



IEEE Standard Requirements for Capacitor Switches for AC Systems (1 kV to 38 kV)

STANDARDS

IEEE Power and Energy Society

Developed by the
Switchgear Committee

IEEE Std C37.66™-2021
(Revision of IEEE Std C37.66-2005)



IEEE Standard Requirements for Capacitor Switches for AC Systems (1 kV to 38 kV)

Developed by the

Switchgear Committee
of the
IEEE Power and Energy Society

Approved 8 December 2021

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 definitions, ratings, and procedures for performing design tests, production tests, and construction requirements for capacitor switches for ac systems from 1 kV to 38 kV are covered in this standard.

Keywords: back-to-back capacitor switching, capacitor load, capacitor switches, IEEE C37.66™, inrush current, operation, pole discrepancy, probability of restrike classification, restrike, simultaneous operation

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

Copyright © 2022 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 18 March 2022. 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 978-1-5044-8313-1 STD25179
Print: ISBN 978-1-5044-8314-8 STDPD25179

IEEE prohibits discrimination, harassment, and bullying.

For more information, visit <https://www.ieee.org/about/corporate/governance/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 the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE SA) Standards Board. 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.

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 Standards Coordinating Committees are not able to provide an instant response to comments, or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in 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 and Interests area of the [IEEE SA myProject system](#). An IEEE Account is needed to access the application.

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

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 US and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate 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](#). 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](#). 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](#).

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.

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 IEEE standard was completed, the Capacitor Switches Working Group had the following membership:

Harold J. Hirz, *Chair*
Edgar Dullni, *Secretary*

Roy Alexander
Chris Ambrose
Antone Bonner
Frank DeCesaro

Anil Dhawan
Brendan Kirkpatrick
Neil McCord

Tom Mulcahy
Kirk Smith
Francois Soulard
Donald Swing

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

Roy Alexander
Chris Ambrose
Thomas Barnes
Paul Barnhart
Michael Bayer
Craig Befus
Steven Bezner
Antone Bonner
Anne Bosma
Thomas Callsen
Paul Cardinal
Alice Cervellieri
Yunxiang Chen
Michael Christian
Charles Corley
Frank DeCesaro
Edgar Dullni
Thomas Dunmore II
Donald Dunn
Doug Edwards
Clay Fellers
Sergio Flores
Jalal Gohari
John Harley
Gary Haynes
Jeffrey Helzer
Harold J. Hirz
Werner Hoelzl
Robert Hoerauf

Richard Jackson
Joseph Johnson
Andrew Jones
Laszlo Kadar
John Kaminski
John Kay
Peter Kelly
Tanuj Khandelwal
Yuri Khersonsky
James Kinney
Boris Kogan
Jim Kulchisky
Chung-Yiu Lam
Hua Liu
Federico Lopez
Colby Lovins
Arturo Maldonado
Reginaldo Maniego
Neil McCord
Tom Mulcahy
Arun Narang
Dennis Neitzel
Arthur Neubauer
Joe Nims
SivaramanP.
Lorraine Padden
Bansi Patel
Stephen Pell
Branimir Petosic

Christopher Petrola
Reynaldo Ramos
Lakshman Raut
Charles Rogers
Ian Rokser
Jesse Rorabaugh
Bartien Sayogo
Devki Sharma
Kirk Smith
Gary Smullin
Francois Soulard
Jon Spencer
K. Stump
Michael Thompson
Marcelo Valdes
James Van De Ligt
Raul Velazquez
John Vergis
Jane Verner
Jim Vo
John Webb
Steven Whalen
Kenneth White
Jonathan Woodworth
Terry Woodyard
Yu Yuan
Nicholas Zagrodnik
Kris Zibert
Sandeep Zope

When the IEEE SA Standards Board approved this standard on 8 December 2021, it had the following membership:

Gary Hoffman, *Chair*
Jon Walter Rosdahl, *Vice Chair*
John D. Kulick, *Past Chair*
Konstantinos Karachalios, *Secretary*

Edward A. Addy
Doug Edwards
Ramy Ahmed Fathy
J. Travis Griffith
Thomas Koshy
Joseph L. Koepfinger*
David J. Law

Howard Li
Daozhuang Lin
Kevin Lu
Daleep C. Mohla
Chenhui Niu
Damir Novosel
Annette Reilly
Dorothy Stanley

Mehmet Ulema
Lei Wang
F. Keith Waters
Karl Weber
Sha Wei
Howard Wolfman
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std C37.66™-2021, IEEE Standard Requirements for Capacitor Switches for AC Systems (1 kV to 38 kV).

This standard has been revised and updated from the 2005 version of IEEE Std C37.66™-2005, incorporating enhancements and improvements associated with present capacitor switch technology. These improvements include changes and additions in the following areas:

- a) Harmonization with IEEE Std C37.100.1™-2018 IEEE Standard for Common Requirements for High-Voltage Power Switchgear Rated Above 1000 V.
- b) Removal of radio influence voltage (RIV) tests under 6.8 removed as a requirement for this standard.
- c) Expansion of the preferred ratings tables through 38 kV, which includes short-time withstand ratings by a factor of two. Values included in these tables have been updated and revised where appropriate.
- d) Harmonization with IEEE Std C37.100.2™-2018 IEEE Standard for Common Requirements for Testing of AC Capacitive Current Switching Devices over 1000 V. The following are several key highlights of the changes in this revision associated with this harmonization:
 - 1) The capacitive voltage k factors for equivalent single-phase testing for non-simultaneous opening changed from a factor of 1.2-times line-to-line voltage to 2.1-times line-to-ground voltage.
 - 2) The switching duty tests clause ([Clause 6](#)) now recognizes the performance of all three phases in three-phase testing as part of the number of required operations, which reduced the total number of required operations.
 - 3) The damping under [6.5.2](#) was changed from the previous 0.40 and 0.55 to 0.75.

Contents

1. Overview	12
1.1 Scope	12
1.2 Purpose	12
1.3 Word usage	12
2. Normative references	13
3. Definitions	13
4. Usual and unusual service conditions	14
4.1 Usual service conditions	14
4.2 Unusual service conditions	14
5. Ratings and requirements	15
5.1 General	15
5.2 Rating information	15
5.3 Rated maximum voltage (V) or (U_r)	16
5.4 Rated power frequency (f_r)	16
5.5 Rated peak fault-making current	16
5.6 Rated symmetrical fault-making current	16
5.7 Rated capacitive switching current (I_r)	19
5.8 Rated peak withstand current (I_p)	20
5.9 Rated short-time (symmetrical) withstand current and duration (I_k)	21
5.10 Rated transient peak inrush current	21
5.11 Transient inrush frequency	21
5.12 Rated lightning impulse withstand voltage	21
5.13 Rated power-frequency withstand voltage	21
5.14 Rated control voltages and ranges	21
6. Design tests	22
6.1 General	22
6.2 Insulation (dielectric) tests	22
6.3 Short-time current tests	23
6.4 Rated fault-making current tests	23
6.5 Switching duty tests	24
6.6 Condition of capacitor switch after short-time current tests, rated fault-making current tests, and switching duty tests (see 6.3, 6.4, and 6.5)	25
6.7 Temperature-rise tests	25
6.8 Radio influence voltage (RIV) tests	26
6.9 Mechanical life tests	26
6.10 Control wiring tests	27
7. Production tests	27
7.1 Dielectric withstand test; 1 min dry power-frequency	27
7.2 Control, secondary wiring, and accessory devices check tests	28
7.3 Measurement of the resistance of the main circuit	28
7.4 Tightness tests	28
7.5 Design and visual checks	28
7.6 Mechanical operations tests	28
8. Construction requirements	28
8.1 Requirements for liquids in capacitor switches	28
8.2 Requirements for gases in capacitor switches	28

8.3	Grounding provisions	29
8.4	Auxiliary and control equipment	29
8.5	Dependent power operation	29
8.6	Stored energy mechanism charge indicator	29
8.7	Independent manual operation	29
8.8	Operation of releases	29
8.9	Low- and high-pressure interlocking devices	29
8.10	Nameplate markings	29
8.11	Interlocking devices	30
8.12	Position indicator	30
8.13	Degrees of protection by enclosures	30
8.14	Creepage distances for outdoor insulators	30
8.15	Gas and vacuum tightness	31
8.16	Liquid tightness	31
8.17	Flammability	31
8.18	Electromagnetic compatibility (EMC)	31
8.19	X-ray emission	31
Annex A (informative) Fault-handling ratings for capacitor switches		32
Annex B (informative) Consideration of inrush current in back-to-back capacitor switching		34
Annex C (informative) Bibliography		38

IEEE Standard Requirements for Capacitor Switches for AC Systems (1 kV to 38 kV)

1. Overview

1.1 Scope

This standard applies to single- or multi-pole ac switches for rated maximum voltage above 1 kV to 38 kV for use in switching shunt capacitor banks (see the note in this clause). This standard covers the application of capacitive load switching wherein the capacitive loads are separated by sufficient inductance to limit the ~~high-frequency transient-making~~ peak inrush current to the peak values shown in Table 2 and Table 3. Switches designed and built in accordance with this standard are rated ~~not intended~~ for routine switching of ~~use as fault current or non-~~capacitive load currents only ~~current interrupting devices~~.

NOTE—This standard is intended to be a comprehensive standard for all “specific duty” applications of switches in the area of switching shunt capacitor banks, but it is limited in scope up to and including 38 kV. However, subject to agreement between the user and manufacturer, it may be used as a specification guide for other rated voltages.¹

1.2 Purpose

This standard provides comprehensive and detailed requirements for designing and building switches whose specific operating duty is to routinely energize and de-energize shunt capacitor banks with a rated maximum voltage above 1 kV to 38 kV.

¹Notes in text, tables, and figures of a standard are given for information only, and do not contain requirements needed to implement the standard.

1.3 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*).^{2,3}

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*).

2. Normative references

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

~~ANSI C63.2 1996, American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 kHz to 40 GHz Specifications.~~²

²~~The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.~~

³~~The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.~~

²~~This standard is available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).~~

~~IEC 60694-2002, Common Specifications for High-Voltage Switchgear and Controlgear Standards.~~³

~~IEEE Std 4™-1995, IEEE Standard Techniques for High-Voltage Testing.~~^{4,5}

~~IEEE Std 1247™-1998, IEEE Standard for Interrupter Switches for Alternating Current Rated Above 1000 Volts.~~

IEEE Std C37.100™-1992 (~~Reaf~~ ~~Reaff~~ 2001), IEEE Standard Definitions for Power Switchgear.^{4,5}

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

[IEEE Std C37.100.2™-2018, IEEE Standard for Common Requirements for Testing of AC Capacitive Current Switching Devices over 1000 V.](#)

~~NEMA 107-1987 (Reaff-1993), Methods of Measurement of Radio Influence Voltage (RIV) of High-Voltage Apparatus.~~⁶

3. Definitions

For the purposes of this [document](#) ~~standard~~, the following terms and definitions apply. The ~~Authoritative Dictionary of IEEE Standards~~ [Dictionary Online](#) ~~Terms~~ should be [consulted](#) ~~referenced~~ for terms not defined in this clause.⁶

³~~IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, CH 1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.~~

⁴IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (~~[https](https://standards.ieee.org/)~~ <http://standards.ieee.org/>).

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

⁶[IEEE Standards Dictionary Online is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.](#)

⁶~~NEMA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (<http://global.ihs.com/>).~~

The definitions of terms contained in this standard, or in other standards referred to in this document, are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this standard. For additional definitions, see IEEE Std C37.100-1992.⁷

An asterisk (*) indicates that, at the time this standard was approved, there was no corresponding definition in IEEE Std C37.100-1992. A dagger (+) indicates that the definition in this standard differs from that of IEEE Std C37.100-1992.

capacitive load: A lumped capacitance that is switched as a unit.

capacitor switch: A switch capable of making and breaking capacitive currents of capacitor banks.

rated-capacitor switching current: The rms symmetrical value of the ~~highest~~ capacitive load current that a capacitive current switching device is required to make, carry continuously, and break interrupt at a rated maximum voltage as part of its designated operation duty cycle.

NOTE—When applying a capacitor switch, the capacitive switching current rating should be at least 125% of the nominal capacitor bank current for ungrounded capacitor banks and at least 135% for grounded capacitor banks. The excess current can be caused by harmonics, overvoltage, and/or plus tolerance in the capacitance of the capacitor bank units. The current multipliers for grounded and ungrounded applications are different because the potential for harmonic current flow is higher in grounded banks when compared to the current flow in ungrounded banks.

operation cycle: A closing followed by an opening. +

pole simultaneity: The time interval, in electrical degrees, between the first capacitor switch pole contact and the final capacitor switch pole contact ~~to~~ mechanically closing ~~close~~ or opening ~~open~~ ~~when single pole capacitor switches are configured as a three phase system.~~ *

rated symmetrical fault-making current: The rms ~~maximum-peak~~ current at rated power frequency, without dc component, against which a device is required to close and hold in the presence of a fully charged parallel capacitor bank. ~~two times the rated high~~

⁷For information on references, see Clause 2.

NOTE—For identical capacitors and inductance, the making current in this case comprises the power-frequency fault current and the outrush current of the charged parallel back with 1.414 of the rated transient peak inrush making current at a frequency of 0.707 equal to one-half of the rated transient inrush frequency.*

rated high-frequency transient peak inrush -making current: The peak value of the high-frequency current, with specified damping, against which a device is required to close and latch under specified conditions.

recovery voltage: The voltage that occurs across the terminals of a pole of a circuit-interrupting device upon interruption of current.

restrike: A resumption of current between the contacts of a switching device during an opening operation after an interval of zero current of one-quarter cycle at normal power frequency or longer.

simultaneous operation: A capacitor switch is considered to have simultaneous closing or opening capability if its pole discrepancy is ~~equal to or~~ less than or equal to 90 electrical degrees.*

NOTE—Simultaneous operation can be achieved through electrical operation of three single-pole switches operating on a three-phase system or through mechanical joining of three single poles on a three-phase switch.

synchronous operation (opening or closing): Operation of a switching device in such a manner that the contacts are closed or opened at a predetermined point on a reference voltage or current wave.

~~rated~~ transient inrush frequency: The ~~highest~~ frequency of the transient inrush current of a designated operating duty.

transient overvoltage: The peak voltage condition resulting from the operation of a switching device that is measured at the source side terminals of the device and is expressed in per unit of the peak values of the operating line-to-ground voltage at the device with the load connected.†

4. Usual and unusual service conditions

4.1 Usual service conditions

Subclause 3.2 of IEEE Std C37.100.1 is applicable for indoor and outdoor capacitor switches conforming to this standard ~~shall be suitable~~ for operation at their standard ratings with ~~provided~~ ~~that~~ the following addition ~~conditions are met~~:

The switching limits of total voltage and current harmonic distortion do not exceed 5% and 3%, respectively, of the fundamental for any single harmonic.

- ~~a) The temperature of the air (ambient temperature) is not above 40 °C or below 30 °C.~~
- ~~b) The altitude does not exceed 1000 m.~~

4.2 Unusual service conditions

Subclause 3.3 of IEEE Std C37.100.1 is applicable with the following addition:

~~Unusual service conditions shall include, but are not limited to, service conditions that exceed those defined in 4.1 or extremes in the following:~~

- ~~a) Duty cycle~~
- ~~b) System conditions~~
- ~~c) Site conditions~~
- ~~d) Shock and/or vibration~~
- ~~e) Damaging fumes or vapors~~
- ~~f) Excessive or abrasive dust~~
- ~~g) Explosive mixtures of dust or gases~~
- ~~h) Salt air and/or extreme humidity~~

Unusual service conditions should be brought to the attention of those responsible for the manufacture of the equipment to define or prevent loss of performance or service life, if any, from specified values. ~~Applicable standards such as those for altitude correction should be used when available.~~

When special environmental or operating conditions—such as harmonic distortion greater than 5% for voltage and 3% for current—prevail at the location where capacitor switches are to be put in service, they shall be specified by the user and discussed with manufacturers.

~~4.2.1 Abnormal ambient temperature~~

~~Capacitor switches may be applied at higher or lower ambient temperatures than specified in 4.1, but performance may be affected and special consideration shall be given to these applications.~~

~~4.2.2 Altitudes above 1000 m~~

~~Capacitor switches may be applied at altitudes higher than 1000 m; however, the rated lightning impulse withstand voltage, rated maximum voltage, and rated capacitive current shall be multiplied individually by a correction factor.⁸ Users should consult the manufacturer for appropriate de-rating when the equipment is applied above 1000 m. Annex D can also be referred to for comments on altitude correction factors.~~

5. Ratings and requirements

5.1 General

Switches with interrupting mediums other than vacuum shall be rated as given in Column 5 of Table 1 for both the line-to-ground and open gap conditions.

⁸ ~~Altitude correction factors are being studied by the Switchgear Committee and will be adopted by issuance of a supplement or revision to this standard when they are approved.~~

When the interrupting medium is vacuum, the capacitor switch shall withstand the rated impulse voltage in the closed position. [In the open position, a reduced impulse voltage may apply according to Column 6 of Table 1.](#)

NOTE— ~~However,~~ The unique characteristics of an open vacuum interrupter or vacuum gap make it permissible to have random sparkovers of the open vacuum interrupter as much as 25% below the rated terminal-to-terminal lightning impulse withstand voltage of the capacitor switch. If such an impulse surge sparks over the open interrupter contacts, the impulse current will pass through the open contacts without damage to the interrupter unit. An impulse sparkover of the open vacuum contacts may be followed by a flow of power current that will be interrupted without damage to the capacitor switches.

~~Switches with interrupter mediums other than vacuum shall be rated as given in Column 5 of Table 1 for both the line-to-ground and open-gap conditions.~~

Table 1—Preferred voltage ratings and related test requirements for capacitor switches

Line number	Rated maximum rms voltage (kV)	Power-frequency withstand tests (kV rms)		Rated lightning impulse peak withstand voltage (kV)	Lightning impulse peak withstand voltage (Open gap for vacuum only ^{a)} (kV)
		1 min dry	1 min wet		
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
1	15.0	36	36	95	95
2	15.5	36	36	95	95
3	15.5	50	50	110	95
4	15.5	50	50	110	110
5	27	60	60	125	95
6	27	60	60	125	125
7	27	60	60	150	125
8	38	70	70	150	125
9	38	70	70	150	150
10	38	80	80	200	150
11	38	80	80	200	200

[\(New\)](#)

Line number	Rated maximum rms voltage (kV)	Power-frequency insulation level withstand tests (kV rms)		Rated lightning impulse withstand peak voltage line-to-ground (kV)	Lightning impulse withstand peak voltage terminal-to-terminal (open gap) (kV) (vacuum only ^a)
		1 min dry	10 s wet		
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
1	15.0	36	30	95	95
2	15.5	36	30	95	95
3	15.5	50	45	110	95
4	15.5	50	45	110	110
5	27	60	50	125	95
6	27	60	50	125	125
7	27	60	50	150	125
8	38	70	60	150	125
9	38	70	60	150	150
10	38	70	60	200	150
11	38	70	60	200	200

(Deleted)

^aIt is permissible to have a lower lightning impulse withstand rating across the open gap of a vacuum interrupter since the switch is not intended to be applied as an isolation device, and a flashover across the open gap is not detrimental to the performance and power-frequency withstand capability of the vacuum interrupter device.

5.2 Rating information

The rating shall include the following items:

- Rated maximum voltage (V) or (U_r)
- Rated power frequency (f_r)
- Rated peak fault-making current
- Rated symmetrical fault-making current
- Rated capacitive switching current (I_r)
- Rated peak withstand current (I_p)

- g) Rated short-time withstand (symmetrical) current (I_k)
- h) Rated ~~high frequency~~ transient peak inrush ~~-making~~ current
- i) Rated transient inrush frequency
- j) Rated lightning impulse withstand voltage
- k) Rated power-frequency withstand voltage (U_d)
- l) Rated control voltage
- m) Classification of restrike probability
- ~~l) Probability of restrike classification~~

5.3 Rated maximum voltage (V) or (U_r)

The preferred values for the maximum rated voltage of capacitor switches are shown in Column 2 of Table 1.

5.4 Rated power frequency (f_r)

The rated frequency of capacitor switches is 50 Hz or 60 Hz.

5.5 Rated peak fault-making current

The preferred values for the rated peak fault-making current (~~asymmetrical~~), expressed in peak amperes, are shown in Column 4 of Table 2 and Table 3 and are defined as a multiple of the symmetrical fault-making current shown in Column 5 of the tables. For switches rated according to Table 2, the multiplication factors are 2.46 ~~45~~ for 50 Hz and 2.51 ~~50~~ for 60 Hz. For switches rated according to Table 3, the multiplication factors are 2.55 for 50 Hz and 2.59 for 60 Hz.

5.6 Rated symmetrical fault-making current

The preferred values for the rated symmetrical fault-making current of capacitor switches are shown in Column 5 of Table 2 and Table 3.

Table 2—Preferred ratings for capacitor switches applied on systems with a circuit time constant less than 32 ms^a

Line number ^b	Maximum voltage (kV)	Power-frequency current ratings					High-frequency inrush current ratings	
		Capacitive switching current (A)	Peak fault-making current (A)	Symmetrical fault-making current (A) (10 cycle)	Withstand ^d peak current (A)	Short-time symmetrical withstand current (A) (1 s)	Transient peak inrush current (A)	Transient inrush frequency (Hz)
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9
1	15	200	15 000	6 000	15 000	4 500	6 000	4 000
2	15.5	200	15 000	6 000	15 000	4 500	10 000	4 000
3	27	200	15 000	6 000	15 000	4 500	6 000	4 000
4	27	200	15 000	6 000	15 000	4 500	10 000	4 000
5	38	200	15 000	6 000	15 000	4 500	6 000	4 000
6	38	200	15 000	6 000	15 000	4 500	10 000	4 000

(New)

Line number ^b	Rated maximum voltage (kV)	Power-frequency current ratings				High-frequency inrush current ratings		
		Capacitive switching current (A)	Fault-making ^c peak current (A)	Symmetrical fault-making current (A)	Withstand ^d peak current (A)	Short-time symmetrical withstand current (A)	High frequency transient-making peak current (A)	Rated transient inrush frequency (Hz)
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9
1	15	200	9 000	6 000	9 000	4 500	6 000	6 000
2	15.5	200	15 000	6 000	15 000	4 500	9 000	6 000
3	27	200	9 000	6 000	9 000	4 500	6 000	6 000
4	27	200	15 000	6 000	15 000	4 500	9 000	6 000
5	38	200	9 000	6 000	9 000	4 500	6 000	6 000
6	38	200	15 000	6 000	15 000	4 500	9 000	6 000

(Deleted)