

IEEE Guide for Designing Multistress Aging Tests of Electrical Insulation in a Radiation Environment

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of the
IEEE Dielectrics and Electrical Insulation Society**

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Abstract: Guidelines for evaluating electrical insulation materials that are subjected to more than one significant aging stress are provided. The focus is on materials or equipment intended for use in nuclear facilities, such as power stations, where thermal, moisture, and radiation stresses frequently are of importance. Factors to consider in accelerated aging programs are identified. Only the design of tests is addressed. Specific procedures are not prescribed.

Keywords: electrical insulation, multistress aging, single stress aging

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street,
New York, NY 10017-2394, USA

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Introduction

(This introduction is not part of IEEE Std 775-1993, IEEE Guide for Designing Multistress Aging Tests of Electrical Insulation in a Radiation Environment.)

This guide, which is intended for use by engineers and researchers designing aging tests, has been compiled from inputs primarily from scientists involved in polymer research. The need for it is made evident by the variety of approaches to aging program design in current practice that have uncertainties or disagreements regarding their fundamental validity.

As a number of research projects now under way bear directly on the fundamental understanding of the chemistry and physics of multifactor aging, standards developers in this field are aiming at a moving target. Thus, the working group acknowledges that any guide will be outdated by the time of its printing. The working group also recognizes that much more material could have been included that might have been of value to some users. Therefore, the working group welcomes input from readers, particularly concerning basic concepts of aging mechanisms other than those included in this guide, that lead to an understanding of multistress interactions or the validity of making time extrapolations from accelerated aging tests.

At the time that this guide was approved, the working group had the following membership:

J. Laghari, *Chair*

B. Bernstein	F. Campbell	W. Sarjeant
E. Brancato	J. Gardner	J. Winslow
L. Bustard	K. Gillen	

The following persons were on the balloting committee:

K. Baker	R. Flaherty	W. Sargeant
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1. Overview

1.1 Purpose

The purpose of this document is to provide guidelines for the evaluation of electrical insulation materials that are subjected to more than one significant aging stress. The focus of this guide is on materials or equipment that are intended for use in nuclear facilities, such as power stations, where thermal, moisture, and radiation stresses frequently are of importance. This guide is intended to help in the designing of aging tests; however, it does not prescribe any specific test procedures.

1.2 Scope

This guide identifies factors that should be considered in accelerated aging programs and is intended to be supportive of the aging requirements called for in IEEE Std 323-1983 ¹ and its subsidiary standards. This guide presents methodologies for conducting accelerated aging tests in which factors of synergistic interactions, radiation dose-rate effects, oxygen diffusion rates, etc., need to be considered.

This guide does not define specific requirements for appropriate radiation exposure sources, selection of specific levels of thermal or radiation exposure, or specific properties to be monitored; nor does it make recommendations for sequencing or combining aging stresses for particular materials or circumstances. For such guidance, one should employ the general guidelines herein, supplemented by considerations of the specific equipment and environment, together with prior experience or the experience of others who have published data on the aging of materials closely related to those in question.

1.3 References

The following standards are to be used in conjunction with this guide. When any of these standards are superseded by an approved revision, the latest version shall apply.

¹Information regarding references can be found in 1.3.

IEEE Std 101-1987, IEEE Guide for the Statistical Analysis of Thermal Life Test Data (ANSI).²

IEEE Std 323-1983, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations (ANSI).

IEEE Std 627-1980 (Reaff 1991), IEEE Standard Design Qualification of Safety System Equipment Used in Nuclear Power Generating Stations (ANSI).

2. Definitions

2.1 absorbed dose: The energy imparted to the material by the incident radiation (usually abbreviated to “dose”). It is dependent on the magnitude of the radiation field and on the degree of interaction between the radiation and the material. The SI unit of absorbed dose is the gray (Gy), which equals one joule per kilogram. A special unit of absorbed dose, the rad (rd), is also widely used. One gray equals 100 rd (10 Gy = 1 Mrd).

2.2 absorbed dose rate: The increment of absorbed dose in a given time interval (usually abbreviated to “dose rate”). The SI unit is grays per second. Special units of rads per second or per hour are also widely used at present.

2.3 accelerated aging: The application of intensified aging stress or stresses in order to increase the degradation rate above that expected in service.

2.4 aging mechanism: The microscopic or molecular level process or processes (such as chain scission, cross-linking, oxidation, evaporation, or diffusion) that produce changes in the material.

2.5 combined-stress aging: A form of accelerated aging in which several stresses are applied simultaneously. Ideally, the relative levels of the stresses are adjusted to produce the anticipated effects of the operational and environmental stresses in service.

2.6 external stress: An aging stress that is derived from the environment to which insulation is exposed, such as temperature, gas composition, or radiation.

2.7 insulation failure: The state of the insulation in which relevant physical, chemical, or electrical properties are altered sufficiently to cause operational failure or to jeopardize future failure-free operation under postulated conditions.

2.8 insulation system: An assembly of one or more dielectric materials used in a functional mode in the design of an electrical component or equipment, including adjacent components that may influence aging.

2.9 internal stress: An aging stress that arises from the operational use of the equipment, e.g., voltage, temperature rises or gradients from losses, or self-induced mechanical vibration.

2.10 normal operating conditions: The environmental stresses and operating stresses, such as voltage, current loading, or mechanical loading, encountered in normal service, including anticipated overloads and periodic testing but not including accidents or other extraordinary events.

2.11 radiation: The electromagnetic waves or corpuscular emissions released as a result of atomic nuclear changes that penetrate into insulation to cause ionizing reactions that then change the chemical, electrical, or physical properties of the insulation.

2.12 sequential-stress aging: A form of accelerated aging in which two or more individual stresses are applied or intensified in sequence.

2.13 single-stress aging: A form of accelerated aging in which the level of one aging stress is intensified, while the others are minimized or held constant.

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