



IEEE Standard for Low-Voltage AC (1058 V and Below) Power Circuit Breakers Used in Enclosures

IEEE Power and Energy Society

Developed by the
Switchgear Committee

IEEE Std C37.13™-2024
(Revision of IEEE Std C37.13-2015)

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Switchgear Committee
of the
IEEE Power and Energy Society

Approved 12 November 2024

IEEE SA Standards Board

Recognized as an American National Standard

Abstract: The following enclosed low-voltage ac power circuit breakers are covered in this standard: a) stationary or drawout type of two-, three-, or four-pole construction, with one or more rated maximum voltages of 1058 V, 730 V, 635 V (600 V for units incorporating fuses), 508 V, or 254 V for application on systems having nominal voltages of 1000 V, 690 V, 600 V, 480 V, or 240 V; b) unfused or fused circuit breakers; c) manually or power operated; and d) with or without electromechanical or electronic trip devices. Service conditions, ratings, functional components, temperature limitations and classifications of insulating materials, insulation (dielectric) withstand voltage requirements, test procedures, application, and the preferred ratings are discussed in this standard.

Keywords: circuit breaker, fused circuit breaker, IEEE C37.13™, low-voltage ac power circuit breaker, open-fuse trip device, unfused circuit breaker

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Introduction

This introduction is not part of IEEE Std C37.13-2024, IEEE Standard for Low-Voltage AC (1058 V and Below) Power Circuit Breakers Used in Enclosures.

The 2024 revision of IEEE Std C37.13 incorporates significant changes since the 2015 edition with respect to rating structures, test requirements, time-current curve documentation, and application information.

The first notable area of change is the introduction of rating classes. Historically, IEEE Std C37.13 has classified all low-voltage power circuit breakers as general-purpose—encompassing worst-case testing protocols for thermal testing, overload testing, endurance testing, and short-circuit testing. However, with the widespread growth of renewable energy generation systems, new topologies, and applications within low-voltage power systems have brought about new requirements to support emerging markets. Likewise, some power system configurations have increased in application as well as others being depreciated because of aspects related to personnel and equipment safety factors such as ground fault and arc-flash associated with electrical equipment grounding. Voltage levels within the band of low-voltage have risen, affecting many aspects of power system design. This edition of IEEE Std C37.13 segregates these applications and associated requirements to clearly define minimum performance requirements and preferred ratings.

Another major area of revision is regarding the test requirements. This edition introduces a new [Annex A](#) for the definition of design test conditions and test sequences of low-voltage power circuit breakers. Historically, ANSI C37.50 was referenced for the majority of the design test requirements. [Annex A](#) reflects the design test conditions and test sequence requirements previously contained in ANSI C37.50 and has been updated to coordinate with changes made to IEEE Std C37.13 during this revision. A second annex, [Annex B](#), was introduced to cover accessory testing requirements.

A significant change was made regarding electromagnetic compatibility (EMC) testing. Previous testing procedures pointed to the IEEE C37.90 series; however, the scope of these documents is to mitigate the impact of EMC within protective relays. Requirements were revised to harmonize with IEC standards for EMC emissions and radiation tailored to circuit breaker applications.

[Annex C](#) is added to describe the method for determining the power factor associated with the test circuits described in [Annex A](#). Other methods, including the use of computerized or digital techniques, may be used; however, [Annex C](#) is included as a standardized method of validating results from these other methods.

Finally, the last major area of new work is the inclusion of an annex to describe minimum requirements for time-current curve descriptions. The leading edge of the time-current curve is critical for understanding selectivity capabilities. The trailing edge of the time-current curve also impacts selectivity but is also often applied to determine minimum personal protective equipment requirements. This annex creates uniform requirements for consistency across the electrical equipment industry.

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IEEE Standard for Low-Voltage AC (1058 V and Below) Power Circuit Breakers Used in Enclosures

1. Overview

1.1 Scope

This standard covers the following types and preferred ratings for enclosed low-voltage ac power circuit breakers:

- a) Stationary-mounted or drawout-mounted type of two-, three-, or four-pole construction with one or more rated maximum voltages of 1058 V, 730 V, 635 V (600 V for units incorporating fuses), 508 V, or 254 V for application on systems having nominal voltages of 1000 V, 690 V, 600 V, 480 V, or 240 V respectively
- b) Unfused or fused type
- c) Manually operated or power operated, with or without a trip system
- d) Fused drawout-mounted assemblies consisting of current-limiting fuses in a drawout-mounted assembly intended to be connected in series with a low-voltage ac power circuit breaker to form a nonintegrally fused circuit breaker

In this standard, the term circuit breaker shall mean enclosed low-voltage ac power circuit breaker, either fused or unfused. The term unfused circuit breaker shall mean a circuit breaker without either integrally or nonintegrally mounted fuses, and the term fused circuit breaker shall mean a circuit breaker incorporating current-limiting fuses, whether integrally mounted or nonintegrally mounted.

1.2 Purpose

This standard:

- a) Establishes minimal functional requirements.
- b) Establishes preferred rating structure.
- c) Provides preferred ratings.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{6, 7}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). 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 C37.50, American National Standard Switchgear—Low-Voltage AC Power Circuit Breakers Used in Enclosures—Test Procedures.⁸

ASTM D 229, Standard Test Methods for Rigid Sheet and Plate Materials Used for Electrical Insulation.⁹

FCC 47 CFR Part 15, Federal Communications Commission Part 15—Radio Frequency Devices.¹⁰

IEC 60073, Basic and safety principles for man-machine interface, marking and identification—Coding principles for indicators and actuators.¹¹

IEC 60947-2 (2019), Low-voltage switchgear and controlgear—Part 2: Circuit-breakers.

IEEE Std 4™, IEEE Standard Test Techniques for High-Voltage Testing.^{12, 13}

IEEE Std C37.09™, IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated Maximum Voltage above 1000 V.

⁶ The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁷ The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

⁸ 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/>).

⁹ ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (<http://www.astm.org/>).

¹⁰ <https://www.ecfr.gov/current/title-47/part-15>

¹¹ IEC publications are available from the Sales Department of the International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, CH-1211 Geneva 20, Switzerland (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA.

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IEEE Std C37.17™, IEEE Standard for Trip Systems for Low-Voltage (1000 V and below) AC and General Purpose (1500 V and below) DC Power Circuit Breakers.

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

IEEE Std C37.20.10™, IEEE Standard for Definitions for AC (52 kV and below) and DC (3.2 kV and below) Switchgear Assemblies.

UL 94, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.¹⁴

UL 248-1, Low-Voltage Fuses—Part 1: General Requirements.

UL 248-8, Low-Voltage Fuses—Part 8: Class J Fuses.

UL 248-10, Low-Voltage Fuses—Part 10: Class L Fuses.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply.

When multiple definitions exist, the definitions should be evaluated in the following priority:

- a) Definitions embedded in this standard shall be used.
- b) For terms not defined within this standard, the definitions within IEEE Std C37.20.10 shall be used.
- c) For terms not defined in either this standard or IEEE Std C37.20.10, the *IEEE Standards Dictionary Online* should be consulted.¹⁵

anti-pump (pump-free) device: A device that prevents reclosing after an opening operation as long as the device initiating closing is maintained in the position for closing.

clearing time (of a mechanical switching device): The interval between the time the actuating quantity in the main circuit reaches the value causing actuation of the release and the instant of final arc extinction on all poles of the primary arcing contacts.

definite-purpose circuit breaker: A circuit breaker that has been designed, tested, and rated in accordance with the requirements of one or more specific performance requirements.

direct-acting trip system: A tripping system that is completely self-contained on a switching device but does not require external power to function.

frame size: The maximum continuous current rating in amperes for all parts except coils and sensors of trip systems and the fuses (for fused circuit breakers).

¹⁴ UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (<http://global.ihs.com/>).

¹⁵ *IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

indirect-acting trip system: A tripping system that is completely self-contained on a circuit breaker but requires external power to function.

NOTE—Some indirect-acting trip systems hold the circuit breaker trip-free in the absence of control power.¹⁶

low-voltage fused power circuit breaker: An assembly of an ac low-voltage power circuit breaker with either integrally mounted or non-integrally mounted current-limiting fuses that function together as a coordinated protective device.

low-voltage integrally fused power circuit breaker: An assembly of an ac low-voltage power circuit breaker with current-limiting fuses integrally mounted to the circuit breaker that function together as a coordinated protective device.

low-voltage non-integrally fused power circuit breaker: An assembly of an ac low-voltage power circuit breaker and non-integrally mounted current-limiting fuses that function together as a coordinated protective device.

manual close device: A device that is connected to the closing linkage and that can be operated manually to close a switching device.

open-fuse trip device: A device that operates to open (trip) all poles of a switching device in response to the opening, or absence, of one or more fuses integral or nonintegral to the switching device with which the device is associated.

primary disconnecting devices (of a switchgear assembly): Self-coupling separable contacts provided to connect and disconnect the main circuits between the removable element and the housing.

NOTE—Primary disconnecting devices are often referred to as “primary disconnects.”

secondary disconnecting devices (of a switchgear assembly): Separable contacts provided to connect and disconnect the auxiliary and control circuit between the removable element and the housing.

NOTE—Secondary disconnecting devices are often referred to as “secondary disconnects.”

silver-surfaced or equivalent: Metallic materials having satisfactory long-term performance that operate within the temperature rise limits established for silver-surfaced electrical contact parts and conducting mechanical joints.

time-current curve (of a mechanical switching device): The correlated values of time and current that designate the performance of all or a stated portion of the functions of a mechanical switching device. The time-current curve for a mechanical switching device is generally presented as a curve and includes the minimum and maximum clearing time of the switching device.

time-overcurrent characteristic curve: The correlated values of time and current that designate the performance of all or a stated portion of the functions of a direct-acting or indirect-acting over-current trip device, or trip system, of a mechanical switching device. The time-overcurrent characteristic curve for a trip device or trip system is generally presented as a curve and includes the minimum and maximum opening time of the mechanical switching device. *See: time-current curve.*

trip-free: The capability of a switching device to have the moving contacts return to and remain in the open position when the opening operation is initiated after the initiation of the closing operation.

¹⁶ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

trip system response curve: The correlated values of time and current that designate the performance of all or a stated portion of the functions of a direct-acting or indirect-acting overcurrent trip device or trip system. The trip system response curve for a trip device or trip system are generally presented as a curve and does not include the opening or clearing times of the mechanical switching device. *See: time-overcurrent characteristic curve.*

3.2 Acronyms and abbreviations

CO	close-open operation of a switching device
HAI	high-current arc resistance to ignition
HWI	hot wire ignition
MOC	mechanism-operated contacts
O	opening operation of a switching device
PLC	performance level category (with regard to properties of insulating materials)
rms	root mean square
t	time delay between switching operations.
TOC	truck-operated contacts

4. Service conditions

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

- a) The temperature of the air surrounding the circuit breaker is not below -5°C .

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

- b) The altitude does not exceed 2000 m (6600 ft).
- c) The relative humidity of the air surrounding the circuit breaker is such that no condensation occurs on the circuit breaker parts at any time.
- d) None of the service conditions as listed in [D.8.3](#) prevail.

For the application of circuit breakers under service conditions other than those in item a) through item d), see [Annex D](#).

5. Ratings

5.1 General

The rating of a circuit breaker is a designated limit of operating characteristics based upon service conditions in [Clause 4](#) and shall include the following, as applicable:

- a) Rating class
- b) Rated maximum voltage(s)
- c) Rated power frequency(s)
- d) Rated frame size
- e) Rated continuous current
- f) Rated short-time-current
- g) Rated short-time current duration
- h) Rated short-circuit current at each rated maximum voltage
- i) Rated control voltage(s)

The designated ratings in this document are preferred but are not considered to be restrictive. Manufacturers may choose to offer, and users may elect to require, ratings that differ from those in this standard.

5.2 Rating class

Circuit breakers shall be classified based on the power system configuration within which they are intended to be applied. Each rating class designation shall be followed by the appropriate suffix, see [5.2.3](#).

5.2.1 Class I

Class I circuit breakers are considered to be general-purpose circuit breakers, suitable for application in the types of power systems outlined in [Table 1](#).

5.2.2 Class II

Class II circuit breakers are considered to be definite-purpose circuit breakers with restricted capabilities based on the type of power system. Class II circuit breakers shall only be used in solidly grounded wye power systems.

Table 1—Class ratings for use in power system types

Power system type	Class I	Class II
Ungrounded	X	
Solidly grounded	X	
Corner grounded	X	
Resistance grounded	X	
Solidly grounded wye	X	X

5.2.3 Rating class suffixes

Each rating class designation shall be followed by the appropriate suffix.

5.2.3.1 Suffix A: Automatic circuit breakers with electronic direct-acting trip systems

Suffix A shall be applied to all automatic circuit breakers using electronic direct-acting trip systems in accordance with IEEE Std C37.17.

NOTE—An automatic circuit breaker may include functionality beyond that required by IEEE Std C37.17 that requires external control power (e.g., phase-loss protection) and still qualifies as Suffix A.

5.2.3.2 Suffix E: Automatic circuit breakers with electromechanical direct-acting trip systems

Suffix E shall be applied to all automatic circuit breakers using electromechanical direct-acting trip systems in accordance with IEEE Std C37.17.

5.2.3.3 Suffix N: Automatic circuit breakers with indirect-acting trip systems

Suffix N shall be applied to all automatic circuit breakers using indirect-acting trip systems.

5.2.3.4 Suffix X: Non-automatic circuit breakers

Non-automatic circuit breakers include no integral overcurrent protection.

5.3 Rated maximum voltage

The rated maximum voltage of a circuit breaker is the highest rms (root mean square) voltage, three-phase or single-phase, at which it is designed to perform.

5.3.1 Class I

The preferred rated maximum voltages for unfused Class I circuit breakers are 254 V, 508 V, 635 V, 730 V, or 1058 V.

The preferred rated maximum voltages for fused Class I circuit breakers are 254 V, 508 V, or 600 V. The upper limit of 600 V is established by the maximum voltage for fuses per UL 248-1.

NOTE—The rated maximum voltages above correspond to nominal system voltages of 208 V (or 240 V), 480 V, 600 V, 690 V, or 1000 V.

5.3.2 Class II

The preferred rated maximum voltage for an unfused Class II circuit breaker is 1058Y/611 V.

NOTE—The rated maximum voltage above corresponds to a nominal system voltage of 1000Y/577 V.

5.4 Rated power frequency

The rated power frequency of a circuit breaker is the frequency at which it is designed to operate.

Preferred frequencies are 50 Hz, 60 Hz, or 50/60 Hz. Application at other frequencies should receive special consideration.

5.5 Rated frame size

The rated frame size of a circuit breaker is the designated limit of rms current at a rated power frequency that it shall be required to carry continuously without exceeding the temperature limitations designated in [Clause 7](#).

The preferred rated frame sizes are 600 A, 800 A, 1200 A, 1600 A, 2000 A, 3000 A, 3200 A, 4000 A, 5000 A, or 6000 A.

5.6 Rated continuous current

The rated continuous current of a circuit breaker equipped with trip systems or fuses of a lower rating than the frame size of the circuit breaker shall be the rating of the trip systems or fuses.

The circuit breaker rated continuous current capabilities are demonstrated by compliance with the applicable test requirements in [A.6](#).

- a) Circuit breakers with a rated power frequency of 50 Hz shall be required to meet the temperature rise limits of [Table 2](#) when tested in accordance with the continuous current test requirements of [A.6](#) at either rated power frequency of 50 Hz or 60 Hz.
- b) Circuit breakers with a rated power frequency of 60 Hz or 50 Hz/60 Hz shall be required to meet the temperature rise limits of [Table 2](#) when tested in accordance with the continuous current test requirements of [A.6](#) at a rated power frequency of 60 Hz.

Table 2—Limits of temperature rise and total temperature

	Limit of temperature rise over air surrounding enclosure (K)	Limit of total temperature (°C)
Class 90 insulation	50	90
Class 105 insulation	65	105
Class 130 insulation	90	130
Class 155 insulation	115	155
Class 180 insulation	140	180
Class 220 insulation	180	220
Circuit breaker contacts, conducting joints, and other parts, except the following: Fuse terminals ^a Series coils with over Class 220 insulation or bare ^a	85	125
Terminal connections ^b	55	95

^a Adjacent metallic parts shall not be damaged, and nearby insulating material, whether or not in contact with the parts, shall not exceed the temperature limits stated in this table.

^b Terminal connection temperatures are based on connections to the bus in low-voltage metal-enclosed switchgear when the circuit breaker is tested in accordance with continuous current test requirements of A.6. If the circuit breaker is tested in an enclosure that meets the requirements of A.6 and IEEE Std C37.20.1, the terminal connection temperature listed are not applicable, and the temperature rise limits for buses and connections in accordance with IEEE Std C37.20.1 apply. If connections are made to cables, recognition must be given to possible thermal limitations of the cable insulation and appropriate measures taken.

5.6.1 Preferred electronic trip system current ratings and settings

The continuous current rating for a circuit breaker with an electronic trip system shall be one of the following preferred values: 100 A, 150 A, 200 A, 400 A, 600 A, 800 A, 1200 A, 1600 A, 2000 A, 3000 A, 3200 A, 4000 A, 5000 A, or 6000 A.

The continuous current rating for the trip system shall be no higher than the frame rating of the circuit breaker.

5.6.2 Preferred electromechanical trip system current ratings and settings

The continuous current rating for circuit breaker with an electromechanical trip system shall be one of the following preferred values: 40 A, 50 A, 70 A, 90 A, 100 A, 125 A, 150 A, 175 A, 200 A, 225 A, 300 A, 350 A, 400 A, 500 A, 600 A, 800 A, 1000 A, 1200 A, 1600 A, 2000 A, 2500 A, 3000 A, 3200 A, 4000 A, or 5000 A.

The continuous current rating for the trip system shall be no higher than the frame rating of the circuit breaker.

5.7 Rated short-circuit current

5.7.1 General

The circuit breaker rated short-circuit current capabilities are demonstrated by compliance with the applicable test requirements in Annex A.

The short-circuit current duty cycle of a low-voltage power circuit breaker is an opening operation followed by a close-open operation after an interval of 15 s (O–15 s–CO) at rated maximum voltage.

5.7.2 Circuit breaker (50 Hz or 60 Hz)

A circuit breaker with a rated power frequency of 50 Hz shall be required to perform its short-circuit current duty cycle at a rated power frequency of 50 Hz.

A circuit breaker with a rated power frequency of 60 Hz shall be required to perform its short-circuit current duty cycle at a rated power frequency of 60 Hz.

5.7.3 Circuit breaker (50/60 Hz)

A circuit breaker with a rated power frequency of 50/60 Hz shall be required to perform its short-circuit current duty cycle as follows:

- a) When the published tolerance bands of the time-current curves of the circuit breaker trip system (see [Annex E](#)) at 50 Hz do not fall entirely within the published tolerance bands of the time-current curves at 60 Hz, the short-circuit current tests shall be conducted at each rated power frequency.¹⁷
- b) When the published tolerance bands of the time-current curves of the circuit breaker trip system (see [Annex E](#)) at 50 Hz falls entirely within the published tolerance bands of the time-current curves at 60 Hz:
 - 1) For an unfused circuit breaker with a clearing time of less than one power-frequency cycle, the circuit breaker shall be required to perform its short-circuit current duty cycle at both 50 Hz and 60 Hz rated power frequency.
 - 2) For an unfused circuit breaker with a clearing time of one power-frequency cycle or more, the circuit breaker shall be required to perform its short-circuit current duty cycle at a power frequency of 50 Hz ($\pm 5\%$) or 60 Hz ($\pm 5\%$).
 - 3) For a fused circuit breaker, the circuit breaker shall be required to perform its short-circuit current duty cycle at both 50 Hz and 60 Hz rated power frequency if the clearing time of the circuit breaker element (without fuses) is less than one power-frequency cycle.
 - 4) For a fused circuit breaker, the circuit breaker shall be required to perform short-circuit current duty cycle Test 11 and Test 12 per [Table A.7](#) at a power frequency of 50 Hz ($\pm 5\%$) or 60 Hz ($\pm 5\%$), if the clearing time of the circuit breaker element (without fuses) is one power-frequency cycle or more.

5.7.4 Unfused circuit breakers

The rated short-circuit current of an unfused circuit breaker is the designated limit of available (prospective) current at which it shall be required to perform its short-circuit current duty cycle of an opening operation followed by a 15-second delay, followed by a close-open operation (O–15 s–CO) at rated maximum voltage under the prescribed test conditions and at the rated power frequency corresponding to the short-circuit rating. This current is expressed as the rms symmetrical value of current measured from the available current wave envelope at a time one-half cycle after short-circuit initiation.

When short-time delay tripping devices are used, the tripping on each opening shall be delayed by these tripping devices, except when equipped with instantaneous tripping elements effective only during closing.

The basis of the rated short-circuit current of an unfused circuit breaker is the rms symmetrical current value at a power factor of 15% lagging (X/R ratio of 6.6).

¹⁷ For clarification of the term “one power-frequency cycle,” for circuit breakers operating at 50 Hz rated power frequency, the one power-frequency cycle equates to 20 ms and for circuit breakers operating at 60 Hz rated power frequency, the one power-frequency cycle equates to 16.7 ms.

Unfused circuit breakers shall be tested to and capable of performing the short-circuit current duty cycle with all degrees of current asymmetry produced by three-phase or single-phase circuits that have a short-circuit power factor of 15% lagging or less (X/R ratio of 6.6 or greater).

Unfused circuit breakers with instantaneous phase trip elements shall have short-circuit current ratings at each rated maximum voltage assigned by the manufacturer. Preferred ratings are listed in [Table 3](#).

Unfused circuit breakers without instantaneous phase trip elements shall have short-circuit current ratings at each rated maximum voltage assigned by the manufacturer. Preferred ratings are listed in [Table 4](#).

When unfused circuit breakers are equipped with short-time-delay phase trip elements in addition to instantaneous phase trip elements, they may have the short-circuit current ratings listed in [Table 3](#) provided that the maximum instantaneous trip setting does not exceed the short-circuit current ratings listed in [Table 3](#).

[Table 3](#) provides the short-circuit current ratings and the preferred ranges for circuit breakers with instantaneous tripping elements. [Table 4](#) provides the short-time current ratings and short-circuit current rating for unfused low-voltage ac power circuit breakers with short-time-delay elements or protective devices not integral to the circuit breaker but without instantaneous phase trip elements.

The short-circuit currents are given as rms symmetrical values for single-phase (2-pole) circuit breakers and three-phase average rms symmetrical values of three-phase (3-pole) circuit breakers. On systems where the voltage across a single pole exceeds 58% of the rated maximum voltage, the short-circuit rating shall be 87% of the three-phase value.

5.7.5 Fused circuit breakers

5.7.5.1 Integrally and non-integrally fused circuit breakers

The rated short-circuit current of a fused circuit breaker is the designated limit of available (prospective) current at which it shall be required to perform its short-circuit current duty cycle at the rated maximum voltage under the prescribed test conditions and at the rated frequency corresponding to the short-circuit rating. The short-circuit current duty cycle consists of an O–t–CO operation, where t is the time necessary to replace fuses and reset the open-fuse trip device. This current is expressed as the rms symmetrical value of current measured from the available current wave envelope at a time one-half cycle after short-circuit initiation.

There is a practical limit of load impedance above which the open-fuse trip device (which is provided with all non-integrally fused circuit breakers) may not function as described (see [6.7](#)).

The basis of the rated short-circuit current of a fused circuit breaker is the rms symmetrical current value at a power factor of 20% lagging (X/R ratio of 4.9).

Fused circuit breakers shall be tested to and capable of performing the short-circuit current duty cycle with all degrees of current asymmetry produced by three-phase or single-phase circuits that have a short-circuit power factor of 20% lagging or less (X/R ratio of 4.9 or greater).

The circuit breaker element of a fused circuit breaker shall have a short-circuit current rating. The preferred short-circuit current ratings are listed in [Table 3](#) for the particular frame size for a system nominal voltage of 600 V. The fuses are required to operate in their current limiting region for short-circuit currents at or below the short-circuit current ratings. Preferred ratings are listed in [Table 3](#).

Table 3— Ranges of preferred short-circuit current ratings for low-voltage ac power circuit breakers with instantaneous phase trip elements

Line No.	Circuit-breaker frame size amperes	Short-circuit current rating (kA) ^a					
		Minimum (up to 730 V ^c)	Maximum at 254 V ^d	Maximum at 508 V ^d	Maximum at 635 V ^d	Maximum at 730 V ^d	Maximum at 1058 V ^d
		Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
1	600 ^b	22	42	30	22	—	—
2	800	22	200	200	130	30	30
3	1200	22	200	200	130	30	30
4	1600	42	200	200	130	50	50
5	2000	42	200	200	130	65	50
6	3000 ^b	65	85	65	65	—	—
7	3200	65	200	200	130	100	50
8	4000	85	200	200	130	100	50
9	5000	85	200	200	130	100	50
10	6000	85	200	200	130	100	50

^a The preferred rated short-circuit current (for circuit breakers with a maximum voltage rating of 730 V and below) shall be one of the following values: 22 kA, 30 kA, 42 kA, 50 kA, 65 kA, 85 kA, 100 kA, 130 kA, 150 kA, or 200 kA.

^b Preferred ratings for 600 A and 3000 A frame sizes are provided for historical reference.

^c For 1058 Vac applications, the minimum preferred short-circuit current rating shall be twice the circuit breaker frame size.

^d Rated maximum voltage.

5.7.5.2 Nonintegrally fused circuit breakers—fused drawout-mounted assembly

A fused drawout-mounted assembly shall be tested in combination with the specific circuit breaker with which it is intended to be used.

5.7.5.3 Fused circuit breaker frames

The preferred rated short-circuit current is 200 kA.

This rating is the rms symmetrical value for single-phase (2-pole) circuit breakers and three-phase average rms symmetrical value of three-phase (3-pole) circuit breakers. On systems where the voltage across a single pole exceeds 58% of the rated maximum voltage, the short-circuit rating shall be 87% of the three-phase value.

Fused circuit breakers do not have a short-time current rating.

The preferred current ratings for fuses are as follows: 300 A, 600 A, 800 A, 1000 A, 1200 A, 1600 A, 2000 A, 2500 A, 3000 A, 4000 A, 5000 A, or 6000 A. Fuses shall be of the current-limiting type. (See UL 248-1, UL 248-8, and UL 248-10.)

5.8 Rated short-time current and short-time current duration

5.8.1 Unfused circuit breakers

For an unfused circuit breaker, the rated short-time current is the designated limit of available (prospective) current at which it shall be required to perform its short-time current duty cycle. The short-time current duty cycle shall be two periods of the short-time current flow of rated duration (at least 0.5 s), separated by a 15 s

interval of zero current at rated maximum voltage under the prescribed test conditions. Rated short-time current is expressed as the rms symmetrical value of current measured from the available current wave envelope at a time one-half cycle after short-circuit initiation.

Preferred short-time current ratings are listed in Table 4.

Preferred short-time current duration rating is 0.5 s. Any other non-preferred ratings shall be no less than 0.5 s.

5.8.2 Fused circuit breakers

Fused circuit breakers do not have a rated short-time current rating or short-time current duration rating.

Table 4—Ranges of preferred short-time and short-circuit current ratings for unfused low-voltage ac power circuit breakers with short-time-delay elements or protective devices not integrally mounted with the circuit breaker but without instantaneous phase trip elements

Line No.	Circuit-breaker frame size amperes	Short-circuit and short-time current rating (kA) ^a			
		Minimum (up to 730 V ^c)	Maximum (up to 730 V ^c)	Minimum (1058 V ^c)	Maximum (1058 V ^c)
	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
1	600 ^b	22	22	—	—
2	800	22	85	10	85
3	1600	42	85	10	85
4	2000	42	85	10	85
5	3000 ^b	65	65	—	—
6	3200	65	100	22	100
7	4000	85	100	22	100
8	5000	85	100	22	100
9	6000	85	100	22	100

^a The preferred rated short-time and short-circuit currents shall be the same and one of the following values: 10 kA, 22 kA, 30 kA, 42 kA, 50 kA, 65 kA, 85 kA, or 100 kA.

^b Preferred ratings for 600 A and 3000 A frame sizes are provided for historical reference.

^c Rated maximum voltage.

5.9 Rated control voltage

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

Operating mechanisms are designed for the rated control voltages listed with operational capability throughout the indicated voltage ranges to accommodate variations in source regulation, coupled with low charge levels, as well as high charge levels maintained with floating charges. The maximum voltage is the open circuit voltage measured at the control power terminals of the operating mechanism and the minimum voltage is measured with operating current flowing.

The performance capability of individual devices (that are not part of the control for a circuit breaker) over the full range of closing, auxiliary, and opening voltages specified here shall be as defined in the standard that covers the particular device.

Auxiliary control relays, motors, or other auxiliary equipment that function as a part of the control for a circuit breaker shall be subject to the voltage limits imposed by this standard, whether mounted at the device or at the remote location.

Electrically operated motors, contactors, solenoids, valves, and the like need not carry a nameplate voltage rating that corresponds to the rated control voltage shown in Table 5 as long as these components perform the intended duty cycle (usually intermittent) in the voltage range specified and meet the endurance requirements of A.8.

Preferred rated control voltage and their ranges for circuit breaker are listed in Table 5.

Table 5—Preferred rated control voltage and their range

Rated control voltage (V)	Voltage characteristics	Closing ^d and auxiliary ^a voltage ^b (V)	Opening ^c voltage ^b (V)
Col. 1	Col. 2	Col. 3	Col. 4
24 ^{Note 2}	dc ^{Note 1}	19–28	14–28
48 ^{Note 2}	dc ^{Note 1}	38–56	28–56
125	dc ^{Note 1}	100–140	70–140
250	dc ^{Note 1}	200–280	140–280
120	ac, 60 Hz	104–127 ^a	104–127 ^{a c}
208	ac, 60 Hz	180–220 ^a	180–220 ^{a c}
240	ac, 60 Hz	208–254 ^a	208–254 ^{a c}
220	ac, 50 Hz	190–233	190–233 ^c
208Y/120	ac, 60 Hz	180Y/104–220Y/127 ^a	180Y/104–220Y/127 ^{a c}
NOTE 1—It is recommended that the coils of closing, auxiliary, and tripping components that are connected continuously to one dc potential should be connected to the negative control bus so as to reduce electrolytic deterioration. NOTE 2—24 Vdc or 48 Vdc control voltages are recommended only when both the control components and devices are located near the battery or where special effort is made to help ensure adequate control voltage at the control terminals. The 24 Vdc closing function is not recommended.			

^a Includes heater circuits.

^b The devices utilizing standard auxiliary relays for control may not function at lower extremes of voltage ranges when relay coils are hot, as after repeated or continuous operation.

^c Shunt trip devices used with protective devices not integrally mounted with the circuit breaker ground fault relaying shall operate at 50% of the nominal voltage.

^d Closing functions include (a) the closing power mechanism, and (b) the means (coils, contactors, seal-in relays, and the like) to actuate the power mechanisms. Auxiliary functions include all functions except closing and opening.

^e Opening functions are those electrical functions performed intentionally to release the stored energy mechanism allowing the device to separate its primary contacts.

6. Functional components

6.1 General

The required functional components are listed in [Table 6](#). Additional accessory devices may be available. The manufacturer should be consulted for specific information.

6.2 Nameplate(s)

The following minimum information shall be given on the nameplate(s) of all circuit breakers:

- a) Manufacturer's name
- b) Type of circuit breaker
- c) Rated continuous current of trip devices (where applicable) and type designation
- d) Frame size
- e) Rating class
- f) Rated maximum voltage(s)
- g) Rated short-circuit current at each rated maximum voltage
- h) Rated short-time current (where applicable)
- i) Rated short-time current duration (where applicable)
- j) Suitable fuse type and sizes (where applicable)
- k) Rated power frequency(s)
- l) Rated control voltage (where applicable)
- m) Year and month of manufacture (as minimum)—date codes may be used
- n) Identification number (e.g., serial number)
- o) Manufacturer's data sheets or instruction book reference

Table 6—Functional components

Functional component		Operating mechanism type	
		Manual	Power
(1)	Protective device in accordance with one of the following means:	X ^a	X ^a
	— Direct-acting electronic trip system		
	— Direct-acting electromechanical trip system		
	— Indirect-acting trip system		
	— No integral protection. Shunt trip device with necessary control auxiliary switches		
(2)	Manual close device in accordance with 6.3 b)	X	Optional
(3)	Manual trip device in accordance with 6.3 a)	X	X
(4)	Contact position indicator in accordance with 6.4	X	X
(5)	Independent, manually-operated mechanism, trip-free, and attached operating handle	X	Optional
(6)	Power-operated mechanism, trip-free, with anti-pump feature	—	X
(7)	Shunt trip device with necessary control auxiliary switches	Optional	X
(8)	Stored energy indicator in accordance with 6.6	X ^b	X ^b
(9)	Nameplate(s), with markings in accordance with 6.2	X	X
(10)	Fuses, one per pole	Optional ^c	Optional ^c
(11)	Open-fuse trip device in accordance with 6.7	Optional ^{c, g}	Optional ^{c, g}
(12)	Locking provisions in accordance with 6.8	X	X
(13)	Primary disconnecting devices in accordance with 6.9	X ^d	X ^d
(14)	Circuit breaker ground connection in accordance with 6.10	X	X
(15)	Secondary disconnecting device(s)	X ^e	X ^{d, e}
(16)	Fused drawout-mounted assembly in accordance with 6.11	Optional ^f	Optional ^f
(17)	Drawout-mounted circuit breaker interlocking in accordance with 6.11	X ^d	X ^d

^a One of the four potential protective means shall be provided.

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

^c Required on fused circuit breakers only.

^d Required on drawout-mounted circuit breakers only.

^e Required for drawout-mounted circuit breakers with external secondary connections. For stationary-mounted circuit breakers, an alternative method, such as terminal blocks or an umbilical cable, may provide the method of connection to the circuit breaker.

^f Required as part of nonintegrally fused circuit breaker construction only.

^g Required as part of fused circuit breakers.

6.3 Manual trip and close devices

Manual trip and close devices to open and close the circuit breaker shall be provided as detailed in Table 6. If provided, they shall be labeled clearly so that a local operator can easily read and operate them.

Manual trip and close devices shall be marked either on the device or labeled separately as follows:

- Red background with the word “Open” or “Trip” in contrasting letters to indicate that operating the manual trip device opens the circuit breaker.

- b) Green or black background with the word “Close” in contrasting letters to indicate that operating the manual close device closes the circuit breaker.

As an alternative to the required manual trip and close device indicator words, a symbol, in accordance with IEC 60947-2, may be used.

6.4 Contact position indicator

A reliable mechanical contact position indicator, which can easily be read by the local operator without opening the enclosure door on indoor equipment construction, shall be supplied.

- a) Red background with the word “Closed” or “On” in contrasting letters to indicate closed contacts
- b) Green background with the word “Open” or “Off” in contrasting letters to indicate open contacts

As an alternative to the required mechanical contact position indicator word, a symbol, in accordance with IEC 60947-2, may be used.

6.5 Trip-free

The switching device shall be capable of having the moving contacts return to and remain in the open position when the opening operation is initiated after the initiation of the closing operation, even if the closing force and command are maintained.

NOTE 1—In order to help ensure proper breaking of the current that may be established, it may be necessary for the contacts to momentarily reach the closed position.

NOTE 2—If the release circuit is completed through an auxiliary switch, electrical release will not take place until such auxiliary switch is closed.

6.6 Stored energy indicator

A stored energy indicator, which can easily be read by the local operator without opening the enclosure door on indoor equipment construction, shall be supplied. A reliable indicator with the following colors shall be used:

- a) Yellow background with black lettering with the word “Charged” in contrasting lettering to indicate the mechanism is charged.
- b) White background with black lettering with the word “Discharged” to indicate the mechanism is discharged.

As an alternative to the required stored energy indicator word, a symbol may be used that indicates when the storing mechanism is fully charged and discharged. Guidance on the symbols should be taken from IEC 60073.