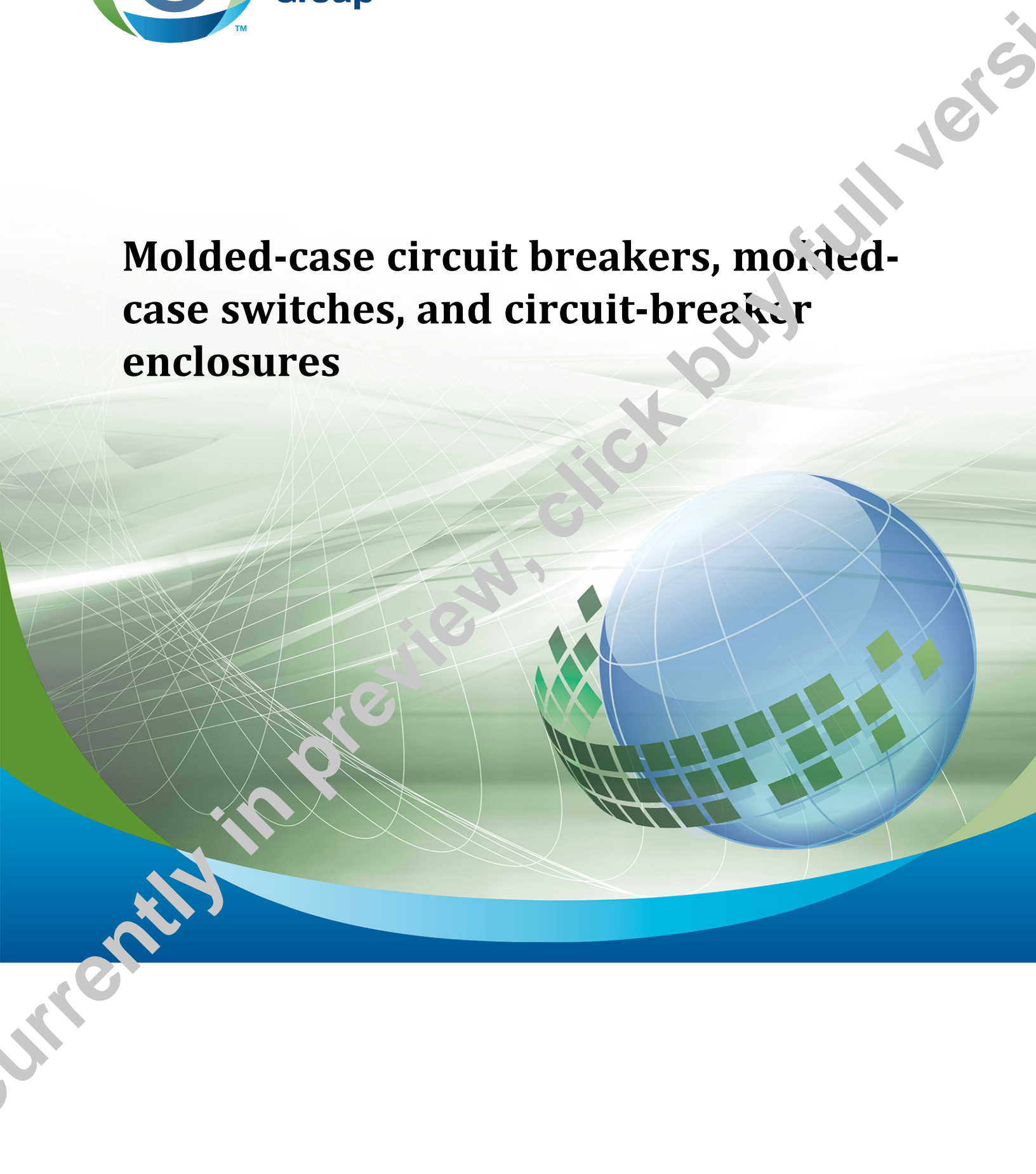




**CSA
Group**

C22.2 No. 5-16

Molded-case circuit breakers, molded-case switches, and circuit-breaker enclosures



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Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

Fourth Edition, Dated October 24, 2016

SUMMARY OF TOPICS

This revision dated April 22, 2019, incorporates the following:

Exception for 6" Minimum Length of Field Wiring Conductor (Lead)

Revision to the Requirements for Draw-out Circuit Breakers

Revisions to the Calibration Requirements for Supplement SB

Revision to Table 7.1.7.3 – Available current in test circuits

Revised Requirements for Accessory Terminal Leads Wire Size

Addition of Requirements from UL 489G into UL 489

Editorial corrections

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Association of Standardization and Certification
NMX-J-266-ANCE-2016
Fifth Edition



CSA Group
CSA C22.2 No. 5-16
Fourth Edition



Underwriters Laboratories Inc.
UL 489
Thirteenth Edition

Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

October 24, 2016

(Title Page Reprinted April 22, 2019)



ANSI/UL 489-2019

Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as "CSA Group"), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

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The Department of Defense (DoD) has adopted UL 489 on January 18, 1985. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

NEMA (National Electrical Manufacturers Association) has adopted UL 489 (US Requirements) on August 11, 1999 as NEMA Standard AB1. The publication of revised pages or a new edition of this Standard will not invalidate the NEMA adoption.

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PREFACE

This is the harmonized ANCE, CSA Group, and UL standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures. It is the fifth edition of NMX-J-266-ANCE, the fourth edition of CSA C22.2 No. 5, and the thirteenth edition of UL 489. This harmonized standard has been jointly revised on April 22, 2019. For this purpose, CSA Group and UL are issuing revision pages dated April 22, 2019, and ANCE is issuing a new edition dated April 22, 2019.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), CSA Group, and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Subcommittee, 121A, Molded Case Circuit Breakers on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

The present Mexican standard was developed by the CT CDI Control y Distribución Industrial from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of the circuit breaker manufacturers and users.

This standard was reviewed by the CSA Subcommittee on Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard.

This standard is published as an equivalent standard for ANCE, CSA Group, and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

- c) The installation of the terminal kit shall not involve the loosening or disassembly of parts other than those normally disassembled for installation and wiring;
- d) If the wire connector provided in a component terminal kit requires the use of a special tool for securing the conductor, any necessary instructions shall be included in the component terminal kit package or with the circuit breaker;
- e) Installation of the wire connectors in the intended manner shall result in a product that meets the requirements of this standard; and
- f) The circuit breaker or circuit breaker frame, and component terminal kit shall be marked in accordance with 9.1.2.11.

6.1.4.2.6 A wire-binding screw shall be permitted to be used at a field wiring terminal intended for the connection of a 10 AWG (5.3 mm²) or smaller wire if upturned lugs or the equivalent are provided to retain the wire under the head of the screw should the screw become loosened.

6.1.4.2.7 A plug-in circuit breaker shall not have a screw or wire connector that can be used simultaneously for the connection of a conductor on the same side as the plug-in connection. A conversion kit with instructions may be provided to accomplish a change in the type of plug-in connection.

6.1.4.2.8 The plug-in connection members on a circuit breaker and on a receiving means shall have the strength necessary for the forces applied during inserting and removing the circuit breaker.

6.1.4.2.9 A plug-in circuit breaker shall be retained on the stabs without depending on the trim or cover of the enclosure.

6.1.4.2.10 If a screw-and-washer construction is used at a field wiring terminal, the screw shall not be smaller than No. 10 (4.8 mm) with no more than 32 threads per inch (per 25.4 mm).

6.1.4.2.11 A terminal plate tapped for a wire-binding screw shall be of metal not less than 1.27 mm (0.050 inch) thick and shall have not less than two full threads in the metal; except that a special alloy plate less than 1.27 mm (0.050 inch) but not less than 0.76 mm (0.030 inch) thick shall be permitted if the tapped threads have the necessary mechanical strength.

6.1.4.2.12 A terminal plate shall be permitted to have the metal extruded at the tapped hole so as to give the thickness necessary for at least two full threads provided that the thickness for the unextruded metal is not less than the pitch of the thread.

6.1.4.2.13 If conductors of the next larger size than that described in Table 6.1.4.2.1 can be inserted into main terminals of a circuit breaker, the terminals shall be capable of securing such larger conductors, unless marked in accordance with 9.1.2.7.

6.1.4.2.14 Pressure terminal connectors capable of holding the next larger size wire as described in 6.1.4.2.13 additionally shall be capable of withstanding the secureness and pullout tests described in Annex B, Ref. No. 6 with the size conductors described in 6.1.4.2.13 and Table 6.1.4.2.1.

6.1.4.2.15 A terminal for the connection of conductors other than those specified in Table 6.1.4.2.1 shall be acceptable only if found appropriate for the particular application.

6.1.4.2.16 Using normally available tools such as screwdrivers, pliers or wrenches, it shall be possible to retighten the conductor securing means of a wire connector without removal of the connector from the terminal plate or bus or without removal of any conductor from the connector.

6.1.4.2.17 For an interchangeable trip circuit breaker frame rated 100 A or less, a single pressure terminal connector shall be made available by the circuit breaker manufacturer that properly accommodates all sizes of wire for which the frame is intended.

6.1.4.2.18 A dc circuit breaker intended to have poles connected in series shall have all connecting hardware, bus, and the like, either attached at the factory or provided as a kit. The kit shall comply with the requirements of 6.1.4.2.5. If other than normally available building wire is required, it shall be provided as part of the kit.

6.1.4.2.19 Jumpers requiring building wire to be bent with a radius less than the cold bend mandrel requirements of Annex B, Ref. No. 27, shall be provided with the circuit breaker or be made available as a kit.

6.1.4.3 Field wiring conductors

6.1.4.3.1 Conductors shall not differ by more than two wire sizes from the size referred to in Table 6.1.4.2.1. The wire size shall not be smaller than 14 AWG (2.1 mm²).

6.1.4.3.2 Conductors shall consist of wire suitable for the particular application, when considered with respect to the temperature and voltage and conditions of service to which the wiring is likely to be subjected.

6.1.4.3.3 A conductor shall be constructed so as to withstand the stress of normal handling without damage to itself or to the unit. See 7.1.10.1.2.

6.1.4.3.4 Green coloring, with or without one or more yellow stripes, and white or gray coloring shall not be used for the covering of a conductor unless intended for connection to grounding and grounded circuit conductors, respectively.

6.1.4.3.5 The free length of a wiring conductor shall be at least 152 mm (6 inches).

6.1.4.3.6 Notwithstanding 6.1.4.3.5, the free length of a wiring conductor may be less than 152 mm (6 inches) when all of the following conditions are met:

- a) The device shall be manufactured with the conductor factory installed as intended for field installation in the specified end-use equipment;
- b) The conductor shall be of sufficient length for connection in the specified end-use equipment;
- c) The device shall be marked for use only in specific end-use equipment. This information may be provided with the installation instructions if the device is marked to reference the appropriate publication;
- d) Instructions for installation shall be provided with the device unless readily apparent; and

e) The acceptability of the device shall be determined in the end-use equipment.

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- d) Combustibility; and
- e) Resistance to distortion at temperatures to which the casing may be subjected under conditions of normal or abnormal use.

All of these factors shall be considered with regard to thermal aging.

6.6.11 Connections between the link and the terminals of a high-fault protector shall be such that a permanent electrical connection is provided. The connection shall be soldered, brazed, or welded, or shall otherwise be made permanently and adequately secure.

6.6.12 An adhesive used in a high-fault protector or high-fault module shall adequately and reliably secure together the parts that it is intended to secure.

6.6.13 To determine whether the adhesive complies with the requirement in 6.6.12, samples of the high-fault protector or high-fault module shall be subjected to appropriate interrupting tests, in combination with the circuit breaker after conditioning. Conditioning tests on the adhesive shall not be required if the device performs acceptably during the interrupting tests with the adhesive omitted.

6.7 Adjustable circuit breakers

6.7.1 This section covers additional requirements for adjustable circuit breakers.

6.7.2 As concerns the current setting, these circuit breakers are classed as either Type A or Type B. See 6.7.3 and 6.7.4.

6.7.3 The current setting (I_r) of a Type A circuit breaker shall not be adjustable to a value greater than the rated current (I_n) of the circuit breaker.

6.7.4 A Type B circuit breaker shall be restricted so that the current setting (I_r), once fixed at a particular value, cannot be changed to one higher, except by the addition or substitution of a part requiring use of a tool.

6.7.5 For a Type A circuit breaker, the current setting (I_r) shall be that which can be inferred from the device's settings, markings, or instruction literature. For a Type B circuit breaker, the current setting shall be that of the marking.

6.8 Heating, air conditioning, and refrigeration (HACR) circuit breakers

6.8.1 Heating, air conditioning, and refrigeration (HACR) circuit breakers shall comply with the construction requirements in All Types, Section 6.1.

6.9 Remotely-operated circuit breakers

6.9.1 This section covers additional requirements for remotely-operated circuit breakers.

6.9.2 A remotely-operated circuit breaker shall be trip free and the operating handle and mechanism shall be independent of the remotely-controlled operation.

6.9.3 In a 2-pole remotely-operated circuit breaker, the remotely controlled operation shall be permitted to operate only one pole.

6.10 Switching duty (SWD) rated circuit breakers

6.10.1 Switching duty (SWD) rated circuit breakers shall comply with the construction requirements in All Types, Section 6.1.

6.11 400 Hz rated circuit breakers

6.11.1 Circuit breakers rated 400 Hz shall comply with the construction requirements in All Types, Section 6.1.

6.12 Draw-out circuit breakers

6.12.1 This section covers additional requirements for draw-out circuit breakers.

6.12.2 The configuration of the grounding means between a metal part of a draw-out type circuit breaker intended to be grounded and any permanently grounded part shall be such that grounding continuity is established 3.2 mm (1/8 inch) before either primary or secondary disconnects of the draw-out unit are energized; and also be maintained until both primary and secondary disconnects have been de-energized by at least 3.2 mm (1/8 inch). See the electrical continuity test described in 7.12.1.

6.12.3 Draw-out circuit breakers shall be equipped with self-coupling disconnecting devices.

6.12.4 Interlocks shall be provided:

- a) To prevent moving the circuit breaker to or from the connected position when the circuit breaker is in the closed position, and
- b) To prevent closing the circuit breaker unless the primary disconnecting devices are in full contact or are separated by a distance that will withstand a minimum voltage described in 7.12.2.

6.12.5 Secondary disconnects and interlock switches shall be designed and rated for their applications and shall comply with the requirements of Annex B, Ref. No. 28.

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7.1.3.3 The line terminals shall be connected to a supply circuit as indicated below, and the load terminals shall be connected to the necessary impedance. The open circuit voltage of the supply circuit shall be not less than 100 percent nor more than 105 percent of the rated voltage of the circuit breaker, except that a higher voltage may be used if agreeable to the submitter and the testing agency. Except as permitted by 7.1.3.4, the current capacity of the supply circuit shall be such that the closed-circuit voltage across the circuit breaker and load with 600 percent of the rated current of the circuit breaker flowing is within 15 percent of the rated voltage of the circuit breaker.

7.1.3.4 The closed circuit voltage across the circuit breaker shall be permitted to deviate by more than 15 percent from the rated voltage of the circuit breaker if the supply circuit complies with the requirements for recovery voltage, as indicated for interrupting tests, using a load equal to the overload or if the supply circuit is considered to be acceptable for the interrupting test.

7.1.3.5 Wiring diagrams illustrating the test of circuit breakers under overload conditions are indicated in Figure 7.1.3.1. Refer to explanation of test methods and circuit characteristics given in this clause and 7.1.3.8 – 7.1.3.14. All conductors of an ac circuit shall pass through the same knockout, or all line conductors through one knockout and all load conductors through another knockout. Where parallel conductors are used, more than one knockout shall be permitted to be used if an equal number of conductors from each phase and from the same line or load side are routed through each knockout.

7.1.3.6 A circuit breaker intended for use on a system having one conductor grounded shall be tested with the enclosure, if of metal, connected to the grounded conductor through a fuse described in 7.1.1.26. If a circuit breaker is intended for use on other types of systems, the enclosure shall be connected through a similar fuse to the live pole least likely to strike to ground.

7.1.3.7 A circuit breaker intended for use on a dc system, see 7.1.1.7, shall be tested with dc and with the device connected so that the enclosure will be positive in potential with regard to the nearest arcing point. The dc circuit shall have a time constant not less than 0.003 second.

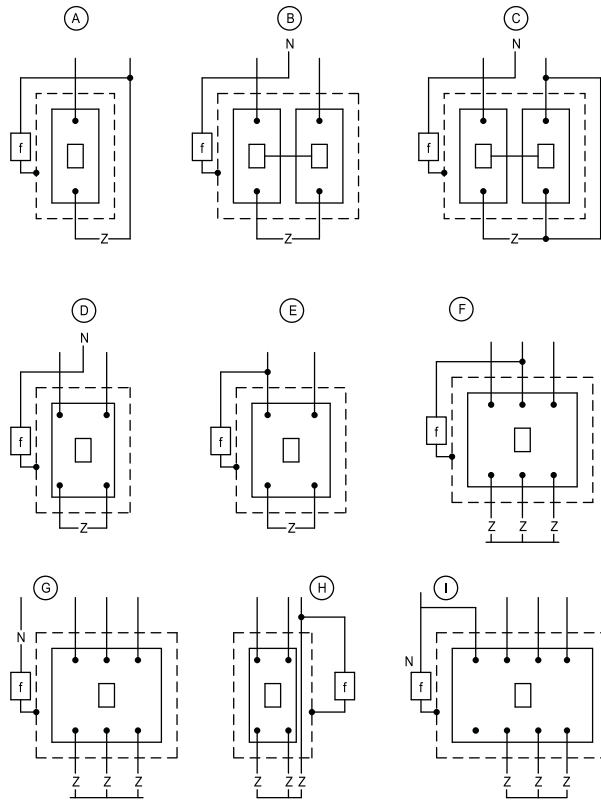
7.1.3.8 Except as permitted by 7.1.3.9, a circuit breaker intended for use on an ac system shall be tested with ac with an air core inductive load. The power factor of the load shall be from 0.45 to 0.50 lagging except as noted in 7.1.3.14. Reactive components of the load shall be permitted to be paralleled but no reactances shall be connected in parallel with resistances, except that an air-core reactor in any phase shall be permitted to be shunted by resistance, the loss of which is approximately 1 percent of the total power consumption in that phase.

7.1.3.9 An iron-core reactor shall be permitted to be used if the maximum test current is not more than 225 A and the current wave shape at maximum current is such that the ratio of peak-to-rms values is equal to 1.414 ± 5 percent (essentially sinusoidal). If referee tests are necessary, they shall be conducted using air-core reactors in accordance with 7.1.3.8.

7.1.3.10 For the overload test and for the endurance test, see 7.1.5.3, the resistance per phase in which the power loss is approximately 1 percent of the total power consumption in that phase will be as indicated in Table 7.1.3.2.

7.1.3.11 Circuit characteristics are normally determined using laboratory type meters. Where required because of high current conditions, the circuit shall be determined by oscillographic or equivalent means as described in Interrupting Test, 7.1.7. It is not necessary that a circuit breaker be in the circuit when making the circuit determination, so long as during the test it is shown that the circuit breaker is interrupting the correct value of current. The test current required shall be the rms symmetrical current value.

Figure 7.1.3.1
Overload test connection diagrams



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A – 1-Pole

B, C – 1-Pole “Tested in Pairs” (also represents 2-Pole independent-trip type circuit breaker)

D – 2-Pole Common-Trip “slant” (120/240, 125/250 V) Rating

E – 2-Pole Common-Trip Rating other than D

F – 3-Pole

G – 3-Pole wye-connected system ratings

H – 2-Pole Common-Trip for 3-Phase Rating

I – 4-Pole wye-connected system ratings

N – Neutral

Z – Load Impedance

f – 30 A “ground” Fuse – Enclosure

Table 7.1.3.2
Shunting resistance per phase

	Shunting resistance per phase in Ohms	
	Power factor 0.45 – 0.50	Power factor 0.75 – 0.80
Single phase	$\frac{163 E}{I}$	$\frac{52 E}{I}$
Three phase	$\frac{94 E}{I}$	$\frac{30 E}{I}$
<p>E = Closed circuit line potential in Volts. I = Line current in Amperes.</p>		

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7.1.3.12 Except as noted in 7.1.3.14, a 2-pole circuit breaker intended for use on a dc or a single-phase ac, 3-wire system with a grounded neutral shall be tested on a 3-wire supply circuit having the neutral grounded. The circuit breaker shall be connected as shown in diagram D of Figure 7.1.3.1 with the poles connected to the ungrounded conductors of the circuit, with no connection to the midpoint of the load, and with the enclosure connected to the neutral through a fuse as indicated in 7.1.1.27.

7.1.3.13 A 3-pole circuit breaker intended for use in an ac circuit shall be tested in a 3-phase circuit with a 3-phase balanced load, except for a circuit breaker rated only 120/240 V, single phase. See 9.1.1.22.

7.1.3.14 Following the 35 cycles of manual operation, a 2-pole circuit breaker constructed so that either pole may trip independently of the other and a single-pole circuit breaker as indicated in 7.1.1.19 shall be tested by operating each pole separately for 15 cycles of automatic operation. The circuit breaker shall be connected as shown in diagram C of Figure 7.1.3.1 with both the line and load terminals of the other pole connected to the line wire of opposite polarity to that of the pole under test. If the circuit breaker is intended for use with ac, it shall be tested at a power factor of 0.75 – 0.80 for these automatic operations only. At the option of the manufacturer, a 2-pole common-trip circuit breaker as described in 7.1.3.12 may be tested in the same manner.

7.1.4 Temperature Test

7.1.4.1 General

7.1.4.1.1 A circuit breaker shall be subjected to the temperature test described in 7.1.4.2 or 7.1.4.3 as part of the X sequence. See 7.1.4.1.2 and 7.1.4.1.3.

7.1.4.1.2 A non 100 percent circuit breaker shall be tested in accordance with 7.1.4.2 without an enclosure, at 100 percent of its rated current. At the conclusion of this test, as an option in accordance with 7.1.4.2.4, a circuit breaker is permitted to be tested at 80 percent of its rated current while installed in an enclosure.

7.1.4.1.3 A 100 percent rated circuit breaker marked for use at 100 percent of its rated current shall be tested as described in 7.1.4.3 using one of the following options:

- a) In the smallest enclosure with which it is intended to be used, or
- b) In open air as part of the X sequence followed by a second test in the smallest enclosure with which it is intended to be used. If this option is used a new sample is allowed for the second test.

7.1.4.1.4 When tested without an enclosure under the conditions described in 7.1.4.1.5 – 7.1.4.1.23, or in an enclosure as described in 7.1.4.2.4, a circuit breaker shall operate without tripping until constant temperatures are attained, and materials used in the construction of a circuit breaker shall not be affected adversely by the temperatures to which they are exposed during the test.

7.1.4.1.5 The materials shall be considered as being affected adversely if temperature rises greater than those indicated in Tables 7.1.4.1.1 and 7.1.4.1.2 are attained.

**Table 7.1.4.1.1
Maximum acceptable temperature rise**

Material and components	°C	°F
Wire insulation or insulating tubing ^a	35	63
Electrical tape ^a	55	99
Varnish-cloth insulation ^a	60	108
Fiber employed as electrical insulation ^a	65	117
Phenolic composition or melamine ^b	110	198
Urea composition ^b	60	108
Other insulating materials ^b	–	–
Sealing compound ^c	50	90
^a The limitations on insulating materials in 7.1.4.1.5 do not apply to a material or compound that has been investigated and has special heat-resistant properties.		

Table 7.1.4.1.1 Continued on Next Page

7.1.4.3 100 percent rated

7.1.4.3.1 A circuit breaker shall be permitted to be rated for continuous operation at 100 percent of its ampere rating if it:

- a) Is of a frame size rated 250 A or more or a multi-pole type of any ampere rating and rated higher than 250 V;
- b) Is marked in accordance with 9.1.4.4; and
- c) Complies with the requirements of 7.1.4.3.2 – 7.1.4.4.4.

7.1.4.3.2 A 100 percent rated circuit breaker shall be tested in the smallest enclosure or cubicle with which it is intended to be used.

7.1.4.3.3 The temperature rises where connections are made to external bus bars, when bus bars are used; or on a wiring terminal at a point to which the insulation of a wire is brought up as in actual service when tested with insulated wire shall not exceed 60°C (108°F), if marked in accordance with 9.1.2.14. The marking shall be permitted to indicate only specific current ratings (I_n) if a rating less than the frame rating does not exceed the 50°C (90°F) temperature rise.

7.1.4.4 Coils

7.1.4.4.1 The maximum temperature rise of a coil, when operating at its rated voltage or current, shall be not greater than that indicated in Table 7.1.4.1.2.

7.1.4.4.2 The preferred method of measuring the temperature of a coil shall be the resistance method; but the temperature measurements by either the thermocouple or resistance method are acceptable, except that the thermocouple method shall not be used for a temperature measurement at any point at which the winding is not accessible for the placement of a thermocouple.

7.1.4.4.3 The resistance method consists of the determination of the temperature of a copper or aluminum winding by comparing the resistance of the winding at the temperature to be determined with the resistance at a known temperature, according to the formula:

$$T = \frac{R}{r} (234.5 + t) - 234.5 \text{ (copper)}$$

$$T = \frac{R}{r} (225 + t) - 225 \text{ (aluminum)}$$

in which:

r is the resistance in ohms at the known temperature;

R is the resistance in ohms at the temperature to be determined;

t is the known temperature in degrees C; and

T is the temperature in degrees C to be determined.

7.1.4.4.4 As it is generally necessary to de-energize the winding before measuring R, the value of R at shutdown shall be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time shall be plotted and extrapolated to give the value of R at shutdown.

7.1.5 Endurance Test

7.1.5.1 A circuit breaker shall be capable of performing successfully when operated manually or by means of a machine constructed to simulate manual operation for the number of cycles and at the rate indicated in Table 7.1.5.1. When an electrical load is involved, the circuit breaker shall be caused to make and break its rated current at rated voltage. There shall be no electrical or mechanical breakdown of the device. The fuse specified in 7.1.1.27, connected to indicate arc-over to the enclosure or grounded metal, shall not have cleared.

7.1.5.2 The rate of operation may be increased at the option of the submitter but shall not exceed 20 operations per minute.

7.1.5.3 To determine if a circuit breaker complies with the requirements of 7.1.5.1 and Table 7.1.5.1, the device shall be mounted, connected, and operated as indicated in 7.1.1.25, 7.1.1.26, and 7.1.3.3 – 7.1.3.14 under "Overload," except that the power factor for an alternating current test shall be 0.75 – 0.80 lagging. A two-pole circuit breaker that has independent trip operation of each pole shall be tested with both poles operating simultaneously. In each cycle of operation of the endurance test with load, the circuit breaker shall be closed and then opened immediately unless a longer "on" period is agreeable to the submitter and the testing agency.

7.1.5.4 The current capacity of the supply circuit may be determined with rated current flowing (instead of 600 percent of rated current, as required in 7.1.3.3), in which case the voltage across the circuit breaker and load shall be not less than 97-1/2 percent of rated voltage of the circuit breaker except that the capacity of the supply circuit need not be greater than that of a circuit that is considered to be acceptable for the interrupting test.

7.1.5.5 Eight wiring diagrams illustrating the test of circuit breakers under endurance conditions are indicated in Figure 7.1.5.1. See the explanation of test methods and circuit characteristics given in 7.1.5.1 – 7.1.5.4.

Table 7.1.5.1
Endurance test operations

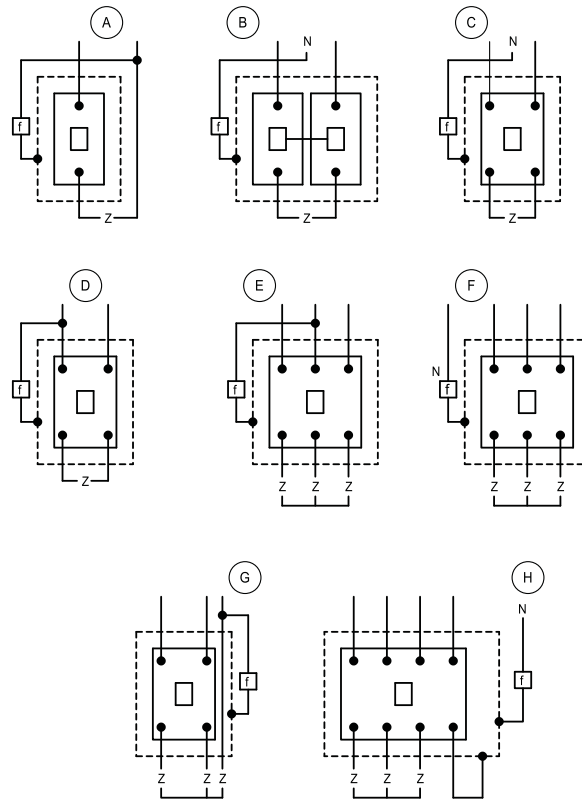
Maximum frame size in amperes	Number of cycles of operation			
	Per minute ^a	With current	Without current	Total
100	6	6,000	4,000	10,000
150	5	4,000 ^b	4,000	8,000 ^b
225	5	4,000	4,000	8,000
600	4	1,000	5,000	6,000
800	1	500	3,000	3,500
1200	1	500	2,000	2,500
2500	1	500	2,000	2,500
6000	1 ^c	400	1,100	1,500

^a For circuit breakers rated more than 800 A, the endurance test may, at the option of the manufacturer, be conducted in groups of 100 load operations. No-load operations may be conducted between groups of load operations at the option of the manufacturer.

^b Where tests are required on samples having ratings of 100 A or less, 250 V or less, the number of operations is to be the same as for the 100 A frame.

^c Rate of operation: 1 cycle per minute for first 10 operations; thereafter in groups of 5, at 1 cycle per minute, with an interval between groups that is agreeable to the submitter and the testing agency.

Figure 7.1.5.1
Endurance test connection diagrams



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A – 1-Pole

B – 1-Pole “Tested in Pairs” (also represents 2-Pole independent-trip type circuit breaker)

C – 2-Pole Common-Trip “slant” (120/240, 125/250 V) Rating

D – 2-Pole Common-Trip Rating other than C

E – 3-Pole

F – 3-Pole wye-connected system ratings

G – 2-Pole Common-Trip for 3-Phase Rating

H – 4-Pole wye-connected system ratings

N – Neutral

Z – Load Impedance

f – 30 A “ground” Fuse – Enclosure

Table 7.1.7.1
Interrupting test operations^a

Poles	Frame rating	Circuit breaker AC voltage rating	Letters indicate diagram in Figure 7.1.7.1						Total number of operations
			Operations on each pole			Common operations			
			O	CO	O	O	CO	O	
1	All	120, 127, 208, 240, 277, 347, 480, 600, 650, 690, or 700 to 1000 in 50V increments	A	A	A	–	–	–	3
1	All	120/240 (tested in pairs)	–	–	–	B	B	B	3
2	All	240, 480, 600, 1000 or any delta connected system rating between 600V and 1000V.	E	E	–	D	–	–	5
2	All	120/240	–	–	–	C	C	C	3
2	0 – 1200 A	208Y/120, 480Y/277, 600Y/347 or any wye connected system rating between 600V and 1000V.	L	L	–	C	–	–	5
2	All	1 ϕ – 3 ϕ	E	E	–	H	–	–	5
3	0 – 1200 A	240, 480, 600, 1000 or any delta connected system rating between 600V and 1000V.	G	G	–	F	–	–	7
3	1200 – Up	240, 480, 600, 1000 or any delta connected system rating between 600V and 1000V.	G	G	–	F	–	–	7
3	All	120/240	–	–	–	J	J	J	3
3	All	208Y/120, 480Y/277, 600Y/347 or any wye connected system rating between 600V and 1000V.	K	K	–	I	–	–	7
4	All	208Y/120, 480Y/277, 600Y/347, or any wye connected system rating between 600V and 1000V.	K	K	–	M	–	–	7

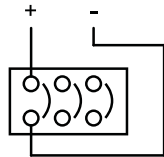
^a For the 125/250 V dc rating, the number of operations is the same as for the 120/240 V ac rating. For the 250 V dc rating, the number of operations is the same as for the 240 V ac rating.

7.1.7.4 Except as permitted by 7.1.7.5, a dc circuit breaker with poles intended to be wired in series shall be subjected to the number and type of operations indicated in Table 7.1.7.2 when connected as shown in Figure 7.1.7.2 and shall interrupt the current indicated in Table 7.1.7.3. The tests shall be conducted in accordance with 7.1.7.3.

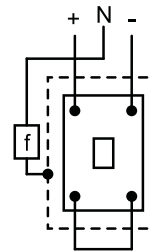
Table 7.1.7.2
Interrupting test operations

Poles in series	Intended configuration	Intended system	Letters indicate diagram in Figure 7.1.7.2				Total number of operations
			Operations on each pole			Common operations	
1	A	Grounded or ungrounded	O	CO	O	CO	3
2	B	Slash rated, grounded, or ungrounded	A	A	–	B	5
2,3,4	C	Grounded or ungrounded	C	C	C		3
2,3,4	D	Ungrounded	D	D	D		3

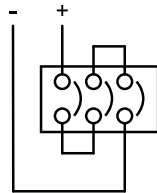
Figure 7.1.7.2
DC rated circuit breakers interrupting test connection diagrams



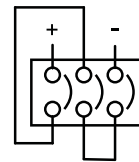
A



B



C (3 pole typical)



D

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7.1.7.5 For the Y Test Sequence, the number and type of operations, and the test current shall be as indicated in Table 7.1.7.4.

7.1.7.6 A circuit breaker with a short-time delay element shall additionally be evaluated by the tests in 7.1.7.6. The tests shall be conducted at both the maximum short-time pickup setting and maximum short-time delay setting. For these tests, the instantaneous element shall not operate to trip the circuit breaker. If the maximum short-time pickup setting and maximum short-time delay setting do not occur together, so that it is necessary to conduct separate tests for each setting, separate samples shall be permitted to be used for each test.

7.1.7.7 The test shall be a 3-phase, "O" and "CO" test conducted at rated voltage and a current between 100 and 120 percent of the current for the short-time pickup setting. The circuit breaker shall trip within the manufacturer's time band for the pickup setting.

7.1.7.8 When a circuit breaker is tested in accordance with note a of Table 7.1.7.3, the same sample – or at the option of the manufacturer an additional sample – shall be subjected to an additional test at any convenient voltage. The circuit breaker's delayed tripping element shall be set to the maximum delay position. The circuit breaker shall carry, and trip, a current equal to that required for the single-pole short circuit test. The test shall be performed once as a type "O" operation and repeated as a type "CO" operation.

7.1.7.9 With regard to Figure 7.1.7.1, during the common operation when using alternating current, the location of the fuse connection referred to in 7.1.1.27 shall be to that side of the supply least likely to arc to grounded metal and not necessarily as shown.

7.1.7.10 The time interval between the interrupting operations of a circuit breaker shall be 2 minutes, except that the time interval may be extended to whatever is necessary to allow the circuit breaker to be reset, but not more than 1 hour.

Table 7.1.7.3
Available current in test circuits

Frame rating	RMS symmetrical or DC amperes				
	1 pole	2 pole		3 pole	
		Individual ^a	Common	Individual ^a	Common
100 A maximum 250 V maximum	5,000	5,000	5,000	4,330 ^{b,c,d}	5,000
100 A maximum 251 – 1500	10,000	10,000	10,000	8,660 ^{b,c,d}	10,000
101 – 800 A	10,000	10,000	10,000	8,660 ^{b,c,d}	10,000
801 – 1200 A	14,000	14,000	14,000	12,120 ^{b,c,d}	14,000
1201 – 1600 A	–	14,000	20,000	14,000	20,000
1601 – 2000 A	–	14,000	25,000	14,000	25,000
2001 – 2500 A	–	20,000	30,000	20,000	30,000
2501 – 3000 A	–	25,000	35,000	25,000	35,000
3001 – 4000 A	–	30,000	45,000	30,000	45,000
4001 – 5000 A	–	40,000	60,000	40,000	60,000
5001 – 6000 A	–	50,000	70,000	50,000	70,000

Table 7.1.7.3 Continued on Next Page

Table 7.1.7.3 Continued

Frame rating	RMS symmetrical or DC amperes				
	1 pole	2 pole		3 pole	
		Individual ^a	Common	Individual ^a	Common
^a At the option of the manufacturer, the adjustable response of a circuit breaker that incorporates a delayed-tripping element may be adjusted to less than the maximum position for the individual pole tests. ^b This value is the current available when using two legs of the 3-phase circuit indicated under "Common." ^c For dc ratings, the current indicated under "Common" shall be used for individual pole operation. ^d The current indicated for 2-pole under the "Individual" column shall be used for either of the following: <ol style="list-style-type: none"> 1) Circuit breakers marked with 208Y/120 V, 480Y/277 V, 600Y/347 V ratings, or other wye-connected system rating; or 2) 3-pole circuit breakers marked in accordance with 9.1.1.24. 					

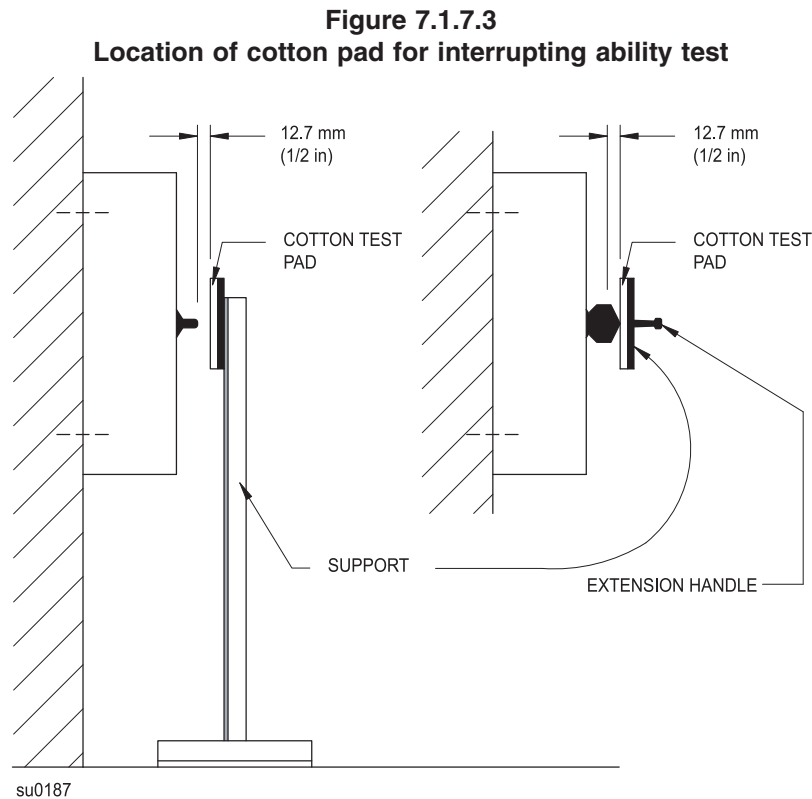
Table 7.1.7.4
Available current in test circuit^a

Frame rating	RMS symmetrical or DC amperes	
	1-pole	2-, 3-, and 4-pole
		Common
100 A maximum, 250 V maximum	1500	1500
100 A maximum, 251 – 1500 V maximum	3000	3000
101 – 225 A	3000	3000
226 – 400 A	5000	5000
401 – 600 A	6000	6000
601 – 800 A	10,000	10,000
801 – 1200 A	14,000	14,000
1201 – 1600 A	–	20,000
1601 – 2000 A	–	25,000
2001 – 2500 A	–	30,000
2501 – 3000 A	–	35,000
3001 – 4000 A	–	45,000
4001 – 5000 A	–	60,000
5001 – 6000 A	–	70,000

^a Sequence of operations shall be O-t-CO, where t is a minimum of 2 minutes and a maximum of 1 hour.

7.1.7.11 A cotton pad at least 12.7 mm (1/2 inch) thick, and having a length and width 4 times the handle opening but not less than 76.2 mm (3 inches) in either dimension shall be centered and placed 12.7 mm (1/2 inch) from the end of the circuit breaker handle (see 7.1.7.2). If a handle extension longer than 25.4 mm (1 inch) is used, the cotton pad shall be firmly supported and anchored to the extension as shown in

Figure 7.1.7.3. The cotton pad may be supported on either a solid surface or on 12.7 mm (1/2 inch) mesh hardware cloth. A small opening shall be permitted in a cotton pad to pass a plunger to operate a push-type circuit breaker.



7.1.7.12 The cotton used shall be surgical cotton, such as is commonly used for medical purposes.

7.1.7.13 A circuit breaker intended for use in a ventilated enclosure shall be tested in that enclosure. A cotton pad indicator at least 12.7 mm (1/2 inch) thick shall be attached to the outside of and shall completely cover any louvers or other openings to determine compliance with 18.4.2.

7.1.7.14 The line terminals shall be connected to a supply circuit as indicated in 7.1.7.21 – 7.1.7.25, and the leads for both line and load connections shall be as indicated in 7.1.7.16. Any impedance that may need to be added to limit the current shall be connected in the circuit on the line side of the circuit breaker. The open-circuit voltage of the supply circuit shall be not less than 100 percent nor more than 105 percent of the rated voltage of the circuit breaker, except that a higher voltage may be used if agreeable to the submitter and the testing agency.

7.1.7.15 With regard to the requirement in 7.1.7.14, the limiting impedance added in the test circuit may be divided appropriately between the supply lines. The grounding connection for the frame, enclosure, or both, of the circuit breaker shall be made on the load side of the added impedance.

7.1.7.16 Each circuit breaker shall be subjected to all the operations of the interrupting test, without replacement of any lead during the test. All leads shall consist of Type TW, TW75, RW75, THW, or THWN copper wires of the size indicated in Table 6.1.4.2.1 corresponding to the current rating (I_n) and markings of the circuit breaker, except as noted in 7.1.7.17, the leads for tests on 277 V, 347 V, 480 V, and 600 V or greater circuit breakers rated 15 A or less shall be permitted to be 12 AWG (3.3 mm²). For a circuit breaker rated 125 A or less, the 60°C (140°F) wire shall be used except as required by 7.1.7.17. A circuit breaker rated 1600 A or more shall be permitted to be tested with copper bus bars having a cross-section not less than indicated in Table 7.1.4.1.3. Line terminal leads shall be not more than 1.219 m (4 feet) in length. Load terminal leads shall be not more than 254 mm (10 inches) in length per terminal for multipole operation, and not more than 1.219 m (4 feet) in length for single-pole operations. However, for 600 A frame size and larger, leads of any AWG size not more than 1.219 m (4 feet) in length and that were included in the calibration circuit shall be permitted as load leads for multipole operation and as extension leads for single-pole operation. Leads shall be routed as described in 7.1.3.5.

7.1.7.17 For a circuit breaker rated 100 A or less that is not marked for use with wire sizes of 1/0 or larger, and marked for use with 75°C (167°F) wire only, 75°C wire shall be used. See note a of Table 7.1.11.4.1.1.

7.1.7.18 If a circuit breaker rated less than 1600 A has terminals that have no provision for wire the connections to those terminals for the interrupting test shall be as indicated in 7.1.4.1.18 with the combined length of the bus bars and the wires as indicated in 7.1.7.16.

7.1.7.19 A circuit breaker that has specially formed terminals intended only for connection to mating parts (plug-in type) shall be connected for the test as indicated in 7.1.4.1.19 or 7.1.4.1.22 with the length of the test leads as indicated in 7.1.7.14.

7.1.7.20 If a circuit breaker is constructed so that the points where wires or bus bars are attached are located on integral or separable parts that extend from the circuit breaker housing, the connections for the interrupting test shall be made to the intended points on these extension members with leads or bus bars as indicated in 7.1.7.14.

7.1.7.21 A circuit breaker intended for use on a dc system, see 7.1.1.7, shall be tested with dc and with the circuit breaker connected so that the frame and enclosure will be positive in potential with regard to the nearest arcing point.

7.1.7.22 The time constant of the test circuit shall not be less than 0.003 seconds for currents of 10,000 A or less and 0.008 seconds for currents greater than 10,000 A.

7.1.7.23 The DC open circuit voltage of the circuit shall not be less than 100% nor more than 105% of the rated voltage of the unit under test, except that a higher voltage may be used if agreeable to the submitter and the testing agency.

7.1.7.24 A circuit breaker intended for use on an ac system only shall be tested with essentially sinusoidal ac at rated frequency (as specified in 7.1.1.15). The power factor of the test circuit with required current flowing shall be as tabulated in Table 7.1.7.5, except that a lower power factor may be used if agreeable to the submitter and the testing agency. Reactive components of the impedance in the line shall be of the air core type and may be paralleled. No reactance shall be connected in parallel with resistances, except that an air-core reactor(s) in any phase shall be permitted to be shunted by resistance, the volt-ampere loss of which is approximately 0.6 percent of the reactive volt-amperes in the air-core reactor(s) in that phase. The shunting resistance (R) used with an air-core reactor having negligible resistance shall be calculated from the formula:

$$R = 167 \frac{E}{I}$$

in which:

E is the voltage across the air-core reactor with current; and

I is the current flowing as determined by oscillographic measurement during the short-circuit calibration, or, by proportion, from meter measurements at some lower current.

7.1.7.25 Oscillograph recordings, or an equivalent method, shall be used to determine circuit characteristics. See Annex C.

Table 7.1.7.5
Power factor of test circuits

Test circuit in amperes	Power factor
10,000 or less	0.45 – 0.50
10,001 – 20,000	0.25 – 0.30
Over 20,000	0.15 – 0.20

7.1.7.26 If a dc circuit breaker is intended to be wired in series but two of the poles are connected to the load and the breaker complies with a) through d) below, interrupting tests shall be conducted in accordance with 7.1.7.27:

- a) Is a multi-pole type;
- b) Is marked for 2 or more poles to be wired in series;
- c) Is marked for use in a grounded system; and
- d) Requires a direct connection to both the grounded and ungrounded circuit conductors.

7.1.7.27 The circuit breaker shall be wired to both the grounded and ungrounded circuit conductor of the test station with the fewest number of poles intended to be connected in series in accordance with the circuit breaker instructions. The normal load side terminal(s)/pole(s) intended to be connected to the grounded circuit conductor shall not be used, and instead the load side of the positive terminal(s)/pole(s) shall be connected directly to the grounded terminal of the test station.

7.1.8 Trip-out at 200 Percent Current Test

7.1.8.1 Following the interrupting ability test, a circuit breaker shall be capable of operating automatically, when carrying 200 percent of its rated current, within the time limits given in Table 7.1.2.2.1 when tested as indicated in 7.1.2.2. No minimum tripping time is specified for circuit breakers of the time-delay type.

7.1.9 Dielectric Voltage-Withstand Test

7.1.9.1 A circuit breaker shall be capable of withstanding for 1 minute without breakdown the application of a 48 – 62 Hz essentially sinusoidal potential of 1000 V plus twice the voltage that is to be applied between the parts in question, when the breaker is connected in accordance with its maximum voltage rating:

- a) Between line and load terminals with the breaker open – with the breaker in the tripped and off positions. The test voltages shall be based on the voltage rating of the circuit breaker. The test voltage for a circuit breaker rated for a wye-connected system shall be based on the phase to phase voltage;
- b) Between terminals of opposite polarity with the breaker closed. The test voltages shall be based on the voltage rating of the circuit breaker. The test voltage for a circuit breaker rated for a wye-connected system shall be based on the phase-to-phase voltage; and
- c) Between live parts and the overall enclosure, as described in 7.1.1.25, with the breaker both open and closed. The test voltage for a circuit breaker rated for a wye connected system shall be based on the phase-to-neutral voltage.

7.1.9.2 The test potential shall be 1000 V plus twice the voltage rating that is to be applied between the parts in question, when the circuit breaker is connected in accordance with its maximum voltage rating.

7.1.9.3 To determine if a circuit breaker complies with the requirement of 7.1.9.1, the test shall be made using a 500 VA or larger transformer, the output voltage of which can be varied. Starting at zero, the applied potential shall be increased to the required test value and held at that value for 1 minute. The increase in the applied potential shall be at a uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter. The transformer shall be permitted to be less than 500 VA if the output voltage is measured directly.

Table 7.1.11.4.1.1 Continued

Manner tested	Ampacity	Ampere rating relative to frame or group within frame	Size of copper test leads ^{a,b}	
			Line	Load ^c
^f See 7.1.11.4.1.11 and 7.1.11.4.1.12.				

7.1.11.4.1.9 For multipole circuit breakers and for pairs of single-pole circuit breakers, the load terminals of the circuit breaker shall be connected together with 254 mm (10 inch) test leads (per pole) brought to a common point, or brought to a shorting bar of adequate current-carrying capacity.

7.1.11.4.1.10 When testing a single-pole circuit breaker, the load side test lead shall be not more than 1.219 m (4 feet) long except that if the circuit breaker rating is less than 100 A and is the maximum of the frame or test group within the frame, the rated size wire shall be 254 mm (10 inches) long and shall be connected to the load supply terminal by 1.219 m (4 feet) of 1 AWG (42.4 mm²) copper wire.

7.1.11.4.1.11 Except as permitted by 7.1.11.4.1.12, a circuit breaker that is rated 100 A and less shall be tested additionally under "bus bar conditions." See Table 7.1.11.4.1.1 for ratings to be tested. The line terminals of single and multipole circuit breakers, and the load terminals of single pole circuit breakers shall be connected with a 254 mm (10 inch) long lead of rated wire size. To the ends of each of these leads, 1 AWG (42.4 mm²) leads, each 1.219 m (4 feet) long, shall be joined for connection to the test terminals.

7.1.11.4.1.12 If agreeable to the submitter and the testing agency, the 254 mm (10 inch) long lead of rated wire size may be omitted if the circuit breaker is connected to a copper bus bar that is directly connected to the 1 AWG (42.4 mm²) leads. The bus bar shall have a cross-section greater than or equal to the rated wire and shall be not longer than 254 mm (10 inches).

7.1.11.4.1.13 The leads shall enter the test enclosure through a bushed hole, and shall be lashed together outside of the enclosure to the extent necessary to prevent appreciable motion during the interrupting test. Where parallel conductors are used, more than one bushed opening may be used if an equal number of conductors from each phase are run through each opening or equivalent methods, such as the use of conduit, shall be permitted. Line and load conductors shall be permitted to enter through different bushed openings.

7.1.11.4.1.14 The test enclosure shall be connected through a fuse as indicated in 7.1.1.27 to the line lead least likely to arc to the enclosure, or the neutral, if the circuit breakers are rated for a wye-connected system. The connection shall be made to the load side of the limiting impedance by means of 10 AWG (5.3 mm²) copper wire not more than 1.829 m (6 feet) in length.

7.1.11.4.1.15 For tests with leads, the circuit shall be closed on the circuit breaker by means of a switching device, using random closing. After a 2-minute interval, or the time necessary to allow the circuit breaker to reset, but no more than 1 hour, the circuit breaker shall be closed on the circuit.

7.1.11.4.1.16 For tests under "bus bar conditions" the test circuit shall be closed on the circuit breaker using random closing. No other operation is required. See also 7.1.11.4.1.11.

7.1.11.4.2 Circuit characteristics

7.1.11.4.2.1 The prospective current shall be determined as described in Annex C with the test-circuit terminals connected together by a conductor of negligible impedance.

7.1.11.4.2.2 The currents determined as in 7.1.11.4.2.1 shall be not less than the intended interrupting rating involved.

7.1.11.4.2.3 The open circuit voltage shall be not less than 100 percent nor more than 105 percent of the rated voltage for the test being conducted, except that a higher voltage may be used if agreeable to the submitter and the testing agency.

7.1.11.4.2.4 The power factor of the test circuit with the required current flowing shall be in accordance with 7.1.7.23 and Table 7.1.7.4.

7.1.11.4.2.5 The characteristics of ac circuits and dc circuits recovery voltage and ac decrement shall be as described in Annex C.

7.1.11.4.2.6 A circuit breaker intended for use on a dc system, see 7.1.1.7, shall be tested with dc and with the circuit breaker connected so that the frame and enclosure will be positive in potential with regard to the nearest arcing point.

7.1.11.4.2.7 The time constant of the test circuit shall not be less than 0.003 seconds for currents of 10,000 A or less and 0.008 seconds for currents greater than 10,000 A.

7.1.11.4.2.8 The DC open circuit voltage of the circuit shall not be less than 100% nor more than 105% of the rated voltage of the unit under test, except that a higher voltage may be used if agreeable to the submitter and the testing agency.

7.1.11.4.2.9 Oscillograph recordings, or an equivalent method, shall be used to determine circuit characteristics. See Annex C.

7.1.11.5 Trip-out test

7.1.11.5.1 The trip-out test following the interrupting test shall be made as described in 7.1.8 except that the test current shall be 250 percent of rated current.

7.1.11.5.2 If the pole under test does not trip within the time indicated in Table 7.1.2.2.1, the current shall be immediately increased to 400 percent of rated current under which condition the pole under test shall trip within 2 additional minutes. When a multipole circuit breaker is being tested, this additional 400 percent test shall be made on only one pole of the multipole circuit breaker.

7.1.11.5.3 The trip-out test shall not be required for those circuit breaker samples tested under the "bus bar conditions" of Table 7.1.11.4.1.1 that are not capable of reestablishing continuity.

7.1.11.6 Other functionality calibration test

7.1.11.6.1 Calibration of the additional functionality shall be conducted as required in 7.1.11.1.8.

7.1.11.7 Dielectric voltage-withstand test

7.1.11.7.1 A circuit breaker shall be capable of withstanding for 1 minute without breakdown the application of a 48 – 62 Hz essentially sinusoidal potential:

- a) Between line and load terminals with the circuit breaker open – that is, with the circuit breaker in the tripped and off positions;
- b) Between terminals of opposite polarity with the circuit breaker closed; and
- c) Between live parts and the overall enclosure with the circuit breaker both open and closed.

7.1.11.7.2 For circuit breakers rated 600V and less, the test potential shall be twice the voltage rating at which the interrupting test was conducted but not less than 900 V. For circuit breakers greater than 600 V, the test potential shall be twice the voltage rating at which the interrupting test was conducted but not less than 150 percent of rated voltage. Also, see 7.1.9 for circuit breakers rated for a wye-connected system.

7.1.11.7.3 For samples that have been subjected to the interrupting test under bus bar conditions it may not be possible to relatch and close the sample as required for the test of 7.1.11.7.1 and 7.1.11.7.2. In such cases, tests shall be made only under those conditions possible. An opposite polarity test between line terminals shall be made in any case.

7.1.11.7.4 To determine if a circuit breaker complies with the requirements in 7.1.11.7.1, the test shall be conducted in accordance with 7.1.9.3.

7.1.11.8 Interpretation of results

7.1.11.8.1 During performance testing for interrupting ratings, 7.1.11.1 – 7.1.11.7, test results may include the conditions described in 7.1.11.8.2 and 7.1.11.8.3.

7.1.11.8.2 "Type A" performance results include the following:

- a) Inability of the circuit breaker under test to clear the test circuit;
- b) Inability of a multipole common-trip circuit breaker to open all poles during the interrupting test;
- c) Breakage of or holes in the circuit breaker case. See 7.1.11.8.5;
- d) Welding of contacts;
- e) Ejection of wire from the wire connector or burn off of leads during the interrupting test;
- f) Inability of more than one pole of a multipole circuit breaker to trip during the trip-out test;
- g) Ground fuse clearing;
- h) Dielectric voltage-withstand test breakdown;

- i) Inability of a multi-pole circuit breaker that includes a common - trip element to open all poles upon the tripping of any pole being tested during the trip-out test;
- j) Inability of circuit breakers with additional functionality to trip when tested in accordance with 7.1.11.1.8; and
- k) Other types of similar results.

7.1.11.8.3 "Type B" performance results include the following:

- a) Burned out shunts;
- b) Burned out bimetals or heaters;
- c) Conditions that do not permit relatching or reclosing of the circuit breaker;
- d) Inability of one pole of a 2-, 3-, or 4-pole circuit breaker to trip during the trip out test;
- e) Damage to conductor insulation; and
- f) Other types of similar results.

7.1.11.8.4 The inability to relatch, reclose, or otherwise reestablish continuity – such as due to solid state components or braid – shall be considered acceptable for circuit breakers which are tested under "bus bar conditions."

7.1.11.8.5 Hairline cracks shall be considered acceptable but cracks where a portion of the case is deflected outward or inward are not acceptable. Any hole or opening in the case caused by the interrupting test operation is not acceptable. A crack that would permit separation of two sections of the case is acceptable only if the two sections are caused to maintain their proper relative positions because of securing means, such as mounting bolts, cover screws, or the like.

7.1.11.8.6 If no test result is classified as Type A or Type B, the construction shall be considered as meeting the test program for the rating.

7.1.11.8.7 If any test result is classified as Type A, or if more than one test result in any one interruption is classified as Type B, the construction shall be considered not to meet the requirements of the test program for the rating.

7.1.11.8.8 In the event of a single test result classified as Type B, a second sample of the same rating shall be subjected to the test program. If the second sample performs in the same manner as the original, the construction shall not be considered as meeting the test program for the rating. If the performance of the second sample is classified as Type B, but in a manner different than the original sample, a third sample shall be tested. If the performance of the third sample is classified as Type B, but in a manner different than the first or second sample, a fourth sample shall be tested. If the performance of the fourth sample is classified as Type A or B, the construction shall not be considered as meeting the test program.

7.2.3.5 Each circuit breaker shall be tested at its rated frequency, or if rated with a range of frequencies, at the highest frequency in the range.

7.2.3.6 Each circuit breaker shall be tested with leads and shall be caused to interrupt the circuit twice. The first interruption shall be an "O" operation and the second shall be a "CO" operation. There shall be a two-minute interval, or the time necessary to allow the circuit breaker to be reset, but not more than one hour between the operations. For a 3-pole circuit breaker, or a 2-pole circuit breaker tested on a 3-phase circuit, circuit closing on the "O" operation shall be at random. For a single-pole circuit breaker, or a 2-pole circuit breaker tested on a single-phase circuit, controlled closing shall be used so as to close at the closing or contact separation angle (on the voltage wave) that results in greatest I^2t let-through.

7.2.3.7 Each circuit breaker type where the maximum rating of the frame or the group tested is 100 A or less shall be tested under "bus bar" conditions and shall be caused to interrupt the circuit once, under "O" operation. Circuit closing shall be at random.

7.2.3.8 All impedance shall be connected on the line side of the circuit breaker test terminals, except that low-impedance metering shunts shall be permitted to be connected to the load terminals. If coaxial shunts are used and one is connected on the load side, the outer shell of a single (coaxial) shunt, or the common connection of the outer shells, if more than one shunt is used, shall be permitted to be grounded if there is no other ground on the circuit.

7.2.3.9 The prospective current shall be determined as described in Annex C with the test-circuit terminals connected together by a conductor of negligible impedance.

7.2.3.10 The open-circuit voltage shall be not less than 100 nor more than 105 percent of the rated voltage of the circuit breaker for the test being conducted, except that a higher voltage shall be permitted if agreeable to the submitter and the testing agency.

7.2.3.11 The power factor of the test circuit with the required current flowing shall be as indicated in Table 7.1.7.4, except that a lower power factor shall be permitted if agreeable to the submitter and the testing agency. Reactive components of the impedance in the line shall be permitted to be paralleled if of the air core type, but no reactance shall be connected in parallel with the resistances, except that an air core reactor in any phase shall be permitted to be shunted by resistance, the volt-ampere loss of which is approximately 0.6 percent of the reactive volt-amperes in the air-core reactor in that phase.

7.2.3.12 Each circuit breaker shall be mounted in the smallest metallic enclosure (box and cover) in which it is intended to be used. Openings shall be permitted in the enclosure if the combined area of all openings does not exceed 10 percent of the total external enclosure area and if no opening is directly opposite a vent in the circuit breaker case. A nonconducting enclosure shall be used if the circuit breaker is marked as precluding use in a metallic enclosure. See 9.1.1.19.

7.2.3.13 The test leads shall be as indicated in Table 7.2.3.2. The line terminal connections shall be not more than 1.219 m (4 feet) in length, except that a greater length shall be permitted if the excess over 1.219 m (4 feet) per terminal is in the circuit during the test-circuit calibration.

Table 7.2.3.2
Test leads

Manner tested	Ampacity	Ampere rating relative to frame or group within frame	Size of copper test leads ^{a,b}	
			Line	Load ^c
Tested with leads	100 A and above	Maximum Minimum	Rated wire Rated wire	Rated wire Rated wire
	Less than 100 A	Maximum Minimum	Rated wire Rated wire ^e	Rated wire ^d Rated wire ^e
Tested under "bus bar condition"	100 A and less	Maximum Minimum	1 AWG ^f (42.4 mm ²)	Rated wire (2 and 3 pole) 1 AWG (42.4 mm ²) (1 pole) ^f

^a "Rated wire" refers to size as specified in Table 6.1.4.2.1. For a circuit breaker rated 100 A or less or that is not marked for use with wire sizes of 1/0 or larger, the 60°C (140°F) wire shall be used.

^b Circuit breakers of frame size rated 1600 A or more shall be permitted to be tested with bus bars of a size shown in Table 7.1.4.1.3.

^c A copper bus bar may be substituted for the load leads if the ampacity is equal to or greater than the required lead ampacity.

^d See 7.2.3.14 and 7.2.3.15.

^e For circuit breakers rated 15 A at 277, 347, 480, 600 V, or 650 V or more: 12 AWG (3.3 mm²) wire shall be permitted instead of 14 AWG (2.1 mm²) wire.

^f See 7.2.3.16.

7.2.3.14 In both the single-phase (multipole, including single-pole circuit breakers tested in pairs) and 3-phase tests, the load terminals of the circuit breaker shall be connected together with 254 mm (10-inch) test leads (per pole) brought to a common point, or brought to a shorting bar of rated current-carrying capacity.

7.2.3.15 When testing a single-pole circuit breaker, the load-side test lead shall be not more than 1.219 m (4 feet) long, except that if the circuit breaker rating is less than 100 A and is the maximum of the frame or test group within the frame, the rated size wire shall be 254 mm (10 inches) long and shall be connected to the load supply terminal by 1.219 m (4 feet) of 1 AWG (42.4 mm²) copper wire.

7.2.3.16 A circuit breaker that is rated 100 A or less shall be tested under "bus bar" conditions. See Table 7.2.3.2 for ratings to be tested. The line terminals of single-pole and multipole circuit breakers, and the load terminals of single-pole circuit breakers shall be connected with a 254 mm (10 inch) long lead of rated wire size. To the ends of each of these leads, 1 AWG (42.4 mm²) leads, each 1.219 m (4 feet) long, shall be joined for connection to the test terminals.

7.2.3.17 The leads shall enter the test enclosure through a bushed hole and shall be lashed together outside of the enclosure to the extent necessary to prevent appreciable motion during the interrupting and let-through measurement tests. Where parallel conductors are used, more than one bushed opening shall be permitted to be used if an equal number of conductors from each phase are run through each opening. Equivalent methods, such as the use of conduit, shall be permitted.

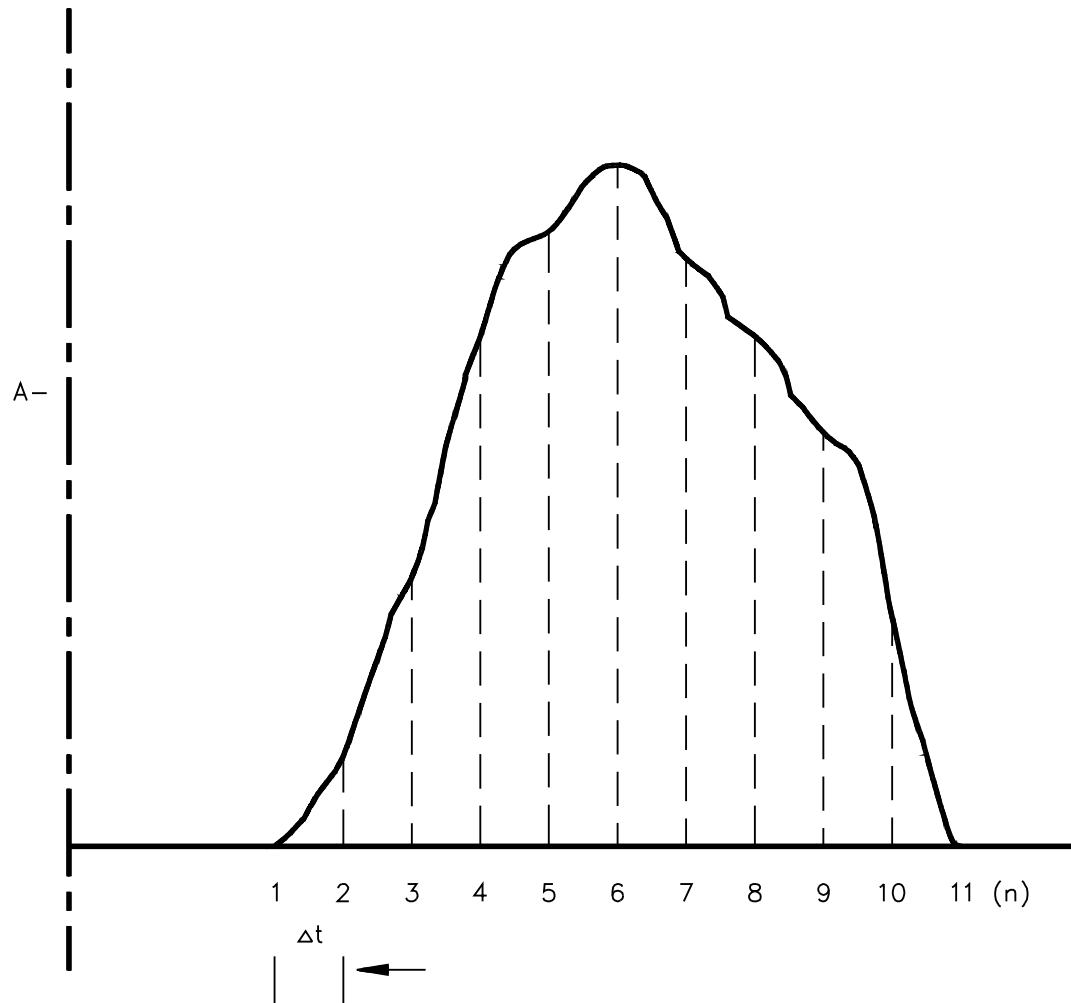
7.2.3.18 The tightening torque applied to any circuit breaker lead terminal shall be as marked on the circuit breaker.

7.2.3.19 A metallic test enclosure shall be connected through a 30-A fuse to the line lead least likely to arc to the enclosure, or the neutral, if the circuit breakers are rated for a wye-connected system. The connection shall be made to the load side of the limiting impedance by means of 10 AWG (5.3 mm²) copper wire no more than 1.829 m (6 feet) in length. The fuse shall be acceptable for branch-circuit protection and have a voltage rating not less than the circuit breaker being tested.

7.2.3.20 The peak current and I^2t let-through – in each phase for a multipole circuit breaker tested on a 3-phase circuit – shall not exceed the value specified by the manufacturer (see 8.7) at that particular prospective current and voltage level. In addition, the I^2t let-through at test points at prospective currents from the threshold current to the interrupting rating current shall not exceed the I^2t of a 1/2 cycle wave of the symmetrical prospective current (for example where the symmetrical prospective current is 100,000 A, the I^2t would be 83.3×10^6). The peak current and I^2t let-through limits shall not be applicable for circuit breakers tested under "bus bar" conditions.

7.2.3.21 The let-through I^2t shall be determined from an oscillogram showing a current trace during the interruption of the circuit by the circuit breaker. The determination shall be made by the application of Simpson's rule (Figure 7.2.3.1), the use of an integrating planimeter, or equivalent method. The use of approximation equations that use the peak let-through of the current and the time from initiation of the current to current zero shall not be used.

Figure 7.2.3.1
Application of Simpson's rule to current oscillogram to obtain let-through I^2t

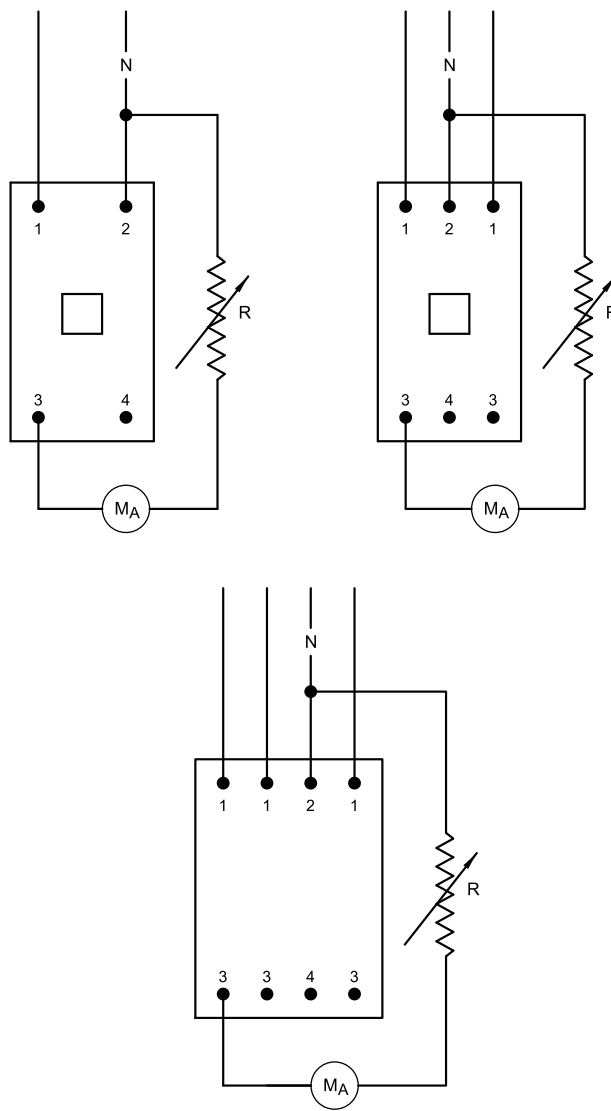


1. Odd numbers of ordinates (n) are to be chosen evenly spaced (Δt). The more uneven the curve, the more ordinates.
2. Each ordinate is to be measured, multiplied by ampere scale (indicated by A in this figure), and squared.
3. I^2t is calculated as follows:

$$I^2t = \frac{\Delta t}{3} [(I_1^2 + I_n^2) + 4(I_2^2 + I_4^2 + I_6^2 \dots I_{(n-1)}^2) + 2(I_3^2 + I_7^2 \dots I_{(n-1)}^2)]$$

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Figure 7.4.2.1
Ground-fault calibration



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N – Neutral

Terminal Designations

- 1 – Line
- 2 – Line Neutral or Panel Neutral
- 3 – Load or Load Power
- 4 – Load Neutral

7.4.2.3 Endurance test

7.4.2.3.1 One-half of the "with current" operations of the endurance test shall be performed as follows:

- a) Turn the circuit breaker on,
- b) Depress the supervisory (test) switch to cause tripping, and
- c) Relatch the circuit breaker.

7.4.2.4 Interrupting tests

7.4.2.4.1 For the interrupting test, the number of operations shall be performed in accordance with Table 7.4.2.2 and the connecting diagrams shown in Figure 7.4.2.2 shall be used. The length of integral leads shall be reduced to 152 mm (6 inches).

7.4.2.4.2 For the interrupting test during the Y test sequence, the test current shall be as indicated in Table 7.1.7.4 and the connections shall be per Figure 7.4.2.2, items A or C, as appropriate. The test shall consist of one "O" and one "CO" operation.

Table 7.4.2.2
Z Sequence
Interrupting test operations

Poles	Frame ratings	Circuit breaker AC voltage ratings	Operations on each pole ^a		Common operations ^a	Total number of operations
			"O"	"CO"		
1	All	120 or 127	B	B	A	3
2	All	120/240	D	D	C	5
3	All	208Y/120 and/or 220Y/127	F	F	E	7

^a Letters indicate diagram in Figure 7.4.2.2.

7.19 Circuit breakers and surge protective devices

7.19.1 Circuit breakers and surge protective devices shall comply with Standard circuit breakers, 7.1, and Annex B, Ref. No. 22.

7.20 Special purpose not for general use circuit breakers

7.20.1 A special purpose not for general use circuit breaker shall comply with the requirements of Tables 7.1.1.1 and 7.1.1.2.

8 Ratings

8.1 A circuit breaker shall be rated in amperes, volts, and frequency. A circuit breaker shall be permitted to be rated for ac, dc, or both.

8.2 A circuit breaker shall have one or more of the following voltage ratings:

a) DC: 24, 48, 60, 65, 80, 125, 125/250, 160, 200, 200/400, 250, 400, 500, 600, and 650 to 1500 Vdc, in 50 V increments.

b) AC: 120, 127, 120/240, 208, 208Y/120, 240, 277, 347, 480Y/277, 480, 600Y/347, 600, 650, 690, and 700 to 1000 Vac in 50 volt increments. In addition, any wye-connected system voltage with the above mentioned values meets the intent of the requirement.

8.3 The interrupting rating of a circuit breaker, or a circuit breaker frame with an interchangeable trip unit shall be the value as prescribed in Table 7.1.7.3, "common" for 2- and 3-pole, or one or more of the values shown in Table 8.1 that are higher.

Table 8.1
Current-interrupting ratings rms symmetrical or dc amperes

7,500	25,000	65,000
10,000	30,000	85,000
14,000	35,000	100,000
18,000	42,000	125,000
20,000	50,000	150,000
22,000		200,000

8.4 The interrupting rating of a circuit breaker frame with an interchangeable trip unit shall be permitted to be less than that of the frame in which it is to be used.

8.5 If the interrupting ratings of all ampere ratings of a frame size of a non-interchangeable trip circuit breaker are not the same, all such interrupting ratings shall be permitted to be incorporated in an appropriate marking if each interrupting rating is clearly associated with the circuit breaker ampere rating or ratings to which it applies.

8.6 A current-limiting circuit breaker shall be rated additionally in terms of peak current and I^2t let-through, together with the frequency related to the let-through values. The rating for peak current and I^2t let-through shall be provided in terms of let-through versus prospective current curve, or in tabulated form. Such information shall be made available by the manufacturer and shall correlate with the particular circuit breaker. The let-through for at least the threshold current, interrupting rating current, and one intermediate point shall be indicated.

8.7 A current-limiting circuit breaker shall have a threshold current rating not more than the lesser of either:

- a) The value indicated in Table 8.2 corresponding to its interrupting-current rating, or
- b) 65 times the maximum current of the circuit breaker frame size.

8.8 A circuit breaker with equipment ground-fault protection shall have a ground-fault trip level rating.

Table 8.2
Maximum threshold current for interrupting rating

Interrupting rating	Maximum threshold current Amperes-rms, symm. or DC
5,000	1,500
7,500	3,000
10,000	5,000
14,000	7,500
18,000	10,000
20,000	12,000
22,000	14,000
25,000	15,000
30,000	18,000
35,000	20,000
42,000	25,000
45,000	27,000
50,000	30,000
60,000	36,000
65,000	42,000
70,000	45,000
85,000	55,000
100,000	65,000
125,000	85,000
150,000	100,000
200,000	130,000




9 Markings

9.1 General

9.1.1 Details

9.1.1.1 Location of required markings shall be in accordance with the "Location Categories" given in Table 9.1. See Table 21.1.1 for location of markings on circuit breaker enclosures.

Advisory Note: For products intended for use in Canada, markings shall be in English or in French and English; caution and warning markings shall be in French and English. For products intended for use in Mexico, all markings shall be at least in Spanish. For products intended for use in the United States, all markings shall be at least in English. See Annex D for suitable translations of caution and warning markings.

9.1.1.2 A circuit breaker and a circuit breaker frame shall be marked with the manufacturer's name or trademark, or with other means for identifying the manufacturer, the electrical rating, and with the type designation or the equivalent. Location Category B. The symbols  for AC,  for DC, or  for both, as applicable, shall be used. Additional wording may be provided.

9.1.1.3 For recommended symbols and abbreviations, see Annex F.

9.1.1.4 The marking of a circuit breaker shall be durable and legible.

9.1.1.5 The determination of the durability of the marking shall take into consideration the material used, the security with which the marking is attached, and the degree of abuse expected because of the marking location.

9.1.1.6 Ink stamped marking shall not be easily obliterated.

9.1.1.7 Paper stickers are not acceptable for the marking of a circuit breaker. A paper label with an adhesive that has been investigated and found to be acceptable and is not subject to delamination by moisture or heat shall not be considered a "paper sticker."

9.1.1.8 The ampere rating of a circuit breaker rated higher than 100 A shall be visible after removal of a trim or cover. Location Category B.

9.1.1.9 The ampere rating of a circuit breaker rated 100 amperes or less shall be molded, stamped, or etched into; ink-stamped onto; or similarly marked on the handle or the escutcheon area of the circuit breaker so as to be visible without removing the trim or cover of the enclosure. Location Category A. For handle marking of switches, see 13.4.

9.1.1.10 If the ampere rating marking is placed on the handle of the circuit breaker, the numerical value alone shall be considered to be adequate.

9.1.1.11 If a circuit breaker has characteristics which may affect adversely its operation under certain conditions of use, such as that of polarity or position, such characteristics shall be clearly indicated by a marking on the device. Location Category C.

Table 9.1
Location of markings circuit breaker

Clause numbers	Subject	Location categories ^a (See notes)
General		
9.1.1.1	Location	–
9.1.1.2	Type designation	B
9.1.1.2	Manufacturer's name	B
9.1.1.2	Voltage rating	B
9.1.1.2	Frequency	B
9.1.1.4	Durability & legibility	–
9.1.1.8	Ampere rating – more than 100 A	B
9.1.1.9, 9.1.1.10	Ampere rating – 100 A or less	A
9.1.1.11 – 9.1.1.13	Special characteristics	C, F
9.1.1.14	Line and load	B
9.1.1.15	Factory identification	I
Position Indication		
9.1.1.16	Open and Closed (On and Off)	A
9.1.1.17	Trip and Reset	B, D
9.1.1.18	Electrical operation (On and Off)	B, E
9.1.1.18	Electrical operation (Trip and Reset)	B, E
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9.1.2.1 – 9.1.2.4	CU–AL	B
9.1.2.5, 9.1.2.6	Tightening torque	B, C
9.1.2.7	Maximum wire size	C, G
9.1.2.8	Multiple-conductor connectors	C
9.1.2.9, 9.1.2.10	60° C/75° C (140° F/167° F) – 100 A max or circuit breakers not marked for use with wire sizes of 1/0 or larger	B, C
9.1.2.11	Separately shipped connectors	C
9.1.2.12	Cable connection only	B
9.1.2.13	Bus bar sizes	B
9.1.2.14	90° C/Aluminum or copper-clad aluminum wire	B
9.1.4.8	Configuration of connections of the terminals	B
Interrupting Ratings		
9.1.3.1 – 9.1.3.3	Ratings	B, C
Special Markings		
9.1.1.19	Nonconducting enclosures	C
9.1.1.20	Ventilated enclosures	B
9.1.1.21	2-pole – 3-phase rated	B
9.1.1.22	Multi-wire circuit	B

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9.1.1.13 Where the proper operation or installation of a circuit breaker is dependent upon a barrier or similar member that is part of the circuit breaker, such as a terminal cover, a marking shall be provided to indicate the need for the replacement of this part. Location Category F. The marking shall not be on the removable part.

9.1.1.14 Circuit breakers shall be marked "line" and "load" unless the construction and the test results are acceptable with the line and load connections reversed. A frame with interchangeable trip units that complies with 6.1.5.13 is not required to be marked "line" and "load". Location Category B.

9.1.1.15 If a manufacturer produces or assembles circuit breakers at more than one factory, each finished circuit breaker shall have a distinctive marking, which shall be permitted to be in code, by which it may be identified as the product of a particular factory. Location Category I.

9.1.1.16 A circuit breaker shall indicate clearly whether it is open or closed and such marking shall be visible with a trim or cover in place except that when enclosed it may require the opening of a hinged cover or door. Location Category A. For switches see 13.5.

9.1.1.17 If a circuit breaker handle has an additional or intermediate position which it takes upon automatic tripping, that position shall be marked to indicate that the circuit breaker has tripped. If the circuit breaker has two operating poles, either of which may trip independently of the other as described in 6.1.5.1, the tripping of each pole shall be separately indicated. Instructions for resetting the circuit breaker shall be included. See 9.1.1.18. Location Categories B and E. For switches see 13.5. Marking indicating the tripped position and the resetting instructions need not be provided on the circuit breaker if they are provided on the intended receiving device.

9.1.1.18 If the marking required in 9.1.1.16 to indicate whether a circuit breaker is in the open or closed position is not readily visible when an electrical operator is installed, the electrical operator shall clearly indicate whether the circuit breaker is in the ON or OFF position and may also indicate if the circuit breaker is in the tripped position. Location Categories B and E.

9.1.1.19 A circuit breaker not intended for use in a metal enclosure, see 7.1.1.26, shall be marked "Suitable for use in a nonconducting enclosure only". Equivalent wording shall be permitted. Location Category C.

9.1.1.20 A circuit breaker intended for use only in a ventilated enclosure shall either be marked with the type number, or equivalent, of the enclosure with which it is to be used or indicate the proper size of the enclosure and location and size of the ventilating openings. This marking shall be located where it will be readily visible after installation. See 7.1.4.2.4 and 18.4.1. Location Category B.

9.1.1.21 A 2-pole circuit breaker that has been investigated and found acceptable for controlling a 3-phase circuit shall be permitted to be marked "1 ϕ – 3 ϕ ". Location Category B.

9.1.1.22 A 3-pole circuit breaker that is intended for use only on a single phase multiwire circuit (one that includes the neutral or grounded conductor) shall include in its marked voltage rating the term, "Only for Use in 1-Phase Circuits or equivalent. The neutral pole shall be clearly identified. Location Category B.

9.1.1.23 A 3-pole circuit breaker that is acceptable for 250 V direct current use shall be permitted to be marked "250 V DC" if it is clearly indicated that the rating applies to the use of at least two poles to control the circuit. Location Category B.

9.1.1.24 A 3-pole circuit breaker shall be permitted to be marked, "Also Suitable For Use In Single Phase Applications up to ___V" or the equivalent if tested in accordance with Note d of Table 7.1.7.3. The applicable voltage (240V, 480V, or 600V) shall be specified. The marking shall also indicate the poles to be used, such as, "Use Outside Poles for Single Phase Applications" or "Use Any Two Poles for Single Phase Applications". Location Category C.

9.1.1.25 240V, 480V, or 600V rated 3-pole circuit breakers, employing one pole for single phase applications in wye system, and 208Y/120 V, 480Y/277 V, or 600Y/347 V rated circuit breakers, are permitted to be marked, "Also Suitable For Use In Single Phase Applications up to ___V", or the equivalent. The applicable voltage (120V, 277V, or 347V) shall be specified.

9.1.2 Terminations

9.1.2.1 The abbreviation "CU" for the word "copper" and "AL" for the word "aluminum" shall be permitted in any required marking.

9.1.2.2 A circuit breaker with wiring terminals intended and found acceptable for use with copper and aluminum conductors shall be marked "Use copper or aluminum wire" or with the abbreviations "CU", and "AL", "CU/AL", or the equivalent. Location Category B.

9.1.2.3 A circuit breaker with terminals intended and found acceptable for copper wire only shall be marked "USE COPPER WIRE ONLY" or with the abbreviation "CU ONLY". If the terminals are intended and found acceptable for aluminum wire only, the marking shall be "USE ALUMINUM WIRE ONLY" or "AL ONLY". Location Category B.

9.1.2.4 A circuit breaker with wiring terminals having a wire range of 14 – 10 AWG (2.1 – 5.3 mm²) solid wire only shall be marked "14 – 10 AWG SOLID", "14 – 10 AWG SOL.", or with equivalent wording. The marking shall be located adjacent to the terminal and shall be visible after the circuit breaker has been installed in the intended manner. Location Category B.

9.1.2.5 With regard to the requirements in 6.1.4.2.3, a circuit breaker shall be marked to show a range of values or a nominal value of tightening torque to be applied to the clamping screws of all terminal connectors for field wiring. This marking shall be visible when a front or trim is removed. Location Category B.

9.1.2.6 Notwithstanding 9.1.2.5, a circuit breaker that is 38.1 mm (1-1/2 inch) wide per pole or less shall be permitted to have the marking at any convenient location on the circuit breaker except on the rear. Location Category C.

9.1.2.7 If the terminals of a circuit breaker will not acceptably hold the next larger size conductor than that required, the circuit breaker or the terminal shall be marked to indicate the maximum wire size. This marking shall be visible when the connector is in place. See 6.1.4.2.13. Location Categories C and G.

- g) The accessory is an essentially complete unit and does not require detailed assembly in the field. Except as permitted in (h), the installation of the accessory does not expose live or mechanical functional parts that would not be exposed during the replacement of an interchangeable trip unit. An arrangement that requires cutting, splicing of existing wires, or resoldering of connections within the circuit breaker housing is not acceptable.
- h) Except as noted in (i) and (j) means for mounting the accessory require no drilling, cutting, or filing of holes. Openings to provide for the accessory actuator to operate the trip mechanism may be provided in the trip unit housing. If breakouts are provided for this purpose they shall be removable in one piece.
- i) Drilling, cutting, or filing is acceptable in the circuit breaker or switch housing only to provide an opening for the accessory leads and the location of such openings is indicated by drill points or breakouts.
- j) It is possible to accomplish the operation described in (i) in a manner so that debris inside the circuit breaker or switch housing does not accumulate.
- k) Strain or pushback relief, if required to meet the requirements of 14.1.5.1 and 14.1.5.2, is provided as an integral part of the accessory or is furnished as part of the kit along with any instructions or tools necessary to comply with the requirements of this standard.
- l) The accessory complies with the marking requirements of 17.4.
- m) The installation of the accessory does not affect the performance of the circuit breaker or switch.

14.1.2.2 So that instructions are always available should it become necessary to replace a circuit breaker or trip unit, a circuit breaker or interchangeable trip unit intended to accept field-installed accessories shall be provided with information for the proper reinstallation of the accessory.

- a) If interchangeable trip units are involved, this information may be:
 - 1) Part of the trip unit installation instruction;
 - 2) Marked on the trip unit; or
 - 3) Provided on a separate tag attached to the trip unit.
- b) If noninterchangeable trip units are involved, this information may be:
 - 1) Marked on the circuit breaker; or
 - 2) Provided on a separate sheet packaged with the circuit breaker.
- c) The information shall comply with one of the following:
 - 1) Be complete as required by 14.1.2.1 (d).
 - 2) Provide a condensed version of the instructions specified in 14.1.2.1 (d); or

3) Refer to where installation instructions for each accessory may be obtained; in this case, the information shall include a statement of the need to determine that the accessory performs its intended function after it has been reinstalled.

14.1.3 Mounting

14.1.3.1 An accessory shall be securely mounted in position and prevented from loosening or turning if such motion may affect adversely the intended performance of the circuit breaker or switch or reduce the minimum spacing to less than that indicated in 14.1.6.1.

14.1.4 Field Wiring

14.1.4.1 An accessory shall be provided with means for the connection of wires having ampacity corresponding to the rating of the accessory. See Tables 6.1.4.2.1 and 14.1.4.1.

14.1.4.2 Terminal leads of a circuit breaker accessory shall consist of wire suitable for the particular application, when considered with respect to the temperature and voltage and conditions of service to which the wiring is likely to be subjected.

14.1.4.3 Terminal leads shall be 24 AWG (0.20 mm²) minimum. The free length of a terminal lead shall be at least 150 mm (6 inches).

Table 14.1.4.1
Ampacities of insulated conductors

Wire size		60°C (140°F)	
AWG	(mm ²)	Copper	Aluminum
24	(0.20)	2	–
22	(0.32)	3	–
20	(0.52)	5	–
18	(0.82)	7	–
16	(1.3)	10	–

14.1.4.4 A pressure connector provided for use with an accessory shall comply with 6.1.4.2.2.

14.1.5 Strain Relief

14.1.5.1 Strain relief shall be provided to prevent a mechanical stress on the accessory supply leads to which field connections are made from being transmitted to terminals, splices, or interior wiring. See 15.1.3.

14.1.5.2 Means shall be provided to prevent the accessory supply leads to which field connections are made from being pushed into the housing of a circuit breaker or switch through the lead entry holes, if such displacement is likely to subject the lead to mechanical injury, or if it is likely to reduce spacings – such as to a metal strain-relief clamp – below the minimum acceptable values, or if the mechanical operation of the circuit breaker or switch, or accessory is impaired.

14.1.5.3 Any surface with which the leads may come in contact shall be free from any projections, sharp edges, burrs, fins, or the like that may cause abrasion of the insulation on the conductors.

14.1.6 Spacings

14.1.6.1 With any combination of accessories installed, the circuit breaker or switch spacings shall not be less than those required in General, 6.1.6.1.

14.1.6.2 The requirements in 14.1.6.1 do not apply:

- a) Between uninsulated live parts of opposite polarity within a component, such as an auxiliary switch;
- b) Between uninsulated live parts of the component and dead metal that is part of the component; or
- c) Between uninsulated live parts of the component and that part of the dead metal surface of the circuit breaker or switch on which the component is mounted in the intended manner.

14.1.6.3 The requirements in 14.1.6.1 do apply:

- a) Between live parts in different components; and
- b) Between an uninsulated live part of a component and a live part or the dead metal of the circuit breaker or switch, other than the dead metal surface on which the component is mounted.

14.1.6.4 The spacings at an accessory and its field-wiring terminals shall be in accordance with Table 14.1.6.1.

Table 14.1.6.1
Minimum acceptable spacings in millimeters (inches)^{a,b,c}

Location		Potential involved in volts			
		0 – 130	131 – 300	301 – 600	650 – 1000
Between any uninsulated live part and uninsulated live parts of opposite polarity, uninsulated grounded parts other than the enclosure, or exposed metal parts	Through air	3.2 (1/8)	6.4 (1/4)	9.5 (3/8)	9.5 (3/8)
	Over surface	6.4 (1/4)	9.5 (3/8)	12.7 (1/2)	12.7 (1/2)

^a An isolated dead metal part (such as a screw head or a washer) interposed between uninsulated live parts of opposite polarity or between an uninsulated live part and a grounded dead metal part is considered to reduce the spacing by an amount equal to the dimension of the interposed part along the path of measurement.

^b In measuring an over surface spacing, any slot, groove, or the like, 0.33 mm (0.013 inch) wide or less in the contour of insulating material shall be disregarded.

^c In measuring spacings, an air spacing of 0.33 mm (0.013 inch) or less between a live part and an insulating surface shall be disregarded, and the live part considered in contact with the insulating material.

14.2 Shunt trip release devices

14.2.1 A shunt trip release device shall have a normally open auxiliary switch contact ("a" type) connected in series with its coil, except that the auxiliary switch may be omitted under any one of the following conditions:

- a) The shunt trip coil is rated for continuous duty,
- b) The operating voltage for the coil is taken from the load side of the circuit breaker, or
- c) The supply voltage to the coil is reduced, such as with electronic circuits. In this instance it shall be necessary to conduct the temperature test on the coil at the voltage to which the operating voltage has been reduced.

14.3 Undervoltage-trip release devices

14.3.1 An undervoltage-trip release device shall normally have its coil connected to the line side of the circuit breaker or switch without an auxiliary switch.

14.3.2 An attempt to close the circuit breaker or switch during an undervoltage condition shall not result in maintaining contacts in a closed position for more than ten cycles.

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- g) Be marked in accordance with 17.9.

14.9.2 The ON-OFF marking mentioned in 14.9.1 (f) may appear on the lock-on device.

15 Performance

15.1 General

15.1.1 One sample of each accessory is to be installed in the intended manner to determine compliance with the construction requirements of this standard. It shall also be determined that with the accessory(ies) installed in the intended manner, the combination complies with the performance requirements of this Standard. More than one type of accessory shall be permitted to be installed.

15.1.2 To determine compliance with the performance requirement section the following factors shall be considered with regard to the test program to be performed:

- a) Whether the circuit breaker or switch has been found to comply with the performance section.
- b) Whether the accessories have been found to comply with the requirements covering the accessory classification.
- c) Whether the installed accessory(ies) affect(s) the operating characteristics, mechanical, arcing, calibration, and the like, of the circuit breaker or switch.

15.1.3 The strain-relief means provided on the accessory leads to which field connections are made, when tested in accordance with 15.1.4 shall be capable of withstanding for 1 min, without displacement, the force as required in Table 15.1.1. The force shall be applied to the leads with the connections within the circuit breaker or switch disconnected.

Table 15.1.1
Pull force

Wire size, AWG	Force, N (lbf)
18 and larger	89 (20)
20 – 24	44.5 (10)

15.1.4 The specified force shall be applied to the individual leads and so supported by the circuit breaker or switch that the strain-relief means will be stressed from any angle that the construction of the circuit breaker or switch permits. The strain relief is not acceptable if:

- a) There is enough movement of the leads to indicate that stress on the connections would have resulted;
- b) A metal strain-relief has moved to have reduced electrical spacings below the minimum acceptable values; or
- c) The mechanical operation of the device is impaired.

15.1.5 Except as specified in 15.1.8 and 15.1.9, if an accessory affects parts involving mechanical or arcing characteristics, because of its proximity to such parts, and for all circuit breakers or switches where an accessory replaces a part as described in 14.1.2.1 (c) (4), the device with the accessory installed shall be subjected to the interruption type tests specified in 15.1.6. If an accessory affects the calibration of a circuit breaker, the calibration tests shall also be performed.

15.1.6 The interruption type tests to be performed in accordance with 15.1.5 are as follows:

- a) For circuit breakers – overload, endurance and interrupting as well as high available fault current if the circuit breaker has such a rating.
- b) For switches – overload, endurance, and withstand, if applicable.

15.1.7 During tests on the circuit breaker or switch, the accessory and the circuit breaker or switch shall, except where otherwise noted, carry rated current at rated voltage. The voltage shall be applied to cause the most severe opposite polarity possible, including reverse line and load connection, unless the circuit breaker or switch is marked to indicate line-load connections.

15.1.8 For circuit breaker or switch frame sizes rated over 150 A, interrupting type tests shall not be required on the combination if a solid barrier with no holes is located between the accessory and the arcing contacts.

15.1.9 Interrupting type tests shall not be required on circuit breaker or switch frame sizes rated over 150 A with the accessory installed, if the accessory is located more than 50.8 mm (2 inches) from the nearest point of the open end of the arc plate, measured as a straight line between the arc plate and uninsulated live parts or the uninsulated dead metal parts of the accessory itself.

15.1.10 Should there be any questions regarding the acceptability of the barrier mentioned in 15.1.8, such as material size and the like, or should the accessory be mounted less than 50.8 mm (2 inches) from the nearest point of the open end of an arc plate in circuit breaker or switch frame sizes rated greater than 150 A, then the combination shall be subjected to the maximum voltage interrupting test or withstand test to determine whether additional interrupting type tests are necessary. The accessory shall be energized as intended during the test.

15.1.11 No additional interrupting type tests shall be necessary if the combination of circuit breakers or switches rated greater than 150 A and installed accessories satisfactorily completes the maximum voltage interrupting test followed by the recalibration and dielectric voltage-withstand tests.

15.1.12 Interruption type tests shall be required on circuit breaker or switch frame sizes rated 150 A or less with the accessories installed within the circuit breaker or switch housing, except when there are no uninsulated live or exposed dead metal parts on the accessory and the accessory does not interfere with the intended operation – mechanical, calibration, or arcing characteristics – of the circuit breaker.

15.1.13 More than one type of accessory, shunt trip, alarm switch, and the like may be installed in the circuit breaker or switch when it is subjected to any one of the interrupting type tests.

19.4 Line connections

19.4.1 The circuit breaker enclosure or circuit breaker line terminals shall be connected by means of copper cables having an ampacity, based on Table 6.1.4.2.1, nearest to but not less than the rating of the circuit breaker enclosure or the installed circuit breaker. The cables shall enter the gutter through approximately 305 mm (12 inches) of conduit at the line end of the enclosure, at a point that provides the maximum length of unsupported cables within the enclosure. The line terminals shall be wired and tightened to the torque marked on the circuit breaker. The cables shall not be braced inside the enclosure unless the construction includes provision for such bracing. A cable shall be permitted to be braced as it leaves the conduit on the supply side.

19.4.2 The value of tightening torque marked on a circuit breaker enclosure with meter-mounting equipment shall be used if such marking appears on the enclosure.

19.4.3 Each line circuit breaker enclosure terminal or circuit breaker terminal shall be supplied through a cable having a length of 1.2 m (4 feet). Cable length as described in 19.5.2 shall be permitted.

19.5 Load connections

19.5.1 The circuit breaker enclosure load terminals or circuit breaker load terminals shall be short-circuited by a cable to each terminal having a length of 1.2 m (4 feet) and an ampacity not less than the rating of the circuit breaker. The cables shall be lashed outside the cabinet to keep them from whipping during the test. The cables to the load terminals or the instrument shunts shall be short-circuited by a copper bus bar having a cross-sectional area not less than that of the cables. Cable length as described in 19.5.2 shall be permitted.

19.5.2 If the physical arrangement of the test facilities requires leads longer than specified in 19.4.3 and 19.5.1, or lengths of bus bars necessary to extend the terminals, the additional length of leads or bus bars shall be included in the circuit calibration.

19.6 Meter-mounting equipment

19.6.1 If a circuit breaker enclosure uses meter-mounting equipment, a watt-hour meter shall be in place during any required short-circuit tests. Copper bus bars shall be permitted to be used in the jaws of meter-mounting equipment when such equipment is used in conjunction with current transformers. The cross-sectional dimensions of such bars shall be 2.4 by 19.1 mm (3/32 by 3/4 inch).

19.7 Short-circuit procedure

19.7.1 A 3-phase circuit breaker enclosure shall be tested on a 3-phase circuit using a 3-phase circuit breaker. These tests shall be permitted to qualify a single-phase circuit breaker enclosure.

19.7.2 A single-phase circuit breaker enclosure using adjacent bus bars of the 3-phase construction shall be tested on a single-phase circuit controlled as indicated in 19.7.7.

19.7.3 A circuit breaker enclosure rated for a wye-connected system and intended to accommodate only single-pole circuit breakers shall be tested on a wye-connected, 3-phase, 4-wire supply at the highest marked voltage rating, with a short circuit from one line to neutral and line potential applied to the adjacent circuit breaker with that circuit breaker in the on position.

Exception: A delta connected supply may be used at the phase-to-phase voltage rating of the device connected in accordance with UL 489.

19.7.4 A circuit breaker enclosure having a higher short-circuit current rating for line-to-neutral faults than for line-to-line faults shall be tested with line-to-neutral faults as well as line-to-line faults.

19.7.5 The open-circuit voltage at the supply connection shall be 100 – 105 percent of rated voltage for the test being conducted, except that, a voltage higher than 105 percent shall be permitted to be used if agreeable to the submitter and the testing agency. The supply frequency shall be in the range of 48 – 60 Hz.

19.7.6 Random closing shall be used for the 3-phase maximum current withstand test.

19.7.7 Controlled closing shall be used for the single-phase maximum current withstand test. Closing of the test circuit shall occur within 10 electrical degrees of the zero point of the supply-voltage wave.

19.7.8 The available rms symmetrical current shall be determined at the test-station terminals unless cable lengths, as described in 19.5.2, are used.

19.7.9 The magnitude of the test current and the power factor shall be determined by the applicable method described in C1 – C5 of Annex C. The power factor shall be in accordance with Table 7.1.7.4.

19.7.10 The available short-circuit current in rms symmetrical amperes shall not be less than the short-circuit current specified for the test. The circuits used for the tests described in 19.7.3 and 19.7.4 shall be calibrated line-to-neutral.

19.7.11 The maximum peak let-through current shall be measured during the short-circuit testing of circuit breaker enclosures with meter-mounting equipment. The short-circuit rating of the circuit breaker enclosure shall be such that the measured value does not exceed 30,000 A. Short-circuit fault currents can adversely affect the accuracy and operation of a watthour meter. This measurement need not be made if:

- a) The I_p value of the overcurrent protective device is known to be 30,000 A or less, or
- b) The meter-mounting equipment is on the secondary side of current transformers.

Annex B (Normative)

Referenced Standards

B1 Referenced Standards

When reference is made to other organization's Standards, such reference shall be considered to refer to the latest edition and all amendments published to that edition up to the time when this standard was approved.

REFERENCED STANDARDS			
Ref. No.	United States	Canada	Mexico
1	ANSI/NFPA 70, National Electrical Code	CSA C22.1, Canadian Electrical Code-06	NOM-001–SEDE, Electrical installations (utility)
2	ANSI/NFPA 70, National Electrical Code	No equivalent	NOM-001–SEDE, Electrical installations (utility)
3	ANSI/IEEE C37.13-1993, Low Voltage AC Power Circuit Breakers Used in Enclosures	Same as U.S.	No equivalent
4	ANSI/IEEE C37.14-1999, Low Voltage DC Power Circuit Breakers Used in Enclosures	Same as U.S.	No equivalent
5	UL 1077 Standard for Supplementary Protectors for Use in Electrical Equipment	CSA C22.2 No. 235–04, Supplementary Protectors	No equivalent
6	UL 486A-486B Standard for Wire Connectors	CAN/CSA–C22.2 No. 65–03, Wire Connectors	NMX-J-543-ANCE, Wire Connectors
7	UL 486E Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors	CAN/CSA–C22.2 No. 65–03, Wire Connectors ^a	No equivalent
8	ASTM E28, Test Method for Softening Point by Ring-and-Ball Apparatus	Same as U.S.	NMX-J-412-ANCE
9	UL 840 Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment	CSA C22.2 No. 0.2–93, Insulation Coordination	NMX-J-150/1-ANCE
10	UL 5085-1 Standard for Low Voltage Transformers – Part 1: General Requirements and UL 5085-3 Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers	CSA C22.2 No. 66.3–06, Low-Voltage Transformers – Part 3: Class 2 and Class 3 Transformers	No equivalent

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REFERENCED STANDARDS			
Ref. No.	United States	Canada	Mexico
11	UL 943 Standard for Ground-Fault Circuit-Interrupters	CAN/CSA-C22.2 No. 144- M1991(R2006), Ground-Fault Circuit Interrupters	NMX-J-520-ANCE, Ground- Fault Circuit Interrupters
12	UL 746C Standard for Polymeric Materials – Use in Electrical Equipment Evaluations	No equivalent	No equivalent
13	UL 1053 Standard for Ground-Fault Sensing and Relaying Equipment	CAN/CSA C22.2 No. 144- M91, Ground Fault Circuit Interrupters: Industrial Products – General Instruction No 1-2	No equivalent
14	UL 50 Standard for Enclosures for Electrical Equipment	CAN/CSA-C22.2 No. 94-M1991(R2006), Special Purpose Enclosures	NMX-J-235/1-ANCE and NMX-J-235/2-ANCE
15	UL 50 Standard for Enclosures for Electrical Equipment	CAN/CSA-C22.2 No. 94-M1991(R2006), Special- Purpose Enclosures and CAN/CSA-C22.2 No. 4-04, Enclosed and Dead-Front Switches	NMX-J-235/1-ANCE and NMX-J-235/2-ANCE
16	UL 414 Standard for Meter Sockets	CSA C22.2 No. 115- M1989(R2005), Meter- Mounting Devices	No equivalent
17	N/A	CAN/CSA-C22.2 No. 14-05, Industrial Control Equipment	N/A
18	Standard for Motor Craft, (Pleasure and Commercial), National Fire Protection Association (NFPA) 302	No equivalent	No equivalent
19	UL 67 Standard for Panelboards	CSA C22.2 No. 29-M1989(R2004), Panelboards and Enclosed Panelboards	NMX-J-118/1-ANCE
20	ANSI/IEEE C37.09- 1979(R1989), Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis	Same as U.S.	No equivalent
21	UL 1500 Standard for Ignition- Protection Test for Marine Products	No equivalent	No equivalent
22	UL 1449 Standard for Surge Protective Devices	CSA-C22.2 No. 8-M1986, Electromagnetic Interference (EMI) Filters, CSA Technical Information Letter No. I-IIB, Surge/Transient Voltage Surge Suppressors	No equivalent
23	UL 1008 Standard for Transfer Switch Equipment	C22.2 No. 178.1-14, Transfer Switch Equipment	NMX-J-672 ANCE, Standard for Transfer Switch Equipment
24	UL 1699 Standard for Arc-Fault Circuit Interrupters	C22.2 No. 270, Arc Fault Protective Devices	No equivalent

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Table Continued

REFERENCED STANDARDS			
Ref. No.	United States	Canada	Mexico
25	UL 60947-4-1 Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-Starters - Electromechanical Contactors and Motor-Starters	CAN/CSA-C22.2 No. 60947-4-1, Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-Starters - Electromechanical Contactors and Motor-Starters	No equivalent
26	UL 508A Industrial Control Panels	CSA C22.2 No. 286, Industrial control panels and assemblies	No equivalent
27	UL 83 Thermoplastic-Insulated Wires and Cables	CSA C22.2 No. 75, Thermoplastic-Insulated Wires and Cables	NMX-J-010-ANCE, Thermoplastic-Insulated Wires and Cables
28	UL 1977 Component Connectors for Use in Data, Signal, Control and Power Applications	CSA C22.2 No. 182.3, Special use attachment plugs, receptacles, and connectors	No equivalent
^a The pull-out force values of Table 22 of the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E, are permitted to be used for the evaluation of equipment wiring terminals as described in 6.1.4.2.2(b).			

Annex C (Normative)

Circuit Calibration and Instrumentation Test Circuits

C1 Instrumentation

C1.1 The galvanometers in a magnetic oscillograph used for recording voltage and current during circuit calibration and while testing shall be of a type have a flat (± 5 percent) frequency response from 50 to 1200 cycles per second, except that for tests involving fused circuit breakers and current-limiting circuit breakers, the galvanometers shall have a flat (± 5 percent) frequency response from 50 to 3000 cycles per second.

C2 Calibration of Galvanometers

C2.1 When a shunt is used to determine the circuit characteristics, a dc calibrating voltage is generally used. The voltage applied to the oscillograph galvanometer circuit shall result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer circuit is connected to the shunt and the intended short-circuit current is flowing. The voltage shall be applied so as to cause the galvanometer to deflect in both directions. Additional calibrations shall be made using approximately 50 percent and approximately 150 percent of the voltage used to obtain the deflection indicated above, except that if the anticipated maximum deflection is less than 150 percent, such as in the case of a symmetrically closed single-phase circuit, any other appropriate calibration point is to be chosen. The sensitivity of the galvanometer circuit in volts per mm (or inch) shall be determined from the deflection measured in each case, and the results of the six trials averaged. The peak amperes per mm (or inch) is obtained by dividing the sensitivity by the resistance of the shunt. This multiplying factor is used for the determination of the rms current as described in C4.1.

C2.2 A 50- or 60-Hz sinusoidal potential may be used for calibrating the galvanometer circuit using the same general method described in C2.1. The resulting factor must be multiplied by 1.414.

C2.3 When a current transformer is used to determine the circuit characteristics, an ac current shall be used to calibrate the galvanometer circuit. The value of current applied to the galvanometer circuit shall result in a deflection of the galvanometer approximately equivalent to that which is expected when the same galvanometer is connected to the secondary of the current transformer and nominal short-circuit current is flowing in the primary. Additional calibrations shall be made at approximately 50 percent and approximately 150 percent of the current used to obtain the deflection indicated above, except that if the anticipated maximum deflection is less than 150 percent, such as in the case of a symmetrically closed single-phase circuit, any other appropriate calibration point is to be chosen. The sensitivity of the galvanometer circuit in rms amperes per mm (or inch) shall be determined in each case and the results averaged. The average sensitivity is multiplied by the current transformer ratio and by 1.414 to obtain peak amperes per inch (or mm). This constant is used for the determination of the rms current as described in C4.1.

C2.4 All the galvanometer elements used shall line-up properly in the oscillograph, or the displacement differences shall be noted and used as needed.

SB2.2 Resonance frequency test

SB2.2.1 A search shall be made to determine the presence of resonance. A circuit breaker or switch shall be vibrated at a peak-to-peak amplitude of 0.51 ± 0.05 mm (0.020 ± 0.002 inch) in three rectilinear axes, horizontal, vertical, and lateral at frequencies starting at 4 Hz (or the lowest attainable frequency) to 33 Hz. A change in frequency shall be made in discrete intervals of 1 Hz and maintained at each frequency for 15 seconds. The frequency and orientation at which resonances occur shall be noted.

SB2.2.2 If a resonance has been determined in accordance with SB2.2.1, the circuit breaker or switch shall be subjected to that resonant frequency, displacement, and orientation in accordance with SB2.2.1 for 2 hours. If no resonance is observed in accordance with SB2.2.1, the test shall be conducted at 33 Hz at an amplitude of 0.51 ± 0.05 mm (0.020 ± 0.002 inch) for 2 hours in any plane.

SB2.3 Variable frequency test

SB2.3.1 A variable frequency test shall be conducted separately in each of the three rectilinear axes, horizontal, vertical, and lateral. All tests in one direction shall be completed before proceeding to the tests in another direction. The circuit breaker or switch shall be energized as intended in actual service during the test. The test shall be conducted at room temperature.

SB2.3.2 Two circuit breakers or two switches shall be mounted as specified in SB2.3.3 and subjected to the vibration displacement ranges and amplitude specified in Table SB2.3.1. The vibration equipment shall be varied in discrete frequency intervals of 1 Hz and shall be maintained at each interval for 5 minutes.

Table SB2.3.1
Displacement of vibration

Frequency range Hz	Table amplitude	
	mm	(inch)
4 to 15	1.52 ± 0.15	(0.060 ± 0.006)
16 to 25	1.02 ± 0.10	(0.040 ± 0.004)
26 to 33	0.51 ± 0.05	(0.020 ± 0.002)

SB2.3.3 Two circuit breakers or two switches shall be mounted in separate 3.43 mm (0.135 inch) steel or aluminum panels, which shall in turn be secured to two rigid, welded test fixtures secured to the vibration table, see Figure SB2.3.1. One device and panel shall be secured in the intended manner to the vertical surface of the test fixture and the other to a surface inclined 30 degrees from the vertical. If the devices are provided with their own enclosure, two enclosures, with the devices installed, shall be mounted directly to the test fixtures in the manner and positions described for the individual panels. Unsupported panel surfaces shall be kept to a minimum to avoid resonance of the panels within the test frequency range. Each device shall be wired with stranded copper conductors of the appropriate size for the rating and properly torqued. The wires shall be connected to a power supply and instrumentation located off the platform of the vibration-test machine. The wiring shall be installed to simulate a normal installation and shall be secured within 178 mm (7 inches) of the terminals. As installed, the wiring shall not be resonant.

SB3 Calibration Test**SB3.1 200 percent calibration test**

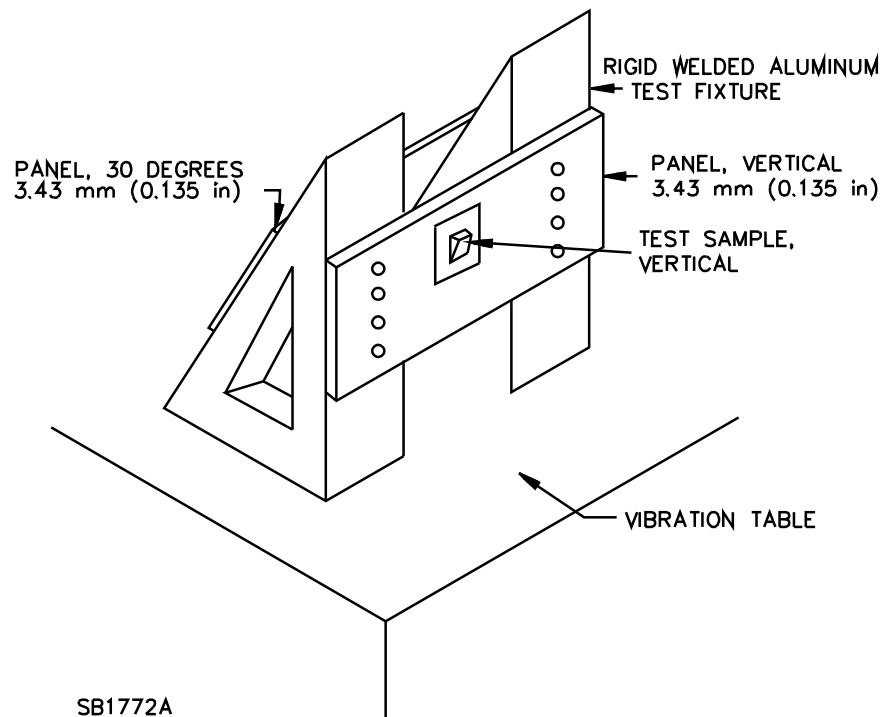
SB3.1.1 A calibration test at 200 percent of rated current shall be made as described in 7.1.2. The calibration shall not exceed ± 5 percent of the limits. The test shall be conducted at 50°C (122°F).

SB3.2 100 percent calibration test

SB3.2.1 A circuit breaker shall be capable of carrying 100 percent of its rated current without tripping until temperatures become constant. The test shall be conducted on a new representative device with the temperature of the ambient air at $50 \pm 3^{\circ}\text{C}$ ($122 \pm 5^{\circ}\text{F}$). See 7.1.2.4.

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Figure SB2.3.1
Typical vibration-table test setup



MARKINGS

SB4 General

SB4.1 In addition to the requirement in SB4.2, a circuit breaker or switch shall be provided with all the applicable required markings specified in the marking sections of this standard.

SB4.2 A circuit breaker or switch that complies with the requirements in SB1 – SB3, in addition to the requirements in this standard, shall be marked “Naval”, or the equivalent. Location Category C.

SB4.3 A circuit breaker that complies with the requirements in SB1 – SB3, in addition to the requirements in this standard, shall be permitted to be marked “50 °C”.

SB4.4 For recommended symbols and abbreviations, see Annex F.

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Underwriters Laboratories Inc.
UL 489
Thirteenth Edition

Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

October 24, 2016



ANSI/UL 489-2016

Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as CSA Group), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

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PREFACE

This is the harmonized ANCE, CSA Group, and UL Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures. It is the fifth edition of NMX-J-266-ANCE, the fourth edition of CSA C22.2 No. 5, and the thirteenth edition of UL 489. This edition of NMX-J-266-ANCE supersedes the previous edition published on January 15, 2013. This edition of CSA C22.2 No. 5 supersedes the previous edition published on January 15, 2013. This edition of UL 489 supersedes the previous edition published on January 15, 2013.

This harmonized standard was prepared by the Association of Standardization and Certification (ANCE), CSA Group, and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Subcommittee, 121A, Molded Case Circuit Breakers on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This Standard is considered suitable for use for conformity assessment within the stated scope of the Standard.

The present Mexican Standard was developed by the CT CDI Control y Distribución Industrial from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of the circuit breaker manufacturers and users.

This standard was reviewed by the CSA Subcommittee on Molded Case Circuit Breakers, Molded Case Switches and Circuit Breaker Enclosures under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee.

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard. This standard is published as an equivalent standard for ANCE, CSA Group, and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Reasons for differences from IEC

This standard provides requirements for molded-case circuit breakers, molded-case switches, and circuit-breaker enclosures for use in accordance with the electrical installation codes of Canada, Mexico, and the United States. At present there is no IEC standard for these products for use in accordance with these codes. Therefore, this standard does not employ any IEC standard for base requirements.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

INTRODUCTION

1 Scope

1.1 The requirements of this standard cover molded-case circuit breakers, circuit breaker and ground-fault circuit-interrupters, fused circuit breakers, high-fault protectors, and high-fault modules. These circuit breakers are specifically intended to provide service entrance, feeder, and branch circuit protection in accordance with the National Installation Codes in Annex B, Ref. No.1. This standard also covers instantaneous-trip circuit breakers (circuit interrupters) specifically intended for use as part of a combination motor controller in accordance with the National Installation Codes in Annex B, Ref. No. 1.

1.2 This standard covers molded-case switches and fused molded-case switches.

1.3 This standard covers devices rated at 1000 volts ac and 1500 volts dc or less and 6000 amperes or less.

1.4 The devices referenced in 1.1 and 1.2 are intended for installation in an overall enclosure or as parts of other devices such as panelboards. The acceptability of the combination will be determined when the complete product is investigated.

1.5 This standard covers circuit-breaker enclosures and accessory devices intended for use with the devices described in 1.1 and 1.2.

1.6 This standard does not cover low-voltage power circuit breakers covered in Annex B, Ref. No. 3 and Ref. No. 4 or supplementary protectors covered in Annex B, Ref. No. 5.

1.7 This standard contains supplements covering the requirements for molded-case circuit breakers for:

- a) Marine Use;
- b) Naval Use;
- c) Uninterruptible Power Supply Use;
- d) Classified Circuit Breakers;
- e) Software in Programmable Components;
- f) Additional Tests for Circuit Breakers with Electronic Overcurrent Protection;
- g) Electromagnetic Compatibility (EMC) – Requirements and Test Methods for Circuit Breakers;
and
- h) Molded-Case Circuit Breakers with Additional Motor Overload Protection.

2 Definitions

2.1 For the purposes of this standard, the following definitions apply.