UL 1416

STANDARD FOR SAFETY

Overcurrent and Overtemperature Protectors for Radio- and Television-Type Appliances

UL Standard for Safety for Overcurrent and Overtemperature Protectors for Radio- and Television- Type Appliances, UL 1416

Sixth Edition, Dated October 29, 1999

SUMMARY OF TOPICS

This revision to ANSI/UL 1416 dated February 7, 2022 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The requirements are substantially in accordance with Proposal(s) on this subject dated December 17, 2021.

No Text on This Page

OCTOBER 29, 1999
(Title Page Reprinted: February 7, 2022)

UL 1416

Standard for Overcurrent and Overtemperature Protectors for Radio- and Television- Type Appliances

The First edition was titled Standard for Overcurrent and Overtemperature Protectors for Radio and Television Receiving Appliances and Other Electronic Equipment and numbered UL 492.6.

First Edition – October, 1974
Second Edition – January, 1976
Third Edition – December, 1978
Fourth Edition – February, 1986
Fifth Edition – September, 1994

Sixth Edition

October 29, 1999

This ANSI/UL Standard for Safety consists of the Sixth Edition including revisions through February 7, 2022.

The most recent designation of ANSI/UL 1416 as a Reaffirmed American National Standard (ANS) occurred on February 7, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

PERFORMANCE

ALL PROTECTORS

MULTIPLE-OPERATION, MANUAL-RESET OVERTEMPERATURE PROTECTORS

MULTIPLE-OPERATION, SELF-RESETTING OVERTEMPERATURE PROTECTORS

TWO-TERMINAL, MANUAL-RESET OVERCURRENT PROTECTORS

TWO-TERMINAL, SELF-RESETTING OVERCURRENT PROTECTORS

THREE- OR MORE-TERMINAL (TWO-OR MORE-ELEMENT) OVERCURRENT PROTECTORS

MULTIPLE-FUNCTION PROTECTORS

MANUFACTURING AND PRODUCTION TESTS

RATING

MARKING

Appendix A

INTRODUCTION

1 Scope

1.1 These requirements apply to overtemperature protectors, and overcurrent protectors to be employed in radio- and television-type appliances in applications where the protectors are relied upon to limit power, current, or both and where the equipment is to be supplied by a maximum 20 A branch circuit. Compliance with these requirements is not to be regarded as indication that an overcurrent or overtemperature protector would be acceptable in the end-use product.

1.2 The acceptability of any protector covered by these requirements in any particular component, device, or appliance depends upon the conditions of continued use that prevail in actual service. Accordingly, for a particular application, the protector may be affected by the requirements for the component, device, or appliance in question, and it may be necessary to employ protective devices having features other than or in addition to those specified in these requirements.

1.3 These requirements do not apply to thermal cutoffs (single-operation meltable-type overtemperature devices). Thermal cutoffs are covered in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

1.4 *Deleted*

2 Glossary

2.1 OVERCURRENT PROTECTOR – A device that:

a) Is intended for free standing use,

b) Is current sensitive, and

c) Is intended to be reset or is self-resetting following operation. Operation is the interrupting of a circuit(s) when the current flowing through it exceeds a preselected value.

2.2 OVERTEMPERATURE PROTECTOR – A device intended for freestanding use or for installation in components and that interrupts a current flow when it attains a predetermined temperature. It may be resettable or self-resetting following operation but shall not be of the single-operation type.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this Standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this Standard.

3.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

3.3 A component shall be used in accordance with its rating established for the intended conditions of use.

3.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

4 Units of Measurement

4.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

5 References

5.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

CONSTRUCTION

6 General

6.1 Each protector shall be complete and shall include a means for connection.

6.2 Each manually operated reset protector shall be trip-free; that is, the automatic tripping shall be independent of the manipulation or position of the reset button, handle, lever, and the like.

6.3 6.2 does not preclude the acceptance of a protector in which the contacts return automatically to the closed position after acceptable operating conditions have been restored if the reset button, handle, lever, and the like is held in the reset position.

7 Live Parts

7.1 Current-carrying parts shall be manufactured of materials that are capable of meeting the operating conditions of the particular application (for example, with respect to mechanical strength and ampacity).

7.2 Uninsulated live parts, including terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they are kept from turning or shifting in position if such motion may result in reduction of spacings to less than those required elsewhere in this standard. The security of contact assemblies that open in service shall be such as to maintain the continued alignment of contacts. A positive keying arrangement or the equivalent is required for maintenance of contact assembly alignment.

8 Insulating Material

8.1 A base for the support of current-carrying parts shall be insulating material that is able to withstand the conditions of actual service. Strength, flammability, arc resistance, moisture resistance, and resistance to hot-wire ignition are among the characteristics that shall be considered.

8.2 Insulating material, including barriers between parts of different potential and material that may be subject to the influence of the arc formed by the opening of the interruption mechanism, shall be capable of meeting the operating conditions for the particular application. Among things that shall be considered are flammability and performance under the overload and limited short-circuit tests, and the arc-, moisture, and hot-wire-, ignition tests described in Sections 13 and 15 – 17.

9 Corrosion Protection

9.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, cementation, plating, or other equivalent means.

Exception: Corrosion protection shall not be provided when it is detrimental to the operation.

9.2 9.1 applies to all enclosing cases and to other parts upon which acceptable mechanical operation may depend. It does not apply to small minor parts of iron or steel, such as washers, screws, bolts, and the like that are not current-carrying, if the deterioration of such unprotected parts is not likely to result in a risk of fire or electric shock or inability of the device to operate, but the protection of all such parts is recommended. Parts made of stainless steel (polished or treated if necessary) do not require additional protection against corrosion.

10 Mounting

10.1 Performance of a protector shall not be affected by strain, pressure, or torsion on terminals or leads. Bolts, screws, or other parts used for mounting a protector shall be independent of those used for securing parts of the assembly (in other words, the mounting means shall not be the assembly means).

11 Bushings

11.1 Any opening in a nonmetallic compartment wall for lead passage shall be smooth and free of sharp edges that may damage the wire.

11.2 If conductors pass through an opening in a sheet-metal wall that is 0.042 inch (1.07 mm) or less thick, they shall be held away from the edges of the opening, or shall be protected by a bushing, a grommet, or by rolling the edge of the metal at the opening not less than 120 degrees. A bushing, if used, shall be securely held in place.

11.3 An insulating bushing shall be not less than 3/64 inch (1.2 mm) thick.

11.4 The edges of an opening in sheet metal thicker than 0.042 inch (1.07 mm) shall be treated to reduce the possibility of abrasion of the insulation by the removal of burrs, fins, and sharp edges.

12 Spacings

12.1 General

12.1.1 The minimum spacings between any uninsulated live part and an uninsulated live part of different potential or an uninsulated dead metal part that is not conductively connected to live parts shall be not less than that specified in Table 12.1 .

Table 12.1
Minimum acceptable spacings in inches[a,b]

Potential involved in volts	Over the surface	Through the air
0 — 125 (rms)	1/16 (1.6mm)	1/16 (1.6 mm)
126 — 250 (rms)	3/32 (2.4 mm)	3/32 (2.4 mm)
251 — 600 (rms)	3/16 (4.8 mm)	5/32 (4.0 mm)
850 — 2500 (peak)	5/16 (8.0mm)	3/16 (4.8 mm)

[a] When protection against contamination (externally or internally generated) is provided, lesser spacings may be considered.

[b] This tabulation is based on sinusoidal waveforms. Protectors intended for use in circuits with other waveforms shall be considered with regard to the intent of the requirements.

12.2 Barriers

12.2.1 Barriers or liners of materials other than fiber shall be considered with regard to their dielectric strength, mechanical strength, and other factors needed for the application.

12.2.2 For 600 V rms potentials or less, a fiber barrier or liner used in place of required spacings shall be not less than 0.028 inch (0.71 mm) thick. For 600 V rms potentials or less, a fiber barrier or liner used in place of one-half the required spacings shall be not less than 0.013 inch (0.33 mm) thick.

12.2.3 A required barrier shall be held in place by means more secure than friction between surfaces.

13 Flammability Classification of Materials

13.1 Each material used in an overcurrent protector and in an overtemperature protector that is required to be V-0 shall comply with the test for V-0 material in the requirements for tests for flammability of plastic materials for parts in devices and appliances, UL 94.

PERFORMANCE

ALL PROTECTORS

14 General

14.1 Unless otherwise indicated, all voltages and current are rms values.

15 Hot-Wire Ignition Test

15.1 If a material is required to be resistant to flaming from hot-wire ignition, there shall be no ignition of any representative protector within 15 seconds when the material is tested as described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

16 Arc Resistance Test

16.1 General

16.1.1 If a material is required to be arc resistant, tracking shall not occur before 120 seconds when tested in accordance with the Standard Methods of Test for High-Voltage, Low-Current Dry Arc Resistance of Solid Electrical Insulation, ASTM D495-89, or to the extent described in 16.1.2 – 16.2.2 (low-voltage) or both.

16.1.2 Each of three specimens of a material that is to be evaluated for resistance to low-voltage arcing is to be tested as described in 16.2.1 and 16.2.2. There is to be no ignition of the test devices with fewer than 30 electrical arcs.

16.2 Low-voltage arcing test

16.2.1 Each of three flat, rectangular specimens of the material nominally 5 inches (127 mm) long by 1/2 inch (12.7 mm) wide and of the smallest thickness used, is to be mounted horizontally in air. Two electrodes, one stationary, a No. 8 AWG (8.4 mm^2) solid copper conductor having a chisel point, and one movable, a 1/8 inch (3.18 mm) diameter tungsten-steel rod with a pyramid-type point, are to be located opposing each other at an angle of 45 degrees to the horizontal. The electrodes when short circuited are to pass a current of 32.7 A at a 50 percent power factor. The supply voltage is to be 240 V ac.

16.2.2 With the electrodes at a selected position above the top surface of the representative protector and just touching the representative protector, the movable electrode is to be moved in a horizontal direction to make and break electrical contact with the copper electrode at 40 contacts per minute.

17 Resistance to Moisture Test

17.1 If a material is required to be moisture resistant, the volume resistivity, as measured by the Standard Methods of Tests for D-C Resistance or Conductance of Insulating Materials, ASTM D257-92, shall be a minimum of 10 megohm centimeters after conditioning as described in 17.2. Further, the initial (before conditioning) volume resistivity shall be a minimum of 50 megohm centimeters.

17.2 Each of three flat, circular, square, or rectangular specimens of the material nominally 4 inch square (101.6 mm) or in diameter and 1/8 inch (3.2 mm) thick (or in the thickness actually used) is to be placed in a 32.0 ±3.0°C (91.4 ±5.4°F), 85 ±5 percent relative humidity environment for 96 hours.

18 Strain Relief of Leads and Connectors Test

18.1 A lead or terminal shall be capable of withstanding for 1 minute without damage to itself or the protector, a 5 lbf (22.2 N) applied in any direction permitted by the construction.

19 Torque Test

19.1 A tab, terminal, or tang shall be capable of withstanding for 1 minute without damage to itself or the protector, a torque of 25 inch ounces (0.031 N·m) applied at a right angle to the direction of the terminal extension from the protector.

MULTIPLE-OPERATION, MANUAL-RESET OVERTEMPERATURE PROTECTORS

20 Calibration Verification

20.1 The opening temperature of each multiple-operation, manual-reset overtemperature protector shall differ by not more than 5°C (9°F) from the rated opening temperature.

20.2 Unless otherwise specified by the manufacturer, the overtemperature protector is to be mounted in the position that has the greatest tendency to impede performance.

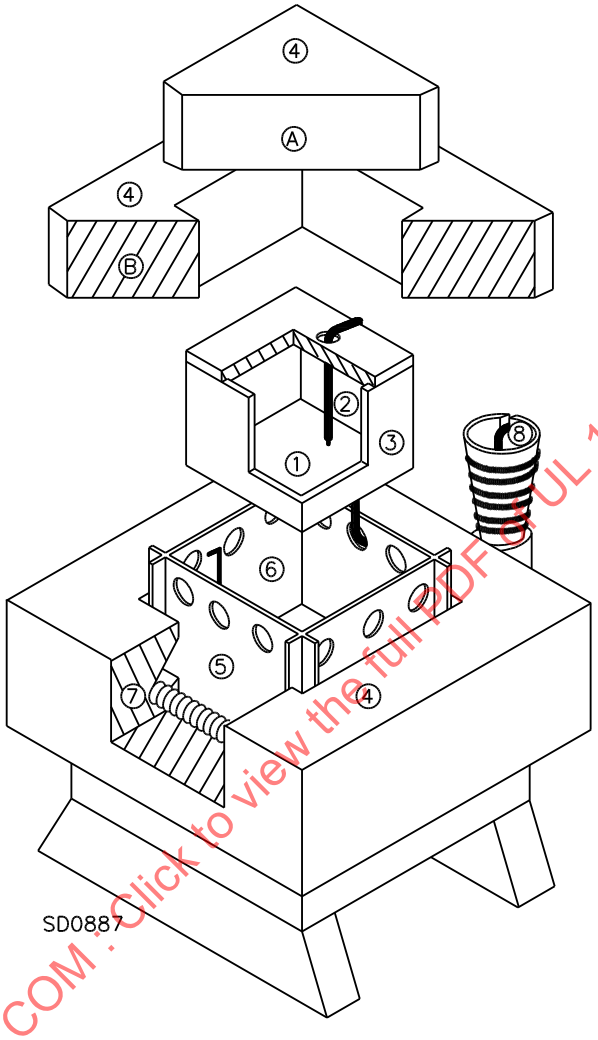
20.3 Three representative protectors for each rating are to be placed in a static air oven for 2 hours at 10°C (18°F) below the rated operating temperature. The oven temperature is then to be increased 0.25 – 0.50°C (0.45 – 0.90°F) per minute until all protectors open. Opening is to be determined by a means that does not cause a current of more than 3 percent of the rated protector current but not more than 0.010 A to

flow through the protector. Each representative protector is to be removed upon opening, given time to cool to room temperature, reset, and reinserted in the oven. Each representative protector tested is to be subjected to this test three times.

20.4 A typical test apparatus is shown in Figure 20.1. This test apparatus consists of an electrically heated, static warm-air oven, a two-section unit consisting of a nonmetallic inner compartment in which is placed a metal box. The interior surfaces of the oven consist of a firebrick type of surface, or the like, to shield against radiant heat and are insulated to reduce heat losses. Seams or joints are to be tight to reduce heat losses. The inner metal container shall have a 1/4 inch (6.4 mm) wall thickness. The container resets on inorganic blocks and is shielded from radiant heat. The temperatures around the protectors are monitored by the thermocouples located inside the metal container. The means for heating the air in the oven is such that the temperature of the air at the test location is maintained within 0.5°C (0.9°F). The oven is located in a room free of drafts and the ambient air temperature is maintained reasonably constant.

Figure 20.1

Typical calibration oven



1. Test device chamber.
2. Temperature monitoring and recording thermocouple.
3. Aluminum test box, supported on four ceramic buttons.
4. Low-density fire brick oven.
5. Ceramic oven liner.
6. Temperature controlling thermocouple inserted from the bottom of the oven between test box and oven liner.
7. Heating coil recessed in inside face of oven.
8. Heating element in series with oven heater used as ballast resistor.

A = 2-1/2 by 4-1/2 by 4-1/2 inches (63 by 114 by 114 mm).

B = 2-1/2 by 9 by 9 inches with hole 3-1/4 by 3-1/4 inches (63 by 228 by 228 mm with hole 82 by 82 mm).

21 Endurance Test

21.1 A multiple-operation, manual-reset overtemperature protector shall open when a temperature 7.0°C (12.6°F) above rated operating temperature is attained. There shall be no burning or pitting of the contacts and the protector shall remain operable following 50 cycles of operation.

21.2 The three representative protectors subjected to the tests described in 20.3 are to be placed in a static air oven maintained at 7.0°C (12.6°F) above rated opening temperature while carrying their rated current through a resistive load at rated voltage. Each is to be removed individually upon its opening, given time to cool to room temperature, reset, and reinserted in the oven. This is to be conducted a total of 50 times on each representative protector.

22 Calibration Reverification

22.1 The three representative protectors subjected to the tests described in 20.3 and 21.2 are to be rechecked for calibration using the method described in 20.3 and shall comply with 20.1.

23 Limited Short-Circuit Test

23.1 A multiple-operation, manual-reset overtemperature protector intended for use in primary circuits shall be tested as described in 23.2 and 23.3. There shall be no evidence of a risk of fire or electric shock during or after the test.

Exception: At the manufacturer's request, this test may instead be performed with the protector installed as intended in the end product.

Table 23.1
Limited short-circuit test

Rating amperes, maximum	Wire size AWG copper	Test current amperes
10	18	1000
13	16	1000
15	14	1000
20	12	2000

23.2 Three representative protectors of each multiple-operation, manual-reset overtemperature protector intended for use in primary circuits are to be subjected to a limited short-circuit from a branch circuit of rated voltage fused with a 20 A nonrenewable fuse, the characteristics of which are such that the fuse does not open in less than 12 seconds when carrying 40 A in series with the protector. Each pole of the protector is to be subjected to the test three times if it is in operating condition after the previous operation. The first operation is to be with the contacts of the overtemperature protector closed and then the short circuit closed on the protector. The second and third operations are to be with the contacts of the overtemperature protector open and then closed on the short circuit. The circuit is to limit the current in accordance with Table 23.1, and is to be measured without the overtemperature protect or and the connecting wires and fuse in the circuit. The power factor of the circuit is to be 0.9 – 1.0. The protector is to be connected in the circuit by two 5-1/2 ft (1.68 m) lengths of copper wire sized in accordance with Table 23.1. Cotton is to be wrapped around the overtemperature protector. Dead metal parts and metal placed adjacent to nonconductive exterior parts are to be connected to earth ground through a 1 A fuse.

23.3 The results are acceptable if the overtemperature protector or the branch circuit fuse, or both, opens the circuit without ignition of the cotton, if there is no damage to the leads or terminals of the protector, and if the 1 A fuse to earth ground is not ruptured. Such performance is still considered

acceptable if the overtemperature protector is rendered inoperable during the first or second operation of the limited short-circuit test.

24 Dielectric Voltage-Withstand Test

24.1 A multiple-operation, manual-reset overtemperature protector shall be capable of withstanding for 1 minute without breakdown a 60 Hz essentially sinusoidal potential of 1000 V plus twice rated voltage applied between the following parts:

a) Uninsulated live parts and dead metal parts.

b) Live parts of opposite polarity.

c) Uninsulated live parts and a metal foil wrapped around insulating material when provided.

24.2 To determine if a protector complies with 24.1, the protector is to be tested by means of a transformer whose output voltage is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test potential is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be at a uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

24.3 Six representative protectors are to be tested for compliance with 24.1.

25 Positive Opening Test

25.1 The opening of a multiple-operation, manual-reset overtemperature protector shall be positive.

25.2 Ten open representative protectors are to be individually connected in series with a supply source of rated voltage and a resistive load calibrated to carry rated current. This circuit is to remain intact for 2 hours. At no time is there to be any current flow greater than 1 percent of the rated current, or 0.5 mA, whichever is smaller.

26 Overload Test

26.1 A multiple-operation, manual-reset overtemperature protector shall be capable of breaking a test current of 1.5 times the rated current at the rated voltage with a power factor of 0.75 – 0.80.

Exception: This test may be omitted if the protector is not intended for unenclosed use.

26.2 The contacts shall positively open the circuit without damage to themselves that renders the protector inoperable. The case of an enclosed element shall remain intact. An open mechanism shall not arc-over to a conductive screen located 1/2 inch (12.7 mm), or less if so specified by the manufacturer, away from live parts and connected to the opposite pole of the supply circuit through a 3 A fuse. In no case shall there be any damage to the integral leads of the protector.

26.3 Dead metal parts that are an inherent part of the overtemperature protector and that may be bonded to grounded or exposed parts of the end product are to be connected during the test through a 3 A fuse to the live pole least likely to strike (arc) to ground.

26.4 Ten representative overtemperature protectors are to be subjected to the overload test for each rating, each protector being tested 50 times.

MULTIPLE-OPERATION, SELF-RESETTING OVERTEMPERATURE PROTECTORS

27 Calibration Verification

27.1 The opening temperature of a multiple-operation, self-resetting overtemperature protector shall differ by not more than 5°C (9°F) from the rated opening temperature.

27.2 Unless otherwise specified by the manufacturer, the overtemperature protector is to be mounted in the position that has the greatest tendency to impede performance.

27.3 Three representative overtemperature protectors for each rating are to be placed in a static air oven for 2 hours at 10°C (18°F) below the rated operating temperature. The oven temperature is then to be increased 0.25 – 0.50°C (0.45 – 0.90°F) per minute to cause the protector to open. Opening is to be determined by a means that does not cause a current of more than 3 percent of the rated protector current but not more than 0.010 A to flow through the protector. Each representative protector is to be removed upon opening, cooled to room temperature, and reinserted in the oven. Each representative protector tested is to be subjected to this test three times.

27.4 A typical test apparatus is described in 20.4.

28 Endurance Test

28.1 A self-resetting overtemperature protector shall operate for 6000 cycles at the current levels described in 28.2 without experiencing damage that renders it inoperable or substantially modifies its calibration.

Exception: If 6000 cycles of operation, including self-resetting time, are accomplished in less than 15 days, such operation is to continue to completion of a total of 15 days.

28.2 The three representative protectors, after being subjected to the test described in 27.3, are to be subjected to a heat source that causes the contacts to operate at the rate of no more than 1 cycle per minute with an on time of 50 ±20 percent. Rated current through a resistive load at rated voltage is to flow through the protector.

29 Calibration Reverification

29.1 The opening temperature of an overtemperature protector, measured after endurance test, shall differ by not more than 10°C (18°F) from the rated opening temperature.

29.2 The three representative protectors subjected to the tests described in 27.3 and 28.2 are to be reevaluated using the method described in 27.3 except that the initial oven temperature shall be 15°C (27°F) below the rated opening temperature.

30 Limited Short-Circuit Test

30.1 A self-resetting overtemperature protector for use in primary circuits shall be tested as described in 30.2 and 30.3. There shall be no evidence of a risk of fire or electric shock during or after the test.

Exception: At the manufacturer's request this test may instead be conducted with the protector in the end product.

30.2 Three representative devices of each self-resetting overtemperature protector intended for use in primary circuits are to be subjected to a limited short circuit from a branch circuit of rated voltage, fused

with a 20 A nonrenewable fuse, the characteristics of which are such that the fuse does not open in less than 12 seconds when carrying 40 A in series with the protector. Each pole of the protector is to be subjected to the test three times if in operating condition after the previous operation. The first operation is to be with the contacts of the overtemperature protector closed and then the short circuit closed on the protector. The second and third operations are to be with the contacts of the overtemperature protector open and then closed on the short circuit. The circuit is to limit the current in accordance with Table 30.1, and is to be measured without the overtemperature protector and the connecting wires and fuse in the circuit. The power factor of the circuit is to be 0.9 – 1.0. The protector is to be connected in the circuit by two 5-1/2 ft (1.68 m) lengths of copper wire sized in accordance with Table 30.1. Cotton is to be wrapped around the overtemperature protector. Dead metal parts and metal placed adjacent to nonconductive exterior parts are to be connected to earth ground through a 1 A fuse.

Table 30.1
Limited short-circuit test

Rating amperes, maximum	Wire size AWG copper	Test current amperes
10	18	1000
13	16	1000
15	14	1000
20	12	1000

30.3 The results are acceptable if the overtemperature protector or the branch circuit fuse, or both, opens the circuit without ignition of the cotton, if there is not any damage to the leads or terminals of the protector, and if the 1 A fuse to earth ground is not ruptured. Such performance is still considered acceptable if the overtemperature protector is rendered inoperative during the first or second operation of the limited short-circuit test.

31 Dielectric Voltage-Withstand Test

31.1 A self-resetting overtemperature protector shall be capable of withstanding for 1 minute without breakdown, a 60 Hz essentially sinusoidal potential of 1000 V plus twice rated voltage applied between the following parts:

a) Uninsulated live parts and dead metal parts,

b) Live parts of opposite polarity, and

c) Uninsulated live parts and a metallic foil wrapped around insulating material when provided.

31.2 To determine compliance with 31.1, the protector is to be tested by means of a transformer whose output voltage is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test potential is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be a uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

31.3 Three representative protectors are to be tested for compliance with 31.1.

32 Positive Opening Test

32.1 The opening of a self-resetting overtemperature protector shall be positive.

32.2 Ten representative protectors heated to obtain open contacts are to be individually connected in series with a rated voltage supply source and a resistive load calibrated to carry rated current. This circuit

is to remain intact for 2 hours. At no time is there to be any current flow greater than 1 percent of the rated current or 0.5 mA, whichever is smaller.

33 Overload Test

33.1 A self-resetting overtemperature protector shall be capable of breaking a test current of 1.5 times the rated current at the rated voltage with a power factor of 0.75 – 0.80.

Exception: This test may be omitted if the protector is not intended for unenclosed use.

33.2 The contacts shall positively open the circuit without experiencing damage that would render the protector inoperable. The case of an enclosed element shall remain intact. An open mechanism shall not arc-over to a conductive screen located 1/2 inch (12.7 mm), or less if so specified by the manufacturer, away from live parts and connected to the opposite pole of the supply circuit through a 3 A fuse. In no case shall there be any damage to the integral leads of the protector.

33.3 Dead metal parts that are an inherent part of the overtemperature protector and that may be bonded to grounded or exposed parts of the end product are to be connected during the test through a 3 A fuse to the live pole least likely to arc to ground.

33.4 Three representative overtemperature protectors are to be subjected to the overload test for each rating, each representative protector being tested 50 times.

TWO-TERMINAL, MANUAL-RESET OVERCURRENT PROTECTORS

34 General

34.1 A two-terminal, manual-reset overcurrent protector is to be mounted in the position that has the greatest tendency to impede performance.

34.2 The same six representative overcurrent protectors are to be subjected to all of the tests described in Sections 35 – 39.

34.3 All tests are to be conducted in air at a temperature of 25.0 ±3.0°C (77.0 ±5.4°F).

34.4 A rating includes either ac or dc. If a protector is to have both a-c and d-c ratings it is to be tested in both such manners, unless one mode of testing represents both.

35 Calibration Verification and Calibration Reverification

35.1 A two-terminal, manual-reset overcurrent protector shall carry rated current (see 50.1) for a minimum of 1 hour after thermal stability is reached without opening, both before and after being subjected to the overload test described in Overload Test, Section 36.

35.2 Each of the six representative overcurrent protectors is to be connected in series with a variable load resistor to a rated voltage supply source. Thermal stability is considered to exist when there is no change in temperature measured by a thermocouple attached to a protector terminal. A series of three readings at 5-minute intervals is to be taken for this determination.

35.3 A two-terminal, manual-reset overcurrent protector shall open within 2 minutes when carrying 175 percent of rated current (see 50.1) and within 1 minute when carrying 200 percent of rated current, both before and after being subjected to the overload test described in Overload Test, Section 36.

35.4 For the calibration tests the overcurrent protector is to be wired with not less than 4 ft (1.22 m) of wire sized in accordance with Table 39.1 connected to each wiring terminal. The ampacity of the wire is to be at least equal to the maximum rated current of the overcurrent protector. If the terminals of the overcurrent protector are too small to receive that size wire, the maximum wire size the terminals are intended to accept is to be used.

35.5 Each of the six representative overcurrent protectors is to be operated for six operations for each current level. After opening, a minimum 2 minute cooling period is to elapse before resetting.

36 Overload Test

36.1 A two-terminal, manual-reset overcurrent protector shall operate for 50 cycles at the current level specified by its manufacturer, without experiencing damage that renders it inoperable, changes its calibration, creates a risk of electric shock, or causes any flaming of materials.

36.2 Each representative overcurrent protector, after being subjected to the calibration tests, is to be connected in series with a variable resistance load (unity power factor) in the ungrounded leg of a supply source of rated voltage. A 1 A fuse is to be connected between dead metal parts and earth ground. Cotton is to be wrapped around the protector. Each representative protector is to be subjected to 50 cycles of operation interrupting this circuit at the current level described in 36.1. A 30 second interval is to separate each cycle of operation. The representative protectors are to be closed on the test circuit for the first 10 cycles of operation and the test circuit closed on the representative protectors for the remaining 40 cycles. If this is not possible, the test circuit is to be closed on the representative protectors for all 50 cycles.

36.3 The results are acceptable if, at conclusion, each representative protector is operable (there is no electrical breakdown or mechanical malfunction), the 1 A earth-grounding fuse is intact, and no part of the protector or the cotton flamed.

36.4 Following completion of the overload test described in this section, each representative protector is to be subjected to the tests described in Calibration Verification and Calibration Reverification, Section 35.

37 Dielectric Voltage-Withstand Test

37.1 A two-terminal, manual-reset overcurrent protector shall be capable of withstanding for 1 minute without breakdown, a 60 Hz essentially sinusoidal potential of 1000 V plus twice rated voltage applied to the following parts:

a) Uninsulated live parts and dead metal parts.

b) Live parts of opposite polarity.

c) Uninsulated live parts and a metallic foil wrapped around insulating material.

37.2 To determine if a protector complies with 37.1, the protector is to be tested by means of a transformer whose output voltage is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test potential is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be at a uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter.

37.3 Each of the six representative overcurrent protectors, after being subjected to the overload test, are to be tested for compliance with 37.1.

38 Positive Opening Test

38.1 The opening of a two-terminal, manual-reset overcurrent protector shall be positive.

38.2 Three open representative overcurrent protectors (the representative overcurrent protectors previously tested) are to be individually connected in series with a rated-voltage supply source and a resistive load calibrated to carry rated current. This circuit is to remain intact for 2 hours. At no time is there to be any current flow greater than 1 percent of the rated current or 0.5 mA, whichever is smaller.

39 Limited Short-Circuit Test

39.1 A two-terminal, manual-reset overcurrent protector for use in primary circuits shall be tested as described in 39.2 and 39.3. There shall be no evidence of a risk of fire or electric shock during or after the test.

Exception: At the manufacturer's request, this test may instead be conducted with the protector installed as intended in the end product.

39.2 Three representative protectors of each two-terminal, manual-reset overcurrent protector intended for use in primary circuits are to be subjected to a limited short-circuit from a branch circuit of rated voltage, fused with a 20-A nonrenewable fuse, the characteristics of which are such that the fuse does not open in less than 12 seconds when carrying 40 A in series with the device. Each pole of the protector is to be subjected to the test three times if it is in operating condition after the previous operation. The first operation is to be with the contacts of the overcurrent protector closed and then the short circuit closed on the protector. The second and third operations are to be with the contacts of the overcurrent protector open and then closed on the short circuit. The circuit is to limit the current in accordance with Table 39.1, and is to be measured without the overcurrent protector and the connecting wires and fuse in the circuit. The power factor of the circuit is to be 0.9 – 1.0. The protector is to be connected in the circuit by two 5-1/2 ft (1.68 m) lengths of copper wire sized in accordance with Table 39.1. Cotton is to be wrapped around the protector. Dead metal parts and metal placed adjacent to nonconductive exterior parts are to be connected to earth ground through a 1-A fuse.

Table 39.1
Limited short-circuit test

Rating amperes, maximum	Wire size AWG copper	Test current amperes
10	18	1000
13	16	1000
15	14	1000
20	12	2000

39.3 The results are acceptable if the overcurrent protector opens the circuit without ignition of the cotton, if there is no damage to the leads or terminals of the protector, and if the 1 A earth-ground fuse is not ruptured. Such performance is still considered acceptable if the overcurrent protector is rendered inoperable during the first or second operation of the limited short-circuit test.

TWO-TERMINAL, SELF-RESETTING OVERCURRENT PROTECTORS

40 General

40.1 A two-terminal, self-resetting overcurrent protector is to be mounted in the position that has the greatest tendency to impede performance.

40.2 The same six representative overcurrent protectors for each rating are to be subjected to all of the tests described in Sections 41 – 45.

40.3 All tests are to be conducted in air at a temperature of 25 ±3.0°C (77.0 ±5.4°F).

40.4 A rating shall be either ac or dc. If a protector is to have both ac and dc ratings, it is to be tested in both such manners, unless one mode of testing represents both.

41 Calibration Verification and Calibration Reverification

41.1 A two-terminal, self-resetting overcurrent protector shall carry rated current (see 50.1) continuously for a minimum of 1 hour after thermal stability is reached without opening, both before and after being subjected to the overload test described in Overload Test, Section 42.

41.2 Each of the six representative overcurrent protectors is to be connected in series with a variable-load resistor to a supply source of rated voltage. The circuit is to be constructed so that any interruption of the current flow disables the circuit until it is manually reset. Thermal stability is considered to exist when there is no change in temperature measured by a thermocouple attached to a protector terminal. A series of three readings, at 5 minute intervals, is to be taken for this determination.

41.3 A two-terminal, self-resetting overcurrent protector shall open within 2 minutes when carrying 175 percent of rated current (see 50.1) and within 1 minute when carrying 200 percent of rated current, both before and after being subjected to the overload tests described in Overload Test, Section 42. Self-resetting after each of these calibration openings shall take a minimum of 1 minute, both before and after the overload test.

41.4 For the calibration tests, the overcurrent protector is to be wired with not less than 4 ft (1.22 m) of wire sized in accordance with Table 45.1 connected to each wiring terminal. The ampacity of the wire is to be at least equal to the maximum rated current of the overcurrent protector. If the terminals of the overcurrent protector are too small to receive that size wire, the maximum wire size the terminals are intended to accept is to be used.

41.5 Each of the six representative overcurrent protectors is to be operated for six operations for each current level.

42 Overload Test

42.1 A two-terminal, self-resetting overcurrent protector shall operate for a minimum of 6000 cycles at a current level chosen by its manufacturer without damage to itself that renders it inoperable, changes its calibration, creates a risk of electric shock, or causes any flaming of material.

Exception: If 6000 cycles of operation, including self-resetting time, in a 25°C (77°F) ambient, are accomplished in less than 15 days, such operation is to continue to completion of a total of 15 days.

42.2 Each representative overcurrent protector, after being subjected to the calibration tests, is to be connected in series with a variable resistance load (unity power factor) in the ungrounded leg of a rated-voltage supply source. A 1 A fuse is to be connected between dead metal parts and earth ground. Cotton is to be wrapped around the protector. Each representative overcurrent protector is to interrupt this circuit at the current level described in 42.1, with self-resetting being acceptable.

42.3 The results are acceptable if at conclusion, each representative protector is in an operating condition, the 1 A earth-grounding fuse is intact, and no part of the device or the cotton flamed.