

IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures

Sponsor

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of the
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Abstract: This standard covers enclosed low-voltage dc power circuit breakers of the stationary or draw-out type of single- or two-pole construction with one or more rated maximum voltages of 300 V, 325 V, 800 V, 1200 V, 1600 V, or 3200 V for applications on dc systems having nominal voltages of 250 V, 275 V, 750 V, 1000 V, 1500 V, or 3000 V, with general-purpose, high-speed, semi-high-speed and rectifier circuit breakers; manually or power-operated; and with or without electro-mechanical or electronic trip devices. It deals with service conditions, ratings, functional components, temperature limitations and classification of insulating materials, dielectric withstand voltage requirements, test procedures, and application.

Keywords: current-limiting, general purpose, high-speed, impulse trip device, reverse-current trip device, semi-high-speed or rectifier circuit breaker.

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

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Introduction

(This introduction is not a part of IEEE C37.14-1999, IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures.)

IEEE Std C37.14-1979 superseded IEEE Std C37.14-1969 to properly recognize the widespread use of solid-state rectifiers in industry, particularly for the traction power systems that evolved in the 1970s. It was based on known applications, as well as considerations for future system development, with basic ratings and tests evolving from the classic mathematical solutions available at the time.

The revision working groups for IEEE Std C37.14-1992 concluded that certain major changes were necessary. One of the changes made was the replacement of the 1200 V maximum design rating with a new 1000 V rating. Dielectric withstand test voltages were correspondingly increased.

This latest revision of IEEE Std C37.14 reestablishes the 1200 V maximum design rating and removes the 1000 V maximum design rating, while keeping the increased dielectric withstand voltages. This change recognizes the existence of installed 1200 V maximum design rated systems and also maintains a more uniform division between steps of preferred maximum design ratings. This revision also attempts to clarify endurance design test requirements in order to eliminate confusion on the number of electrical operations required. There is a specific requirement to perform one group of no less than 120 consecutive close-open operations during electrical endurance testing.

Some considerations addressed in the 1992 revision and retained here are as follows.

The need for lower-rated circuit breakers for light-duty transit systems, which are generally 800 V catenary surface systems, was recognized. The power requirements are approximately one-half those of a heavy-duty transit system, with the rectifier circuit breakers requiring maximum continuous current ratings of 4000 A and feeder circuit breakers with proportionately lower ratings. Tables 12 and 12A were replaced with a new Table 12 in ANSI C37.16-1997, which was revised to reflect a reduced base rating of 4000 kW in order to provide a lower level of design rated circuit breakers, which allows the use of designs different from those utilized for heavy-duty systems.

The question of rectifier and feeder circuit breakers being rated identically was previously addressed in the IEEE Std C37.14-1979 appendix, but this has now been recognized and addressed in the body of the standard. Specific installation applications normally differentiate rating requirements between rectifier and feeder breakers in the reverse/forward-current tripping modes, as well as in the short-time/momentary rating modes. Therefore, it is important to recognize this difference in rating structures to provide for realistic design ratings and testing.

The designs of high-speed and semi-high-speed circuit breakers with two different rating/test tables were conceptually reviewed, and recognition of actual field application conditions forced a concept change. A given track system will produce given short-circuit currents and circuit stored energy at various locations regardless of the circuit breaker type applied. Thus, there is a need for only two tables: one for low-frequency impedance bonds and one for high-frequency impedance bonds. Actually, the high-speed type circuit breaker is truly current-limiting by limiting let-through current to less than the available (prospective) peak in all cases. The semi-high-speed type is “semi-current limiting,” limiting let-through current to less than the sustained in all cases, except in allowing the maximum peak current available to flow on low inductance (close-in) faults.

Any dc circuit breaker must be capable of handling all short-circuit conditions based on the speed of operation, current interrupted, and circuit energy interrupted as verified by the short-circuit tests “a,” “b,” “c,” and “d” of Tables 11, 11A, and 12 in the latest version of ANSI C37.16-1997. It is noted for comparison that ac low-voltage power circuit breakers are required by ANSI C37.50-1989 to be tested in four sequences for certification/conformance. Similar analysis of required testing resulted in the assignment of two sequences in the 1992 standard.

Depending on transformer/rectifier design impedance, coupled with primary short-circuit current capacity and a low dc inductance, it may be possible to obtain a higher peak current and/or sustained current under certain conditions. This design combination needs to be properly investigated and applied to prevent overrating of all circuit breakers that cannot be rated higher than the rated peak and sustained currents listed in the preferred rating tables in ANSI C37.16-1997.

This standard represents the standard practice in the United States for low-voltage dc circuit breakers. Molded case circuit breakers are covered by other standards, but in some instances may be able to meet this standard.

There is presently no specific IEC LV dc circuit breaker standard. IEC 60947-2 (1995-12) covers both ac and dc breakers to 1000 VDC and 1500 VDC, but is limited to breakers of 2500 A rated current and 50 kA short-circuit breaking capacity. Circuit breakers for traction applications are not addressed. There is also an IEC 60077 (1968-01), which applies only to electrical equipment installed on motive power units.

Participants

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

E. Byron, Chair

Andrew K. McCabe, Vice Chair, High-Voltage Standards

J. C. Scott, Vice Chair, Low-Voltage Standards

D. L. Swindler, Vice Chair, IEC Activities

<i>Organization Represented</i>	<i>Name of Representative</i>
Edison Electric Institute (EEI)	T. E. Bruck (<i>Alt.</i>) D. E. Galicia Joseph L. Koepfinger D. G. Komassa Gary Miller J. H. Provanzana
Institute of Electrical and Electronics Engineers	Steve C. Atkinson (<i>Alt.</i>) L. R. Beard Peter W. Dwyer David G. Kumbera (<i>Alt.</i>) Lawrence V. McCall (<i>Alt.</i>) A. Monroe David F. Peelo Dean Sigmon
MET Electrical Testing Association	Leonard Frier
National Electric Contractors Association	Darrell Harwood
National Electrical Manufacturers Association	E. Byron (<i>Alt.</i>) Ruben D. Garzon Gary T. Jones (<i>Alt.</i>) William Kracht Lee H. Miller T. Olsen G. Sakats (<i>Alt.</i>) David L. Stone D. L. Swindler (<i>Alt.</i>)
Tennessee Valley Authority	David N. Reynolds
Underwriters Laboratories	P. Notarian
US Department of the Army, Office of the Chief of Engineers	John A. Gilson
US Department of the Navy, Construction Battalion Center	Romulo R. Nicholas
Western Area Power Administration	Gerald D. Birney

The personnel of the IEEE Working Group of the Low-Voltage Switchgear Devices Subcommittee, IEEE Switchgear Committee, who developed this document were:

G. R. Nourse, *Chair*

W. E. Laubach

D. Mazumdar
M. D. Sigmon

P. G. H. Wong

The following members of the balloting group voted on this standard:

M. P. Baldwin
T. Burse
E. R. Byron
T. R. Childer
J. F. Christensen
A. Dixon
P. W. Dwyer
D. J. Edwards
R. D. Garzon
M. Glinkowski
D. Gohil
K. I. Gray

H. L. Hess
D. G. Kumbera
S. R. Lambert
W. E. Laubach
G. N. Lester
L. V. McCall
N. P. McQuin
P. J. Notarian
G. R. Nourse
T. W. Olsen
G. O. Perkins
R. J. Puckett
H. C. Ross

G. Sakats
L. H. Schmidt
M. D. Sigmon
G. St. Jean
A. D. Storms
D. Swindler
C. Z. Tailor
S. H. Telander
F. C. Teufel
C. L. Wagner
P. G. H. Wong
L. E. Yonce

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E. G. "Al" Kiener
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L. Bruce McClung
Daleep C. Mohla
Robert F. Munzner

Louis-François Pau
Ronald C. Petersen
Gerald H. Peterson
John B. Posey
Gary S. Robinson
Akio Tojo
Hans E. Weinrich
Donald W. Zipse

*Member Emeritus

Noelle D. Humenick
IEEE Standards Project Editor

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IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures

1. Scope

This standard covers the following types of enclosed low-voltage dc power circuit breakers:

- a) Stationary or draw-out type of one- or two-pole construction;
- b) Having one or more rated maximum voltages of 3200 V, 1600 V, 1200 V, 800 V, 325 V, or 300 V for applications on systems having nominal voltages of 3000 V, 1500 V, 1000 V, 750 V, 275 V, or 250 V;
- c) Manually-operated or power-operated; and
- d) With or without overcurrent trip devices.

NOTE—In this standard, the use of the words “circuit breaker” shall be considered to mean “enclosed low-voltage dc power circuit breaker.”

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

ANSI C37.16-1997, American National Standard for Switchgear—Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors—Preferred Ratings, Related Requirements, and Application Recommendations.¹

ANSI C37.17-1997, American National Standard for Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers.

IEEE Std 1-1986, IEEE Standard General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.²

¹ANSI 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/>).

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

IEEE Std 4-1995, IEEE Standard Techniques for High-Voltage Testing.

IEEE Std C37.20.1-1993, IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

IEEE Std C37.100-1992, IEEE Standard Definitions for Power Switchgear.

3. Definitions

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 these terms. They are applicable only to the subject treated in this standard.

The definitions of most terms used in this standard are found in IEEE Std C37.100-1992.³

3.1 circuit breaker, general purpose low-voltage dc power: A circuit breaker that, during interruption, does not limit the current peak of the available (prospective) fault current and may not prevent the fault current from rising to its sustained value.

NOTE—This design circuit breaker requires a peak, a short-time, and a short-circuit current rating.

3.2 circuit breaker, high-speed low-voltage dc power: A circuit breaker that, during interruption, limits the current peak to a value less than the available (prospective) fault current.

NOTE—This design circuit breaker requires a short-circuit current rating and may have a short-time current rating assigned.

3.3 circuit breaker, semi-high-speed low-voltage dc power: A circuit breaker that, during interruption, does not limit the current peak of the available (prospective) fault current on circuits with minimal inductance, but that does limit current to a value less than the sustained current available on higher inductance circuits.

NOTE—This design circuit breaker requires a peak and a short-circuit current rating, and may have a short-time current rating assigned.

3.4 circuit breaker, rectifier low-voltage dc power: A circuit breaker that carries the normal current output of one rectifier and during fault conditions, functions to withstand and/or interrupt abnormal current as required.

NOTES

1—This design circuit breaker requires a short-circuit current rating for $n-1$ rectifiers and a short-time current rating for its own rectifier.

2—For total performance at other than test circuit parameter values, consult the manufacturer.

3.5 trip device (opening release), impulse: A trip device that is designed to operate only by the discharge of a capacitor into its release (trip) coil and is utilized on high-speed circuit breakers to produce the tripping times that are independent of di/dt .

³Information on references can be found in Clause 2.

4. Service conditions

A circuit breaker conforming to this standard shall be suitable for operation up to and including all of its standard ratings, providing that:

- a) The temperature of the air surrounding the circuit breaker is not below -5°C (23°F);
- b) The altitude does not exceed 2000 m (6600 ft)⁴;
- c) The relative humidity of the air surrounding the circuit breaker is such that there will be no condensation on the circuit breaker parts at any time; and
- d) None of the conditions listed in 10.5.2 prevail.

NOTE—When properly applied in metal-enclosed power switchgear or individual enclosures, a circuit breaker will operate within the limits of ambient temperature of the air surrounding the enclosure as specified in IEEE Std C37.20.1-1993.

Whenever the service conditions vary from those defined in this clause, consultation between the user and manufacturer is recommended. Some of the service conditions that may require additional attention are listed in 10.5.2.

5. Ratings

5.1 Rating information

The rating of low-voltage dc power circuit breakers is a designated limit of operating characteristics based upon the service conditions of Clause 4 and shall include the following, as applicable.

- a) Rated maximum voltage(s)
- b) Rated continuous current
- c) Rated peak current
- d) Rated short-time current
- e) Rated short-circuit current
- f) Rated control voltage(s)

The designated ratings in ANSI C37.16-1997 are preferred, but are not to be considered restrictive.

5.2 Rated maximum voltage

The rated maximum voltage of a circuit breaker is the highest average dc voltage at which it is designed to perform with a recurring crest voltage no higher than that which occurs with a three-phase full-wave bridge rectifier. The circuit breakers shall be rated at one of the maximum rated voltages as specified in ANSI C37.16-1997.

5.3 Rated continuous current

The rated continuous current of a circuit breaker is the designated limit of sustained current in rms amperes that it shall require to carry continuously without exceeding the temperature limitations designated in Clause 7. The preferred continuous current ratings of the various frame sizes are listed in ANSI C37.16-1997. The rated continuous current of a circuit breaker, which is equipped with direct-acting

⁴Altitude limits are presently under review by the IEEE Switchgear Committee Common Clause Working Group.

trip devices of a smaller rating than the frame size of the circuit breaker, is determined by the rating of those devices.

5.4 Rated peak current

The rated peak current of a circuit breaker is the designated limit of nonrepetitive available (prospective) peak amperes that it shall require to close into and still be able to open and then close. This rating will apply to circuit breakers having direct-acting instantaneous trip devices active in the direction of the current flow.

5.5 Rated short-time current

The rated short-time current of a circuit breaker is the designated limit of available (prospective) sustained current in rms amperes that it shall require to carry for a period of 250 ms without impairing its ability to operate and perform all other ratings. This rating will apply both without direct-acting instantaneous trip devices and with current flow in the nonactive direction of polarized direct-acting instantaneous trip devices.

This rating also requires that the circuit breaker be able to withstand a peak current equal to at least 1.65 times the value of its rated short-time current occurring approximately 8 ms after the start of the current flow.

5.6 Rated short-circuit current

The rated short-circuit current of the circuit breakers is the designated limit of available (prospective) rms current in amperes at which they shall be required to perform their short-circuit current duty cycle of Open - 15 seconds - Close-Open (O - 15 s - CO) at rated maximum voltage and under the prescribed test conditions given in 9.2.7.

5.6.1 General-purpose dc circuit breakers

The preferred ratings are listed in Table 8 of ANSI C37.16-1997.

5.6.2 General-purpose dc circuit breakers for mining operations

The preferred ratings are listed in Table 10 of ANSI C37.16-1997.

5.6.3 Semi-high-speed dc circuit breakers

The preferred ratings are listed in Tables 11 and 11A of ANSI C37.16-1997.

5.6.4 High-speed dc circuit breakers

The preferred ratings are listed in Tables 11 and 11A of ANSI C37.16-1997.

5.6.5 Rectifier dc circuit breakers

The preferred ratings are listed in Tables 11 and 11A of ANSI C37.16-1997.

NOTE—Any applicable type circuit breaker may be utilized to meet Table 12 requirements.

5.7 Rated-control voltage

The rated-control voltage is the voltage at which the mechanism of the circuit breaker is designed to operate when measured at the control power terminals of the operating mechanism with operating current flowing.

Rated control voltages and their ranges for low-voltage power circuit breakers are listed in Table 23 of ANSI C37.16-1997.

NOTE—Mining circuit breakers may require control voltage up to 325 V.

6. Functional components

The functional components required for manually and power-operated circuit breakers are listed in Table 1. Additional accessory devices may be available. The manufacturer should be consulted for specific information.

Table 1—Functional components

Functional component	General purpose dc circuit breakers ^a ; Frame size 600–6000 A		Rectifier or feeder Semi-high-speed and high-speed dc circuit breakers; Frame size 1200–12 000 A
	Operating mechanism type		
	Manual	Power	
Direct-acting trip device (calibrated in accordance with ANSI C37.17-1997)	X ^b	X ^b	—
Overcurrent release (in response to forward or reverse current flow as necessary)	—	—	X ^b
Manual trip device	X	X	X
Contact position indicator—in accordance with 6.2	X	X	X
Manually-operated mechanism, trip-free with standard operating handle	X ^c	—	—
Power-operated mechanism, trip-free, with anti-pump feature and maintenance closing device	—	X	X
Shunt trip device or opening release with necessary control auxiliary switches	—	X	X
Stored energy indicator—in accordance with 6.3	X ^d	X ^d	X ^d
Locking—in accordance with 6.4	X	X	X
Nameplate(s), with markings, in accordance with 6.1	X	X	X

^aGeneral-purpose dc circuit breakers for mining applications are not covered in this table; the manufacturer should be consulted for functional components.

^bAs required by the application.

^cManually-operated circuit breakers 3000 A and above shall be furnished with closing mechanisms that provide for only independent manual operation.

^dRequired only on closing mechanisms that provide for stored energy operation when the mechanism can be left in the charged position.