 h). The temperature index (TI) may be reported for materials and insulation systems. However, for insulation systems it may be preferable to make comparison at a particular temperature, for example, 130 °C, 155 °C, or over a range of temperatures (The TI is not used for equipment.). See Fig A.1.

2.3.10 relative temperature index (RTI): The temperature index of a new or candidate insulating material, which corresponds to the accepted temperature index of a reference material for which considerable test and service experience has been obtained. Both new and reference material are subjected to the same aging and diagnostic procedure in a comparative test. See Fig A.1.

2.3.11 halving interval (HIC): The number corresponding to the interval in °C determined from the thermal endurance relationship expresses the halving of the time-to-end-point centered on the temperature of the TI or RTI. In case of graphical derivation the times corresponding to the TI RTI (for example, 20 000 h) and one half that value (for example, 10 000 h) will usually produce an acceptable approximation. See Fig A.1.

2.3.12 temperature class: A standardization designation of the temperature capability of the insulation in electric equipment, as defined by the appropriate technical committee. It may be determined by experience or test and expressed by letters or numbers.

2.3.13 material temperature class: The lowest value of a range of temperature indices for insulating materials.

3. References

This standard shall be used in conjunction with the following publications:

[1] ANSI/IEEE Std 98-1984, IEEE Standard for the Preparation of Test Procedures for the Thermal Evaluation of Solid Electrical Insulating Materials.²

[2] ANSI/IEEE Std 99-1980, IEEE Recommended Practice for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment.

[3] ANSI/IEEE Std 853-1984, IEEE Recommended Practice for Voltage-Endurance Testing of Enameled Wire.

[4] ANSI/IEEE Std 943-1986, IEEE Guide for Aging Mechanisms and Diagnostic Procedures in Evaluating Electrical Insulation Systems.

[5] IEEE Std 97-1969, IEEE Recommended Practice for Specifying Service Conditions in Electrical Standards.³

[6] IEEE Std 101-1972 (R 1980), IEEE Guide for the Statistical Analysis of Thermal Life Test Data.

[7] IEEE Std 119-1974, IEEE Recommended Practice for General Principles of Temperature Measurements as Applied to Electrical Apparatus.

4. General Concepts

The temperature limits for electric equipment should be selected so that the equipment will result in a satisfactory life under normal operating conditions. In addition, permissible emergency temperature limits and corresponding ratings may be established, including the durations and frequencies of emergency, or peak-load operation to which these limits apply. In the establishment of temperature limits, it should be recognized that:

- 1) The ambient temperature is unlikely to be maintained at its minimum or maximum value for long periods of time
- 2) Load cycles are generally such that the average load for a period of days to months is appreciably lower than the rated continuous load.

Standards for electric equipment usually specify temperature rise rather than maximum temperature. While it is beyond the scope of this standard to specify the permissible temperature rise of insulated parts, or to prescribe the methods by which such temperature rises shall be determined, it should be noted that in normal practice the maximum temperature (hottest spot) attained by an insulated part is seldom measured directly. The permissible temperature rise is, therefore, generally specified to be less than the differences between the temperature recognized in this standard and the temperature of the ambient air or other cooling medium.

The method of measurement to be used for determining the temperature rise of insulated parts should be prescribed in the standards for the equipment.

²ANSI publications are available from the Sales Department of American National Standards Institute, 1430 Broadway, New York, NY 10018.

³IEEE publications are available from IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854.