



IEEE Standard for Interrupter Switches for Alternating Current, Rated Above 1000 V

IEEE Power Engineering Society

Sponsored by the
Switchgear Committee

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Abstract: The basic requirements of interrupter switches used indoors, outdoors, and in enclosures are covered. This standard does not apply to load-break separable insulated connectors.

Keywords: enclosed switch, indoor switch, interrupter switch, outdoor switch, switching ability, switching current, switching rating

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Introduction

This introduction is not part of IEEE Std 1247-2005, IEEE Standard for Interrupter Switches for Alternating Current, Rated Above 1000 Volts.

Over many years, standards covering interrupter switches have been developed in subcommittees other than the High Voltage Switch Subcommittee. As a result, different and sometimes conflicting requirements for interrupter switches have been developed. Where there is a clear need for different requirements in different applications, diverging standards are appropriate. However, where application requirements are similar, the body of standards should treat the requirements uniformly. As a result of this philosophy, the Switchgear Administrative Subcommittee passed the following motion at the May 1991 meeting in Fort Lauderdale.

In an effort to promote a uniform approach to standards, the following policy is set:

Future standards and revisions to standards that incorporate fuses, switches, circuit breakers, and/or reclosers and sectionalizers shall reference the basic fuse, switch, circuit breaker, and/or recloser and sectionalizer standard wherever possible and treat material differently only when there are unique application requirements.

This standard was written to provide the basic standard for interrupter switches. As such, an attempt was made to encompass as many different types of interrupter switches as practical. This standard has also provided the opportunity to update and revise the general treatment of interrupter switches, and address newer technologies that are being used to provide switching functions.

Part of the heritage of this document comes from the treatment of interrupter switches in other IEEE C37 standards. It is anticipated that material relating to interrupter switches, currently in the IEEE C37.30 series, will be removed from those documents when this document is published. Further, when this document is published, it is anticipated that other standards, not in the IEEE C37.30 series, will begin to reference this document, as outlined in the above AdsCom motion.

Although this standard does not apply to circuit-breakers, circuit-switchers, or reclosers, standards for circuit-breakers, circuit-switchers, and reclosers should reference this document for their load-interrupting requirements. A further intent of this document is to provide test circuits to be used to establish ratings for common applications of switching devices not generally covered by standards.

Although this document will be published before the work on IEEE Std C37.100.1™ (Common Clauses) is finished, it is the intention of the Interrupter Switch Working Group to adopt or reference common clauses as they become available. Specifically the treatment of:

- Altitude correction factors, and
- Total temperature limits for contacts, connections, and insulation

will conform to the Common Clauses Document.

Conformance and field testing are not covered in this document. The user is referred to apparatus-specific test documents such as IEEE Std C37.41™, ANSI C37.57, and ANSI C37.58.

This standard has adopted the approach of many other standards in avoiding asymmetrical current ratings. For example, the traditional momentary (asymmetrical) current rating is now covered in the peak current withstand. Because of the lack of a need to calculate asymmetrical currents, and the common use of data

acquisition systems (which automatically calculate rms currents), IEEE Std C37.09™ is not referenced as a means to determine symmetrical or asymmetrical values.

The actual revision is limited to the correction of technical errors that have been identified in subclauses 8.3.1.3, 8.3.2.1, 8.3.2.2.1, 8.3.2.5 and 8.2.2.6, 8.3.2.3, and 8.3.2.6; Figures 1, 2, 3, 4, 7, 8, 9, 10, and 11; and Tables 6, 7, and 9.

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Participants

At the time this standard was completed, the working group had the following membership:

Lyne Brisson, Co-Chair

Marcel Fortin, Co-Chair

John Angelis
Charles Ball
Frank DeCesaro

Jim Domo
Erik M. Guillot
Ronald Lavorin
Peter Meyer

Radakrishna Ranjan
David Stone
Jan Zawadzki

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

Roy Alexander
Chris Ambrose
Edwin Averill
Charles Ball
W. J. (Bill) Bergman
Edward Bertolini
Behdad Biglar
Lyne Brisson
Robert Brown
Ted Burse
Eldridge R. Byron
Raymond Capra
Tommy Cooper
Ronald Daubert
Alexander Dixon
Randall Dotson
Denis Dufournet
Doug Edwards
Marcel Fortin
Kenneth Gettman
David Gilmer
Mietek Glinkowski
Randall Groves
Erik M. Guillot
Ian Harvey
Luther Holloman

Edward Horgan Jr.
George House
William Hurst
David Jackson
Edward Jankowich
Joseph L. Koepfinger
Thomas LaRose
Stephen R. Lambert
Ward E. Laubach
John Leach
George Lester
Jason Lin
Albert Livshitz
Gregory Luri
William Majeski
Neil McCord
Nigel McQuin
Bryan Melville
Peter Meyer
Gary Michel
Alec Monroe
Georges Montillet
Anne Morgan
Peter Morgan
Frank Muench
Yasin Musa

Jeffrey Nelson
Paul Notarian
Ray O'Leary
T. W. Olsen
Paulette Payne
Anthony Picagli
Jackson Richard
Hugh Ross
Timothy Royster
James Ruggieri
E. William Schmunk
Devki Sharma
R. Kirkland Smith
David Stone
Chand Tailor
Stanton Telander
Jane Ann Verner
Charles Wagner
Steve Whalen
James Wilson
John Wood
Elbert Worland
Zhenxue Xu
Larry Yonce
Jan Zawadzki

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Lowell G. Johnson
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Joseph L. Koepfinger*
David J. Law
Daleep C. Mohla
Paul Nikolic

T. W. Olsen
Glenn Parsons
Ronald C. Petersen
Gary S. Robinson
Frank Stone
Malcolm V. Thaden
Richard L. Townsend
Joe D. Watson
Howard L. Wolfman

*Member Emeritus

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

Satish K. Aggarwal, *NRC Representative*
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Alan H. Cookson, *NIST Representative*

Michael D. Fisher
IEEE Standards Program Manager, Document Development

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IEEE Standard for Interrupter Switches for Alternating Current, Rated Above 1000 V

1. Overview

1.1 Scope

This standard applies to switching devices, interrupters, and interrupter switches (as defined in IEEE Std C37.100™) for alternating current, rated above 1000 V and used indoors, outdoors, or in enclosures for which a switching rating is to be assigned. While this standard covers the basic requirements of interrupter switches used indoors, outdoors, and in enclosures, other standards such as IEEE Std C37.20.2™, IEEE Std C37.20.3™, IEEE Std C37.20.4™, and IEEE Std C37.74™ also contain requirements for switches used in enclosures. This standard does not apply to load-break separable insulated connectors, which are covered by IEEE Std 386™-1995 [B8].¹ This standard also does not apply to circuit-breakers, circuit-switchers, or reclosers.

1.2 Purpose

The purpose of this standard is to provide a basic standard for switches as defined in 3.5. The broad definition of a switch, given in 3.5, encompasses devices that meet the strict definition of an interrupter switch in IEEE Std C37.100, and also encompass devices that utilize insulating media other than air.

2. Normative references

The following referenced documents are indispensable for the application of this document. 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 C2-2002, National Electrical Safety Code® (NESC®).²

ANSI C29.1-2002, Test Methods for Electrical Power Insulators.

ANSI C37.22-1997 (Reaff 2003), American National Standard Preferred Ratings and Related Required Capabilities for Indoor AC Medium-Voltage Switches Used in Metal-Enclosed Switchgear.

¹ The numbers in brackets preceded by the letter B correspond to those of the bibliography in Annex E.

² ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

ANSI C37.32-2002, Schedule of Preferred Ratings, Construction Guidelines and Specifications for High-Voltage Air Disconnect Switches Interrupter Switches, Fault Initiating Switches, Grounding Switches, Bus supports and Accessories Control Voltage Ranges.

ANSI C37.66-1969 (Reaff 1997), American National Standard Requirements for Oil-filled Capacitor Switches for Alternating-Current Systems.

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

IEEE Std 4TM-1995, IEEE Standard Techniques for High-Voltage Testing, including IEEE 4aTM-2001, Amendment to IEEE Standard Techniques for High-Voltage Testing.^{3,4}

IEEE Std C37.09-1999 IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.

IEEE Std C37.20.2-1999, IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear.

IEEE Std C37.20.3-2001, IEEE Standard for Metal-Enclosed Interrupter Switchgear.

IEEE Std C37.20.4-2001, IEEE Standard for Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear.

IEEE Std C37.30TM-1997, IEEE Standard Requirements for High-Voltage Air Switches.

IEEE Std C37.34TM-2002, IEEE Standard Test Code for High-Voltage Air Switches.

IEEE Std C37.74-2002 IEEE Standard Requirements for Subsurface, Vault, and Padmounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems up to 38 kV.

IEEE Std C37.100-1992 (Reaff 2001), IEEE Standard Definitions for Power Switchgear.

NEMA 107-1987 (Reaff 2000), Methods of Measurements of Radio Influence Voltage (RIV) of High Voltage Apparatus.⁵

NEMA SG6-1995, Power Switching Equipment.

3. Definitions

If a term is not defined in this standard, the definition in IEEE Std C37.100 or in *The Authoritative Dictionary of IEEE Standards Terms* [B5] applies. An asterisk (*) indicates that the definition in this standard is not contained in IEEE Std C37.100. A dagger (†) indicates that the definition in this standard differs from that in IEEE Std C37.100.

3.1 interrupter switch: (†) A switching device, designed for making specified currents and breaking specified steady state currents. (HVS, Swg)

³ IEEE publications are 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/>).

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⁵ NEMA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (<http://global.ihs.com/>).

NOTE—The nature of the current made or broken, or both, may be indicated by suitable prefix; that is, load interrupter switch, loop interrupter switch, unloaded line interrupter switch, etc.⁶

3.2 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.

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

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

3.5 switch: (†) Within this standard, the noun “switch” shall refer to switching devices, interrupters, current interrupting devices, interrupting aids, or interrupter switches (as defined in IEEE Std C37.100).

4. Service conditions

4.1 Usual service conditions

Switches conforming to this standard shall be suitable for operation at their standard ratings provided that

- a) The temperature of the cooling air (ambient temperature) does not exceed 40 °C (104 °F)
- b) The ambient temperature is not less than –30 °C (–22 °F)
- c) The altitude does not exceed 1000 m (3300 ft)
- d) The wind velocity does not exceed 36 m/s (130 km/h, 80 mph)

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

4.1.1 Outdoor switch

Switches designated as outdoor switches shall be suitable for operation outside buildings or enclosures. Outdoor switches may be exposed to the weather. They experience no restriction of heat transfer to the ambient atmosphere.

4.1.2 Indoor switch

Switches designated as indoor switches shall be suitable for operation inside buildings or weather-resistant enclosures. 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.

4.1.3 Enclosed switch

Switches designated as enclosed switches shall be suitable for operation inside a weather-resistant enclosure that restricts heat transfer to the ambient atmosphere. Enclosed switches may also be suitable for use in enclosures filled with a dielectric medium other than air, e.g., oil or SF₆.

4.2 Unusual service conditions

⁶ Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

Unusual conditions shall be considered. Examples of such conditions are as follows:

- a) Altitudes greater than 1000 m (3300 ft) (see Annex A)
- b) Damaging fumes or vapors, excessive or abrasive dust, explosive mixtures of dust or gases, steam, salt spray, excessive moistures, or dripping water
- c) Abnormal vibration, shocks, or tilting
- d) Seismic requirements
- e) Excessively high or low temperatures
- f) Unusual transportation or storage conditions
- g) Unusual space limitations
- h) The application of an outdoor switch, indoor switch, or an enclosed switch for another purpose, which may include concerns regarding weather exposure and restricted heat transfer (see Table 1)
- i) Unusual operating duty, frequency of operation, difficulty of maintenance, high harmonic content waveforms, unbalanced voltage, and special insulation requirements

Table 1 lists applications that may be considered unusual.

Table 1—Applications that may be considered unusual

Switch type	Switch exposed to weather	Installation with restricted heat transfer
Outdoor switch	Usual	Unusual
Indoor switch	Unusual	Unusual
Enclosed switch	Unusual	Usual

5. Description of ratings and capabilities

Subclauses 5.1 through 5.11 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 preferred values for ratings and capabilities are found in Clause 6. The test procedures to establish the ratings and capabilities are found in Clause 8.

5.1 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.

5.2 Rated voltage

5.2.1 Rated maximum voltage

The rated maximum voltage of a switch is the highest root-mean-square (rms) three-phase system voltage of rated power frequency for which the switch is designed to operate.

5.2.2 Rated loop-switching voltage

The rated loop-switching voltage of a switch is the highest rms recovery voltage that the switch is designed to withstand upon breaking loop current.

5.2.3 Rated differential capacitance voltage range

The rated differential capacitance voltage range consists of upper and lower limits for the difference in the magnitude of the rms power-frequency voltage, with and without a capacitance connected.

5.3 Rated withstand voltages

The rated withstand voltage is the voltage of the appropriate waveshape, magnitude, and duration that the switch shall withstand under specified conditions, without damage to the insulating materials.

5.3.1 Rated power-frequency withstand voltage

The rated power-frequency withstand voltages are rms values of sinusoidal waveforms of rated power frequency.

5.3.1.1 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 switches shall withstand 100% or 110% of the rated power-frequency dry withstand voltage, if required by other standards such as the IEEE C37.20 series. The nameplate shall relate the 110% open-gap rated power-frequency dry withstand voltage, if appropriate.

5.3.1.2 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 are no power-frequency wet withstand 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.

If, utilizing good engineering judgment, one cannot determine that solid insulation that fully or partially bridges the open gap will not adversely affect the open-gap withstand, a wet-withstand test shall be made and the open gap shall withstand 100% of the rated wet power-frequency withstand voltage.

5.3.1.3 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 s with condensate (dew) over the switch's solid insulation. There is no power-frequency dew withstand requirement for outdoor switches. 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.

5.3.2 Rated lightning-impulse withstand voltage

The rated lightning-impulse withstand voltage is the peak value of $1.2 \times 50 \mu\text{s}$ positive and negative impulses that the switch shall be required to withstand.

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 switches shall withstand 100% or 110% of the rated lightning-impulse withstand voltage, if required by other standards such as IEEE Std C37.34. The nameplate shall relate the 110% open-gap lightning-impulse withstand voltage, if appropriate.

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.

5.3.3 Rated switching-impulse withstand voltage

The rated switching-impulse withstand voltage is the peak value of $250 \times 2500 \mu\text{s}$ positive and negative impulses that the switch shall be required to withstand. There are no rated switching-impulse withstand requirements for switches with rated lightning-impulse withstand voltages less than 1050 kV.

All insulation, including open gaps, shall withstand 100% of the rated switching-impulse withstand voltage.

5.4 Rated currents

5.4.1 Rated continuous current

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.

5.4.2 Rated short-time (symmetrical) withstand current

The rated short-time (symmetrical) withstand current has two associated ratings. They are as follows:

- a) *Rated peak withstand current.* The measure of the switch's ability to withstand the magnetic forces associated with a short-circuit
- b) *Rated short-time (symmetrical) withstand current duration.* The 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 at 60 Hz, which leads to a peak current to rms symmetrical current ratio of 2.6.

5.4.2.1 Rated peak withstand current

The rated peak withstand current is the maximum instantaneous current at the major peak of an offset rated power-frequency current that the switch shall be required to carry while in the closed state.

5.4.2.2 Rated short-time (symmetrical) withstand current duration

The rated short-time (symmetrical) withstand current duration is the maximum duration that the switch shall be required to carry rated short-time (symmetrical) withstand current while in the closed state.

5.4.3 Rated fault-making current

The rated fault-making current is the maximum rms power-frequency current, expressed in symmetrical amperes, that the switch shall be required to make and carry at its rated maximum voltage for a specified duration. The switch shall have the related ability to make and carry the asymmetrical current (based on an approximate X/R of 17 at 60 Hz with a peak current of 2.6 times the symmetrical fault-making current) associated with the symmetrical fault-making current.

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

5.4.4 Rated switching abilities

The following ratings and abilities are common duties associated with switches. To be classified as an interrupter switch, the switch must be rated for at least one of the duties described in 5.4.4.1 through 5.4.4.6, but need not be rated for all of them.

The ability to make a switching current does not imply the ability to fault-close. The ability to fault-close is explicitly determined by a rated fault-making current.

The rated switching abilities are established under the conditions prevalent in non-effectively grounded systems. Any of the ratings can be modified to apply to systems with grounded sources and loads only (where the system on both sides of the switch is grounded); but, in such cases, the words "for systems with grounded sources and loads only" shall appear with the rating.

5.4.4.1 Rated load-switching current

The rated load-switching current is the maximum rms symmetrical power-frequency load current flowing in a circuit that the switch shall be required to make and interrupt at its rated maximum voltage.

5.4.4.2 Rated loop-switching currents

5.4.4.2.1 Rated line or cable loop-switching current

The rated line or cable loop-switching current is the maximum rms symmetrical power-frequency circulating current flowing in a line or cable formed loop circuit that the switch shall be required to make and interrupt at its rated loop-switching voltage.

5.4.4.2.2 Rated parallel transformer loop-switching current

The rated parallel transformer loop-switching current is the maximum rms symmetrical power-frequency circulating current flowing between adjacent parallel transformers that the switch shall be required to make and interrupt at its rated loop-switching voltage.

5.4.4.3 Rated line-charging switching current

The rated line-charging switching current is the maximum rms symmetrical power-frequency charging current flowing into an unloaded line that the switch shall be required to make and interrupt at its rated maximum voltage.

NOTE—The making current will include a transient that has a magnitude that is much higher than that of the rated line-charging switching current.

5.4.4.4 Rated cable-charging switching current

The rated cable-charging switching current is the maximum rms symmetrical charging current flowing into an unloaded cable that the switch shall be required to make and interrupt at its rated maximum voltage.

NOTE—The making current will include a transient that has a magnitude that is much higher than that of the rated cable-charging switching current.

5.4.4.5 Rated unloaded transformer switching current

The rated unloaded transformer switching current is the maximum transformer exciting current that the switch shall be required to make and interrupt at its rated maximum voltage. The current is expressed in rms symmetrical amperes. Optionally, the rating may be expressed as the maximum transformer size associated with the exciting current that can be switched.

NOTE—The making current may include a transient current several orders of magnitude larger than that of the rated unloaded transformer switching current.

5.4.4.6 Rated shunt capacitor bank-switching current

The rated shunt capacitor bank-switching current is the maximum rms symmetrical power-frequency capacitor bank current that the switch shall be required to make and interrupt at its rated maximum voltage within its rated differential capacitance voltage. Filter bank-switching requires special consideration and is not currently covered by this document. The capacitive switching current rating has two associated ratings. They are as follows:

- a) *Rated peak capacitive inrush current.* Determines the switch's suitability for switching back-to-back applications.
- b) *Rated shunt capacitor bank switching endurance.* Determines the switch's suitability for long-term repetitive switching of capacitors.

The capacitive switching current rating also has a class of rating. Class of shunt capacitor bank-switching current ratings are Class A, B, and C, as defined by differences in the specified test procedure in 8.3.2.6. Class A is the most severe with respect to restriking, Class B is somewhat less severe, and Class C has no test criteria directed at restrikes.

Grounded systems have lower transient recovery voltage requirements. Switches rated "systems with grounded sources and loads only" may not be used in non-grounded systems.

The harmonic content of the rated switching current shall be <10% and should cause no extraneous current zeros.

5.4.4.6.1 Rated peak capacitive inrush current

The rated peak capacitive inrush current is the maximum instantaneous value of transient inrush current that the switch shall be required to make when energizing either single or parallel capacitor banks. (See Figure 10 and Figure 11.)

NOTE—Expected maximum ratios of (rated peak capacitive inrush current) / (rated capacitive switching current) are in the range of 200 for back-to-back capacitors. For single capacitors, the ratio is normally <20.

5.4.4.6.2 Shunt capacitor switching endurance

The shunt capacitor switching endurance is the number of shunt capacitor switching operations that the switch shall be capable of successfully performing while maintained per the manufacturer's instructions.

5.5 Rated ice breaking ability

The rated ice breaking ability is the maximum thickness of ice, as defined by the ice loading test of Clause 8, under which the switch shall be required to successfully open or close.

5.6 Rated control voltage

The rated control voltage is the nominal voltage for which a power-operated mechanism is designed to operate.

5.7 Rated mechanical operations

The rated mechanical operations 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.

5.8 Rated mechanical terminal load

The rated mechanical terminal load is the static force, (equivalent to an external mechanical load) applied at each terminal in specified directions, that a switch shall withstand while stationary and during operation.

5.9 Visible corona-free voltage

The visible corona-free voltage is the line-to-ground voltage at which there is an onset of visible plumes or spikes under dark conditions. (See IEEE Std C37.34.)

5.10 Radio-influence voltage limit

The radio-influence voltage limit is the maximum allowable radio-influence voltage (at a specified detection frequency and at a specified distance) produced by a switch when energized at a specified voltage at rated power frequency.

5.11 Partial discharge limits

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

6. Preferred ratings

Preferred ratings for outdoor, indoor, and enclosed switches are given in referenced standards (see 6.1, 6.2, and 6.3). Where the referenced standard does not specify a preferred rating, the preferred rating given in 6.4, if appropriate, shall apply.

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

6.1 Preferred ratings—Outdoor switches

Preferred ratings for outdoor switches are given in ANSI C37.32.

6.2 Preferred ratings—Indoor switches

6.2.1 General

Preferred ratings for indoor switches are given in ANSI C37.32.

6.2.2 For metal-enclosed switchgear

Preferred ratings for indoor ac medium voltage switches to be used in metal-enclosed switchgear are given in ANSI C37.22.

6.3 Preferred ratings—Enclosed switches

6.3.1 For metal-enclosed switchgear

Preferred ratings for enclosed switches to be used in metal-enclosed switchgear are given in ANSI C37.22.

6.3.2 For manually operated subsurface load interrupting switchgear

Preferred ratings for enclosed switches to be used in manually operated subsurface load interrupting switchgear are given in IEEE Std C37.74.

6.3.3 For padmounted fused switchgear

Preferred ratings for enclosed switches to be used in padmounted fused switchgear are given in IEEE Std C37.74.

6.4 Other preferred ratings

6.4.1 Preferred rated power frequency

The preferred rated power frequency of interrupter switches shall be 60 Hz.

6.4.2 Rated loop-switching voltage

The preferred rated loop-switching voltage is 20% of the rated maximum voltage.

6.4.3 Rated differential capacitance voltage range

The preferred limits for the differential capacitance voltage range are

- a) 100 V for the lower limit
- b) 4% of rated maximum voltage for the upper limit