

IEEE Guide for Conducting Functional Life Tests on Switch Contacts Used in Insulating Liquid-Immersed Transformers

IEEE Power and Energy Society

Sponsored by the
Transformers Committee

IEEE Guide for Conducting Functional Life Tests on Switch Contacts Used in Insulating Liquid–Immersed Transformers

Sponsor

**Transformers Committee
of the
IEEE Power and Energy Society**

Approved 26 October 2015

IEEE-SA Standards Board

Abstract: This guide is intended for use in establishing a methodology to evaluate expected long-term performance of infrequently operated switch contacts used within insulating liquid-immersed transformers. These switch contacts are typically found in de-energized tapchangers, dual voltage switches, reversing switches, on-load tapchangers, and step-voltage regulators, but the test might possibly be used to evaluate any contact that is used in insulating liquids with similar operating characteristics and within similar environments.

Keywords: accelerated life simulation, Arrhenius relationship, contact aging phenomenon, IEEE C57.157, supertemperature

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

Copyright © 2015 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 20 November 2015. 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.

PDF: ISBN 978-0-5044-0064-0 STD20491
Print: ISBN 978-0-5044-0065-7 STDPD20491

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.

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.

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 upon 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.

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.

Participants

At the time this IEEE guide was completed, the Functional Life Tests on Switch Contacts PC57.157 Working Group had the following membership:

Philip Hopkinson, *Chair*
Adam Sewell, *Vice Chair/Secretary*

James Campbell
Craig Colopy
Larry Dix
Dieter Dohnal
Eduardo Garcia
Jeffrey Golarz
Jose Izquierdo

Marion Jaroszewski
John K. John
Axel Kraemer
Bernhard Kurth
Charles Patrick McShane
Shawn Nunn
Amitabh Sarkar

Daniel Sauer
Jeremy Sewell
Hemchandra Shertukde
Mahendrakumar Soni
Bengt-Olof Stenestam
Joe Watson
Baitun Yang

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

Jim Antweiler
Roberto Asano
Donald Ayers
Barry Beaster
Wallace Binder
William Bloethe
William Boettger
Paul Cardinal
Craig Colopy
John Crouse
William Darovny
Dieter Dohnal
Gary Donner
Randall Dotson
Marcel Fortin
Fredric Friend
David Gilmer
William Griesacker
Randall Groves
Jeffrey Helzer
Philip Hopkinson

Richard Jackson
Laszlo Kadar
Sheldon Kennedy
Yuri Khersonsky
Axel Kraemer
Jim Kulchisky
Chung-Yiu Lam
Richard Marek
J. Dennis Marlow
Lee Matthews
Charles Patrick McShane
Daniel Mulkey
Jerry Murphy
Ryan Musgrove
K. R. M. Nair
Kris K. Neild
Joe Nims
Bansi Patel
Branimir Petosic
Donald Platts
Alvaro Portillo

Lewis Powell
Iulian Profir
Jean-Christophe Riboud
Michael Roberts
Thomas Rozek
Daniel Sauer
Bartien Sayogo
Stephen Schroeder
Ewald Schweiger
Adam Sewell
Jeremy Sewell
Hyeong Sim
Jeremy Smith
Jerry Smith
David Tepen
Juan Thierry
Roger Verdolin
John Vergis
Jane Verner
Joe Watson
Kipp Yule

When the IEEE-SA Standards Board approved this guide on 26 October 2015, it had the following membership:

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

Masayuki Ariyoshi
Ted Burse
Stephen Dukes
Jean-Philippe Faure
J. Travis Griffith
Gary Hoffman
Michael Janezic

Joseph L. Koepfinger*
David J. Law
Hung Ling
Andrew Myles
T. W. Olsen
Glenn Parsons
Ronald C. Petersen
Annette D. Reilly

Stephen J. Shellhammer
Adrian P. Stephens
Yatin Trivedi
Philip Winston
Don Wright
Yu Yuan
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std C57.157-2015, IEEE Guide for Conducting Functional Life Tests on Switch Contacts Used in Insulating Liquid-Immersed Transformers.

This guide outlines a test method to simulate long-term life (minimum 30 years) of a de-energized tapchanger in a period of 30 test days by using a combination of elevated liquid temperatures in conjunction with cyclically elevated load currents. The test is performed on specific switch bodies with specific contact materials, geometries, contact pressures in liquid baths so as to closely parallel conditions found in actual operation. The variable that provides the accelerated life simulation is the switch contact temperatures. See Annex B for more background information.

Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	1
2. Normative references.....	2
3. Definitions	2
4. Background	2
4.1 Basis of 10 °C rule and application of Arrhenius relationship.....	3
4.2 Incorporation in test of IEEE transformer loading guide.....	3
4.3 Incorporation in test of typical daily load cycle.....	3
4.4 Derivation of desired aging temperatures	4
4.5 Application of specific switch characteristics to test.....	5
5. General test setup	5
5.1 Safety considerations	5
5.2 Items for test.....	5
5.3 Monitoring locations.....	6
6. Test procedure	9
7. Test data recording	9
8. Pass/fail criteria	10
Annex A (informative) Bibliography	11
Annex B (informative) Contact aging phenomenon in insulating liquid.....	12

IEEE Guide for Conducting Functional Life Tests on Switch Contacts Used in Insulating Liquid–Immersed Transformers

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 guide is intended for use in establishing a methodology to evaluate expected long-term performance of infrequently operated switch contacts used within insulating liquid–immersed transformers. These switch contacts are typically found in de-energized tapchangers, dual voltage switches, reversing switches, on-load tapchangers, and step-voltage regulators, but the test might possibly be used to evaluate any contact that is used in insulating liquids with similar operating characteristics and within similar environments.

1.2 Purpose

This guide outlines a test method to simulate long-term life (minimum 30 years) of a de-energized tapchanger in a period of 30 test days by using a combination of elevated liquid temperatures in conjunction with cyclically elevated load currents. The test is performed on specific switch bodies with specific contact materials, geometries, and contact pressures in liquid baths so as to closely parallel conditions found in actual operation. The variable that provides the accelerated life simulation is the switch contact temperature.