IEEE STANDARDS ASSOCIATION

IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Electrical Equipment Used in Nuclear Power Generating Stations and Other Nuclear Facilities

IEEE Power and Energy Society

Sponsored by the

Nuclear Power Engineering Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 1205™-2014
(Revision of
IEEE Std 1205-2000)

currently in preview, click buy full versi

currently in preview, click buy full versi

IEEE Std 1205™-2014
(Revision of
IEEE Std 1205-2000)

IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Electrical Equipment Used in Nuclear Power Generating Stations and Other Nuclear Facilities

Sponsor

Nuclear Power Engineering Committee
of the
IEEE Power and Energy Society

Approved 27 March 2014

IEEE-SA Standards Board

currently in preview, click buy full versi

Abstract: Guidelines for assessing, monitoring, and mitigating aging degradation effects on electrical equipment used in nuclear power generating stations and other nuclear facilities are provided. This guide also includes informative annexes on aging mechanisms, environmental monitoring, condition monitoring, aging program essential attributes, and examples demonstrating the application of the basic principles described in this guideline.

Keywords: activation energy, aging, aging assessment, aging effects, aging management, Arrhenius, condition monitoring, degradation, environmental monitoring, IEEE 1205™, license renewal, radiation aging model, residual life, stressor, thermal aging model

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2014 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 16 May 2014. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

National Electrical Code and NEC are both registered trademarks of the National Fire Protection Association, Inc.

PDF: ISBN **978-0-7381-9061-7** **STD98618**
Print: ISBN **978-0-7381-9062-4** **STDPD98618**

IEEE prohibits discrimination, harassment, and bullying.
For more information, visit http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html.
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.

currently in preview, click buy full versi

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Standards Documents."

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association ("IEEE-SA") Standards Board. IEEE ("the Institute") develops its standards through a consensus development process, approved by the American National Standards Institute ("ANSI"), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

currently in preview. click buy full versi

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied on as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

currently in preview, click buy full versi

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE-SA Website at http://ieeexplore.ieee.org/xpl/standards.jsp or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at http://standards.ieee.org.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: http://standards.ieee.org/findstds/errata/index.html. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at http://standards.ieee.org/about/sasb/patcom/patents.html. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

currently in preview, click buy full versi

Participants

At the time this guide was submitted to the IEEE-SA Standards Board for approval, the Aging Assessment Working Group had the following membership:

Rebecca L. Steinman, *Chair*
Suresh Channarasappa, *Vice Chair*
George Kyle, *Secretary*

George A. Ballassi
Ramesh Boddula
Nissen M. Burstein
Howard Butler
Hamidreza Heidarisafa
Charles Hills
David A. Horvath
Steven Hutchins
Robert Konnik
James K. Liming
Kirklyn Melson
Sheila Ray
John A. Stevens
Leina Tocchetto

At the time this guide was balloted, Subcommittee 3 on Operations, Maintenance, Aging, Testing and Reliability had the following membership:

James K. Liming, *Chair*
Yvonne Williams, *Vice Chair*
Tom Crawford, *Secretary*

Gopal Aravapalli
George A. Ballassi
John Beatty
Thomas Carrier
Suresh Channarasappa
Marie Cuvelier
John Erinc
Edward Eustace
Hamidreza Heidarisafa*
Sharon Honecker
Steven Hutchins
Peter J. Kang
Jacob Kulangara
Kirklyn Melson
Edward R. Mohtashemi
Joseph Napper
James Parello
Vish Patel
Sheila Ray
Ted Riccio
Glen E. Schinzel
Rebecca L. Steinman
John A. Stevens
John Taylor*

* Nonvoting members

At the time this guide was balloted, the Nuclear Power Engineering Committee had the following membership:

George A. Ballassi, *Chair*
James Parello, *Vice Chair*
Stephen A. Fleger, *Secretary*
Thomas Koshy, *Secretary Elect*

Satish Aggarwal
Ijaz Ahmad
Dheya Al-Chalabi
George Attarian
Farouk D. Baxter *
Roy E. Beacom
Mark D. Bowman
Daniel F. Brosnan*
Nissen M. Burstein
Keith Bush
Robert C. Carruth
John P. Carter
Suresh Channarasappa
Dennis Dellinger
David R. Desaulniers
John Disosway
Walter F. Emerson
Kenneth Fleischer
Robert J. Fletcher
Robert Francis
Robert B. Fuld
David Gladey
James F. Gleason
Dale T. Goodney
Brit Grim*
Robert Hall
Kuljit Hara
Daryl Harmon
David Herrell
Dirk C. Hopp
Christopher Kerr
Bok-Ryul Kim
James K. Liming
Bruce Lord
John D. MacDonald
J. Scott Malcolm
Alexander Marion*
Kenneth Miller
Michael H. Miller
Edward R. Mohtashemi
Yasushi Nakagawa
Warren Odess-Gillett
Ted Riccio
Glen E. Schinzel
Rebecca L. Steinman

Copyright © 2014 IEEE. All rights reserved.
currently in preview, click buy full versi

James E. Stoner *
Marek Tengler
James E. Thomas
Masafumi Utsumi
Michael Waterman
Edward Wenzinger
John White
Yvonne Williams
Paul L. Yanosy
Won Young Yun
Oon-Pyo Zhu

* Nonvoting members

The following members of the individual balloting committee voted on this guide. Balloters may have voted for approval, disapproval, or abstention.

William Ackerman
Satish Aggarwal
George A. Ballassi
Farouk D. Baxter
Robert Beavers
William Bloethe
Thomas Brewington
Daniel F. Brosnan
Nissen M. Burstein
Suresh Channarasappa
Weijen Chen
Tom Crawford
Marie Cuvelier
Edward Eustace
Wells Fargo
Stephen A. Fleger
Rabiz Foda
Doaa Galal
Frank Gerleve
Randall Groves
Daryl Harmon
Hamidreza Heidarisafa
Charles Hills
Werner Hoelzl
David A. Horvath
Greg Hostetter
Steven Hutchins
Yuri Khersonsky
Chad Kiger
J. Koepfinger
Robert Konnik
George Kyle
Greg Luri
John D. MacDonald
John McAlhaney
Kirklyn Melson
John Merando
Michael Newman
Mirko Palazzo
Jan Pirrong
Robert Queenan
Ted Riccio
Fredrick Roy
Bartien Sayogo
Glen E. Schinzel
James Smith
Rebecca L. Steinman
John A. Stevens
Gary Stoedter
Michael Swearingen
John Vergis
John Webb
Yvonne Williams
James Wilson

When the IEEE-SA Standards Board approved this guide on 27 March 2014, it had the following membership:

John Kulick, *Chair*
Jon Walter Rosdahl, *Vice-chair*
Richard H. Hulett, *Past Chair*
Konstantinos Karachalios, *Secretary*

Peter Balma
Farooq Bari
Ted Burse
Clint Chaplain
Stephen Dukes
Jean-Phillippe Faure
Gary Hoffman
Michael Janezic
Jeffrey Katz
Joseph L. Koepfinger*
David Law
Hung Ling
Oleg Logvinov
Ted Olsen
Glenn Parsons
Ron Peterson
Adrian Stephens
Peter Sutherland
Yatin Trivedi
Phil Winston
Don Wright
Yu Yuan

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Don Messina
IEEE Standards Program Manager, Document Development

Malia Zaman
IEEE Standards Program Manager, Technical Program Development

currently in preview, click buy full version

Copyright © 2014 IEEE. All rights reserved.

Introduction

This introduction is not part of IEEE Std 1205-2014, IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Electrical Equipment Used in Nuclear Power Generating Stations and Other Nuclear Facilities.

In 1988, the Nuclear Power Engineering Committee (NPEC) of IEEE recognized a need for, and directed Working Group 3.4 to prepare a guide for, providing guidance and promoting uniformity in the evaluation methods used in aging assessment, monitoring, and mitigation. The working group's effort culminated in 1993 with the original issue of IEEE Std 1205, which reflected the industry focus on identifying and addressing aging mechanisms. The guide was revised in 2000 to incorporate industry feedback and bring the approaches discussed in the guide into closer conformance with the industry philosophy at that time and then was reaffirmed in 2007.

IEEE Std 1205-2014 is the result of a thorough review of IEEE Std 1205-2000 and of present practices in aging management of electrical equipment. This revision incorporates current practices and lessons learned from the implementation of previous versions of this standard by the nuclear industry.

It has never been the intent of this guide to imply that new programs be established for aging assessment. Aging assessments should not be directed toward an endless search for data and information, but rather should be an effort that is practical, cost-effective, and based on collecting and evaluating a minimum set of data and information collected preferably from existing programs.

The working group believes that this guide is useful in supporting equipment qualification program aging assessment updates, failure evaluations related to the Code of Federal Regulations Title 10 Part 50.65 (10CFR50.65) (known as the "Maintenance Rule") [B11], other root cause evaluations, and license renewal aging management reviews. To facilitate these types of uses, the working group changed this guide as follows:

- Expanded the scope to include all electrical equipment instead of only Class 1E equipment in accordance with current industry application of the guide.
- Revised and consolidated the block diagrams that describe the overall aging assessment and management process to be consistent with current industry philosophy and to better show the relationships between the IEEE Std 1205 process steps and other applicable guidance.
- Incorporated Corrigendum 1 to correct the value of Boltzmann's constant and other minor comments received during the prior reaffirmation of the guide.
- Revised Clause 4, Clause 5, Clause 6, and Clause 7 for improved consistency with the new process block diagrams.
- Updated Annex A on aging effects to reflect the current state of industry knowledge for polymers, lubricants, and metals, and added a new table for aging mechanisms and effects for printed circuit boards (PCBs).
- Updated Annex C on condition monitoring to more accurately reflect the current industry practice.
- Deleted extraneous example assessments, and updated the remaining examples in Annex D for consistency with the revised process diagram and main body of the guide.
- Added a new Annex E to provide examples of specific applications of the Arrhenius methodology.
- Updated the bibliography in Annex G to reflect recent aging assessment-related research and industry activities.

A future activity of the working group will be to develop a new annex on risk-informed aging management.

Copyright © 2014 IEEE. All rights reserved.
currently in preview. click buy full versi

Contents

Copyright © 2014 IEEE. All rights reserved.

Copyright © 2014 IEEE. All rights reserved.

IEEE Guide for Assessing, Monitoring, and Mitigating Aging Effects on Electrical Equipment Used in Nuclear Power Generating Stations and Other Nuclear Facilities

IMPORTANT NOTICE: IEEE Standards documents are not intended to ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Documents." They can also be obtained on request from IEEE or viewed at http://standards.ieee.org/IPR/disclaimers.html.

1. Overview

1.1 Scope

This document provides guidelines for assessing, monitoring, and mitigating aging effects on electrical equipment used in nuclear power generating stations and other nuclear facilities.

1.2 Purpose

The purpose of this document is to provide guidance in assessing and monitoring aging effects and in developing and implementing aging management programs for electrical equipment used in nuclear power generating stations and other nuclear facilities.

Copyright © 2014 IEEE. All rights reserved.