

# AMERICAN NATIONAL STANDARD



## ANSI C37.52-1984 (R1995, R2000)

### American National Standard

### Test Procedures for Low Voltage AC Power Circuit Protectors Used in Enclosures



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ANSI C37.52-1974 (R1995, R2000)

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**Test Procedures for  
Low-Voltage  
Power Circuit Protectors  
Used in Enclosures**

Secretariat

**Institute of Electrical and Electronics Engineers  
National Electrical Manufacturers Association**

Approved 02/11/00

**American National Standards Institute, Inc.**

ANSI C37.52-1974 (R1995)

## American National Standard

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**Foreword** (This Foreword is not a part of American National Standard Test Procedures for Low-Voltage AC Power Circuit Protectors Used in Enclosures, C37.52-1974.)

This standard was developed as a replacement for Section 8 (Test Procedures) of American National Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures, C37.29-1974 (IEEE Std 508-1974), for the purpose of providing a separate document to facilitate use by independent testing laboratories. Since these test procedures are considered new by the laboratories, experience factors may require revision and a separate document can be revised quickly and economically.

This standard is one of several in a series of test procedures standards for certification of various switchgear products. They establish the mandatory requirements that a product must meet (as certified by an independent testing laboratory) in order to satisfy federal law and local electrical codes.

In developing this standard, the C37 Subcommittee carefully reviewed testing-laboratory policies on reexamination service. At all times, the subcommittee made a diligent effort to incorporate all aspects known to be required by testing laboratories as well as to retain consistency with Section 8 of American National Standard for Low-Voltage AC Power Service Protectors, C37.29-1970. One necessary but new requirement is the testing in sequence of one circuit protector through a specified series of tests without repair or replacement of parts. This concept differs from Section 8 of American National Standard C37.29-1970 because that permits a new or different circuit protector for each of the different tests, so that no single circuit protector is required to be subjected to a cumulative testing program.

While this standard was being developed, coordination was made with the IEEE Low-Voltage Switchgear Devices Subcommittee at the same time it was revising American National Standard C37.29-1970 and with the NEMA Low-Voltage Power Circuit Breaker Technical Committee. American National Standard C37.29-1974 (IEEE Std 508-1974) and this standard are in accord and have been developed to represent standard practice in the United States for low-voltage power circuit protectors.

This standard was processed and approved for submittal to ANSI by American National Standards Committee on Power Switchgear, C37. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the C37 Committee had the following members:

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- W. E. Laubach, Executive Vice-Chairman, Low Voltage Standards
- W. R. Wilson, Executive Vice-Chairman, International Electrotechnical Commission
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The C37 Subcommittee on Certification Test Procedures, which reviewed and approved this standard, had the following personnel:

- |                            |                   |
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# American National Standard Test Procedures for Low-Voltage AC Power Circuit Protectors Used in Enclosures

This standard replaces Section 8 of American National Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures, C37.29-1974 (IEEE Std 508-1974).

## 1. General

**1.1 Scope.** This standard covers the test procedures for enclosed low-voltage ac power circuit protectors.

**NOTE:** In this standard, the term "circuit protector" shall be considered to mean "enclosed low-voltage ac power circuit protector," unless qualified by other descriptive terms.

**1.2 Related Standards.** This standard is intended for use in conjunction with the following American National Standards (see Section 8):

American National Standard Methods for Determining the Values of a Sinusoidal Current Wave and a Normal-Frequency Recovery Voltage for AC High-Voltage Circuit Breakers, C37.05-1964 (R1969)

American National Standard Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors, C37.16-1973

American National Standard for Switchgear Assemblies Including Metal-Enclosed Bus, C37.20-1969

American National Standard Guide for Determining Methods of Power Factor Measurements for Low-Voltage Inductive Test Circuits, C37.26-1972 (IEEE Std 330-1972)

American National Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures, C37.29-1974 (IEEE Std 508-1974)

American National Standard Definitions for Power Switchgear, C37.100-1972

American National Standard Techniques for Dielectric Tests, C68.1-1968 (R1973) (IEEE Std 4-1969)

American National Standard Voltage Ratings for Electric Power Systems and Equipment (60 Hz), C84.1-1970

## 2. General Test Conditions

The conditions prevailing at the test site during tests on circuit protectors shall be those as stated in Section 2 of American National Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures, C37.29-1974 (IEEE Std 508-1974), except that continuous-current tests and calibration check tests shall be conducted within the range of 10°C (50°F) to 40°C (104°F).

## 3. Design Test Requirements

**3.1 General.** Design tests are performed only on representative circuit protectors to demonstrate the capability of a particular type, style, model, or rating of a circuit protector to meet its assigned ratings and to operate under service conditions given in Section 2 of American National Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures, C37.29-1974 (IEEE Std 508-1974).

**3.2 Design Tests.** Each circuit protector tested, including functional components as listed in Table 1 of American National Standard C37.29-1974 (IEEE Std 508-1974), and accessory devices as given in Section 4 of this standard, with which it is equipped, shall successfully complete all of the following tests, utilizing the test sequences as outlined in Table 1. More than one sample of each continuous-current rating may be required:

- (1) AC dielectric withstand-voltage test (3.4)
- (2) Continuous-current test (3.5)
- (3) Switching-current test (3.6)
- (4) Endurance tests (3.7)
- (5) Short-circuit current tests (3.8)

### 3.3 Test Conditions

**3.3.1 Test Enclosures.** All tests listed in 3.2 shall be performed with a circuit protector in its test enclosure.

**Table 1**  
**Test Sequences**

<p><b>Sequence I (Manually and Power-Operated Circuit Protectors)</b></p> <p>(a) AC Dielectric Withstand-Voltage Test (3.4)</p> <p>(b) Continuous-Current Test (3.5)</p> <p>(c) Endurance Test (3.7)</p> <p>(d) Short-Circuit Current Test (3.8 and Table 3, Test 3 or 4 as applicable)</p> <p>(e) AC Dielectric Withstand-Voltage Test (3.4)</p> <p><b>Sequence II (Manually and Power-Operated Circuit Protectors)</b></p> <p>(a) AC Dielectric Withstand-Voltage Test (3.4)</p> <p>(b) Switching-Current Test (3.6)</p> <p>(c) Short-Circuit Current Test (3.8 and Table 3, Test 1 or 2 as applicable)</p> <p>(d) AC Dielectric Withstand-Voltage Test (3.4)</p>
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**NOTES:**

(1) **Power- and Manually Operated Circuit Protectors.** When power- and manually operated circuit protectors have stored-energy closing mechanisms that differ only in the means of supplying the energy to be stored, the sequence of tests shall be performed as outlined on the power-operated circuit protector only.

When a manually operated circuit protector is not essentially the same as the power-operated circuit protector or does not have any power-operated equivalent, all test sequences shall also be performed on the manually operated circuit protector.

Dependent manually operated circuit protectors are subject to certain rating limitations outlined in American National Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures, C37.29-1974 (IEEE Std 508-1974), Section 9 (Application Guide), and shall be tested accordingly.

(2) **Number of Samples.** Use one circuit protector per rating, either new or rebuilt, to complete each test sequence.

(3) **Omission of Short-Circuit Current Test.** When testing circuit protectors intended for use on grounded neutral systems only and that are so marked, the short-circuit current test of Sequence I may be omitted.

The test enclosure for a particular circuit protector shall be the minimum-dimension single-unit enclosure with the smallest electrical spacings recommended by the manufacturer. The manufacturer's enclosure description shall include minimum clearance to ground, location of ventilation openings and their effective area, total enclosure dimensions, and configuration of connections to the terminals.

**3.4 AC Dielectric Withstand-Voltage Test.** Dielectric-withstand tests shall be conducted on completely assembled circuit protectors, including secondary control wiring, at voltages and under the conditions given under 3.4.1 and 3.4.2. All voltages shall be measured in accordance with American National Standard Techniques for Dielectric Tests, C68.1-1968 (R1973) (IEEE Std 4-1969). The potential is to be increased gradually from zero so as to reach the required test value in between 5 and 10 seconds, and shall be held at that value for 1 minute.

The test voltages shall be essentially sinusoidal and applied with a minimum crest value equal to 1.414 times the specified values. The frequency of the test

voltage shall be within  $\pm 20\%$  of the rated frequency of the circuit protector being tested. If a test transformer of less than 500 VA is used, a suitable voltmeter shall be provided to measure the applied output potential directly.

**3.4.1 Dielectric-Withstand Test Voltages.** The dielectric-withstand test voltages shall be no less than the following:

- (1) 2200 V for primary circuit of a new completely assembled circuit protector.
- (2) 1500 V for secondary control wiring (except 3.4.1(3), (4), and (5)).
- (3) 900 V for motors.
- (4) 500 V for control devices and circuitry operating at 80 V ac rms (110 V dc) or less that are not connected directly to the primary circuit or external secondary control circuits.
- (5) Twice rated voltage plus 1000 V for undervoltage trip devices operating at a voltage above 250 V ac.
- (6) After completion of each test sequence, and before servicing, the withstand test voltage shall be 60% of the values given in 3.4.1(1), (2), (3), (4), and (5).

**3.4.2 Points of Application**

**3.4.2.1** With circuit protector in the open position, apply the test voltage to primary circuits: (1) between live parts, including both line and load terminals, and metal parts that are normally grounded, and (2) between line terminals and load terminals.

**NOTE:** Secondary control wiring terminals that connect to external circuits shall be connected to metal parts that are normally grounded.

**3.4.2.2** With circuit protector in the closed position, apply the test voltage to primary circuits: (1) between live parts and metal parts that are normally grounded, and (2) between terminals of different phases.

**NOTE:** Secondary control wiring terminals that connect to external circuits shall be connected to metal parts that are normally grounded.

**3.4.2.3** When a circuit protector has secondary control wiring, the secondary control wiring test voltage shall be applied between the control-circuit terminals and the main circuit of the circuit protector, and with the circuit protector in either the open or closed position. The main circuit of the circuit protector shall be connected to the circuit-protector frame for this test. The terminals may be wired together with small bare wire, and all intentional circuit grounds shall be disconnected. If the circuit-protector control circuit includes a motor, the motor may be disconnected during the dielectric test on the control circuit and subsequently tested in place at the voltage specified in 3.4.1(3).

Undervoltage trip devices operating at a voltage

above 250 V ac shall be tested separately as specified in 3.4.1(5).

**3.5 Continuous-Current Test.** The continuous-current test is performed to ensure that circuit protectors can carry 100% of their rated continuous current at rated frequency within a test enclosure without exceeding the allowable temperature limits specified in Table 2 of American National Standard C37.29-1974 (IEEE Std 508-1974). Circuit protectors shall be equipped with Class L current-limiting fuses having a continuous-current rating equal to the continuous-current rating of the circuit protector plus all functional components and applicable accessory devices.

Three-pole circuit protectors may be tested using either a three-phase circuit or single-phase circuit (all poles in series) at the option of the manufacturer.

**3.5.1 Duration of Test.** The continuous-current test shall be performed for such a period of time that the temperature rise of the terminals of the circuit protector will not have increased by more than 1.0°C (1.8°F) during each of two successive 30-minute intervals as indicated by three successive readings. If the temperature rise at the end of the second interval is equal to the established limits, and if the temperature rise has increased since the previous reading, the test shall be continued.

**3.5.2 Measuring Temperature of the Air Surrounding the Enclosure (Ambient).** The temperature of the air surrounding the enclosure (ambient) shall be determined by one thermometer or thermocouple having a heat sink attached and placed approximately 12 inches (304.8 mm) from the side surface of the enclosure and midway between the top and bottom of the enclosure.

**3.5.3 Copper Conductors for Use in Continuous-Current Tests.** Bus bar of the size given in Table 2 shall be used.

**3.5.4 Method of Measuring Device Temperature.** Thermocouples shall be used to measure the temperatures on the circuit protector.

Thermocouples used for measuring the temperature of insulation shall be located on the current-carrying member or other metal part at a point as close as practical to the accessible junction of the insulation and the current-carrying member or other metal part.

Thermocouples may be used to determine the air temperature of the areas where devices are mounted, as a means of establishing the required ambient temperature for separate device testing.

Thermocouples used for measuring the temperature of the terminal connections and other conducting joints shall be located approximately 1/2 inch (12.7 mm) from the terminal or other conducting joints on the current-carrying member.

**Table 2**  
**Bus Bar Dimensions**

Continuous-Current Rating (amperes)	Bus* per Terminal	
	Quantity	Size (in)
800	1	1/4 x 3 (6.35 x 76.2 mm)
1200	1	1/4 x 4 (6.35 x 101.6 mm)
1600	2	1/4 x 3 (6.35 x 76.2 mm)
2000	2	1/4 x 4 (6.35 x 101.6 mm)
2500†	2	1/4 x 5 (6.35 x 127 mm)
3000	4	1/4 x 4 (6.35 x 101.6 mm)
4000	4	1/4 x 5 (6.35 x 127 mm)

\*Where multiple bus bars are used, they are to be spaced 1/4 inch (6.35 mm) apart. The 3000- and 4000-ampere groups are to be two sets of two bars with not more than 4 inches (101.6 mm) between pair centers. Configurations shall be vertical unless the design of the test enclosure requires them to be horizontal. The bus bars connected to the terminals shall be a minimum of 4 feet (1.2 m) long.

†Not a preferred rating in accordance with Table 20 of American National Standard Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors, C37.16-1973.

Thermocouples shall be held in intimate contact with the conductor surface by such methods as welding, drilling and peening, or cementing.

**3.5.5 Performance.** Circuit protectors shall be considered to have passed this test if the limits of observable temperature rise specified in Table 2 of American National Standard C37.29-1974 (IEEE Std 508-1974) are not exceeded.

**3.6 Switching-Current Test.** The power circuit protector shall be capable of switching current equal to 1200% of its rated continuous current as given in Table 20 of American National Standard Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors, C37.16-1973.

This test shall be performed with the fuses replaced by links. It shall be performed at no less than the rated maximum voltage and at any rated control voltage.

The power circuit protector shall be required to perform three three-phase closing and opening operations. The time between the three closing and opening operations shall be as determined by test procedures but shall be no less than 3 minutes.

The test current shall flow through the power circuit protector for approximately, but no less than, 0.05 second for each of the three switching-current operations.

**3.6.1 Test Circuit.** The power factor of the test circuit shall be 20% lagging or less ( $X/R$  ratio 4.9 or greater) with  $X$  and  $R$  in series connection. The frequency of the test circuit shall be 60 Hz  $\pm$  20%. The power factor shall be determined in accordance with American National Standard Guide for Determining

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Methods of Power Factor Measurements for Low-Voltage Inductive Test Circuits, C37.26-1972 (IEEE Std 330-1972).

The open-circuit voltage of the supply circuit shall be no less than 100%, or more than 105%, of the rated maximum voltage of the circuit protector, except that a higher voltage may be employed at the option of the manufacturer.

The closed-circuit voltage as measured at the line terminals of the circuit protector shall be no less than 65% of the rated maximum voltage for which the circuit protector is being tested, except that the maximum fault current available at the circuit-protector terminals shall not be required to exceed the short-circuit current rating of the circuit protectors.

The enclosure and the frame of the circuit protector shall be insulated from ground and connected through a 30-ampere fuse to the line side of the phase judged least likely to strike to the enclosure. When testing circuit protectors intended for use on grounded neutral systems only and that are so marked, the 30-ampere fuse may be connected between the neutral of the power supply and the enclosure.

**3.6.2 Performance.** At the conclusion of this test, the circuit protector shall be in a condition to continue Test Sequence II without repair or replacement of parts. The 30-ampere fuse mentioned in 3.6.1 shall not have opened.

### 3.7 Endurance Tests

**3.7.1 General.** All endurance tests shall be performed on the same circuit protector to determine compliance with specified mechanical and electrical requirements as given in Table 21 of American National Standard C37.16-1973. Servicing shall be permitted at the intervals given in the table.

**3.7.1.1 Power-operated circuit protectors** shall be subjected to all endurance tests.

**3.7.1.2 Manually operated circuit protectors,** having stored-energy mechanisms that differ from the power-operated equivalent only in the means of supplying the energy to be stored, shall not be subjected to endurance tests.

**3.7.1.3 Manually operated circuit protectors,** not essentially the same as the power-operated circuit protectors or not having any power-operated equivalent, shall be subjected to all endurance tests except that the number of mechanical endurance operations performed shall be 50% of the number specified in Table 21 of American National Standard C37.16-1973.

**3.7.2 Frequency of Operation.** The frequency of operation shall be one operation every 2 minutes. At the option of the manufacturer, the rate may be increased. During each operation, the circuit protector

shall remain closed for no less than 1/6 of a second.

Due to the large total number of operations required, both electrical and mechanical endurance tests may be conducted in groups. However, at least one group shall consist of no less than 120 operations.

**3.7.3 Electrical Endurance Test.** The electrical endurance test shall be performed with no less than twice rated continuous current, at no less than rated maximum voltage, and at any rated control voltage.

**3.7.3.1 Test Circuit.** The power factor of the test circuit shall be 85% lagging or less with the  $X$  and  $R$  in series connection. The frequency of the test circuit shall be 60 Hz  $\pm$  20%. The power factor shall be determined in accordance with American National Standard C37.26-1972 (IEEE Std 330-1972).

The open-circuit voltage of the supply circuit shall be no less than 100%, or more than 105%, of the rated maximum voltage of the circuit protector, except that a higher voltage may be employed at the option of the manufacturer.

The closed-circuit voltage as measured at the line terminals of the circuit protector shall be no less than 75% of the rated maximum voltage for which the circuit protector is being tested, except that the maximum fault current available at the circuit-protector terminals shall not be required to exceed the short-circuit current rating of the circuit protector.

**3.7.4 Mechanical Endurance Test.** The mechanical endurance test shall be performed at no load and at any rated control voltage.

**3.7.5 Performance.** At the conclusion of these tests, the circuit protector shall be in a condition to continue Test Sequence I without repair or replacement of parts.

**3.8 Short-Circuit Current Tests.** The short-circuit current tests, as described in 3.8.1 and given in Table 3, shall be performed on circuit protectors to determine their ability to close, carry, and interrupt currents within their assigned ratings. See Table 20 of American National Standard C37.16-1973.

**3.8.1 Types of Tests.** Types of short-circuit current tests are the following:

(1) Three-phase tests with line-to-line voltage equal to no less than rated maximum voltage and the average of the rms symmetrical components of the available three-phase currents no less than the applicable rated short-circuit current (test 1 or 2).

(2) Single-phase tests with line-to-line voltage equal to no less than rated maximum voltage applied across any pole and with the available rms symmetrical current equal to, or greater than, 87% of the applicable rated short-circuit current (test 3 or 4).

### 3.8.2 Test-Circuit Conditions

**3.8.2.1** The rms symmetrical current that verifies

**Table 3**  
**Short-Circuit Current Tests**  
(Specified in Table 1)

Test	Duty Cycle	No. of Phases	Rated Maximum Voltage	Available RMS Symmetrical
1	O + t + C-O	3	508	200 000
2	O + t + C-O	3	254	200 000
3*	O	1	508	174 000
4*	O	1	254	174 000

**NOTES:**

(1) O = opening operation; C-O = close-open operation; t = time necessary to replace fuses and reset the anti-single-phase device.

(2) Three-phase tests are to be performed with the upper terminals of the circuit protector connected to the source.

(3) A circuit protector with a rated maximum voltage of 508 V is required to perform only tests 1 and 3, and a circuit protector with a rated maximum voltage of 254 V is required to perform only tests 2 and 4.

\*When testing circuit protectors intended for use on grounded neutral systems only and that are so marked, single-phase tests 3 and 4 need not be performed.

the short-circuit current rating shall be determined by calibrating the test circuit with the circuit protector short-circuited or omitted and shall be measured one-half cycle after inception of the current flow in the test circuit. This current shall be calculated in accordance with American National Standard Methods for Determining the Values of a Sinusoidal Current Wave and a Normal-Frequency Recovery Voltage for AC High-Voltage Circuit Breakers, C37.05-1964 (R1969). For three-phase circuits the symmetrical-current value shall be the average of the phase currents.

**3.8.2.2** The power factor of the test circuit shall be 20% lagging or less ( $X/R$  ratio of 4.9 or greater) with  $X$  and  $R$  in series connection. Any reactor used in the test circuit shall be an air core reactor. The power factor shall be determined in accordance with American National Standard C37.26-1972 (IEEE Std 330-1972).

**3.8.2.3** Transient characteristics of the test circuit:

For the first opening operation of the duty cycle, the current shall be initiated in the test circuit in such a manner as to ensure that the peak current available would be no less than 2.16 times the single-phase rms symmetrical value for the single-phase test and 2.16 times the three-phase rms symmetrical value in one phase for three-phase tests.

**3.8.2.4** The test-circuit voltage prior to the inception of current flow shall be no less than the rated maximum voltage for the short-circuit current rating being verified.

**3.8.2.5** The frequency of the test circuit shall be 60 Hz  $\pm$  20%.

**3.8.2.6** On three-phase tests, either the power

source or fault connections shall be grounded, but not both. When testing circuit protectors intended for use on grounded neutral systems only and that are so marked, the power service must be grounded.

**3.8.2.7** For the three-phase tests, the enclosure and the frame of the circuit protector shall be connected through a 30-ampere fuse to the line side of the phase judged least likely to strike to the enclosure. Metallic contact between protector frame and enclosure shall be considered a connection.

During the opening test of a duty cycle, the maximum current offset shall not exist in the phase to which the 30-ampere fuse is connected.

**3.8.2.8** For the single-phase tests, the test enclosure and circuit-protector frame shall be connected through a 30-ampere fuse to the unused phase of the three-phase source.

**3.8.2.9** When testing circuit protectors intended for use on grounded neutral systems only and that are so marked, the 30-ampere fuse may be connected between the neutral of the power supply and the enclosure. When testing for this type of service, single-phase tests need not be performed.

**3.8.2.10** The test enclosure and circuit-protector frame shall be insulated from ground.

**3.8.3 Short-Circuit-Current Duty Cycle.** For the three-phase short-circuit current test (see 3.8.1(1)), the test duty cycle shall consist of an opening operation and a close-open operation, separated only by the time necessary to replace fuses and reset the anti-single-phase device.

The duty cycle for the single-phase test (see 3.8.1(2)) shall consist of a single opening operation.

**3.8.4 Test Procedure.** The circuit protector shall be inserted in the test circuit and tested in accordance with Test Sequences I and II of Table 1.

**3.8.5 Emission Indicators for Switching-Current and Short-Circuit Current Tests.** An indicator consisting of three layers of cheesecloth shall be employed to detect any excessive emission of flame, hot gases, or molten particles during the switching-current and short-circuit current tests. The cheesecloth shall be loosely stretched on a frame at least as large as the front of the circuit-protector enclosure and shall be located 1 inch (25.4 mm) from, and parallel to, the front door of the circuit-protector enclosure. The cheesecloth may be displaced as necessary to accommodate projections such as handles.

**3.8.6 Recovery Voltage.** The recovery voltage shall be no less than 95% of the rated maximum voltage of the circuit protector. The peak value of the recovery voltage within the first full half cycle after clearing and for the next five successive peaks shall be no less than  $1.343 (\sqrt{2} \times 0.95)$ , times the rated maximum voltage.

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Each of the peaks shall be displaced not more than  $\pm 10$  electrical degrees from the peaks of the open-circuit voltage wave prior to current flow. When making this comparison, it will be necessary to compensate for any frequency change which may occur during the test. This may be done by comparing the positions of the zero crossing points of the voltage wave when referred to a timing wave, before and after the test.

For tests performed at 60 Hz, the average of the instantaneous value of the recovery voltage of each of the first six half cycles measured at the 45-degree and 135-degree points on the wave shall be no less than 85% of the rms value of the recovery voltage. The instantaneous value of the recovery voltage measured at the 45-degree and 135-degree points of each of the first six half cycles shall be no less than 75% of the rms value of the recovery voltage.

For tests performed at 50 Hz (which are intended to establish a 60-Hz rating), the instantaneous value of recovery voltage measured at the 45-degree and 135-degree points of each of the first six half cycles shall be no less than 90% of the rms value of the recovery voltage.

If, in a test circuit which employs secondary closing, there is no attenuation or phase displacement of the first full cycle of the recovery-voltage wave when compared with the open-circuit secondary voltage wave before current flows, the detailed measurement of the recovery-voltage characteristics indicated in the preceding paragraphs is not required.

**3.8.7 Performance.** At the conclusion of this test, the emission indicators shall not have ignited (scorching of the cheesecloth shall not be considered as ignition). The 30-ampere fuse mentioned in 3.8.2.7 and 3.8.2.8 shall not have opened. The circuit protector shall be in the following condition:

(1) **Mechanical:** It shall be substantially in the same mechanical condition as before the test.

(a) The anti-single-phase device shall have functioned to open the power circuit protector.

(b) After resetting of the anti-single-phase device, the power circuit protector shall be capable of being closed and opened.

(c) The fuses (except for the current-responsive element) shall not be cracked or charred, shall show no evidence that molten metal was expelled, and shall not have damaged the supporting means.

(2) **Electrical:**

(a) One or more fuses shall have opened.

(b) There shall be no evidence of arcing from end to end on the exterior of the fuses.

(c) After replacement of opened fuses, the circuit protector shall be in a condition to continue Test

Sequences I and II without repair or replacement of any other parts.

#### 4. Accessory Devices

**4.1 General.** Accessory devices, as contrasted with functional components, are those devices that are not basically required for proper operation of a circuit protector but perform a secondary or minor function as an adjunct or refinement to the primary function of the circuit protector.

Functional components are required parts of the circuit protector during sequential testing, as outlined in 3.2, and successful operation of those components throughout all the test sequences shall constitute sufficient proof of their design and that no further testing of them is necessary.

Available electrical accessory devices, including alarm and auxiliary switches and undervoltage trip devices, shall be operationally tested. An accessory device shall be mounted in its normal place on the circuit protector during the applicable testing sequence when its installation or operation may affect the performance of the circuit protector or if the circuit protector may affect the operation of the accessory. Temperature tests may be conducted on electrical accessory devices separately mounted in an equivalent ambient temperature as determined under 3.5.

#### 4.2 Alarm and Auxiliary Switches

**4.2.1 Temperature Test.** An alarm or auxiliary switch shall be subjected to a temperature test. With the circuit protector and one alarm or auxiliary switch carrying no less than rated continuous current, the switch shall not attain temperatures higher than those permitted for the materials involved, in accordance with Table 2 of American National Standard for Low-Voltage AC Power Circuit Protectors Used in Enclosures, C37.29-1974 (IEEE Std 508-1974).

When more than one alarm or auxiliary switch can be installed on a circuit protector, the temperature test shall be performed with the following:

(1) The maximum number of switches that can be installed

(2) Those switches, which control external circuits and are normally closed when the circuit protector is closed, carrying 50% of their rated current

(3) Those switches used in the internal control of a circuit protector energized and carrying normal control currents

The rated continuous current of a switch rated only in inductive amperes is the highest rated inductive current listed.

**Table 4**  
**Overload Test Conditions**

Type of Assigned Contact-Interrupting Rating	Test Conditions			
	Voltage	Current	Power Factor (ac)	Type of Load (dc)
None assigned	Maximum of applicable range*	150% Continuous rating	75-80% Lagging†	Resistance
Noninductive	Maximum of applicable range*	100% Assigned rating	75-80% Lagging†	Resistance
Inductive	Maximum of applicable range*	100% Assigned rating	30-35% Lagging†	Electromagnet

\*See Table 23 of American National Standard Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors, C37.16-1973.

†At the option of the manufacturer, the power factor may be lower.

**Table 5**  
**Endurance Test Conditions**

Type of Assigned Contact-Interrupting Rating	Test Conditions			
	Voltage	Current	Power Factor (ac)	Type of Load (dc)
None assigned	Rated*	100% Continuous rating	75-80% Lagging†	Resistance
Noninductive	Rated*	100% Assigned rating	75-80% Lagging†	Resistance
Inductive	Rated*	100% Assigned rating	45-50% Lagging†	Electromagnet

\*See Table 23 of American National Standard Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors, C37.16-1973.

†At the option of the manufacturer, the power factor may be lower.

**4.2.2 Overload Test.** Alarm and auxiliary switches shall be subjected to an overload test of fifty operations. The frequency of operation shall be in accordance with 3.7.2. For an alarm switch, this test shall also be proof of the endurance capability of the switch.

The appropriate test(s) is to be selected from Table 4.

**4.2.2.1 Performance.** At the conclusion of the overload test, an alarm switch shall be capable of making and breaking the test circuit without repair or replacement of parts, and to be able to withstand the dielectric test.

An auxiliary switch shall be in a condition to continue with the endurance test.

**4.2.3 Endurance Test - Auxiliary Switch.** An auxiliary switch which has completed the overload test shall be subjected to the number of electrical and me-

chanical operations at the frequency of operation given under 3.7. The endurance test on the auxiliary switch may be performed in conjunction with the endurance test performed on the circuit protector. When the design of an auxiliary switch is common to more than one size of circuit protector, the test shall be performed to meet the endurance test requirements of the smallest size being tested and may be performed in conjunction with the circuit-protector endurance test.

The appropriate test(s) is to be selected from Table 5.

**4.2.3.1 Performance.** At the conclusion of the electrical and mechanical endurance test, the switch shall be capable of making and breaking the test circuit without repair or replacement of parts, and to be able to withstand the dielectric test.

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**4.3 Undervoltage Trip Devices**

**4.3.1 Temperature Test.** With the undervoltage trip-device coil energized at the maximum voltage of the applicable range given in Table 23 of American National Standard Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors, C37.16-1973, the maximum temperature rise of an undervoltage trip-device coil shall not be higher than that permitted in Table 2 of American National Standard C37.29-1974 (IEEE Std 508-1974) for the materials involved.

**4.3.2 Operation Test.** An undervoltage trip device shall operate to open the circuit protector at 30% or less of the voltage rating of its trip coil.

An undervoltage trip device shall not operate to open the circuit protector at values above 60% of the voltage rating of its trip coil.

However, an undervoltage trip device may operate to open the circuit protector when the voltage across the trip coil is greater than 30% but is 60% or less of the voltage rating of its trip coil.

An electrically reset undervoltage trip device shall pick up, and a mechanically reset undervoltage trip device shall seal in, at 85% of rated voltage. They may also pick up and seal in at any lower voltage greater than 30% of the voltage rating of its trip coil.

To determine compliance with these requirements, the test shall be conducted as follows, starting with the circuit protector in the tripped position:

(1) Energize the undervoltage trip device to 85% of the rated voltage of the coil.

(2) Close the circuit protector.

(3) Reduce the voltage to 60% of the rated voltage of the coil. The circuit protector shall not open above this voltage.

(4) Reduce voltage to 30% of the rated voltage of the coil. The circuit protector shall open.

**4.3.3 Endurance Test.** An undervoltage trip device shall cause the circuit protector to trip for 10% of the electrical endurance operations and at the frequency of operation given under 3.7.

The tests may be performed as part of the electrical endurance test on the circuit protector. When so tested, the number of tripping operations to be performed by the shunt trip device shall be reduced to 90% of the total requirements.

At the conclusion of the endurance test, the undervoltage trip device shall be capable of meeting the requirements of 4.3.2.

**4.3.4 AC Dielectric-Withstand Test.** With the electrical accessory device(s) installed on the circuit protector, the accessory device(s) shall meet the requirements set forth in 3.4.

**4.4 Mechanical Accessory Devices.** When accessory devices are mechanical only, such as key interlocks, mechanical interlocks, etc, which are operated relatively infrequently, normal production tests will be the criteria for proving the operational characteristics of these devices.

**5. Treatment of Failures within Test Sequences**

Should failure(s) occur during performance testing, the failure should be evaluated and corrections made before retesting is carried out, and retesting performed as necessary.

A design change made to a circuit protector to correct a failure in a sequence shall be evaluated for its effect on any preceding test.

**6. Production Tests**

**6.1 General.** All applicable production tests shall be performed by the manufacturer on each circuit protector at the factory after final assembly. Production tests shall include the following:

- (1) Calibration
- (2) Control and secondary wiring and devices check test
- (3) Dielectric-withstand test
- (4) No-load operation test

**6.2 Calibration.** Calibration shall include the procedures given in 6.2.1, where applicable.

**6.2.1 Undervoltage Trip Devices.** Each undervoltage trip device shall be calibrated to make sure that it trips the circuit protector when the voltage drops to a value that falls within the range of 30% to 60% of rated voltage. A test shall be performed to determine that the undervoltage trip device with 85% of rated voltage applied will permit the circuit protector to be closed.

For an undervoltage trip device equipped with time delay, the time delay shall also be checked to see that it falls within the manufacturer's specified limits and that the device resets if voltage recovers in the delay period.

**6.3 Control and Secondary Wiring and Devices Check Test.** Control and secondary wiring and devices shall be checked to make sure that all connections have been made correctly. Devices and relays, if used, shall be checked by actual operation where feasible. Those circuits for which operation is not feasible shall be checked for continuity.

**6.4 AC Dielectric-Withstand Test.** The test shall be conducted in accordance with 3.4. The duration of the

test may be 1 second if a voltage 20% greater than that specified in 3.4.1 is used.

#### 6.5 No-Load Operation Test

**6.5.1 Power-Operated Circuit Protectors.** Power-operated circuit protectors shall be given the following no-load operation tests:

- (1) Five closing and five opening operations at minimum control voltage.
- (2) Five closing, five opening, and five trip-free operations at maximum control voltage.
- (3) Two operations to check antipumping, which shall be performed in the following manner:

(a) Apply uninterrupted control power to the closing circuit.

(b) Trip the circuit protector. The circuit protector shall remain open until closing-circuit power has been interrupted and then restored.

If other devices, electrical or mechanical, are applicable, they shall be checked for proper functioning. Such devices shall include key interlocks, mechanical interlocks, electrical interlocks, and padlocking.

**6.5.2 Manually Operated Circuit Protectors.** Manually operated circuit protectors shall be given the following no-load operation tests:

- (1) Five closing and five opening operations.
- (2) When a shunt trip is used, a minimum of five openings using the shunt trip at the minimum control voltage specified for the coil.
- (3) Five trip-free operations.

If other devices, electrical or mechanical, are applicable, they shall be checked for proper functioning. Such devices shall include key interlocks, mechanical interlocks, electrical interlocks, and padlocking.

**6.5.3 Anti-Single-Phase Tripping Device.** The anti-single-phase tripping device shall be tested mechanically or by application of proper voltage to the device coil to establish positive tripping.

## 7. Production Monitoring

Subsequent to certification of a circuit protector in accordance with this standard, production units shall be monitored to ensure that the certified performance capability is maintained. Monitoring of production units shall be done quarterly or at shorter intervals at the discretion of the certifying agency to verify that production tests are in accordance with Section 6 and that the product conforms to the design that was certified.

## 8. Revision of American National Standards Referred to in This Document

When the American National Standards referred to in this document are superseded by a revision approved by the American National Standards Institute, Inc, the revision shall apply.