IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V

C37.06™

IEEE Power & Energy Society

Sponsored by the
Switchgear Committee

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Abstract: The preferred ratings of indoor and outdoor high-voltage circuit breakers rated above 1000 V for use in commercial, industrial, and utility installations are described.
Keywords: capacitance switching, dielectric withstand voltage, endurance, gas-insulated substations, high-voltage circuit breakers, interrupting capability, TRV

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Introduction

This introduction is not part of IEEE Std C37.06-2009, IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V.

This standard is a revision of ANSI C37.06-2000. It reflects changes needed to coordinate with the final wording contained in the defining IEEE Std C37.04-1999 and corrigendum, IEEE Std C37.04a™-2003, IEEE Std C37.04b™-2008, IEEE Std C37.09™-1999 and corrigendum, IEEE Std C37.09a™-2005, IEEE PC37.09b™ (Draft 3, September 2009), IEEE Std C37.010™-1999 and IEEE Std C37.010-2005, and other international standards such as IEC 62271-100:2008 [B5].[a, b]

ANSI C37.06-2000 and the earlier editions were prepared by working groups sponsored by NEMA. In January 2003, NEMA transferred responsibility for ANSI C37.06 to the IEEE Power & Energy Society Switchgear Committee. IEEE Std C37.06 is now the responsibility of the High-Voltage Circuit Breaker Subcommittee of the IEEE Power & Energy Society, Switchgear Committee.

This introduction summarizes significant substantive and editorial changes between this revision and the 2000 version. It also comments historically on the changes made since the 1987 edition and the evolution of the *preferred ratings standards*. This standard, IEEE Std C37.06-2009, identifies preferred ratings of circuit breakers and does not exclude use of circuit-breaker characteristics not identified in this standard.

The major focus of this revision is to adjust the ratings tables to coordinate with the revised scheme for representation of transient recovery voltage (TRV). The new TRV scheme has been defined and elaborated in IEEE Std C37.04b-2008, IEEE PC37.09b (Draft 3, September 2009), and IEEE Std C37.010-2005, and this revision brings ANSI C37.06-2000 into harmony with these documents.

The manner of representing the TRV has been changed as part of a major effort to harmonize with the TRV requirements in IEC 62271-100:2008 [B5]. Accompanying this change in the TRV representation is the introduction of the rate of rise of recovery voltage (RRRV) ratings.

The representation of TRV in this revision is harmonized with that in IEC 62271-100:2008 [B5]. (A joint IEEE and IEC task force working group was established to solve the problem of TRV envelopes). The new TRV capability of circuit breakers according to IEEE Std C37.04b-2008 is described by two- or four-parameter envelopes rather than the former "1–cosine" and "exponential-cosine" envelopes used in previous editions of this standard. The two-parameter method is used on voltages below 100 kV, and the four-parameter method is used at 100 kV and above. Comprehensive explanations of the two-parameter and the four-parameter methods are provided in this standard.

The technical data of the tables remains very much the same, except that some ratings have been updated to reflect the requirements of the users. In particular, the tables now reflect a first pole to clear factor of 1.3 and 1.5 for effectively grounded and non-effectively grounded systems respectively.

In order to keep the tables of reasonable size, it has been necessary to add tables with the data for the new representation of TRV values. These tables make the ratings easier to understand and simplify use during power testing. The tables provide the TRV values for 100% terminal faults (T100), as well as for 60%, 30%, and 10% terminal faults (T60, T30, T10), plus the short-line fault and the out-of-phase switching conditions.

Many technical comments have been given in the text along with curves, or details have been listed explicitly in the tables to assist with a summary understanding of the phenomena involved. The explanatory information clauses for the tables are indicated in clauses that follow the tables. It is noted that according to

[a] Information on references can be found in Clause 2.
[b] The numbers in brackets correspond to those of the bibliography in Annex C.

the IEEE formatting, the Notes on tables are normative (mandatory part of the standard) and that Notes to the text are informative.

Harmonization of voltages was begun with the adoption of 550 kV and 800 kV, replacing 525 kV and 765 kV respectively, in IEC. The transmission voltage classes of 121 kV, 169 kV, and 242 kV were changed to 123 kV, 170 kV and 245 kV (maximum voltages) respectively listed in ANSI C37.06-1997 to complete the harmonization of voltages with IEC.

New symbols for the recovery voltage given in IEEE Std C37.04b-2008 are used in this document, and the correlation between the new and the old symbols is discussed in the "Information" clause referenced in the footnote of the affected tables. The new symbols and TRV representation are in harmony with the revised IEEE Std C37.011™-2005.

To facilitate use of the tables, the individual lines and columns have been identified with line numbers and column numbers.

The TRV values have been revised to reflect the new representation of the TRV, but other key values have not been changed from the 2000 edition.

Throughout this document, the term *peak* traditionally associated with the maximum value of transient or periodic waveform is used. This continues the practice introduced in the 1997 edition, which substituted *peak* for the previously used *crest* term.

In an effort to harmonize with IEC 62271-series standards, new terms *Class S1* and *Class S2* are used to denote traditional terms as *indoor* or *outdoor*. The term *Class S1* circuit breakers is for cable systems (historical predominant use was for indoor circuit breakers) and the term *Class S2* circuit breakers is for overhead line systems (historical predominant use was for outdoor circuit breakers). Definitions are included in IEEE Std C37.04b-2008.

General notes

1) For the previous 1-cosine standard waveform envelope, the time-to-peak (T_2) value is equal to 1.138 times the (t_3) parameter value listed in this standard. This is a purely mathematical translation to fit the new TRV representation. The actual TRV that the circuit breaker must withstand is essentially identical under the old system as in the new system. The restated TRV values are consistent with an amplitude factor of 2.0, namely for non-damped systems. The old envelopes were characterized by the time-to-peak value (T_2) and the peak (E_2) was the focal point of the old TRV. In the new scheme, the parameters are (t_3) and (u_c).

2) The titles of the tables include the term *prospective TRV* to emphasize that the TRV ratings are for the prospective (inherent to the system) TRVs that would result if unmodified by the interruption process either by the arc voltage, circuit-breaker capacitance, capacitors, and/or of any resistor insertion designed in the circuit breaker.

Specific notes on individual tables

Table 1—The data in Table 1 is essentially the same as in Table 1 of ANSI C37.06-2000 edition for indoor circuit breakers. It has been redesignated for Class S1 circuit breakers, those connected by cables rather than directly to overhead lines. The TRV data has been relocated to Table 2 and Table 3. The historic voltage range factor K has been dropped, as it was eliminated from the rating structure in the 1999 revision of IEEE Std C37.04-1999.

Circuit breakers designed and tested in accordance with the 1979 (or earlier) editions of IEEE C37.04-1999 and IEEE Std C37.09-1999, with a voltage range factor K greater than 1.0, should be applied in accordance with the older standards. The preferred ratings for such circuit breakers are shown in ANSI C37.06-1987.

Table 2 and Table 3—These tables contain the expanded TRV data values for the new two-parameter method representation of TRV for circuit breakers rated below 100 kV. The old "rated time-to-peak" (T_2) values for TRV have been replaced by the new t_3 values in accord with IEEE Std C37.04b-2008. The values are harmonized with the values in IEC 62271-100:2008 [B5] and are based on an amplitude factor of 1.40 for the T100 terminal fault. Table 2 includes values for T100 terminal fault and out-of-phase test conditions, while Table 3 includes values for T100, T60, T30, and T10 terminal faults.

Table 4—This table presents the preferred capacitance current switching ratings for Class S1 circuit breakers applied to capacitance switching classes C0, C1, and C2, in accordance with IEEE Std C37.09a-2005 and C1 and C2 coordinated with IEEE Std C37.04a-2003 and the revised application guide IEEE Std C37.012-2005.

Table 5—This table is similar to new Table 1, but includes the preferred ratings for Class S2 circuit breakers, connected directly to overhead lines. In the 2000 edition, these circuit breakers were designated as outdoor circuit breakers. The values are unchanged from the 2000 edition, except that TRV values have been transferred to new Table 6 and Table 7, and restated in the new two-parameter method representation.

Table 6 and Table 7—These tables contain two-parameter method TRV data reformatted in the same manner as Table 2 and Table 3, except that the short-line fault TRV values for outdoor circuit breakers are added to Table 6. The TRV values are based on an amplitude factor of 1.54 for the T100 terminal fault, as in the 2000 edition.

Table 8—This table presents the preferred capacitance current switching ratings for Class S2 circuit breakers (voltage classes below 100 kV) applied to capacitance switching for classes C0, C1 and C2, in accordance with IEEE Std C37.09a-2005, and coordinated with IEEE Std C37.04a-2003 and the revised application guide IEEE Std C37.012-2005 for C1 and C2 applications with voltages rated below 100 kV. The Capacitor Subcommittee of the IEEE PES Transmission and Distribution Committee suggested updated values.

Table 9—This table provides preferred ratings for outdoor circuit breakers rated 100 kV and above. It has been modified in a manner similar to Table 5, and TRV values have been transferred to new Table 10, Table 11, Table 12, and Table 13.

Table 10, Table 11, Table 12, and Table 13—These tables contain revised TRV requirements for circuit breakers rated 100 kV and above. Table 10 and Table 11 include values for T100 terminal fault, short-line fault, and out-of-phase conditions using the four-parameter representation of TRV. The values in these two tables differ by the first pole to clear factor ($\mathbf{k_{pp}}$), 1.3 for Table 10 and 1.5 for Table 11. Table 12 and Table 13 contain the corresponding values for T100, T60, T30, and T10 terminal faults, based on the four-parameter method TRV representation for T100 and T60, and the two-parameter method representation for T30 and T10 terminal fault conditions.

Table 14—This table presents the preferred capacitance current switching ratings for classes C0, C1, and C2 in accordance with IEEE Std C37.09a-2005, and coordinated with IEEE Std C37.04a-2003 and the revised IEEE Std C37.012-2005 for C1 and C2, for voltages rated 100 kV and above. The Capacitor Subcommittee of the IEEE PES Transmission and Distribution Committee suggested updated values.

Table 15—This table presents preferred dielectric withstand ratings. It contains no significant changes from Table 4 in the 2000 edition. Lines 5, 7, 10, 12 were added to include the characteristics of some vacuum circuit breakers in service. The interrupter full-wave withstand was removed in the 1997 version, but reinstated (as a Note) in the 2000 revision. Also in the 2000 edition, the creepage distances were revised to coordinate with IEEE Std C37.010-1999.

Table 16—This table presents preferred dielectric withstand ratings for circuit breakers in gas-insulated substations, previously in Table 5 of the 2000 edition. Some ratings were added to represent what is

manufactured today. Medium voltage ratings have been added, and the 3 μs chopped wave test requirements have been removed to harmonize with IEC.

Table 17—This table presents the schedule of operating endurance capabilities for circuit breakers. Minor modifications have been made.

Table 18—This table presents rated control voltage data, previously in Table 8 of ANSI C37.06-2000. Minor modifications have been made to coordinate with IEEE Std C37.90™-2005 [B8].

Table 19—This table presents minimum reclosing time values, previously in Table 7 of ANSI C37.06-2000. There is no change in content.

Annex A (normative)—This annex describes the symbols used in the tables and is a summary of symbols taken from IEEE Std C37.04b-2008.

Annex B (normative)—This annex describes the symbols used in the tables, and is a summary of symbols taken from IEEE Std C37.04b-2008.

Voltage range factor >1.0—Users should consult ANSI C37.06-1987 when applying indoor circuit breakers with a rated voltage range factor K greater than 1.0.

Line closing switching surge factors—Users should consult ANSI C37.06-1987, Table 7, for line-closing switching surge factors for special purpose 362 kV to 800 kV circuit breakers. Such factors are not circuit-breaker ratings and are based on system characteristics. The table on line closing switching surge values (Table A2 in ANSI C37.06-2000) has been eliminated. Line closing switching surge values were not "ratings" and were the result of a calculation, and not demonstrated during any design test. The reader is referred to ANSI C37.06-1987 and IEEE Std C37.04-1979 for the historical data and discussion.

NOTE 1—Footnotes following tables are normative, i.e., they form part of the table. [c]

NOTE 2—Notes to clauses in the standard are informative, i.e., they are for information and clarification.

NOTE 3—Users are reminded that use of this standard requires selection of one or more alternatives from some of the tables.

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Contents

IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis—Preferred Ratings and Related Required Capabilities for Voltages Above 1000 V

1. Overview

1.1 Scope

This standard applies to all indoor and outdoor types of ac high-voltage circuit breakers rated above 1000 V and rated on a symmetrical current basis.

1.2 Purpose

Inconsistency in application of preferred ratings of high-voltage circuit breakers may result in wrong application of interrupting current and voltage levels.

The recommendations outlined in the following clauses are intended to provide consistent functionality for high-voltage circuit breakers rated above 1000 V.