IEEE STANDARDS ASSOCIATION

IEEE Guide for Determining the Effects of High-Temperature Operation on Conductors, Connectors, and Accessories

IEEE Power and Energy Society

Sponsored by the
Transmission and Distribution Committee

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

IEEE Std 1283™-2013
(Revision of IEEE Std 1283-2004)

IEEE Std 1283™-2013
(Revision of
IEEE Std 1283-2004)

IEEE Guide for Determining the Effects of High-Temperature Operation on Conductors, Connectors, and Accessories

Sponsor

Transmission and Distribution Committee
of the
IEEE Power and Energy Society

Approved 23 August 2013

IEEE-SA Standards Board

Abstract: Possible adverse impacts to an operating overhead transmission line which might occur when operating the line at high temperatures are discussed. Specifically, the transmission line's conductor, connectors, and attached accessories in terms of degradation in mechanical properties due to annealing elastic and in-elastic elongation, and accelerated aging are explored along with limited mitigation recommendations. Additionally, predictor equations for accelerated creep and conductor loss of strength are detailed in annexes with limited example calculations.
Keywords: accelerated aging, accelerated creep, annealing, conductor core, conductors, connectors, IEEE 1283™

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

PDF: ISBN 978-0-7381-8556-9 STD98327
Print: ISBN 978-0-7381-8557-6 STDPD98327

Notice and Disclaimer of Liability Concerning the Use of IEEE Documents: IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. 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.

Use of an IEEE Standard is wholly voluntary. IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon any IEEE Standard document.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained in its standards is free from patent infringement. IEEE Standards documents are supplied "**AS IS**."

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. 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 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.

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 the official position of IEEE or any of its committees and shall not be considered to be, nor 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 to ensure 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. Any person who would like to participate in evaluating comments or revisions to an IEEE standard is welcome to join the relevant IEEE working group at http://standards.ieee.org/develop/wg/.

Comments on standards should be submitted to the following address:

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

Photocopies: Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, 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.

Notice to users

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

This document is copyrighted by the IEEE. It is made available 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 this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Updating of IEEE 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. 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://standards.ieee.org/index.html or contact the IEEE at the address listed previously. For more information about the IEEE Standards Association or the IEEE standards development process, visit IEEE-SA Website at http://standards.ieee.org/index.html.

Errata

Errata, if any, for this and all other standards can be accessed 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 Conductors Working Group had the following membership:

Jerry Reding, *Chair*
Craig Pon, *Vice Chair*

Neal Chapman	Tip Goodwin	Mark Lancaster
Len Custer	Joe Graziano	Joe Renowden
Bruce Freimark	Douglas Harms	Carl Tamm
Waymon Goch		Bob Whapham

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

William Ackerman	Magdi Ishac	Jerry Reding
Saleman Alibhay	Gael Kennedy	Keith Reese
Gordon Baker	Yuri Khersonsky	Michael Roberts
Chris Brooks	Robert Kluge	Stephen Rodick
William Bush	Jim Kulchisky	Charles Rogers
William Byrd	Saumen Kundu	Thomas Rozek
James Chapman	Chung-Yiu Lam	Bartien Sayogo
Robert Christman	Michael Lauxman	Dennis Schlender
Larry Conrad	Greg Luri	Gil Shultz
Glenn Davidson	Otto Lynch	Douglas Smith
Gary Donner	William McBride	James Smith
Gary Engmann	Jerry Murphy	Jerry Smith
Dan Evans	Neal Murray	Nagu Srinivas
George Gela	Arthur Neubauer	Ryan Stargel
Waymon Goch	Michael S. Newman	Gary Stoedter
Tip Goodwin	Joe Nims	John Vergis
Randall Groves	Carl Orde	Mark Walton
Ajit Gwal	Lorraine Padden	Yingli Wen
Douglas Harms	Bansi Patel	Kenneth White
Jeffrey Helzer	Robert Peters	Larry Young
Lee Herron	Douglas Proctor	Jian Yu
Werner Hoelzl	Iulian Profir	Luis Zambrano

When the IEEE-SA Standards Board approved this guide on 23 August 2013, it had the following membership:

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

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

*Member Emeritus

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

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

Julie Alessi
IEEE Standards Program Manager, Document Development

Erin Spiewak
IEEE Standards Program Manager, Technical Program Development

Introduction

This introduction is not part of IEEE Std 1283-2013, IEEE Guide for Determining the Effects of High-Temperature Operation on Conductors, Connectors, and Accessories.

The annexes are provided as either information or representative examples of some computational techniques in use today within the industry; however, they are not the only accepted techniques available nor are they to be considered the recommended techniques by the Task Force under the Conductors Working Group preparing this guide. Other techniques can be found in the references, bibliography, and other sources which provide equally acceptable results. The reader is encouraged to investigate any and all techniques to determine which best suit anticipated applications.

Contents

1. Overview 1
1.1 Scope 1
1.2 Purpose 1

2. Normative references 3

3. Definitions and acronyms 4
3.1 Definitions 4
3.2 Acronyms 5

4. Conductors 5
4.1 Elevated temperature creep 5
4.2 Loss of strength and annealing 6
4.3 High-temperature effects on conductor core 7
4.4 High-temperature effects on sags and tensions 8

5. Connectors 11
5.1 Design of connectors 11
5.2 Connector high-temperature operation 11
5.3 Analysis of connector high-temperature operation 13
5.4 Mitigation of connector high-temperature operation 14

6. Conductor hardware 14
6.1 Metallic conductor hardware 15
6.2 Non-metallic conductor hardware 16
6.3 Insulators and connecting hardware 16

Annex A (informative) Creep predictor equations for high-temperature operation 18
A.1 General 18
A.2 Definition of terms 18
A.3 Creep predictor equations 19
A.4 Temperature change value 21
A.5 Use of predictor equations 21

Annex B (informative) Example of calculating elevated temperature creep and its effect on conductor sag 23
B.1 General 23
B.2 Problem statement 23
B.3 Example calculation (metric) 23
B.4 Example calculation (English) 25

Annex C (informative) Residual conductor strength predictor equations for high-temperature operation 27
C.1 General 27
C.2 Definition of terms 27
C.3 Residual conductor strength predictor equations 27

Annex D (informative) Bibliography 29

IEEE Guide for Determining the Effects of High-Temperature Operation on Conductors, Connectors, and Accessories

1. Overview

1.1 Scope

The scope of this guide is to describe the effects and impacts of high temperature operation on conductors, connectors, and conductor hardware. The guide will identify operating metrics which constitute elevated temperature operation based on present industry practices and its effects on overhead line components, and it will suggest potential mitigation options to manage or avoid identified adverse impacts.

1.2 Purpose

The purpose of this guide is to provide general recommendations for consideration when evaluating existing overhead transmission lines or designing new overhead transmission lines which will be operated at high temperatures. Although this guide is intended for overhead transmission lines, most of the discussion will also be applicable to distribution lines. Recently within the industry a number of new and novel conductors have been designed using non-traditional materials specifically designed for high-temperature operation. The collection of new and novel conductors is identified in the industry as high