IEEE STANDARDS ASSOCIATION

IEEE Guide for Loading Dry-Type Distribution and Power Transformers

IEEE Power and Energy Society

Sponsored by the
Transformers Committee

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

IEEE Std C57.96™-2013
(Revision of
IEEE Std C57.96-1999)

IEEE Std C57.96™-2013
(Revision of
IEEE Std C57.96-1999)

IEEE Guide for Loading Dry-Type Distribution and Power Transformers

Sponsor

Transformers Committee
of the
IEEE Power and Energy Society

Approved 11 December 2013

IEEE-SA Standards Board

Abstract: General recommendations for the loading of dry-type distribution and power transformers installed in ventilated, non-ventilated, and sealed type enclosures are included in this standard.

Keywords: ambient temperature, constant load, hottest-spot temperature, IEEE C57.96™, loading capability, loading transformer, rated output, resin-encapsulated, solid-cast transformer, time constant, transient loading

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 27 January 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.

PDF: ISBN 978-0-7381-8831-7 STD98484
Print: ISBN 978-0-7381-8832-4 STDPD98484

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 Dry-Type Distribution and Power Transformer Loading Working Group had the following membership:

Richard P. Marek, *Chair*

James Antweiler
Robert Ballard
Carl Bush
Terry Drees
Derek Foster
Juan Gutierrez
Timothy Holdway
Mike Iman
John John
Charles Johnson
Aleksandr Levin
Donald MacMillan
Rogelio Martinez
Aniruddha Narawane
Martin Navarro
Dhiru Patel
Paulette Powell
Lewis Powell
Mangesh Rajadhyaksha
Anil Sawant
Sanjib Som
David Stankes
Kerwin Stretch
Vijay Tendulkar
Robert Thompson
Albert Walls

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

James Antweiler
Robert Ballard
Peter Balma
Jeffrey Benach
Wallace Binder
Thomas Bishop
Thomas Blackburn
Carl Bush
William Byrd
Thomas Callsen
Paul Cardinal
John Crouse
Glenn Davis
Ray Davis
Gary Donner
Henry Earle
Dan Evans
Rabiz Foda
Joseph Foldi
Marcel Fortin
Derek Foster
Doaa Galal
Jalal Gohari
Randall Groves
Bal Gupta
Ajit Gwal
Charles Haahr
David Harris
Roger Hayes
Gary Heuston
Timothy Holdway
Jill Holmes
Philip Hopkinson
John Houdek
John John
Charles Johnson
Laszlo Kadar
Sheldon Kennedy
Yuri Khersonsky
Jim Kulchisky
Saumen Kundu
John Lackey
Chung-Yiu Lam
Stephen Lambert
Aleksandr Levin
Thomas Lundquist
Richard P. Marek
Omar Mazzoni
Daniel Mulkey
Jerry Murphy
K. R. M. Nair
Martin Navarro
Arthur Neubauer
Michael Newman
Raymond Nicholas
Joe Nims
Lorraine Padden
Bansi Patel
Wesley Patterson
Paulette Powell
Brian Penny
Alvaro Portillo
Iulian Profir
Michael Roberts
Charles Rogers
Oleg Roizman
John Rossetti
Thomas Rozek
Bartien Sayogo
James Smith
Jerry Smith
David Stankes
Gary Stoedter
Radoslaw Szewczyk
David Tepen
Robert Thompson
John Vergis
Jane Verner
Tony Weekes
Kenneth White
Roger Wicks
James Wilson
Jian Yu
Kipp Yule

Copyright © 2014 IEEE. All rights reserved.

When the IEEE-SA Standards Board approved this guide on 11 December 2013, it had the following membership:

John Kulick, *Chair*
David J. Law, *Vice Chair*
Richard H. Hulett, *Past Chair*
Konstantinos Karachalios, *Secretary*

Masayuki Ariyoshi
Peter Balma
Farooq Bari
Ted Burse
Stephen Dukes
Jean-Philippe Faure
Alexander Gelman
Mark Halpin
Gary Hoffman
Paul Houzé
Jim Hughes
Michael Janezic
Joseph L. Koepfinger*
Oleg Logvinov
Ron Petersen
Gary Robinson
Jon Walter Rosdahl
Adrian Stephens
Peter Sutherland
Yatin Trivedi
Phil Winston
Yu Yuan

*Member Emeritus

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

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

Patrick Gibbons
IEEE Standards Program Manager, Document Development

Erin Spiewak
IEEE Standards Program Manager, Technical Program Development

Copyright © 2014 IEEE. All rights reserved.

Introduction

This introduction is not part of IEEE Std C57.96-2013, IEEE Guide for Loading Dry-Type Distribution and Power Transformers.

This guide covers the loading of dry-type distribution and power transformers and has been developed to cover modern dry-type transformers through 10 000 kVA. The insulation systems referred to in this document meet the thermal evaluation criteria established by the now withdrawn IEEE Std C57.12.56™-1986[a] or the replacement document, IEEE Std C57.12.60™.

Work completed by the IEEE Insulation Life Subcommittee, comprising life test on transformer models, is the basis for the insulation life versus temperature relationship, designated as minimum life expectancy in IEEE Std C57.12.56-1986 and IEEE C57.12.60, which in turn are based on the Arrhenius reaction rate theory. To avoid ambiguity, this guide will use the term "life expectancy" to indicate the life to be expected at a given temperature. The "normal life expectancy" at rated hottest-spot temperature in a 30 °C ambient is expected to be 20 years. For calculation purposes, 180 000 h is used as the expected lifetime.

This revision of the guide combined the content for all dry-type transformers, including those with solid-cast and/or resin-encapsulated epoxy windings into the main body of the document. In addition, the computer programs in Annex B have been updated to include all transformer types, and detailed examples of loading and aging have been provided in Annex C. Moreover, the document has been updated to reflect the current IEEE Style Guide format.

[a] Information on references can be found in Clause 2.

Copyright © 2014 IEEE. All rights reserved.

Contents

Copyright © 2014 IEEE. All rights reserved.

IEEE Guide for Loading Dry-Type Distribution and Power 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 covers general recommendations for the loading of dry-type distribution and power transformers installed in ventilated, non-ventilated, and sealed type enclosures.

1.2 Purpose

This document provides users with guidelines and limitations for loading dry-type transformers according to nameplate rating. Guidance is also provided for assessing the risks and consequences of loading above nameplate rating.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

Copyright © 2014 IEEE. All rights reserved.