



IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000 V

IEEE Power and Energy Society

Developed by the
Switchgear Committee

IEEE Std C37.30.1™-2022
(Revision of IEEE Std C37.30.1-2011)



IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000 V

Developed by the

Switchgear Committee
of the
IEEE Power and Energy Society

Approved 8 November 2022

IEEE SA Standards Board

THIS IS A REDLINE DOCUMENT PRODUCED BY TECHSTREET, AN ASME COMPANY.

This document is intended to provide users with an indication of changes from one edition to the next. It includes a full-text version of the new document, plus an indication of changes from the previous version.

Redlines are designed to save time and improve efficiencies by using the latest software technology to find and highlight document changes. More professionals are using valuable new technologies like redlines, to help improve outcomes in a fast paced global business world.

Because it may not be technically possible to capture all changes accurately, it is recommended that users consult previous editions as appropriate. In all cases, only the current base version of this publication is to be considered the official document.

This Redline is produced solely by Techstreet. IEEE has not prepared this Redline and is not responsible for its accuracy.

Redline Processing Notes:

1. ~~Red Text~~ - Red strikethrough text denotes deletions.
2. Blue Text - Blue underlined text denotes modifications and additions.

Abstract: Required ratings, construction requirements, design test requirements, applications, and suggested practices for all high-voltage enclosed indoor and outdoor and non-enclosed indoor and outdoor switches rated above 1000 V are specified. This includes ratings and requirements for such switches as disconnecting, selector, horn-gap, grounding, etc., for manual and power operation, except for interrupter switches, distribution-enclosed single-pole air switches, and distribution cutouts fitted with disconnecting blades.

Keywords: air switches, disconnect switches, high-voltage switches, IEEE C37.30.1™, indoor switches, outdoor switches

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

Copyright © 2023 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 7 April 2023. 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 978-1-5044-9463-2 STD25983
Print: ISBN 978-1-5044-9464-9 STDPD25983

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 Standards documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page (<https://standards.ieee.org/ipr/disclaimers.html>), appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.”

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

IEEE Standards documents are developed within IEEE Societies and subcommittees of IEEE Standards Association (IEEE SA) Board of Governors. IEEE develops its standards through an accredited consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE Standards are documents developed by volunteers with scientific, academic, and industry-based expertise in technical working groups. Volunteers are not necessarily members of IEEE or IEEE SA 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 makes no warranties or representations concerning its standards, and expressly disclaims all warranties, express or implied, concerning this standard, including but not limited to the warranties of merchantability, fitness for a particular purpose and non-infringement. In addition, IEEE does not warrant or represent that the use of the material contained in its standards is free from patent infringement. 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: THE NEED TO PROCURE 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 is 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, 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 the presenter's views should be considered the personal views of that individual rather than the formal position of IEEE, IEEE SA, the Standards Committee, or the Working Group. Statements made by volunteers may not represent the formal position of their employer(s) or affiliation(s).

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE or IEEE SA. However, **IEEE does not provide interpretations, 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 subcommittees of the IEEE SA Board of Governors 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 evaluating comments or in revisions to an IEEE standard is welcome to join the relevant IEEE working group. You can indicate interest in a working group using the Interests tab in the Manage Profile & Interests area of the [IEEE SA myProject system](#).¹ An IEEE Account is needed to access the application.

Comments on standards should be submitted using the [Contact Us](#) form.²

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 constitute 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.

Data privacy

Users of IEEE Standards documents should evaluate the standards for considerations of data privacy and data ownership in the context of assessing and using the standards in compliance with applicable laws and regulations.

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

¹ Available at: <https://development.standards.ieee.org/myproject-web/public/view.html#landing>.

² Available at: <https://standards.ieee.org/content/ieee-standards/en/about/contact/index.html>.

adoption by public authorities and private users, neither IEEE nor its licensors waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate licensing fees, 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; <https://www.copyright.com/>. 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 10 years. When a document is more than 10 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 [IEEE Xplore](#) or [contact IEEE](#).³ For more information about the IEEE SA or IEEE's standards development process, visit the IEEE SA Website.

Errata

Errata, if any, for all IEEE standards can be accessed on the [IEEE SA Website](#).⁴ Search for standard number and year of approval to access the web page of the published standard. Errata links are located under the Additional Resources Details section. Errata are also available in [IEEE Xplore](#). Users are encouraged to periodically check for errata.

Patents

IEEE Standards are developed in compliance with the [IEEE SA Patent Policy](#).⁵

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 <https://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.

³ Available at: <https://ieeexplore.ieee.org/browse/standards/collection/ieee>.

⁴ Available at: <https://standards.ieee.org/standard/index.html>.

⁵ Available at: <https://standards.ieee.org/about/sasb/patcom/materials.html>.

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.

IMPORTANT NOTICE

IEEE Standards do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. IEEE Standards development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. Implementers and users 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.

Participants

At the time this standard was completed, the PC37.30.1 Working Group had the following membership:

Carl D. Reigart, *Chair*
Jacob Blake, *Secretary*

Brett Boles
Timothy Cook
Jeramie Cooper
Stephen Donahue
Ilya Galinsky

Danny Hoss
James Houston
Bill Hurst
John Kaminski
Peter Kowalik

Laura Reid
Devki Sharma
Jon Spencer
Joseph Unser

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

Saleman Alibhay
Chris Ambrose
Charles Ball
Thomas Barnes
Frank Blalock
Adam Brecklin
Gustavo Brunello
Demetrio Bucaneg, Jr.
Paul Cardinal
Michael Champagne
Michael Chirico
Robert Christman
Robert Cohn
Jeramie Cooper
Glenn Davis
Frank Decesaro
Louis Doucet
Edgar Dullni
Douglas J. Edwards
Kenneth Edwards
Jorge Fernandez Daher
Dale Fox
Jalal Gohari
Joseph Gravelle
Randall Groves
John Hall
John Harley
Gary Haynes
Jeffrey Helzer
Werner Hoelzl
Robert Hoerauf

Danny Hoss
James Houston
David Hughes
Richard Jackson
Joseph Jasinski
Laszlo Kadar
John Kaminski
Yuri Khersonsky
James Kinney
Hermann Koch
Peter Kowalik
Jim Kulchisky
Chung-Yiu Lam
John Leach
Hua Liu
Albert Livshitz
Reginaldo Maniego
Thomas McCarthy
Neil McCord
Peter Meyer
Daleep Mohla
Charles Morse
Ryan Musgrove
Dennis Neitzel
Joe Nims
Ted W. Olsen
Jan Paramalingam
Bansi Patel
Pathik Patel
S. Patel
Howard Penrose
Christopher Petrola

Samala Santosh Reddy
Carl Reigart
Anthony Ricciuti
Caryn Riley
Grant Ringham
Charles Rogers
Daniel Sauer
Bartien Sayogo
Dennis Schlender
Devki Sharma
Sushil Shinde
Jerry Smith
Gary Smullin
Jon Spencer
Allan St Peter
Kyle Stechschulte
Gary Stoedter
Kenneth Stump
Donald Swing
C. Tailor
John Toth
Matthew Vacha
James Van De Ligt
John Vergis
Mark Waldron
Lanyi Wang
John Webb
Kenneth White
Terry Woodyard
Alan Yerges
Jian Yu

When the IEEE SA Standards Board approved this standard on 8 November 2022, it had the following membership:

David J. Law, *Chair*
Ted Burse, *Vice Chair*
Gary Hoffman, *Past Chair*
Konstantinos Karachalios, *Secretary*

Edward A. Addy
Ramy Ahmed Fathy
J. Travis Griffith
Guido R. Hiertz
Yousef Kimiagar
Joseph L. Koepfinger*
Thomas Koshy
John D. Kulick

Johnny Daozhuang Lin
Kevin Lu
Daleep C. Mohla
Andrew Myles
Damir Novosel
Annette D. Reilly
Robby Robson
Jon Walter Rosdahl

Mark Siira
Dorothy V. Stanley
Lei Wang
F. Keith Waters
Karl Weber
Sha Wei
Philip B. Winston
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std C37.30.1-2022, IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000 V.

This standard was originally designed to be a consolidation of the following now-obsolete standards:

- IEEE Std C37.30-1997
- IEEE Std C37.32-2002
- IEEE Std C37.34-1994
- IEEE Std C37.35-1995
- IEEE Std C37.36b-1990
- IEEE Std C37.37-1996

Initially the intent was to make minimal technical changes to the standards. The consolidation effort was the first phase of what was planned to be a two-part process to facilitate harmonization of the IEEE C37.30-series of standards with existing IEC documents covering switch devices. The second phase of the process was to be an effort to both incorporate technical changes where needed and to harmonize with IEC standards; however, copyright issues led to a temporary halt in the harmonization effort. This document incorporates the provisions of IEEE Std C37.30.1a-2017 and supersedes it. Also notable in this revision is the addition of regulator bypass switches to the testing requirements.

Contents

1. Overview	12
1.1 Scope	12
1.2 Word usage	12
2. Normative references	13
3. Definitions	14
4. Service conditions	15
4.1 Usual service conditions	15
4.2 Unusual service conditions	15
5. Description of ratings and capabilities	17
5.1 General	17
5.2 Rated power frequency	17
5.3 Rated voltage	18
5.4 Rated withstand voltages	18
5.5 Rated continuous current	19
5.6 Rated short-time withstand current	24
5.7 Rated fault-making current	24
5.8 Visible corona onset voltage	25
5.9 Radio-influence voltage (RIV) limit	25
5.10 Rated ice breaking ability	25
5.11 Rated mechanical operations	25
5.12 Rated mechanical terminal load	25
5.13 Rated control voltage	25
5.14 Rated closing time (for power operated switches)	26
5.15 Switching endurance—fault-initiating switch	26
5.16 Rated load-making current	26
6. Design and construction	33
6.1 Station class outdoor air disconnect switches	33
6.2 Distribution class outdoor air disconnect switches	35
6.3 Station class outdoor regulator bypass switches	35
6.4 Distribution class outdoor regulator bypass switches	36
6.5 Indoor air switches	37
6.6 Grounding air switches	37
6.7 Fault-initiating switches	38
6.8 Nameplate markings	38
6.9 Switch accessories	39
6.10 Instructions	39
6.11 Grounding requirements	40
6.12 Locking devices	40
6.13 Position indication	40
6.14 Electromagnetic compatibility (EMC)	40
6.15 Welding	40
6.16 Preferred ratings tables and figure	40
7. Test code	49
7.1 General	49
7.2 Withstand voltage tests	49
7.3 Temperature rise tests	56
7.4 Short-time withstand current tests	59

7.5 Fault-making current test.....	61
7.6 Ice loading test	61
7.7 Mechanical operations tests.....	64
7.8 Corona tests	65
7.9 Radio-influence voltage tests	68
7.10 Partial discharge test.....	69
7.11 Routine tests	69
Annex A (informative) Applications, guides, and suggested practices	70
A.1 Selection of insulation levels.....	70
A.2 General application conditions	70
A.3 Use of higher temperature materials.....	72
A.4 Switching impulse voltage tests of switch open gap	72
A.5 Reference data	73
A.6 Historical data.....	74
Annex B (informative) Guide to current interruption with horn gap switches.....	75
B.1 Basic suggestions.....	75
B.2 Arc reach.....	81
B.3 Adequacy of switch clearance	81
B.4 Calculation of suggested current interruption	82
B.5 Sample calculations	82
Annex C (informative) Application conditions for continuous load current capability	87
C.1 Allowable continuous current.....	87
C.2 Switch part class designation.....	87
C.3 Allowable continuous current class (ACCC) designation	87
C.4 Allowable continuous current capability	87
C.5 Allowable continuous current class designation for ANSI C37.30-1962 switches.....	87
C.6 Exceptions to temperature limitations	88
C.7 Precautions.....	88
C.8 Loadability curves for continuous load current	88
C.9 Application conditions for emergency load current capability	90
Annex D (informative) Installation, operation, and maintenance	96
D.1 Receipt and preparation	96
D.2 Installation	96
D.3 Operation	98
D.4 Maintenance	99
Annex E (informative) Short-time (symmetrical) withstand current and electromagnetic force equations	101
E.1 Calculation of short-time (symmetrical) withstand current limits	101
E.2 Calculation of electromagnetic forces.....	102
Annex F (informative) Suggested sizes of conductors for temperature rise testing	104
Annex G (informative) Bibliography	105

IEEE Standard Requirements for AC High-Voltage Air Switches Rated Above 1000 V

~~IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection. 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 standard covers preferred ratings, construction and testing requirements, and application, loading, installation, operation, and maintenance guidelines for all high-voltage enclosed and non-enclosed, indoor and outdoor air switches rated in excess of 1000 V. This includes such switch types as disconnect, horn-gap, fault-initiation, and ground for manual or power operation. The following switch types are not covered by this standard: interrupter switches, distribution cutouts fitted with disconnecting blades, and switches used in metal-enclosed and pad-mounted switchgear. This standard also does not apply to load-break separable insulated connectors, circuit breakers, circuit switchers, or reclosers.

1.2 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{6, 7}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

1.2 Purpose

~~The purpose of this standard is to provide a basic standard for air switches.~~

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, ~~so; therefore~~, each referenced document is cited in text⁷ 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.

⁶ The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

⁷ The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

ANSI C29.1, [Test Methods](#) ~~American National Standard~~ for Electrical Power Insulators⁸—~~Test Methods~~.¹

ANSI C29.8, ~~American National Standard for~~ Wet-Process Porcelain Insulators—Apparatus, Cap and Pin Type.

ANSI C29.9, ~~American National Standard for~~ Wet-Process Porcelain Insulators—Apparatus, Post Type.

ANSI C63.2-2009, American National Standard for Electromagnetic Noise and Field Strength Instrumentation, [9 kHz](#) ~~10-Hz~~ to 40 GHz Specifications.

[ANSI/NEMA CC 1, American National Standard for Electric Power Connection for Substations.](#)⁹

[Accredited Standards Committee C2-2017](#) ~~IEEE Std C2[®]-2007~~, National Electrical Safety Code[®] (NESC[®]).¹⁰³

[AWS D1.1/D1.1M, Structural Welding Code-Steel.](#)¹¹

[AWS D1.2/D1.2M, Structural Welding Code-Aluminum](#)

⁸ ¹ANSI publications are available from the American National Standards Institute (<http://www.ansi.org>).

⁹ NEMA publications are available from the National Electrical Manufacturers Association (<http://www.nema.org>).

¹⁰ ³National Electrical Safety Code and NESC are both registered trademarks and service marks of The Institute of Electrical and Electronics Engineers, Inc.; The NESC is available from The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org>).

¹¹ AWS publications are available from the American Welding Society (<http://www.aws.org>).

IEEE Std 4TM, IEEE Standard [For High-Voltage Testing](#) Techniques, ^{12, 13}~~for High-Voltage Testing.~~
~~4,5~~

IEEE Std [3003.1TM](#) ~~142TM 2007~~, IEEE Recommended Practice For [System](#) Grounding Of Industrial And Commercial Power Systems (~~Green-BookTM~~).

IEEE Std [C37.30.4](#) ~~1247TM~~, IEEE Standard [Test Code](#) for [Switching and Fault Making Tests for High-Voltage](#) Interrupter Switches, [Interrupters or Interrupting Aids Used on or Attached to Switches Rated](#) for Alternating [Currents](#) ~~Current, Rated~~ Above 1000 V. ~~IEEE Std C37.09TM 1999, IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.~~

IEEE Std C37.100.1TM ~~-2018~~, IEEE Standard [for](#) ~~of~~ Common Requirements for High-Voltage Power Switchgear Rated Above 1000 V.

^{12, 4} IEEE publications are available from The Institute of Electrical and Electronics Engineers (<http://standards.ieee.org>).

^{13, 5} The IEEE standards or products referred to in this clause are trademarks of The Institute of Electrical and Electronics Engineers, Inc.

3. Definitions

For the purposes of this document, the following terms and definitions apply. [The IEEE Standards Dictionary Online](#) should be consulted for terms not defined in this clause, with preference given to definitions from IEEE Std C37.30.5™ [B13] above those of other sources outside of this standard.¹⁴ When trying to understand the meaning of terms, when multiple definitions exist, the definitions should be evaluated in the following priority:

- a) [Definitions embedded in this standard shall be used.](#)
- b) [For terms not defined within this standard, the definitions within IEEE Std C37.30.5 \[B13\] shall be used.](#)
- c) [For terms not defined in either this standard or IEEE Std C37.30.5 \[B13\], then the *IEEE Standards*](#)

~~The *IEEE Standards Dictionary Online: Glossary of Terms and Definitions*⁶ should be consulted for terms not defined in this clause.~~

air switch: A switching device designed to close and open one or more electric circuits by means of guided separable contacts that separate in air. ~~The switching device may be equipped with arcing horns.~~

[NOTE—The terms “air switch” and “switch” are used interchangeably in the following definitions and in the remainder of this document.¹⁵](#)

allowable continuous current class (ACCC) designation (of an air switch): A code that identifies the composite curve relating the loadability factor (LF) of the switch to the ambient temperature θ_a as determined by the limiting switch part class designations.

⁶ ~~IEEE Standards Dictionary: Glossary of Terms and Definitions is available at <http://shop.ieee.org>.~~

¹⁴ [The numbers in brackets correspond to those of the bibliography in Annex G.](#)

¹⁵ [Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.](#)

~~arcing horn: One of a pair of diverging electrodes on which an arc is extended to the point of extinction after the main contacts of the switching device have parted.~~

distribution class: A descriptive term used to denote application, restriction, or both to [that](#) ~~the~~ part of an electric system between the substation and the customer.

~~enclosed switch: A switch designated for operation within a housing restricting heat transfer to the external medium.~~

~~horn-gap switch: A switch provided with arcing horns.~~

indoor switch: [Switches](#) ~~A switch~~ designated for operation inside buildings or weather-resistant enclosures [which](#) ~~that~~ do not restrict heat transfer to the ambient ~~atmosphere~~.

loadability factor (LF): The ratio of allowable continuous current at a given ambient temperature to rated current.

loadability: The ratio of allowable continuous current at 25 °C ambient temperature to rated continuous current.

observable temperature rise: The steady state temperature rise of any part of the switch above ambient temperature.

outdoor switch: [An air switch designated for operation outside buildings or enclosures.](#) Switches designated for operation outside buildings or enclosures. ~~Outdoor switches~~ may be exposed to the weather [and](#). ~~Outdoor switches~~ experience no restriction of heat transfer to the ambient ~~atmosphere~~.

peak withstand current: The maximum instantaneous current at the major peak of an offset power frequency sinusoidal current that a switch is required to carry.

~~power frequency: The frequency at which a device or system is designed to operate.~~

rated fault making current: The maximum ~~root-mean-square-(rms)~~ power frequency current, expressed in symmetrical amperes, ~~which that~~ the switch shall be required to make and carry at its rated maximum voltage, for a specified duration. For transient currents, such as fault initiation and capacitive discharge, the rated fault making current shall be the current available from the circuit without the influence of the switching device.

regulator bypass switch: An air switch consisting of multiple blades to connect and bypass a voltage regulator.

short-time (symmetrical) withstand current duration: The maximum duration of short-time (symmetrical) withstand current that a switch is required to carry.

short-time (symmetrical) withstand current: An abnormal power frequency current, the initial portion of which may have a dc offset, expressed in ~~root-mean-square-(rms)~~ symmetrical amperes, that a switch is required to carry.

station class: An air switch ~~A~~-descriptive term typically used to denote application or restriction or both to generating stations, switching stations, substations, and transmission lines.

switch part class designation: A code that identifies the curve that relates the loadability factor ~~(LF)~~ of an air switch part material and function to the ambient temperature θ_a .

~~**visible corona (as applies to an air switch):** A luminous discharge due to ionization of the air surrounding an air switch and caused by a voltage gradient exceeding a certain critical value.~~

4. Service conditions

4.1 Usual service conditions

4.1.1 General

High-voltage switches conforming to this standard shall be suitable for operation at or within their ratings, provided that:

- a) The ambient temperature (temperature of the surrounding air) is within the range of -30°C to $+40^{\circ}\text{C}$.
- b) The altitude does not exceed 1000 m (3300 ft).
- c) The wind velocity does not exceed ~~36~~ 37 m/s (80 mi/~~hr~~ h).

NOTE 1—See IEEE Std C37.30.2™, IEEE Guide for Wind-Loading Evaluation of High Voltage (>1000 V) Air Break Switches for more information about wind loading.

~~NOTE 1—This wind velocity will produce a pressure of approximately 770 N/m^2 (16 lbf/ft^2) of projected area on cylindrical surfaces (see NEMA SG-6 2000 [B20]).^{7,8}~~

NOTE 2—The interrupting ability of some switches that rely on a slowly or rapidly increasing external air gap for circuit interruption (such as standard or quick break ~~whip~~ arcing horns) may be influenced by local wind velocity and direction.

4.1.2 Outdoor switch

~~Switches designated as~~ Outdoor switches shall be suitable for operation outside of buildings or enclosures and. ~~Outdoor switches~~ may be exposed to the weather including wind and various forms of precipitation ~~icing conditions~~. They experience no restriction of heat transfer to the ambient atmosphere.

4.1.3 Indoor switch

~~Switches designated as~~ Indoor switches shall be suitable for operation inside buildings or weather-resistant enclosures that do not restrict heat transfer.

⁷~~Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement the standard.~~

⁸~~The numbers in brackets correspond to the numbers in the bibliography in Annex C.~~

~~If an indoor switch is designed for weather-resistant enclosures, it shall also be considered an enclosed switch. If an indoor switch is designed for operation inside buildings, in a manner that does not restrict heat transfer to the ambient atmosphere, it shall be considered an indoor switch only.~~

4.1.4 Enclosed switch

~~Switches designated as~~ Enclosed switches shall be suitable for operation inside housings that restrict heat transfer to the ambient atmosphere. Enclosed switch housings may be ~~switches may also be suitable for use in enclosures~~ filled with a dielectric media such as ~~other than~~ air, e.g., oil, or sulfur hexafluoride (SF₆).

4.2 Unusual service conditions

Where ~~other~~ unusual service conditions exist, they should be brought to the attention of those ~~the parties~~ responsible for the design and application of the equipment. Examples of such conditions include the following:

- Operation in high altitudes. Equipment that depends on air for its insulating and cooling medium will have a higher temperature rise and a lower dielectric strength when operating at higher altitudes than when operating at lower altitudes. For altitudes above 1000 m (3300 ft), correction factors shown in Table 1 should be applied to the indicated switch ratings. ~~Altitude correction factors are specified in IEEE Std C37.100.1.~~⁹
- Contamination, such as pollution, damaging fumes or vapors, excessive or abrasive dust, explosive mixtures of dust or gases, steam, salt spray, excessive moistures or dripping water.
- Abnormal vibration, shocks, earthquakes, or tilting.
- Excessively high or low ambient temperatures.

⁹~~Information on references can be found in Clause 2.~~

- Unusual transportation or storage conditions.
- Unusual space limitations.
- Unusual operating duty, frequency of operation, difficulty of maintenance, poor current waveform (high harmonic content), unbalanced voltage, ~~or~~—special insulation requirements.

Table 1 – Altitude correction factors (factors to be applied to the switch ratings indicated)

Altitude		Correction factors	
m	(ft)	Rated lightning impulse withstand voltage (BIL) ^a	Current ratings ^{a,b}
(1)	(2)	(3)	(4)
1000	3300	1.00	1.00
1200	4000	0.98	0.995
1500	5000	0.95	0.99
1800	6000	0.92	0.985
2100	7000	0.89	0.98
2400	8000	0.86	0.97
2700	9000	0.83	0.965
3000	10000	0.80	0.96
3600	12000	0.75	0.95
4200	14000	0.70	0.935
4800	16000	0.65	0.925
5400	18000	0.61	0.91
6000	20000	0.56	0.90
NOTE—Correction factors provided are to assist in proper application of air switches and should not be used for design testing.			

(New)

^a Interpolated values shall be used in determining correction factors for intermediate altitudes.

^b For maximum ambient of 40 °C.

~~—The application of an outdoor switch, indoor switch, or an enclosed switch for other purposes, which may include concerns regarding weather exposure and restricted heat transfer; see Table 1.~~

~~Table 1—Applications that may be considered unusual~~

~~Type of switch~~	~~Switch exposed to weather~~	~~Installation with restricted heat transfer~~
~~Outdoor Switch~~	~~Usual~~	~~Unusual~~
~~Indoor Switch~~	~~Unusual~~	~~Unusual~~
~~Enclosed Switch~~	~~Unusual~~	~~Usual~~

~~(Deleted)~~

5. Description of ratings and capabilities

5.1 General

[These](#) subclauses ~~5.1 through 5.16~~ generally define the ratings and capabilities that switches may be required to have. The switch manufacturer can build a switch product that meets any combination of the ratings, or alternately, other apparatus standards may require a specific set of ratings. The ratings of equipment covered by this standard include the items marked with an “X” in Table 2. The preferred values for ratings and capabilities are found in Clause [5](#) ~~6~~. The test procedures to establish the ratings and capabilities are found in Clause [7](#) ~~8~~.

Table 2 — Switch ratings and required tests

Switch rating	Subclause	Switch ^a			
		Disconnecting	Fault-initiating	Grounding	Regulator bypass
		(1)	(2)	(3)	(4)
Rated power frequency	5.2	X	X	X	X
Rated maximum voltage	5.3.1	X	X	X	X
Rated continuous current	5.5	X	—	—	X
Rated lightning-impulse withstand (BIL)	5.4.3	X	X	X	X
Rated switching-impulse withstand (for rated maximum voltage of 362 kV and above)	5.4.4	X	X	X	—
Rated power frequency dry withstand	5.4.2.2	X	X	X	X ^c
Rated power frequency wet withstand	5.4.2.3	X	X	X	X ^c
Rated power frequency dew withstand	5.4.2.4	X	X	X	X ^c
Rated peak withstand current	5.6.2	X	O	X	X ^b
Rated short-time (symmetrical) withstand	5.6.4	X	O	X	X ^b
Rated short-time (symmetrical) withstand current duration	5.6.4	X	O	X	X ^b
Rated mechanical operations	5.11	X	—	X	X
Rated mechanical terminal load	5.12	X	X	X	X
Rated ice-breaking ability—manual	5.10	O	O	O	O
Rated ice-breaking ability—power: single attempt opening and closing (outdoor)	5.10	O	O	O	—
Rated ice-breaking ability—power: single attempt opening, multiple attempts closing (outdoor)	5.10	O	O	O	—
Rated load-making current	5.16	O	—	O	—
Rated fault making current	5.7	O	X	O	—

(New)

Switch rating	Switch ^a		
	Disconnecting	Fault-initiating	Grounding
	(1)	(2)	(3)
Rated power frequency	X	X	X
Rated maximum voltage	X	X	X
Rated continuous current	X	—	—
Rated dielectric withstand voltages	X	X	X
Rated lightning impulse withstand (basic impulse insulation level (BIL))	X	X	X
Rated switching impulse withstand (for rated maximum voltage of 362 kV and above)	X	X	X
Rated power frequency dry withstand	X	X	X

(Deleted)

Table 2 — Switch ratings and required tests (continued)

Switch rating	Switch ^a		
	Disconnecting	Fault-initiating	Grounding
	(1)	(2)	(3)
Rated power frequency wet withstand (outdoor)	X	X	X
Rated power frequency dew withstand (indoor)	X	X	X
Rated peak-withstand current	X	O	X
Rated short-time (symmetrical) withstand current	X	O	X
Rated short-time (symmetrical) withstand current duration	X	O	X
Rated mechanical operations	X	—	X
Rated mechanical terminal load	X	X	X
Rated ice-breaking ability—manual (outdoor)	O	O	O
Rated ice-breaking ability—power: single attempt opening and closing (outdoor)	O	O	O
Rated ice-breaking ability—power: single attempt opening, multiple attempt closing (outdoor)	O	—	O
Rated load-making current	O	—	O
Rated fault-making current	—	X	—

(Deleted)

^a “X” indicates required rating; “O” indicates optional rating; “—” indicates not applicable.

^b Test performed on load and source switch only.

^c The bypass disconnect shall be rated for no less than 10% of the power frequency withstand requirement of the main disconnect blades.

5.2 Rated power frequency

The rated power frequency is the fundamental steady-state supply voltage frequency at which the switch is designed to operate. Typical power frequencies are 50 Hz and 60 Hz.

5.3 Rated voltage

5.3.1 Rated maximum voltage

The rated maximum voltage of a switch is the highest ~~root-mean-square (rms)~~ line-to-line voltage of rated power frequency for which the switch is designed to operate. [The preferred rated maximum voltages for station class outdoor air disconnect switches and grounding switches are given in Table 4. The preferred rated maximum voltages for distribution class outdoor air disconnect switches and grounding switches are given in Table 8. The preferred rated maximum voltages for indoor air switches and indoor grounding switches are given in Table 10.](#)

Specific requirements keyed to the rated maximum voltage are as follows:

- Interrupting ratings
- Making current ratings
- Limit of corona ~~voltage~~ and radio-influence voltage ~~(RIV)~~
- Ratings at which switching surge tests are required

5.4 Rated withstand voltages

5.4.1 General

The rated withstand voltages are the voltages of the appropriate wave shape, magnitude, and duration that the switch shall withstand under specified conditions, without damage to the insulating materials. [The preferred rated withstand voltages for station class outdoor air disconnect switches and grounding switches are given in Table 4. The preferred rated withstand voltages for distribution class outdoor air disconnect and grounding switches are given in Table 8. The preferred rated withstand voltages for indoor air switches and grounding switches are given in Table 10.](#)

5.4.2 Rated power frequency withstand voltage

5.4.2.1 General

The rated power frequency withstand voltage is the rms value of the sinusoidal waveform of rated power frequency.

5.4.2.2 Rated power frequency dry withstand voltage

The rated power frequency dry withstand voltage is a rated power frequency withstand voltage that the switch is required to withstand for a duration of 60 s under dry conditions. Insulation between the live parts of a switch and ground shall withstand 100% of the rated power frequency dry withstand voltage. Insulation across the open gap of air switches shall withstand 110% of the rated power frequency dry withstand voltage. [The preferred ratings are given in Table 4 for station class outdoor switches and grounding switches, Table 8 for distribution class outdoor air switches and grounding switches, and Table 10 for indoor air switches and grounding switches.](#)

5.4.2.3 Rated power frequency wet withstand voltage

The rated power frequency wet withstand voltage is the power frequency withstand voltage that an outdoor switch is required to withstand for a duration of 10 s under wet (rain) conditions. There ~~is~~ ~~are~~ no power frequency wet withstand ~~requirement~~ ~~requirements~~ for indoor or enclosed switches.

Insulation between the live parts of an outdoor switch and ground shall withstand 100% of the rated power frequency wet withstand voltage. [The preferred ratings are given in Table 4 for station class outdoor switches and grounding switches, Table 8 for distribution class outdoor air switches and grounding switches](#)

5.4.2.4 Rated power frequency dew withstand voltage

The rated power frequency dew withstand voltage is the power frequency withstand voltage that an indoor or an enclosed switch is required to withstand, without flashover or damage to any insulation, for a duration of 10 [seconds](#) with dew (condensate) over the switch's solid insulation. Insulation between the live parts and ground shall withstand 100% of the rated power frequency dew withstand voltage. If the open gap of an enclosed switch is effectively bridged by a solid insulation, a dew withstand test shall be made, and the open gap shall withstand 100% of the rated power frequency dew withstand voltage. There is no power frequency dew withstand requirement for outdoor switches. [The preferred ratings are given in Table 10 for indoor switches and indoor grounding switches.](#)

5.4.3 Rated lightning impulse withstand voltage

The rated lightning impulse withstand voltage is the peak value of 1.2/50 μ s positive and negative impulses that the switch shall be required to withstand. [The preferred ratings are given in Table 4 for station class outdoor switches and outdoor grounding switches, Table 8 for distribution class outdoor air switches and distribution class outdoor grounding switches, and Table 10 for indoor air switches and indoor grounding switches.](#)

Insulation between the live parts of a switch and ground shall withstand 100% of the rated lightning impulse withstand voltage.

Insulation across the open gap of air switches shall withstand 110% of the rated lightning impulse withstand voltage.

NOTE—Conformance to this rating does not necessarily provide assurance that a switch with 110% withstand across the open gap will always flashover to ground instead of across open gaps. Where surge protection of the gap is required, switch insulators may be equipped with rod gaps or similar protective devices.

5.4.4 Rated switching impulse withstand voltage

The rated switching impulse withstand voltage is the peak value of 250/2500 μ s positive and negative impulses that the switch shall be required to withstand. There ~~is are~~ no rated switching impulse withstand ~~requirement requirements~~ for switches with rated maximum voltage less than 362 kV.

Insulation between the live parts of a switch and ground shall withstand 100% of the rated switching impulse withstand voltage.

Insulation across the open gap of air switches shall withstand switching impulse voltages listed in Table 5. The preferred ratings are given in Table 5 for station class outdoor switches ~~(in 6.6)~~.

5.5 Rated continuous current

5.5.1 General

The rated continuous current is the maximum current the switch shall be required to carry continuously under usual service conditions without exceeding specified temperature limits. The current is in rms amperes at rated power frequency. The preferred ratings are given in Table 6 for station class outdoor air switches, Table 9 for distribution class outdoor air switches, and Table 11 for indoor air switches. Grounding switches have no continuous current ratings but have withstand current ratings that may be equal to or less than the disconnect switch rating ~~as shown in Table 3. The current is in rms amperes at rated power frequency.~~

5.5.2 Allowable continuous current

The allowable continuous current of a switch at specific ambient temperature is the maximum alternating current, in amperes rms at rated frequency, that a switch will carry without exceeding the allowable maximum temperature for any of its parts, as listed in Column 1 of Table 3.

The allowable continuous current may be determined from Equation (1).

$$I_a = I_r \left(\frac{\theta_{max} - \theta_a}{\theta_r} \right)^{0.5} \quad (1)$$

where

θ_a is [the](#) ambient temperature ([in](#) °C)

I_a is [the](#) allowable continuous current at ambient temperature, θ_a

I_r is [the](#) rated continuous current

θ_{max} is [the](#) allowable maximum temperature ([in](#) °C) of switch part, from Table 3

θ_r is [the](#) limit of observable temperature rise ([in](#) °C) at rated current of switch part, from Table 3

5.5.3 Loadability

The loadability of an air switch is the ratio of [the](#) allowable continuous current, at 25 °C ambient temperature, to [the](#) rated current.

NOTE [1](#)—Loadability is a measure of the allowable continuous current over the average of ambient temperatures from 10 °C ~~to~~ 40 °C for the air surrounding air switches. The loadability of 30 °C rise switches of previous standards is 1.22 at 25 °C. The limits of observable temperature rise at rated current in Table 3 have been selected to maintain a minimum 1.22 loadability at 25 °C.

[NOTE 2](#)—The loadability of switches used in enclosures is covered by other standards and is the ratio of allowable continuous current, at 25 °C ambient temperature outside the enclosure, to rated current. This loadability may be different than 1.22.

5.5.4 Switch part class designation

The switch-part class designation of a switch is a code that identifies the curve that relates the loadability factor, LF , of the switch to the ambient temperature, θ_a . This factor is determined by the allowable maximum temperature, θ_{max} , and the limit of observable temperature rise, θ_r , using ~~the formula in~~ Equation (2):

$$LF = \frac{I_a}{I_r} = \left(\frac{\theta_{max} - \theta_a}{\theta_r} \right)^{0.5} \quad (2)$$

The switch-part class designations are given in Table 3. Refer to Annex C for application curves.

5.5.5 Allowable continuous current class (ACCC) designation

The ACCC designation of an air switch is a code that identifies the composite curve relating the loadability factor, LF , of the switch to the ambient temperature, θ_a , as determined by the limiting switch-part class designations. The first term of the ACCC designation is obtained from the first letter of the class designation of the switch part ~~that has~~ having the lowest limit of observable temperature rise. The middle term is the letter O, designating loadability at 25 °C ambient ~~temperature~~. The last term is obtained from the numeral of the class designation of the switch part ~~that has~~ having the highest limit of observable temperature rise.

5.5.6 Limits of observable temperature rise

The limit ~~maximum value~~ of observable temperature rise of any part of a switch, when tested in accordance with Clause ~~7~~ 8, is given in Table 3, columns (2) and (4).

The limit of observable temperature rise, θ_r , at rated current shall be determined from the following equations ~~either Equation (3) or Equation (4)~~ to maintain an air switch loadability of 1.22.

For non-enclosed switches, use Equation (3):

$$\theta_r = \left(\frac{\theta_{max} - \theta_n}{1.5} \right) \quad (3)$$

For enclosed switches, use the lesser of Equation (4) or Equation (5):

$$\theta_r = \left(\frac{\theta_{max} - \theta_{e1}}{1.5} \right) \quad (4)$$

~~or~~

$$\theta_r = \theta_{max} - \theta_{e2} \quad (5)$$

where

θ_n $\equiv$ ~~is~~ 25 °C, the standard ambient temperature

θ_{e1} $\equiv$ ~~is~~ 40 °C

θ_{e2} $\equiv$ ~~is~~ 55 °C

θ_{max} $\equiv$ ~~is~~ allowable maximum temperature (in °C) of switch part, from Table 3

~~1.5~~ $\equiv$ ~~is~~ $(1.22)^2$, where 1.22 is loadability of switch at θ_n

NOTE—The denominator value of 1.5 in Equation (3) and Equation (4) is derived from 1.22^2 , where 1.22 is the loadability of the switch at θ_n .

Table 3 — Temperature limitations for air switches, enclosed, and non-enclosed

Switch part	Allowable maximum temperature, θ_{max} (°C)	Non-enclosed indoor and outdoor switches		Enclosed indoor and outdoor switches - See NOTE 1	
		Limit of observable temperature rise at rated current, θ_r (°C)	Switch part class designation	Limit of observable temperature rise at rated current, θ_r (°C)	Switch part class designation
(a) Contacts in air ^a (see table NOTE 2)					
(1) Copper or copper alloy	75	33	BO2	20	QO33
(2) Copper or copper alloy to silver or silver alloy, or equivalent	90	43	DO4	33	RO4
(3) Silver, silver alloy, or equivalent	105	53	FO6	43	TO6
(4) Other (see table NOTE 3)	—	—	—	—	—
(b) Conducting mechanical joints					
(1) Copper or aluminum	90	43	DO4	33	RO4
(2) Silver, silver alloy, or equivalent	105	53	FO6	43	TO6
(3) Other (see table NOTE 3)	—	—	—	—	—
(c) Switch terminals with bolted connections	90	43	DO4	33	RO4
(d) Welded or brazed joints or equivalent	105	53	FO6	43	TO6
(e) Other current-carrying parts					
(1) Copper or copper alloy castings	105	53	FO6	43	TO6
(2) Hard-drawn copper parts ^a	80	37	CO3	25	PO22
(3) Heat-treated aluminum alloy parts	105	53	FO6	43	TO6
(4) Woven-wire flexible connectors	75	33	BO2	20	QO33
(5) Other materials	—	—	—	—	—
(f) Insulator caps and pins and bushing caps	110	57	GO7	47	UO7
(g) Current-carrying parts in contact with insulating materials					
(1) Insulation class 90 °C	80	37	CO3	25	PO22
(2) Insulation class 105 °C	95	47	EO5	43	SO5

(New)

Switch part	Allowable maximum temperature, θ_{max} (°C)	Nonenclosed indoor and outdoor switches		Enclosed indoor and outdoor switches	
		Limit of observable temperature rise at rated current, θ_r (°C) ^a	Switch part class designation	Limit of observable temperature rise at rated current, θ_r (°C)	Switch part class designation
(1)	(2)	(3)	(4)	(5)	
(a) Contacts in air ^b					
(1) Copper or copper alloy	75	33	BO2	20	QO33
(2) Copper or copper alloy to silver or silver alloy, or equivalent	90	43	DO4	33	RO4
(3) Silver, silver alloy, or equivalent	105	53	FO6	43	TO6
(4) Other ^c	—	—	—	—	—
(b) Conducting mechanical joints					
(1) Copper or aluminum	90	43	DO4	33	RO4
(2) Silver, silver alloy, or equivalent	105	53	FO6	57	TO6
(3) Other ^c	—	—	—	—	—
(c) Switch terminals with bolted connections	90	43	DO4	33	RO4
(d) Welded or brazed joints or equivalent	105	53	FO6	43	TO6
(e) Other current-carrying parts					
(1) Copper or copper alloy castings	105	53	FO6	43	TO6
(2) Hard drawn copper parts ^d	80	37	CO3	25	PO22

(Deleted)

Table 3 — Temperature limitations for air switches, enclosed, and non-enclosed (continued)

Switch part	(1)	(2)	(3)	(4)	(5)
(3) Insulation class 130 °C	120	63	HO8	60	VO8
(4) Insulation class 155 °C	145	80	IO9	77	WO9
(5) Insulation class 180 °C	170	97	JO10	93	XO10
(6) Insulation class 220 °C	210	123	KO11	120	YO11
(7) Oil ^b	90	43	DO4	33	RO4
(8) SF ₆	350	307	—	297	—
(h) Nonenergizable parts subjected to contact by personnel					
(1) Handled by operator (see table NOTE 4)	50	10	—	10	—
(2) Accessible to operator (see table NOTE 4)	70	30	—	30	—
(3) Not accessible to operator ^c	—	—	—	—	—
(i) Entire switch limited to 30 °C Rise					
(1) Outdoor	70	30	AO1	—	—
(2) Indoor	85	—	—	30	NO1

NOTE 1—The limit of observable temperature rise listed in this column is suitable for use in rating switches for application in enclosures of IEEE Std C37.20.2 and IEEE Std C37.20.3, if the corresponding allowable maximum temperature listed in column 1 is not exceeded when in the enclosure. These temperature rises are chosen to give a loadability of 1.22 at 25 °C.

NOTE 2—Contacts as used here include: (a) stationary and moving contacts that engage and disengage, and (b) contacts that have relative movement but remain engaged.

NOTE 3—Other materials may become available for contacts, conducting mechanical joints, and other current-carrying parts that have a different allowable maximum temperature, θ_{max} . Their limit of observable temperature rise at rated continuous current, I_r , shall be related to their θ_{max} , in accordance with subclause 5.5.

NOTE 4—It is assumed that any parts handled by or accessible to an operator will be in ambient air with a temperature that does not exceed 40 °C.

(New)

Switch part	Allowable maximum temperature, $\theta_{\max}$ (°C)	Nonenclosed indoor and outdoor switches		Enclosed indoor and outdoor switches	
		Limit of observable temperature rise at rated current, θ_r (°C) ^a	Switch part class designation	Limit of observable temperature rise at rated current, θ_r (°C)	Switch part class designation
	(1)	(2)	(3)	(4)	(5)
(3) Heat-treated aluminum alloy parts	105	53	FO6	43	TO6
(4) Woven-wire flexible connectors	75	33	BO2	20	QO33
(5) Other materials ^c	—	—	—	—	—
(f) Insulator caps and pins and bushing caps	110	57	GO7	47	UO7
(g) Current-carrying parts in contact with insulating materials					
(1) Insulation class 90 °C	80	37	CO3	25	PO22
(2) Insulation class 105 °C	95	47	EO5	43	SO5
(3) Insulation class 130 °C	120	65	HO8	60	VO8
(4) Insulation class 155 °C	145	80	IO9	77	WO9
(5) Insulation class 180 °C	170	97	JO10	93	XO10
(6) Insulation class 220 °C	210	123	EO11	120	YO11
(7) Oil ^e	90	43	DO4	33	RO4
(8) SF ₆	350	307	—	297	—
(h) Nonenergizable parts subjected to contact by personnel					
(1) Handled by operator ^f	50	10	—	10	—
(2) Accessible to operator ^f	70	30	—	30	—
(3) Not accessible to operator ^g	—	—	—	—	—
(i) Entire switch limited to 30 °C rise					
(1) Outdoor	70	30	AO1	—	—
(2) Indoor	85	—	—	30	NO1

(Deleted)

^a The limit of observable temperature rise listed in this column is suitable for use in rating switches for application in enclosures of IEEE Std C37.20.2™ 1999 [B8] and IEEE Std C37.20.3™ 1987 [B9], if the corresponding allowable maximum temperature listed in column 1 is not exceeded when in the enclosure. These temperature rises are chosen to give a loadability of 1.22 at 25 °C.

^b Contacts as used here include (a) stationary and moving contacts that engage and disengage and (b) contacts that have relative movement but remain engaged.

~~^e Other materials may become available for contacts, conducting mechanical joints, and other current-carrying parts that have a different allowable maximum temperature, θ_{max} . Their limit of observable temperature rise at rated continuous current, θ_r , shall be related to their θ_{max} , in accordance with 5.4.~~

^a ~~^d~~ If annealing will not impair switch operation or reduce ability to meet any of the ratings, 105 °C may be used for θ_{max} and the corresponding increase in θ_r as determined in [subclause 5.5 4](#).

^b ~~^e~~ The top oil (upper layer) temperature shall not exceed 80 °C total. The 90 °C value refers to the hottest ~~-~~spot temperature of parts where they contact the oil.

~~^f It is assumed that any parts handled by or accessible to an operator will be in ambient air with a temperature that does not exceed 40 °C.~~

^c ~~^g~~ The maximum temperature of any nonenergizable part that is not accessible to the operator shall not exceed a temperature that will necessitate maintenance or replacement of parts during the life of the switch.

5.6 Rated short-time withstand current

[5.6.1 General](#)

The rated short-time withstand current has [the following](#) two associated ratings:

- a) Rated peak withstand current, which is a measure of the switch's ability to withstand the magnetic forces associated with a short-circuit.
- b) Rated short-time (symmetrical) withstand current duration, which is a measure of the switch's ability to withstand the heat generated by a short-time current.

The relationship between peak withstand current and short-time (symmetrical) withstand current is based on an approximate X/R of 17 for 60 Hz applications and X/R of 14 for 50 Hz applications. This leads to a peak current to rms symmetrical current ratio of 2.6 for 60 Hz and 2.5 for 50 Hz. It should be noted that higher X/R ratios are possible, and such occurrences result in higher peak withstand current values due to a slower dc time constant. The preferred ratings are given in Table 5 for station class outdoor air switches and grounding switches, Table 9 for distribution class outdoor air switches and grounding switches, and Table 11 for indoor air switches and grounding switches.

5.6.2 Rated peak withstand current

The rated peak withstand current is the maximum instantaneous current ~~that at the major peak of an offset rated power frequency current, having a total duration of not less than 0.166 s, which~~ the switch shall be required to carry while in the closed position. The peak withstand current as listed in column 3 (or column 4 for 50 Hz) of Table 6 occurs at the first major peak of a dc-offset short circuit current, and the test to prove this capability shall have a total duration of not less than 10 power frequency cycles. The preferred ratings are given in Table 6 for station class outdoor air switches and grounding switches, Table 9 for distribution class outdoor air switches and grounding switches, and Table 11 for indoor air switches and grounding switches.

5.6.3 Rated peak withstand current duration

The preferred peak withstand current duration for station class outdoor disconnect switches is given in footnote b of Table 6. The preferred peak withstand current duration for distribution class outdoor air disconnect switches is given in footnote b of Table 9. The preferred peak withstand current duration for indoor air switches is given in footnote b of Table 11.

5.6.4 Rated short-time (symmetrical) withstand current duration

The rated short-time (symmetrical) withstand current duration is the maximum duration for which the switch shall be required to carry the rated short-time (symmetrical) withstand current while in the closed state. The preferred rated short-time withstand current durations are 1, 2, or 3 seconds, with allowable I^2t variations given in 7.4.6.2.

5.7 Rated fault-making current

5.7.1 Fault-making current rating for fault initiating switches

Fault initiating switches are required to have a prospective fault-making current rating. The preferred fault-making current ratings are given in Table 12.

5.7.2 Fault-making current rating for interrupter switches

Interrupter switches may have a fault-making current rating. The preferred fault-making current ratings are given in Table 12.

CAUTION

Only switches having a ~~that have the~~ closing speed that is independent of operating personnel may ~~can~~ have a fault-making current rating.

~~Switches that have the closing speed dependent on operating personnel may have a fault-making current capability, which indicates that successful circuit closing is dependent upon proper operation of the switch. Nameplates of switches with a fault-making current capability shall have a caution that references the switch's instruction manual and indicates that successful circuit closing is dependent upon proper operation of the switch.~~

5.8 Visible corona onset-free voltage

The visible corona onset voltage is the line-to-ground power frequency voltage at which there is an onset of visible plumes or spikes under dark conditions.

5.9 Radio-influence voltage (RIV) limit

The radio-influence voltage ~~RIV~~ limit (RIV) is the maximum allowable radio-influence voltage ~~RIV~~, at a specified detection frequency and at a specified distance, produced by a switch when energized at a specified voltage at rated power frequency. The limits of radio influence voltage ~~RIV~~ are given in ~~column 6 of~~ Table 4, Column ~~(in 6.6)~~.

~~5.9 Partial discharge limits~~

~~This item is currently under study and is intended to appear in a subsequent revision to this standard.~~

5.10 Rated ice breaking ability

~~6.1.1.4 Ice-breaking ability~~

The rated ice breaking ability is the maximum thickness of ice, as defined by the ice loading test of [subclause 7.6 8-5](#), under which the switch shall be required to successfully open or close. If an outdoor switch has an ice breaking rating, the preferred ratings shall be 10 mm (3/8 in), and 20 mm (3/4 in). A switch that has successfully passed the ice test and is rated for a given thickness of ice is also rated for lesser thicknesses. [Indoor and enclosed switches are not typically rated for ice breaking capability.](#)

5.11 Rated mechanical operations

The rated mechanical operations [refers to](#) ~~is~~ the minimum number of mechanical operating cycles that a switch shall be required to perform without requiring maintenance or adjustment. An operating cycle shall be one close operation and one open operation. For outdoor switches, a specified number of operations must be accomplished with various terminal loads. [The preferred mechanical operation rating shall be 1000 operations: 900 close-open cycles without terminal loading and 100 close-open cycles with terminal loading as specified in 7.7.3.3.](#)

5.12 Rated mechanical terminal load

The rated mechanical terminal load is the static force, equivalent to an external mechanical load, ~~and~~ applied at each terminal in specified directions, that a switch shall withstand, while stationary and during operation. [The preferred ratings for mechanical terminal loadings are given in Table 7.](#)

5.13 Rated control voltage

The rated control voltage is the nominal voltage for which a power-operated mechanism is designed to operate. [The preferred ratings for control voltage are given in Table 13.](#)

5.14 Rated closing time (for power operated switches)

The rated closing time of a switch is the specified interval in a closing operation between the energizing of the close coil, at the lower limit of the rated control-voltage range, and the making of the current ~~carrying-making~~ switch contacts.

[NOTE—Preferred ratings and testing requirements have not been established at this time. Consult the manufacturer for this information.](#)

5.15 Switching endurance — fault-initiating switch

The expected switching endurance of a fault-initiating switch is the number of closing operations, at rated [fault-making](#) current, that a switch is capable of performing when it is new and tested at its rated [fault-making](#) current. After the last rated closing operation, the switch must be capable of being opened. [The manufacturer should be consulted for operating life expectancies for fault-initiating switches.](#)

[NOTE—Preferred ratings and testing requirements have not been established at this time. Consult the manufacturer for this information.](#)

5.16 Rated load-making current

The rated load-making current of a switch is the highest prospective rms current that a switch shall be required to make and carry at its rated maximum voltage.

[NOTE—Preferred ratings and testing requirements have not been established at this time. Consult the manufacturer for this information.](#)

6. Preferred ratings

Preferred ratings for outdoor, indoor, and enclosed switches are given in 6.1 through 6.4.

Preferred ratings for switch accessories are given in 6.5.

All the tables and the figure relating to these preferred ratings (i.e., Table 4 through Table 13 and Figure 1) are presented in 6.6.

The ratings designated in this standard and in reference standards are preferred and are not considered restrictive. Nonpreferred ratings based on performance are acceptable under the provisions of this standard when accepted by the equipment user.

6.1 Outdoor switches—preferred ratings

6.1.1 Station class outdoor air disconnect switches

6.1.1.1 Voltage and current

The preferred voltage, continuous current, and withstand current ratings at the rated power frequency of 60 Hz or 50 Hz are given in Table 4, Table 5, and Table 6.

6.1.1.2 Short-time withstand current duration

The preferred short time (symmetrical) withstand current durations are given in footnote a of Table 6, with allowable I^2t variations given in 8.3.5.1.

6.1.1.3 Peak withstand current duration

The preferred peak withstand current duration is given in footnote b of Table 6.

6.1.1.5 Mechanical operations

The preferred mechanical operation rating shall be 1000 operations: 900 close-open cycles without terminal loading and 100 close-open cycles with terminal loading as specified in 8.6.2.2. Refer to Table 13 for rated control voltages for power-operated switches and 8.6.2.4 for number of operations at minimum and maximum control voltage.

6.1.1.6 Terminal loading

The preferred mechanical terminal loadings are given in Table 7.

6.1.1.7 Dielectric test voltages

6.1.1.7.1 Energized parts to ground

Outdoor switches in either the open or closed positions shall withstand the voltages specified in column 2, column 3, and column 4 of Table 4. See footnote a of Table 4 and Table 5 for switching impulse ratings.

6.1.1.7.2 Open-gap withstand

The air gap of outdoor air switches, when in the fully open position, shall withstand voltages that are 110% of the rated lightning impulse dry withstand and the power frequency dry withstand voltages given in column 2 and column 3 of Table 4. For switches rated 362 kV and higher, the open gap shall also withstand the switching impulse voltages specified in Table 5.

6.1.1.7.3 Corona and radio-influence test voltage limits

Switches rated 123 kV and higher, when tested under dark conditions at the voltage levels specified in column 5 of Table 4, shall be free of visible plumes or spikes. The limits of RIV are given in column 6 of Table 4. Refer to 8.7 and 8.8 of this standard and to Annex A of NEMA CC1.

~~6.1.2 Distribution class outdoor air disconnect switches~~

~~6.1.2.1 Voltage and current~~

~~The preferred voltage, continuous current, and withstand current ratings at the rated power frequency of 60 Hz or 50 Hz are given in Table 8 and Table 9.~~

~~6.1.2.2 Short-time withstand current duration~~

~~The preferred short-time (symmetrical) withstand current durations are given in footnote a of Table 9, with allowable I^2t variations given in 8.3.5.1.~~

~~6.1.2.3 Peak withstand current duration~~

~~The preferred peak withstand current duration is given in footnote b of Table 9.~~

~~6.1.2.4 Ice-breaking ability~~

~~Refer to 6.1.1.4 for preferred ice-breaking ratings.~~

~~6.1.2.5 Mechanical operations~~

~~The preferred number of mechanical operations shall be as specified in 6.1.1.5.~~

~~6.1.2.6 Terminal loading~~

~~The preferred mechanical terminal loading is given in Table 7.~~

6.1.2.7 Dielectric test voltages

6.1.2.7.1 Energized parts to ground

Outdoor switches in either the open or closed positions shall withstand the voltages specified in column 2, column 3, and column 4 of Table 8.

6.1.2.7.2 Open-gap withstand

The air gap of outdoor switches, when in the fully open position, shall withstand voltages that are 110% of the rated lightning impulse dry withstand and the power frequency dry withstand voltages given in column 2 and column 3 of Table 8.

6.1.2.7.3 Corona and radio-influence test voltage limits

Switches rated below 123 kV have no corona voltage requirements or RIV requirements.

6.2 Indoor air switches—preferred ratings

6.2.1 Voltage and current

The preferred voltage and preferred continuous and withstand current ratings at the rated power frequency of 60 Hz or 50 Hz are given in Table 10 and Table 11.

6.2.2 Short-time withstand current duration

The preferred short time (symmetrical) current withstand durations are given in footnote a of Table 11, with allowable I^2t variations given in 8.3.5.1.

6.2.3 Peak withstand current duration

The preferred peak withstand current duration is given in footnote b of Table 11.

~~6.2.4 Mechanical operations~~

~~The preferred number of mechanical operations shall be as given in 6.1.1.5.~~

~~6.2.5 Terminal loading~~

~~Presently, there are no preferred mechanical terminal loadings for indoor switches.~~

~~6.2.6 Dielectric test voltages~~

~~6.2.6.1 Energized parts to ground~~

~~Indoor air switches, in either the open or closed positions, shall withstand the dielectric test voltages specified in column 2, column 3, and column 4 of Table 10.~~

~~6.2.6.2 Open-gap withstand~~

~~The air gap of indoor air switches, when in the fully open position, shall be such that the open gap or gaps will withstand a test voltage that is 110% of the lightning impulse dry and power frequency dry withstand test voltages specified in column 2 and column 4 of Table 10.~~

~~6.2.6.3 Corona and radio-influence test voltage limits~~

~~Switches rated below 123 kV have no corona voltage requirements or RIV requirements.~~

~~6.3 Grounding air switches—preferred ratings~~

~~6.3.1 Voltage and current~~

~~The preferred voltage and withstand current ratings at the rated power frequency of 60 Hz or 50 Hz are given in Table 4, Table 6, Table 8, and Table 9 for outdoor switches and Table 10 and Table 11 for indoor switches. Grounding switches have no continuous current ratings but have withstand current ratings that may be equal to or less than the disconnect switch rating.~~

6.3.2 Short-time withstand current duration

The preferred short-time (symmetrical) withstand current durations are given in footnote a of Table 6, Table 9, and Table 11, with allowable I^2t variations given in 8.3.5.1.

6.3.3 Peak withstand current duration

The preferred peak withstand current duration is given in footnote b of Table 6, Table 9, and Table 11.

6.3.4 Ice-breaking ability

Refer to 6.1.1.4 for preferred ratings for outdoor grounding switches. Indoor grounding switches have no ice-breaking requirements.

6.3.5 Corona and radio-influence test voltage limits

Switches rated 123 kV and higher, when tested under dark conditions at the voltage levels specified in column 5 of Table 4, shall be free of visible plumes or spikes. The limits of RIV are given in column 6 of Table 4. Refer to 8.7 and 8.8 of this standard and to Annex A of NEMA CC 1 for testing procedures.

6.4 Fault-initiating switches—preferred ratings

The preferred fault-making current ratings of fault-initiating switches at the rated power frequency of 60 Hz or 50 Hz are given in Table 12.

6.4.1 Short-time withstand current duration

The preferred short-time (symmetrical) withstand current durations are given in footnote a of Table 12, with allowable I^2t variations given in 8.3.5.1.

~~6.4.2 Peak withstand current duration~~

~~The preferred peak withstand current duration is given in footnote b of Table 12.~~

~~6.4.3 Preferred closing time~~

~~The preferred closing time, which includes blade travel to close the switch, shall not exceed 0.5 s.~~

~~6.4.4 Operating life expectancies~~

~~The expected switching endurance of a fault-initiating switch is the number of closing operations, at rated making current, that a switch is capable of performing when it is new and tested at its rated making current. After the last rated closing operation, the switch must be capable of being opened. The manufacturer should be consulted for operating life expectancies for fault-initiating switches.~~

~~6.4.5 Corona and radio-influence test voltage limits~~

~~Switches rated 123 kV and higher, when tested under dark conditions at the voltage levels specified in column 5 of Table 4, shall be free of visible plumes or spikes. The limits of RIV are given in column 6 of Table 4. Refer to 8.7 and 8.8 of this standard and to Annex A of NEMA CC-1 for testing procedures.~~

~~6.5 Switch accessories—preferred ratings~~

~~6.5.1 Power-operated mechanisms~~

~~6.5.1.1 Rated control voltages~~

~~The rated control voltages and their ranges for power-operated mechanisms used on high-voltage air switches shall be as shown in Table 13. Operating, auxiliary, and tripping functions shall perform satisfactorily when control voltages are within the ranges given in that table.~~