IEEE Guide for Maintenance Methods on Energized Power Lines

IEEE Power & Energy Society

Sponsored by the
Transmission and Distribution Committee
IEEE Guide for Maintenance Methods on Energized Power Lines

Sponsor

Transmission and Distribution Committee of the IEEE Power & Energy Society

Approved 13 May 2009

IEEE-SA Standards Board
Abstract: General recommendations for performing maintenance work on energized power lines are provided. Technical explanations as required to cover certain laboratory testing of tools and equipment, field maintenance and care of tools and equipment, and work methods for the maintenance of energized lines and for persons working in the vicinity of energized lines are included.

Keywords: energized, equipment, maintenance, power lines, tools
IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The 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 the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the 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. The 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 this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, 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 herein 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 five years for revision or reaffirmation, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, 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 this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon his or her 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.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received 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 interpretation requests except in those cases where the matter has previously received formal consideration. 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 interpretation of the 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, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Recommendations to change the status of a stabilized standard should include a rationale as to why a revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretations should be addressed to:

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

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.
Introduction

Live-line maintenance of transmission lines began in the early 1920s and developed into a major working practice as the transmission systems were expanded and the voltages increased.

In the 1950s, when the transmission line voltage exceeded 300 kV line to line, the use of fiberglass to replace wooden tools made a significant change in the industry. Economic conditions prohibited the construction and operation of redundant lines, and the need for live-line maintenance of transmission line increased rapidly.

During the 1950s and 1960s, several papers were written regarding the safety aspects of live-line maintenance. In the early 1970s, the IEEE Transmission and Distribution Committee recognized the need to consolidate information on live-line maintenance, and thus a task group was formed to write a guide. The task group later became the Engineering in Safety, Maintenance, and Operation of Lines (ESMOL) Subcommittee.

This guide was started in the late 1970s and was published in 1986 on a trial-use basis. In 1987, the guide was released as a full-use ANSI/IEEE guide. Since the original publication of the guide, the ESMOL Subcommittee has been working on revisions to the guide to bring it up to the current state of the art and into conformance with other international standards issued in recent years. The ESMOL Subcommittee has added sections from other ESMOL sponsored guides in this edition to expand the scope of the guide to cover more of the industry’s needs.

In the guide editions up to 1995, most of table data were obtained from plots. In the 2003 guide, the tables were calculated using the formulas in the guide in a step calculation method.

In this edition of the guide, the tables were calculated using the formulas in the guide. Additional text has been added on the determination of maximum anticipated per-unit transient overvoltage (TOV) \( T \) and use of the minimum air insulation distance (MAID) and minimum approach distance (MAD).

During the original development of the guide, it was not intended that it would be used as a document to establish government regulations. However, since its publication in 1986, several government regulatory agencies have used the guide in their rule making. This edition of the guide includes revisions that make it more compatible for use in governmental regulations.

Notice to users

Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard 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 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 Standards Association Web site at http://ieeexplore.ieee.org/xpl/standards.jsp, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA website at http://standards.ieee.org.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: http://standards.ieee.org/reading/ieee/updates/errata/index.html. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: http://standards.ieee.org/reading/ieee/interp/index.html.

Patents

Attention is called to the possibility that implementation of this guide may require use of subject matter covered by patent rights. By publication of this guide, no position is taken with respect to the existence or validity of any patent rights in connection therewith. 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 guide 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 guide was submitted to the IEEE-SA Standards Board for approval, the Live Line Guide Working Group of the Engineering in Safety, Maintenance, and Operation of Lines (ESMOL) Subcommittee had the following membership:

<table>
<thead>
<tr>
<th>Charles W. Grose, Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas Buonincontri, Vice Chair</td>
</tr>
</tbody>
</table>

| Gernot Brandt | Ed Hunt | Tim Olson |
| Ken Brown | Robert Isiminger | A. D. Pierce |
| Kris Buchholz | Ernie Jones | Tom Rasler |
| James F. Christensen | Clay King | Larry Schweitzer |
| Don Dodds | Nestor Kolcio | George Stinnett |
| J. Fred Doering | Keith Lindsey | Steve Theis |
| Brian Erga | Sandy Martinez | James Tomaseski |
| George Gela | Thomas McCarthy | Tom Verdeccchio |
| Donald Gillies* | George Niles | Keith Wallace |
| Randy Horton | | David Wallis |

*The Live Line Guide Working Group acknowledges the contributions of Donald Gillies, who passed away shortly before the publication of this guide.

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

| William J. Ackerman | Lee Herron | T. Olsen |
| Chris Ambrose | Werner Hoelzl | Tim Olson |
| Gregory Ardrey | Randy Horton | Carl Orde |
| Stan Arnot | Ed Hunt | Robert Oswald |
| Ali Al Awazi | Magdi Ishac | A. D. Pierce |
| Robert Barnett | R. Jackson | Tom Rasler |
| Robert Bendall | Gael Kennedy | Keith Reese |
| Harvey Bowles | Albert J. Keri | Michael Roberts |
| Gernot Brandt | Tanuj Khandelwal | Charles Rogers |
| Thomas Buonincontri | Yuri Khersonsky | Thomas Rozek |
| William Byrd | J. Koepfinger | Bob Saint |
| James F. Christensen | Nestor Kolcio | Bartien Sayogo |
| Robert Christman | David W. Krause | Dennis Schlender |
| Kevin Coggins | Jim Kulchisky | Larry Schweitzer |
| Tommy Cooper | Saumen Kundu | Charles A. Shaw |
| Luis Coronado | Donald Laird | Jeffrey Sisson |
| F. A. Denbrock | Chung-Yiu Lam | James E. Smith |
| J. Fred Doering | Stephen Lambert | Jerry Smith |
| Gary L. Donner | Keith Lindsey | R. Sundararajan |
| Gary Engmann | Federico Lopez | Michael Swearingen |
| Brian Erga | Faramarz Maghsoudlou | James Tomaseski |
| David Garrett | Keith Malmedal | John Vergis |
| Waymon Goch | Thomas McCarthy | Martin Von Herrmann |
| Edwin Goodwin | Daniel Mulkey | Carl Wall |
| Charles W. Grose | Jerry Murphy | Keith Wallace |
| Randall Groves | Michael S. Newman | Daniel Ward |
| Ajit Gwal | | James Wilson |
When the IEEE-SA Standards Board approved this guide on 13 May 2009, it had the following membership:

Robert M. Grow, Chair  
Thomas Prevost, Vice Chair  
Steve M. Mills, Past Chair  
Judith Gorman, Secretary

John Barr  
Karen Bartleson  
Victor Berman  
Ted Burse  
Richard DeBlasio  
Andy Drozd  
Mark Epstein  
Alexander Gelman  
Jim Hughes  
Richard H. Hulett  
Young Kyun Kim*  
Joseph L. Koepfinger*  
John Kulick  
David J. Law  
Ted Olsen  
Glenn Parsons  
Ronald C. Petersen  
Narayanan Ramachandran  
Jon Walter Rosdahl  
Sam Sciaccia

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

Howard L. Wolfman, TAB Representative  
Michael Janezic, NIST Representative  
Satish K. Aggarwal, NRC Representative

Lisa Perry  
IEEE Standards Program Manager, Document Development

Matthew J. Ceglia  
IEEE Standards Program Manager, Technical Program Development

*Member Emeritus
## Contents

1. Overview ................................................................................................................................. 1
   1.1 Scope ................................................................................................................................. 1
   1.2 Purpose ............................................................................................................................. 1
   1.3 Application ....................................................................................................................... 2

2. Normative references .............................................................................................................. 2

3. Definitions, acronyms, and abbreviations .............................................................................. 5
   3.1 Definitions ........................................................................................................................ 5
   3.2 Acronyms and abbreviations .......................................................................................... 9

4. Technical considerations .......................................................................................................... 10
   4.1 Introduction ..................................................................................................................... 10
   4.2 Insulating properties ....................................................................................................... 11
   4.3 Air as insulation .............................................................................................................. 11
   4.4 Factors that affect the air insulation .............................................................................. 13
   4.5 Air gap distances .......................................................................................................... 13
   4.6 Distance equations ......................................................................................................... 18
   4.7 Factors used to determine MAID, MTID, MAD, Mad for Tools, and MHAD ............ 26
   4.8 Control of TOVs ............................................................................................................ 46
   4.9 Application of MAID, MTID, MAD, Mad for Tools, and MHAD ............................... 49
   4.10 Insulation systems ....................................................................................................... 51

5. Tools and equipment ................................................................................................................. 55
   5.1 Categories of insulating tools and equipment ................................................................ 55
   5.2 Equipment rating ............................................................................................................. 57
   5.3 Electrical current flows ................................................................................................... 59
   5.4 Tool and equipment testing ............................................................................................ 60
   5.5 Testing of FRP live work tools ....................................................................................... 62
   5.6 Typical tests for insulating tools .................................................................................... 64
   5.7 Worksite procedures ....................................................................................................... 65
   5.8 Shop or laboratory procedures ....................................................................................... 66
   5.9 Insulating rope ............................................................................................................... 76
   5.10 Histograms .................................................................................................................... 76
   5.11 Electrical test references ............................................................................................. 77
   5.12 Marking and identification—general ............................................................................ 77
   5.13 Restoration or temporary structures ............................................................................ 77

6. In-service checking and care of insulated tools and equipment ............................................... 78
   6.1 Introduction ..................................................................................................................... 78
   6.2 Scope ............................................................................................................................... 79
   6.3 Field care, handling, and storage ................................................................................... 79
   6.4 Periodic inspection and checking ................................................................................... 82
   6.5 Maintenance and repair of tools and equipment ............................................................. 84
IEEE Guide for Maintenance Methods on Energized Power Lines

IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection in all circumstances. Implementers of the standard are responsible for determining appropriate safety, security, environmental, and health practices or regulatory requirements.

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 provides the general recommendations for performing maintenance work on energized power lines. It is not intended to include all of the proven practical methods and procedures; however, these selected comprehensive recommendations are based on sound engineering principles, engineering safety considerations, and field experience by many utilities. Included are technical explanations as required to cover certain laboratory testing of tools and equipment, in-service inspection, maintenance and care of tools and equipment, and work methods for the maintenance of energized lines for persons working in vicinity of energized lines.

1.2 Purpose

The purpose of this guide is to

a) Present, in one guide, sufficient details of some of the methods and equipment presently in use to enable the performance of energized line maintenance with maximum safety.

b) Direct attention to appropriate standards and other documents for the acquisition of knowledge on the inspection, care, and use of required tools and equipment.

c) Provide guidance for establishing an appropriate work area, taking into consideration safety and the physical effects of the work area on personnel.
It is not intended that this guide should replace present proven utility practices or imply that these recommendations are superior to existing practices and, therefore, should be universally adopted as utility standards. This compilation of many accepted practices is presented specifically in the form of a guide to be used by those electric utilities and agencies that are seeking guidance in establishing methods and procedures for maintenance of energized power lines.

1.3 Application

This guide, although general in scope and purpose, is specific enough to be applicable to all aspects of energized-line maintenance.

Since energized-line maintenance practices for different projects are influenced by the magnitude and nature of each project and by local conditions and circumstances, some alternative methods that have been successfully employed are presented.

The practices described provide for the performance of energized-line maintenance with maximum safety. They are based on practices of operating utilities with many years of successful experience.

The approach used in this guide is to

a) Indicate the engineering and other technical considerations essential to the performance of energized-line maintenance with maximum safety.

b) Provide guidance for the necessary test equipment and procedures associated with manufacturer and user acceptance, testing, and care of equipment.

c) Detail various work methods for working on or near energized lines and associated devices.

Advancement in technology or changes in system design will probably justify modifying the minimum requirements recommended in this guide.

CAUTION

Requirements of federal, state, or local regulations should be observed. When any conflict exists between this guide and the rules of the owner of the line, the owner’s rules shall take precedence.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used; therefore, 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.

ANSI/SIA A92.2, American National Standard for Vehicle-Mounted Elevating and Rotating Aerial Devices.\(^1\)

ASTM D 120, Standard Specification for Rubber Insulating Gloves.\(^2\)

\(^1\) ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://wwwansi.org/).

\(^2\) ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://wwwastmorg/).