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IEEE Standard for DC (3200 V and below) Power Circuit Breakers Used in Enclosures

IEEE Power and Energy Society

Sponsored by the
Switchgear Committee

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USA

IEEE Std C37.14™-2015
(Revision of
IEEE Std C37.14-2002)

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Approved 26 March 2015

IEEE-SA Standards Board

Abstract: Enclosed dc power circuit breakers of the stationary or drawout 32 type of one- or two-pole construction with one or more rated maximum voltages of 300 V, 325 V, 33 600 V, 800 V, 1000 V, 1200 V, 1600 V, or 3200 V for applications on dc systems having nominal 34 voltages of 250 V, 275 V, 500 V, 750 V, 850 V, 1000 V, 1500 V, or 3000 V, with general-purpose, 35 high-speed, semi-high-speed and rectifier circuit breakers; manually or power-operated; and with 36 or without electromechanical or electronic trip devices are covered in this standard. Service conditions, ratings, 37 functional components, temperature limitations and classification of insulating materials, dielectric 38 withstand voltage requirements, test procedures, and application are dealt with in this standard.

Keywords: current-limiting, direct-acting trip, general purpose, high-speed, IEEE C37.14™, impulse trip device, mining duty, reverse-current trip device, semi-high-speed or rectifier circuit breaker

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PDF: ISBN 978-0-7381-9711-1 STD20223
Print: ISBN 978-0-7381-9712-8 STDPD20223

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Introduction

This introduction is not part of IEEE Std C37.14™-2015, IEEE Standard for DC (3200 V and below) Power Circuit Breakers Used in Enclosures.

IEEE Std C37.14-1979 superseded IEEE Std C37.14-1969, and included recognition of the widespread use of solid-state rectifiers in industry, particularly for the traction power systems that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 group 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.

The revision working group maintained the peak-current multiplier of 1.65 times the sustained current, even though it can be shown that a multiplier of 1.42 can be utilized for 12-pulse rectifier designs. However, since the 6-pulse rectifier designs can produce the 1.65 peak, and because of unknown future applications with additional and/or replacement circuit breakers, it was preferred to maintain the 1.65 value.

Rated peak current was maintained as a rating because depending on the transformer/rectifier-design impedance coupled with the primary short-circuit current capacity and a lower dc inductance, it may be possible to obtain a higher peak current and/or sustained current, depending on conditions. This design combination should be investigated to prevent inadvertent application of circuit breakers above their ratings.

Some considerations that were addressed in the IEEE Std C37.14-1992 revision are as follows:

a) 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 C37.16a, 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 differing from those utilized for heavy-duty systems.

b) The question of rectifier and feeder circuit breakers being rated identically was previously addressed in the IEEE C37.14-1979 appendix, but this was now recognized and addressed in the body of the standard. Specific installation applications normally differentiate rating requirements between rectifier and feeder circuit 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.

c) 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 should produce given short-circuit currents and circuit stored-energy at various locations regardless of circuit breaker type applied. Thus, there is a need for only two tables: one for low frequency, 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 current in all cases except in allowing the maximum peak current available to flow on low-inductance (close-in) faults.

IEEE Std C37.14-1999 reestablished the 1200 V maximum design rating, and removed the 1000 V maximum design rating, while keeping the increased dielectric withstand voltages. This change recognized the existence of installed 1200 V maximum design rated systems and also maintained a more uniform

division between steps of preferred maximum design ratings. IEEE Std C37.14-1999 also clarified 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.

IEEE Std C37.14-2002 again reestablished the 1000 V maximum design rating, while also retaining the 1200 V rating, in order to recognize the recent development and use of 1000 V maximum-design rated circuit breakers. Corresponding changes were made by NEMA to Table 11 and Table 11A of ANSI C37.16-2000, which established the preferred ratings for low-voltage power circuit breakers. Dielectric withstand test voltages were also relaxed for the 800 V and 1000 V maximum design ratings so as to differentiate from the 1200 V rating.

Another consideration of IEEE Std C37.14-2002 was that any dc circuit breaker shall 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 test "a," test "b," test "c," and test "d" of Table 11, Table 11A, and Table 12 in ANSI C37.16-2000. It was noted for comparison that ac low-voltage power circuit breakers are required by ANSI C37.50-1989 to be tested in four (4) sequences for certification/conformance. Similar analysis of required testing resulted in the assignment of two (2) sequences in IEEE Std C37.14-1992 standard.

IEEE Std C37.14-2002 acknowledged that 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 C37.16-2000.

The working group for the present revision undertook another significant evolution of this standard. Some of the most significant considerations were as follows:

a) General-purpose dc ratings were capped at 325 V in previous editions. In recent years, many additional dc applications have risen for voltages between 325 V and 1500 V. This revision addresses these voltages, and associated requirements, which has resulted in a number of requirements throughout the document.

b) The preferred ratings, as applicable to dc power circuit breakers, have been incorporated from IEEE Std C37.16™, as IEEE Std C37.16 will be withdrawn when IEEE Std C37.13™ and IEEE Std C37.14 have been revised to incorporate the information previously included within IEEE Std C37.16. This resulted in significant restructuring of the document:

    1) A new clause has been introduced with preferred frame sizes.

    2) Preferred ratings have been introduced to "Ratings," eliminating the references to IEEE Std C37.16. This also led to the inclusion of requirements regarding control voltages.

    3) The application specific preferred ratings and test conditions have been added as additional annexes, with one annex for general-purpose, and an additional annex for high-speed, semi-high-speed, and rectifier circuit breakers for use in traction power applications.

    4) The preferred rating table describing the preferred overcurrent performance of high-speed, semi-high-speed, and rectifier circuit breakers for use in systems with high frequency bonds had initially been removed. High or low frequency bonds is not a rating, but an application condition, and therefore it was open-ended as to which table was to be used for conformance testing. The working group considered the low frequency bonding to be the worst case application, but due to the prevalence of circuit breakers qualified in accordance to the test circuits for high frequency bonding, both the low frequency bonding tables and the high frequency bonding tables were retained, with the additional marking requirement for inclusion of the test circuit's load circuit time constant on the nameplate.

c) Clarifications have been made with regard to required functional components. The most significant changes are:

   1) Dependent-manual operation has been removed as a preferred construction type based on working group concerns about testing (dependence of speed of operation) and because dependent-manual operation is inconsistent with general recommended safety practices.

   2) At the request of users, it is now required that for drawout circuit breakers, primary disconnect assemblies shall be located on the drawout (removable) element for inspection and maintenance purposes. This philosophy is consistent with the ac power circuit breakers described in IEEE Std C37.13.

   3) Requirements for bonding of metallic components that are intended to be grounded for operator safety conditions have been added. Consideration has been given for applications where the intended application may or may not actually be directly connected to ground.

d) Requirements have been added for flame resistance, thermal characteristics, and tracking resistance of insulating materials both in contact and not in contact with primary voltage.

e) With the increased application of solid state trip systems in dc applications, additional testing considerations were added for solid state trip systems. A new test sequence has been added for determining resistance to electromagnetic interference, and surge withstand capability.

f) Qualification of accessory devices has been added in this version, including auxiliary switches and undervoltage trip devices.

g) With consideration that many dc power circuit breakers are third party certified, and of customer requirements for product performance test data, a new clause has been added for production monitoring and product retest requirements.

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

Presently, there are no IEC standards that fully apply to dc power circuit breakers. Several IEC standards apply in part to dc power circuit breakers:

a) IEC 60947-2 [B3][a] applies to industrial circuit breakers with rated voltages which do not exceed 1000 vac or 1500 vdc.

b) Circuit breakers for traction applications are addressed by two IEC standards: IEC 60077-3 [B2] (dc circuit breakers installed on motive power units), and IEC 61992-2 [B4] (dc circuit breakers installed in fixed locations).

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

Contents

IEEE Standard for DC (3200 V and below) Power Circuit Breakers Used in Enclosures

1. Overview

1.1 Scope

This standard covers the following types, preferred ratings, and testing requirements of enclosed dc power circuit breakers:

a) Stationary or drawout type of one- or two-pole functional construction

b) Having rated maximum voltages of up to 3200 V

c) Manually operated or power operated

d) With or without overcurrent trip devices

NOTE—In this standard, the use of the term "circuit breaker" is considered to mean "enclosed dc power circuit breaker."[1]

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