IEEE Std C37.04a™-2003
(Amendment to IEEE Std C37.04™-1999)

IEEE Standards

C37.04a™

IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

Amendment 1: Capacitance Current Switching

IEEE Power Engineering Society

Sponsored by the
Switchgear Committee

This amendment is an approved IEEE Standard. It will be incorporated into the base standard in a future edition.

IEEE

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Amendment 1: Capacitance Current Switching

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Switchgear Committee
of the
IEEE Power Engineering Society

Approved 12 May 2003

IEEE-SA Standards Board

Abstract: This amendment specifies the capacitance current switching portion of the rating structure for all ac circuit breakers rated above 1000 V, including both outdoor and indoor types having preferred ratings listed in ANSI C37.06-2000. The rating structure establishes the basis for all assigned capacitance current ratings including overhead line switching, cable switching, capacitor bank switching, and back-to-back capacitor bank switching.
Keywords: capacitance current, capacitance current switching, capacitor bank switching, restrike

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Introduction

(This introduction is not part of IEEE Std C37.04a-2003, IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Amendment 1: Capacitance Current Switching.)

The capacitance current switching standards have been completely revised. A joint IEEE-IEC task force developed a revised approach to capacitance current switching standardization. IEC has published this task force's work as part of IEC's new circuit breaker standard, designated IEC 62271-100:2003 [B2][a]. IEC 62271-100:2003 superceded IEC 60056:1987.

In May 1995 in the interest of harmonization of high-voltage circuit breaker standards, a joint meeting of the IEC 17A, the IEEE/PES Switchgear Committee, and the IEEE/PES Substations Committee was held in Vienna, VA. One of the outcomes of that meeting was a decision to form a joint IEEE-IEC task force to revise the standards for capacitance current switching. The task force was given the IEC designation "IEC SC17A WG21 TF10." It was agreed that the work of this task force (TF10) would serve as the basis for capacitance current switching standards in IEC and IEEE. TF10 had two 2-day meetings—one in Clamart, France, in September 1995 and one in Berlin, Germany, in December 1995.

TF10 was composed of the following individuals:

R. O'Leary	IEEE
R. W. Alexander	IEEE
R. Jeanjean	IEEE and IEC
D. Dufournet	IEEE and IEC
H. Kempen	IEC
P. Riffon	IEC
M. Seeger	IEC
N. Trapp	IEC

The work of TF10 has been incorporated into the new IEC circuit breaker standard, IEC 62271-100, published in May 2001 (originally IEC 60056:1987) and now in its present edition, IEC 62271-100:2003 [B2]). IEEE Std C37.04a-2003 along with IEEE PC37.09a [B4] and a revised set of tables in ANSI C37.06-2000 [B1] collectively form the IEEE version that corresponds to the capacitance current switching portion of IEC 62271-100:2003. Slight modifications to the IEC version have been made to reflect North American practice. Additionally, slight modifications to the text have been made for the North American reader, such as "ground" has replaced "earth". Most of the text is the same and certain usage may be unfamiliar, but is understandable to the discriminating reader.

In keeping with IEC circuit breaker standard philosophy, the capacitance current switching ratings have been "unbundled." A "basic" circuit breaker has either an overhead line switching rating (outdoor circuit breaker) or a cable switching rating (indoor circuit breaker). Capacitor bank ratings, both single bank and back to back, or additional overhead or cable ratings must be specified separately.

Two classes of circuit breaker regarding restriking performance are specified. "Class C1" has a restriking performance similar to the old "definite purpose circuit breaker" defined in IEEE Std C37.04-1999 and is called *low probability of restrike*. Class C2 is intended to have a very low probability of restriking of about 1/10 or less than the probability of a Class C1 circuit breaker. The probability of restrike classification is applicable to all rated capacitance current ratings.

For circuit breakers rated 362 kV and above, a single-phase test voltage factor of 1.4 (recovery voltage of 2.8 per unit) is required for the overhead line switching test duties. (The 1.4 single-phase test voltage factor requirement is only an option in IEC 62271-100:2003 [B2].) The purpose of this requirement is to acknowledge the long transmission lines and low coefficient of grounding, common in North America. The 1.4 sin-

[a]The numbers in brackets correspond to the numbers of the bibliography in Annex A.

gle-phase test voltage factor is an increase from the 1.2 single-phase test voltage factor (2.4 pu recovery voltage) requirement in IEEE Std C37.04-1999. For circuit breakers rated 72.5 kV and below, the same 1.4 single-phase test voltage factor is required for all capacitance current switching duties. The 1.4 single-phase test voltage factor is to allow for the many ungrounded systems that exist at 72.5 kV and below. IEC 62271-100:2003 [B2] requires this only at 52 kV and below. This is a slight decrease in the requirement for a 1.5 single-phase test voltage factor (3.0 pu recovery voltage) for capacitance current testing in IEEE Std C37.09-1999.

ANSI/IEEE Std C37.012™-1979 [B3] is being revised to align with this new approach and to alert the user concerning these changes.

Participants

The Accredited Standards Committee on Power Switchgear, C37, which reviewed and approved this amendment, had the following members at the time of approval:

T. W. Olsen, *Acting Chair*
A. K. McCabe, *Vice Chair, HV Standards*
J. C. Scott, *Vice Chair, LV Standards*
D. L. Swindler, *Vice Chair, IEC Activities*
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U. S. Department of the Navy—Naval Construction Battalion Center	D. Mills
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At the time this amendment was approved, the working group has the following membership:

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

Roy W. Alexander
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Stan Billings
Anne Bosma
Lyne Brisson
John Brunke
Ted Burse
Carlos L. Cabrera-Rueda
Guru Dutt Dhingra
Dufournet Denis
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Satish K. Aggarwal, *NRC Representative*

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Contents

IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

Amendment 1: Capacitance Current Switching

NOTE: The editing instructions contained in this amendment define how to merge the material contained herein into the existing base standard and its amendments to form the comprehensive standard.

The editing instructions are shown in bold italic. Four editing instructions are used: change, delete, insert, and replace. ***Change*** is used to make small corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is used to make large changes in existing text, subclauses, tables, or figures by removing existing material and replacing it with new material. Editorial notes will not be carried over into future editions because the changes will be incorporated into the base standard.

3. Definitions

Replace the text in Clause 3 with the following:

For this standard, the following terms and definitions apply. These definitions are not intended to embrace all possible meanings of the terms. They are intended solely to establish the meanings of terms used in power switchgear. IEEE Std C37.100™-1992 should be referenced for terms not defined in this clause.

3.1 cable-charging (cable off-load) breaking capacity: Breaking capacity for which the specified conditions of use and behavior include the opening of an insulated cable operating at no-load.

3.2 capacitor bank breaking capacity: Breaking capacity for which the specified conditions of use and behavior include the opening of a capacitor bank.

3.3 capacitor bank inrush making capacity: Making capacity for which the specified conditions of use and behavior include closing into a capacitor bank.

3.4 circuit breaker class C1: Circuit breaker with low probability of restrike during capacitive current breaking as demonstrated by specific design tests.

3.5 circuit breaker class C2: Circuit breaker with very low probability of restrike during capacitive current breaking as demonstrated by specific design tests.

3.6 line-charging (line off-load) breaking capacity: Breaking capacity for which the specified conditions of use and behavior include the opening of an overhead line operating at no-load.

3.7 restrike performance: Expected probability of restrike during capacitance current interruption as demonstrated by specified design tests.

NOTE—Specific numeric probabilities cannot be applied throughout a circuit breaker's service life.

5. Ratings

Replace 5.11 with the following text:

5.11 Rated capacitance switching currents

Capacitance switching currents may include part or all of the operating duty of a circuit breaker, such as the charging current of an unloaded transmission line or cable or the load current of a shunt capacitor bank.

The rating of a circuit breaker for capacitance current switching shall include, where applicable,

a) Rated line-charging breaking current applicable to all outdoor circuit breakers
b) Rated cable-charging breaking current applicable to all indoor circuit breakers
c) Rated single capacitor bank breaking current
d) Rated back-to-back capacitor bank breaking current
e) Rated back-to-back capacitor bank inrush making current and frequency

Preferred values of rated capacitance switching currents are given in Table 1A, Table 2A, and Table 3A of ANSI C37.06-2000.

The recovery voltage related to capacitance current switching depends on

— The grounding of the system
— The grounding of the capacitive load, e.g., shielded cable, capacitor bank, transmission line
— The mutual influence of adjacent phases of the capacitive load, e.g., belted cables, open air lines
— The mutual influence of adjacent systems of overhead lines on the same route
— The presence of single- or two-phase ground faults

Two classes of circuit breakers are defined according to their restrike performances:

— Class C1: low probability of restrike during capacitance current breaking
— Class C2: very low probability of restrike during capacitance current breaking

Each capacitance current switching rating assigned [see item a) through item d) in this subclause] must have an associated class (i.e., C1 or C2) with it.

NOTES

1—The probability is related to the performance during the series of type tests stated in 4.10 in IEEE PC37.09a and subsequently in 4.10.1 through 4.10.12.

2—A circuit breaker can be of Class C2 for one kind of application (e.g., in grounded neutral systems) and of Class C1 for another kind of application where the recovery voltage stress is more severe (e.g., in systems other than grounded neutral systems).

3—Circuit breakers with a restrike probability other than the probability of Class C1 or Class C2 are not covered by this standard.

5.11.1 Rated line-charging breaking current (I_l)

The rated line-charging breaking current is the maximum line-charging current that the circuit breaker shall be capable of breaking at its rated voltage under the conditions of use and behavior prescribed in this standard. The specification of a rated line-charging breaking current is mandatory for all outdoor circuit breakers.

5.11.2 Rated cable-charging breaking current (I_C)

The rated cable-charging breaking current is the maximum cable-charging current that the circuit breaker shall be capable of breaking at its rated voltage under the conditions of use and behavior prescribed in this standard. The specification of a rated cable-charging breaking current is mandatory for all indoor circuit breakers.

5.11.3 Rated single capacitor bank breaking current (I_{sb})

The rated single capacitor bank breaking current is the maximum capacitor current that the circuit breaker shall be capable of breaking at its rated voltage under the conditions of use and behavior prescribed in this standard. This breaking current refers to the switching of a shunt capacitor bank where no shunt capacitors are connected to the source side of the circuit breaker.

5.11.4 Rated back-to-back capacitor bank breaking current (I_{bb})

The rated back-to-back capacitor bank breaking current is the maximum capacitor current that the circuit breaker shall be capable of breaking at its rated voltage under the conditions of use and behavior prescribed in this standard.

This breaking current refers to the switching of a shunt capacitor bank where one or several shunt capacitor banks are connected to the source side of the circuit breaker giving an inrush making current equal to the rated back-to-back capacitor bank inrush making current.

NOTE—Similar conditions could apply for switching at substations with cables.

5.11.5 Rated back-to-back capacitor bank inrush making current (I_{bi})

The rated back-to-back capacitor bank inrush making current is the peak value of the current that the circuit breaker shall be capable of making at its rated voltage and with a frequency of the inrush current (see 5.11.6) appropriate to the service conditions (see Table 1A, Table 2A, and Table 3A of ANSI C37.06-2000). Refer to IEEE Std C37.012™-1979 for discussion of the limitations on I_{bi} magnitude and f_{bi} frequency.

5.11.6 Rated back-to-back capacitor bank inrush making frequency (f_{bi})

The rated back-to-back capacitor bank inrush making frequency is the maximum inrush current frequency to which I_{bi} (see 5.11.5) applies (see Table 1A, Table 2A, and Table 3A of ANSI C37.06-2000). Refer to IEEE Std C37.012-1979 for discussion of the limitations on I_{bi} magnitude and f_{bi} frequency.

Annex A

(informative)

Bibliography

[B1] ANSI C37.06-2000, American National Standard AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities.[1]

[B2] IEC 62271-100:2003, High-Voltage Swichgear and Controlgear—Part 100: High-Voltage Alternating-Current Circuit Breakers.[2]

[B3] IEEE Std C37.012-1979, IEEE Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.[3,4]

[B4] IEEE PC37.09a, Draft Supplement to IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.[5]

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

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