UL 1077

STANDARD FOR SAFETY

Supplementary Protectors for Use in Electrical Equipment

UL Standard for Safety for Supplementary Protectors for Use in Electrical Equipment, UL 1077

Seventh Edition, Dated June 25, 2015

Summary of Topics

This revision of ANSI/UL 1077 dated November 16, 2021 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 September 3, 2021.

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The most recent designation of ANSI/UL 1077 as a Reaffirmed American National Standard (ANS) occurred on November 16, 2021. 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.

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INTRODUCTION

1 Scope

1.1 These requirements apply to supplementary protectors intended for use as overcurrent, or over- or under-voltage protection within an appliance or other electrical equipment where branch circuit overcurrent protection is already provided, or is not required. Compliance with the following is acceptable for use as a component of an end product.

1.2 The acceptability of a protector in any particular application depends upon its ability to be used continuously under the conditions that prevail in actual service. Accordingly, for a particular application a protector may be affected by the requirements for the equipment it is used in, and it may be necessary to additionally evaluate features or performance characteristics that are not specified in this Standard.

1.3 This Standard also covers accessory devices that may be installed in or on the protector to perform a secondary function. Examples of accessories are alarm and auxiliary switches.

1.4 Devices which ensure a manual restart due to the complete loss of voltage are covered by the Standard for Solid-State Controls for Appliances, UL 244A. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

1.5 Automatic reset devices designed to open the circuit automatically on a predetermined value of time versus current or voltage within an appliance or other electrical equipment are covered by the Standard for Solid-State Controls for Appliances, UL 244A. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

2 Glossary

2.1 AUXILIARY SWITCH – A switch that is mechanically operated by the main contact switching mechanism.

2.2 FIELD WIRING TERMINALS – Any terminal to which a supply or other wire can be connected by an installer in the field, unless the wire is provided as part of the appliance or other electrical equipment and a pressure terminal connector, soldering lug, soldered loop, crimped eyelet, or other means for making the connection is factory-assembled to the wire.

2.3 MAGNETIC-TRIP PROTECTOR – A protector that is caused to trip by current through a magnet coil.

2.4 OVERCURRENT-TRIP PROTECTOR – A thermal or magnetic trip protector intended to trip the contact circuit when the current through the thermal element or trip coil, which is in series with contact circuit, exceeds a predetermined value.

2.5 OVERVOLTAGE-TRIP PROTECTOR – A magnetic trip protector intended to trip the contact circuit when the voltage across the trip coil rises above a predetermined value.

2.6 RATED CURRENT – For an overcurrent-trip protector, the current that the protector is intended to carry continuously without opening of the circuit.

2.7 SHUNT TRIP PROTECTOR – A protector with a trip mechanism energized by a separate source of voltage or current that is derived from the main contact circuit or from an independent source. The trip mechanism is either of the overcurrent type or the voltage actuated type.

2.8 SUPPLEMENTARY PROTECTOR – A manually resettable device designed to open the circuit automatically on a predetermined value of time versus current or voltage within an appliance or other electrical equipment. It is permitted to be provided with manual means for opening or closing the circuit.

2.9 THERMAL AND MAGNETIC TRIP PROTECTOR – A combination of 2.3 and 2.4.

2.10 THERMAL TRIP PROTECTOR – A protector that is caused to trip by heat generated from current flowing through a thermal element.

2.11 TRIP CURRENT – The current at which an overcurrent-trip protector is intended to open the contact circuit at a given ambient temperature and a given time.

2.12 TRIP-FREE – A protector designed so that the contacts cannot be held in the closed position by the operating means during trip command conditions.

2.13 TRIP-FREE, CYCLING – A protector designed so that the contacts cannot be held in the closed position by the operating means during trip command conditions, but will reclose when the closing command is maintained. The protector will continue to close momentarily and repeatedly as long as the close command is maintained by the operating means during trip command conditions.

2.14 TRIP MECHANISM – The part of the protector that senses the abnormal condition in the circuit and causes the contact circuit to open.

2.15 TRIP VOLTAGE – The voltage at which an overvoltage protector or undervoltage protector is intended to trip.

2.16 UNDERVOLTAGE-TRIP PROTECTOR – A magnetic trip protector intended to trip the contact circuit when the voltage across the trip coil falls below a predetermined value.

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 Undated 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 A protector shall have an integral housing for all mechanisms and live parts, except the operating handle and the wiring terminals, and shall be capable of being operated or reset without opening the housing.

6.2 A protector shall be so formed and assembled that it shall have the strength and rigidity necessary to resist the ordinary abuses to which it is capable of being subjected (including the tests specified in this Standard), without increasing its risk of fire, shock or personal injury due to partial or total collapse with a resulting reduction of spacings, loosening or displacement of parts, or other serious defect.

7 Corrosion Protection

7.1 Iron and steel parts except for thermal elements, magnet pole faces, hardened and polished parts such as latching surfaces, and other similar parts, where such protection is impractical, shall be acceptably protected against corrosion by enameling, galvanizing, plating, or other equivalent means.

7.2 The requirements of 7.1 apply to all housings and to all springs and other parts upon which proper mechanical operation depends. It does not apply to small minor parts of iron or steel such as washers, screws, bolts, and other similar parts that are not current-carrying, or to other parts where the malfunction of such unprotected parts would not be likely to result in a risk of fire, electric shock or personal injury. Parts made of stainless steel, properly polished or treated when necessary, do not require additional protection against corrosion.

8 Insulating Materials

8.1 Insulating material for the support of current-carrying parts shall be strong, not easily ignited, and moisture resistant. A material other than porcelain, phenolic, or one that has not been evaluated for the support of current-carrying parts shall be investigated under conditions of actual service to determine if it has the necessary electrical, mechanical, and flammability properties and otherwise meets the intent of the requirements for the particular application. The properties of the material shall be such that it shall withstand the most severe conditions likely to be met in service.

8.2 A material that is used for the direct support of an uninsulated live part shall comply with the Relative Thermal Index (RTI), Hot Wire Ignition (HWI), High-Current-Arc Resistance to Ignition (HAI), and Comparative Tracking Index (CTI) values indicated in Table 8.1. A material is considered to be in direct support of an uninsulated live part when:

a) It is in direct physical contact with the uninsulated live part; and

b) It serves to physically support or maintain the relative position of the uninsulated live part.

Exception No. 1: A generic material with a Relative Thermal Index (RTI) as shown in the table for Relative Thermal Indices Based Upon Past Field-Test Performance and Chemical Structure, in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C that is not exceeded during the Temperature Test, Section 20, and is provided in such a thickness that damage does not result from tests required by this Standard, is considered suitable for the direct support of uninsulated live parts.

Exception No. 2: A material without an HWI Performance Level Category (PLC) value or with an HWI PLC value greater (worse) than the value required by Table 8.1 that complies with the end-product Abnormal Overload Test or the Glow-Wire End-Product Test (GWEPT) or the Glow Wire Flammability Index (GWFI) as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, need not comply with the HWI requirements of 8.2.

Exception No. 3: A material without an HAI PLC value or with an HAI PLC value greater (worse) than the value required by Table 8.1 that complies with the Overload Test, Section 21, Endurance, Section 22 and Dielectric strength test, 23.1, need not comply with the HAI requirements of 8.2.

Exception No. 4: A material that is used in a device not incorporating contacts need not comply with the HAI PLC requirements.

Exception No. 5: A material that is used in a device that incorporates contacts but is not used within 1/2 inch (12.7 mm) of the contacts need not comply with the HAI PLC requirements.

Exception No. 6: A material without a CTI PLC value or with a CTI PLC value greater (worse) than the value required by Table 8.1 need not comply with the requirements of 8.2 when:

a) The material complies with the end-product Special Arcing Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C;

b) The material has a High-Voltage-Arc Tracking (HVTR) PLC value of 1 or less; or

c) The over surface spacings between the uninsulated live parts are at least 1/2 inch (12.7 mm).

Table 8.1
Minimum material characteristics necessary for the direct support of uninsulated live parts

Flame class rating	RTI	Performance level category (PLC)		
		HWI[b]	HAI[b]	CTI[c]
HB	a	2	1	4
V-2	a	2	2	4
V-1	a	3	2	4
V-0	a	4	3	4

[a] The Relative Thermal Index (RTI) – Mechanical Without Impact, value of a material is to be determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, by test or by use of the generic RTI table. This material characteristic is dependent upon the minimum thickness at which the material is being used and shall not be exceeded during the Temperature Test, Section 20.

[b] The High Current Arc Resistance to Ignition (HAI) and Hot Wire Ignition (HWI) value of a material is to be determined by test in accordance the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used.

[c] The Comparative Tracking Index (CTI) PLC value of a material is to be determined by test in accordance with UL 746A. This material characteristic is not dependent upon the minimum thickness at which the material is being used.

8.3 Insulating material, including barriers between parts of opposite polarity or material, subject to the influence of the arc formed by the opening of contacts, shall be acceptable for the particular application.

9 Current-Carrying Parts

9.1 Current-carrying parts shall be of silver, copper, a copper alloy, stainless steel or other metals such as plated iron or plated steel acceptable for the particular application with regard to plating, temperature, and other similar factors.

9.2 Unplated iron and steel used in bimetallic elements and heaters is not prohibited.

9.3 Current-carrying parts, including terminals, shall be secured to their supporting surfaces so that they are restricted from rotating or shifting in position when such motion results in reduction of spacings to less than those required elsewhere in this Standard. The security of contact assemblies shall be such as to provide for the continued alignment of contacts.

9.4 Friction between surfaces shall not be used as the sole means to restrict movement of current-carrying parts. Movement is to be restricted by use of:

a) Two screws or rivets;

b) Shoulder or mortises;

c) Pin;

d) Lug;

e) Offset;

f) Connecting strip or clip fitted to an adjacent part; or

g) Some other equivalent method.

9.5 When current-carrying parts are held together by screws, a threaded part shall have not less than two full, clean-cut threads engaged in metal. When the screw does not extend all the way through the threaded parts, the taper or lead and the first full thread are to be disregarded in the determination of the number of threads engaged.

9.6 Aluminum conductors, insulated or uninsulated, used for internal-wiring interconnections between current-carrying parts shall be terminated at each end by a method acceptable for the combination of metals involved at the connection point.

9.7 When a wire-binding-screw construction or a pressure-wire connector is used as a terminating device, as pertains to 9.6, it shall be investigated for use with aluminum under the conditions involved (for example, temperature, heat cycling, vibration).

10 Wiring Terminals

10.1 Terminal parts by which connections are made shall restrict connections from loosening even under hard usage.

10.2 Terminals intended for field wiring shall be pressure wire connectors, terminal leads or wire binding screws that comply with Sections 11, 12 or 13 and shall be rated for use with the conductor size in Table 10.1 based on the applicable current.

10.3 A dc rated supplementary protector intended to have poles wired in series shall have specific instructions as to the correct wiring of the device. If specific hardware or parts are required they shall be:

a) Assembled to the supplementary protector;

b) Shipped with the supplementary protector as a kit with instructions for assembly; or

c) Made available separately as a kit.

See also 18.12 – 18.17, and 34.7.

Table 10.1
Terminal current and conductor size

Terminal current in Amperes[a]	Copper conductor			Aluminum or copper-clad aluminum conductor		
	Number of conductors	Size AWG or kcmil		Number of conductors	Size AWG or kcmil	
		60°C	75°C		60°C	75°C
15 or less	1	14	14	1	12	12
20	1	12	12	1	10	10
25	1	10	10	1	10	10
30	1	10	10	1	8	8
40	1	8	8	1	6	8
50	1	6	8	1	4	6
60	1	4	6	1	3	4
70	1	4	4	1	2	3
80	1	3	4	1	1	2
90	1	2	3	1		2
100	1	1	3	1		1
110	1		2	1		1/0
125	1		1	1		2/0
150	1		1/0	1		3/0
175	1		2/0	1		4/0
200	1		3/0	1		250
225	1		4/0	1		300
250	1		250	1		350
275	1		300	1		500
300	1		350	1		500
325	1		400	2		4/0
350	1		500	2		4/0
400	2		3/0	2		250
	1		500	1		750
450	2		4/0	2		300
500	2		250	2		350
550	2		300	2		500
600	2		350	2		500
700	2		500	3		350
800	3		300	3		400
1000	3		400	4		350
				3		600
1200	4		350	4		500
	3		600			
1400	4		500	5		500
1600	5		400	5		600
	4		600			
2000	6		400	6		600
	5		600			
2500	8		400	8		600
	7		500	7		750

Table 10.1 Continued on Next Page

Table 10.1 Continued

Terminal current in Amperes[a]	Copper conductor			Aluminum or copper-clad aluminum conductor		
	Number of conductors	Size AWG or kcmil		Number of conductors	Size AWG or kcmil	
		60°C	75°C		60°C	75°C
	6		600	9		500
3000	9		400	10		500
	8		500	9		600
	7		600	8		750

[a] For terminal current other than indicated, the next higher rating is to be used – for example, if rated 35 A, enter at 40 A.

mm^2	2.1	3.3	5.3	8.4	13.3	21.1	26.7	33.6	42.4	53.5
AWG	14	12	10	8	6	4	3	2	1	1/0
mm^2	67.4	85.0	107.2	127	152	177	203	253	304	380
AWG or kcmil	2/0	3/0	4/0	250	300	350	400	500	600	750

11 Pressure Wire Connectors

11.1 A pressure wire connector intended for field wiring shall comply with the requirements in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

12 Wiring Leads

12.1 Field wiring leads to be connected to a power circuit shall not differ from the wire size that would correspond to the rating of the protector by more than two sizes. The wire size shall not be smaller than 14 AWG (2.1 mm^2).

12.2 Field wiring leads to be connected to a control circuit shall be 22 AWG (0.32 mm^2) minimum.

12.3 Field wiring leads shall consist of general-use wire or appliance wiring material acceptable for the particular application when considered with regard to the temperature, voltage and conditions of service.

12.4 A field wiring lead shall be constructed so as to withstand the stress of normal handling without damage to itself or to the protector and shall comply with Section 26.

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

12.6 The free length of a field wiring lead shall be at least 6 inches (152 mm).

13 Wire-Binding Screw Terminals

13.1 A wire-binding screw terminal is acceptable only for field wiring of a 10 AWG (5.3 mm^2) or smaller wire. The wire binding screw terminal shall consist of clamps or binding screws with terminal plates having upturned lugs or the equivalent to hold the wire in position.

13.2 A wire-binding screw to which field-wiring connections are made shall not be smaller than No. 8 (4.2 mm diameter), except that a No. 6 (3.5 mm diameter) screw is capable of being used for a terminal to which 14 AWG (2.1 mm^2) or smaller wire is intended to be connected.

13.3 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick for a 14 AWG (2.1 mm^2) or smaller wire, and not less than 0.050 inch (1.27 mm) thick for a wire larger than 14 AWG. In either case there shall not be fewer than two full threads in the metal.

Exception: A terminal plate formed from stock having the minimum required thickness, may have the metal extruded at the tapped hole for the binding screw to provide two full threads; except that two full threads are not required when the threads do not strip upon application of a 20 lbf-in (2.26 N·m) torque value.

14 Mounting

14.1 Provision shall be made for mounting a protector in its normal operating position.

15 Operating Mechanism

15.1 A multipole protector intended to control a 3-phase load shall be so constructed that all poles make and break simultaneously, when operated manually or automatically.

15.2 A multipole protector with one manually operated actuating member shall be so constructed that all poles make and break simultaneously, when operated manually or automatically.

15.3 A multipole protector, with more than one manually operated actuating member that is externally interconnected by a clip or rod to cause all poles to be manually operated simultaneously, is considered to have one manually operated actuating member and shall comply with 15.2.

15.4 The means for manual operation for a protector shall be such that the contacts cannot be held in the closed position when the protector is tripped automatically – that is, the protector shall be trip-free from the operating handle. There are two types of trip-free as defined by 2.12 and 2.13. See also 19.11.

15.5 A protector shall be so sealed that tampering with the calibration or interference with the automatic operation requires dismantling of the device or the breaking of a seal. A protector may be provided with a calibration adjustment when this adjustment moves the trip current downward only towards the rated current.

15.6 An operating handle, when constructed of conducting material extending into the housing, shall have provision for being grounded.

16 Spacings

16.1 The spacings of a protector shall comply with the end-product requirements or shall not be less than those indicated in Table 16.1. The inherent spacings of a component supplied as part of a protector, such as a snap switch, are investigated under the requirements for that component. The spacings from such a component to another component or to grounded metal shall be as specified in Table 16.1.

Table 16.1
Minimum spacings in inches (mm)

		Maximum rating of 600 V A			Maximum rating of 250 V B	Maximum rating of 250 V C	Maximum rating of 600 V D		
		General industrial			Household kitchen appliances (includes household dishwashers, waste disposals, and the like)	Household appliances (includes electric home laundry equipment, and the like)	Commercial appliances (includes office appliances, business machines, electronic data processing equipment, also vending and amusement machines)		
Potential involved in volts		51 – 150	151 – 300	301 – 600	51 – 250	51 – 250	51 – 125	126 – 300	301 – 600
Between any uninsulated live parts of opposite polarity or uninsulated live parts and uninsulated grounded metal parts	Through air or oil	1/8[a] (3.2)[a]	1/4 (6.4)	3/8 (9.5)	3/32[a] (2.4)[a]	1/4 (6.4)	1/16[a] (1.6)[a]	3/32[a] (2.4)[a]	3/8 (9.5)
	Over surface	1/4 (6.4)	3/8 (9.5)	1/2 (12.7)	3/32[a] (2.4)[a]	3/8 (9.5)	1/16[a] (1.6)[a]	3/32[a] (2.4)[a]	1/2 (12.7)

[a] Spacings between field terminals shall be not less than 1/4 inch (6.4 mm) through air and over surface regardless of polarity. Spacing between quick connect terminals shall be not less than 1/4 inch (6.4 mm) through air and over surface when bending of the quick connect terminals is likely to result in short circuiting of the terminals.

16.2 A live screw head or nut on the underside of an insulating base shall be restricted from loosening and shall be insulated or spaced from the mounting surface. This shall be accomplished by:

a) Countersinking such parts not less than 1/8 inch (3.2 mm) in the clear and then covering them with a waterproof, insulating sealing compound that does not soften at a temperature 15°C (27°F) higher than its normal operating temperature in the device, and not less than 65°C (149°F) in any case, or

b) Securing such parts and insulating them from the mounting surface by means of a barrier or the equivalent, or by means of through-air or over-surface spacings as required in Table 16.1.

16.3 A determination of the softening point of a sealing compound is to be made in accordance with the Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring and Ball Apparatus, ASTM E28.

16.4 The spacings at field-wiring terminals are to be measured with wire of the size intended to be connected to the terminal as in actual service.

16.5 In a circuit involving no potential of more than 50 V, spacings at field-wiring terminals shall not be less than 1/8 inch (3.2 mm) through air and 1/4 inch (6.4 mm) over surface, and spacings elsewhere shall not be less than 1/16 inch (1.6 mm) through air or over surface. The insulation and clearances between that circuit and a higher potential circuit shall be in accordance with the requirements that are applicable to the higher potential circuit.

16.6 An insulating barrier or liner used as the sole separation between uninsulated live parts and dead metal parts, including grounded metal parts, or between uninsulated live parts of opposite polarity shall be of a type material that is acceptable for the mounting of uninsulated live parts and not less than 0.028 inch (0.71 mm) thick. Otherwise a barrier shall be used in conjunction with at least 1/32 inch (0.79 mm) air spacing.

16.7 An insulating barrier or liner that is used in addition to an air space in place of the required spacing through air shall not be less than 0.028 inch (0.71 mm) thick. When that barrier or liner is of other material of a type that is not intended for the support of uninsulated live parts, the air space provided shall be such that upon investigation, it is found to be adequate for the particular application.

Exception: A barrier or liner that is used in addition to not less than one-half the required spacing through air may be less than 0.028 inch (0.71 mm) thick but not less than 0.013 inch (0.33 mm) thick provided that the barrier or liner is of a material of a type that is acceptable for the mounting of uninsulated live parts, of adequate mechanical strength when exposed or otherwise likely to be subjected to mechanical injury, and reliably held in place.

16.8 Insulating material having a thickness less than that indicated in 16.6 and 16.7 may be used when, upon investigation, it is found to be acceptable for the particular application.

17 Clearance and Creepage Distances

17.1 As an alternative approach to the spacing requirements specified in Spacings, Section 16, and other than as noted in 17.2 and 17.3, clearances and creepage distances may be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, as described in 17.4.

17.2 Clearances between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable, shall be as noted in Table 16.1. The clearances shall be determined by physical measurement.

17.3 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Spacings, Section 16.

Exception: When the design of the field wiring terminals is such that it will preclude the possibility of reduced spacing due to stray strands or improper wiring installation, clearances and creepage distances at the field wiring terminal may be evaluated in accordance with the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

17.4 In conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, the following guidelines shall be used:

a) Unless specified elsewhere in this standard, the pollution degree shall be considered to be pollution degree 3;

b) Equipment which is evaluated as "General Industrial" equipment shall be considered to be Overvoltage Category III. Other equipment covered under this standard shall be considered to be Overvoltage Category II in accordance with the table for Minimum Clearances for Equipment, as shown in UL 840;

c) Pollution degree 2 may be considered to exist on a printed wiring board between adjacent conductive material which is covered by any coating which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;

d) Any printed wiring board which complies with the requirements in the Standard for Printed Wiring Boards, UL 796, shall be considered to provide a Comparative Tracking Index (CTI) of 100, and when it is used as a direct support of current carrying parts and complies with the requirements for Direct Support, specified in UL 796, then it shall be considered to provide a CTI of 175;

e) For the purposes of compliance with the requirements for coatings of printed wiring boards used to achieve pollution degree 1 in accordance with UL 840, a coating which complies with the requirements for Conformal Coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is considered to be acceptable;

f) Pollution degree 1 may also be achieved at a specific printed wiring board location by application of at least a 1/32 inch (0.79 mm) thick layer of silicone rubber; or for a group of printed wiring boards, through potting, without air bubbles, in epoxy or potting material;

g) Evaluation of clearances only, to determine equivalence with current through air spacings requirements is capable of being conducted in accordance with the requirements of Clearance A (Equivalency) specified in UL 840. An impulse test potential having a value as determined in UL 840 is to be applied across the same points of the device as would be required for the Dielectric Strength Test, 23.1;

h) Evaluation of clearances and creepage distances shall be conducted in accordance with the requirements in UL 840 for Clearance B (Controlled Overvoltage), and Creepage Distances;

i) The Phase-to-Ground Rated System Voltage used in the determination of Clearances shall be the equipment rated supply voltage rounded to the next higher value (in the table for determining clearances for equipment) for all points on the supply side of an isolating transformer or the entire product when no isolating transformer is provided. The System Voltage used in the evaluation of secondary circuitry may be interpolated with interpolation continued across the table for the Rated Impulse Withstand Voltage Peak and Clearance; and

j) Determination of the dimensions of clearance and creepage distances shall be conducted in accordance with the requirements for Measurement of Clearance and Creepage Distances of UL 840.

PERFORMANCE

18 General

18.1 The performance of a protector shall be investigated by subjecting representative production devices to the tests specified in Table 18.1. The test sequence shall be as specified in Table 18.1. The selection of devices for specific test sequences for overcurrent type protectors shall be as specified in Table 18.2. No conditioning of the protector shall take place during or between tests.

Table 18.1
Test sequence

Tests	Tests applicable to				
	Overcurrent protector	Overvoltage protector	Undervoltage protector	Shunt protector overcurrent type	Shunt protector voltage type
Calibration	Yes	No	No	Yes	No
Temperature	Yes	Yes	Yes	Yes	Yes
Overvoltage	No	Yes	Yes	No	Yes
Operation	No	Yes	Yes	No	No
Undervoltage	No	No	No	No	Yes

Table 18.1 Continued on Next Page

Table 18.1 Continued

Tests	Tests applicable to				
	Overcurrent protector	Overvoltage protector	Undervoltage protector	Shunt protector overcurrent type	Shunt protector voltage type
Overload	Yes	Yes	Yes	Yes	Yes
Endurance	Yes	Yes	Yes	Yes	Yes
Dielectric strength	Yes	Yes	Yes	Yes	Yes
Recalibration	Yes	No	No	Yes	No
Short circuit	Yes	No	No	Yes	No

Table 18.2
Representative device selection and test sequences for overcurrent type protector

Section	Test	Test sequence[a]		
		A	B	C
19	Calibration	X	X	X
20	Temperature and 100 percent calibration		X	
21	Overload		X	
22	Endurance		X	
24	Recalibration		X	
23	Dielectric strength		X	
25	Short circuit			X

X – Test required.

[a] Representative device selection:

Sequence A – Two representative devices of the maximum, minimum and intermediate rating are to be tested. Additional intermediate ratings are to be selected when there are changes such as in contacts or braids. See 18.4.

Sequence B – One representative device of the maximum ampere rating is to be tested. Additional intermediate ratings are to be tested to evaluate differences in contact design. See also 18.4 and 18.9.

Sequence C – See 18.9, 25.4, 25.5 and 25.6. Sets of ratings representing maximum and minimum ampere ratings are to be tested. Additional sets are to be selected to evaluate differences in contacts.

18.2 When overcurrent-, overvoltage-, undervoltage- and shunt-trip protectors are constructed in a similar manner, certain tests on one type can represent tests on the other types. Once one type of protector has been subjected to a complete test program, only those additional tests to determine the acceptability of the differences in construction shall be conducted on the other types of protectors.

18.3 When the rating of a protector includes both alternating- and direct-current voltage ratings, tests shall be performed to cover both ratings.

18.4 In reference to 18.3, when the direct-current ampere rating of the protector is numerically identical to the alternating-current ampere rating, and it can be shown that the trip characteristics of a-c and d-c trip elements are similar, it is not necessary to perform the calibration and temperature tests using a direct–current source. However, in all cases overload, endurance, and short–circuit tests shall be performed with both alternating– and direct–current sources.

18.5 For tests made with alternating current, a circuit having the rated frequency of the protector shall be used. When the specified frequency is 60 Hz or when no frequency is indicated, a 60 ±12-Hz circuit shall be used.

18.6 Separately-operable protectors mounted on a common base shall not be considered as a multipole protector; they shall be treated throughout the test sequence as individual protectors. Protectors having two or more poles that are designed to trip independently of one another (not common trip) are considered to be separately operable.

18.7 A multipole protector intended for poly-phase use shall be tested accordingly.

18.8 During the following tests, the protector should be mounted or supported in its position of intended use and tested under conditions approximating those of intended operation, unless otherwise noted by the manufacturer.

18.9 When a protector is not marked to indicate line or load connections, a second device shall be connected with the line and load terminals reversed during the overload and endurance tests and a third device shall be connected with the line and load terminals reversed during the short-circuit tests. See also 34.7.

Exception No. 1: A protector that has only one arrangement for line and load connections need not comply with this requirement.

Exception No. 2: For a dc protector that is required to be wired in series such that the same number of poles (contacts) are exposed to the current in both directions simultaneously, testing in both the forward and reverse direction is not required.

Exception No. 3: For a dc protector constructed such that the contact(s) and arc suppression mechanism is symmetrical in design such that the direction of the current and resultant opposing magnetic field is not a factor in the behavior of the arc, testing in both the forward and reverse direction is not required.

18.10 A protector which is permitted to be marked TC2 for tripping current and U2 for short circuit in accordance with 34.6, may also be marked TC1 for tripping current without repeating the overload, endurance, short-circuit and recalibration tests provided that:

a) The results of the tests previously conducted on the protector indicate the calibration of the protector was unaffected by overload, endurance and short circuit tests, and

b) The protector successfully completes calibration tests in 19.1 for a TC1 tripping current.

18.11 When a protector is tested in an oven to simulate a higher than room ambient temperature, the oven shall be of the natural convection or gravity type.

18.12 A multipole protector intended for dc use shall have poles tested individually unless marked in accordance with 34.8 and investigated in accordance with 18.13 – 18.17.

18.13 For the purposes of this Standard, testing in the forward direction requires the positive terminal of the source to be connected to the normal line terminal of the device. Wiring in the reverse direction requires the positive terminal of the source to be wired to the normal load terminal of the device.

18.14 A multipole dc protector marked for more than one wiring configuration shall be subjected to a sufficient number of tests to represent all configurations. Examples:

a) For interrupting tests, a configuration with the least number of poles energized would represent configurations with more poles energized.

b) For temperature tests, a configuration with the most number of poles energized would represent configurations with a fewer number of poles energized.

c) Calibration tests shall be conducted on the configurations with both the most and least number of poles energized.

18.15 For the endurance, overload, and interrupting tests, a dc supplementary protector intended for use on a system having one conductor grounded shall be tested with the enclosure or mounting surface connected to the negative conductor through a fuse as described in 21.7.

18.16 If a dc supplementary protector is intended to be wired in series and complies with a) through d) below, tests shall be conducted in accordance with 18.17.

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.

18.17 The protector 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 protector instructions. The load side terminal(s)/pole(s) intended to be connected to the grounded circuit conductor shall not be used, and instead the load side positive terminal shall be connected directly to the grounded terminal of the test station.

OVERCURRENT PROTECTORS

19 Calibration

19.1 An overcurrent protector shall be capable of carrying 100 percent of its rated current continuously. This shall be verified during the Temperature Test, Section 20. An overcurrent protector shall trip within the limits of the manufacturer's curve at 105 percent of its rated tripping current and at 300 percent of its rated current.

19.1.1 At the option of the manufacturer, the alternate calibration to 19.1 shown in Table 19.1 shall be permitted for a protector permitted to be marked as indicated in 34.6 (d)(4). The protector shall trip in a time not exceeding the time specified in accordance with the requirements of the table below.

Table 19.1
Alternate calibration

Percent of rated current	Protector rating A/V	Trip time
135	0 – 50 A	1 h
	> 50 A	2 h
200	0 – 30 A, 0 – 250 V	2 min
	0 – 30 A, > 250 V	3 min
	31 – 50 A	4 min
	51 – 100 A	5 min

19.2 To verify that the supplementary protector complies with 19.1, two representative supplementary protectors each of the minimum, an intermediate and the maximum current rating of a family or series similarly constructed are to be selected and subjected to the tests described in 19.3 – 19.10. See also 18.4 and Table 18.2.

19.3 For the calibration tests the protector is to be wired with not less than 4 feet (1.2 m) of 14 AWG (2.1 mm^2) or larger wire connected to each wiring terminal for thermal-trip devices. The length of wire is able to be shorter for magnetic only trip devices. The ampacity of the wire should be at least equal to the maximum rated current of the protector. When the terminals of the protector are too small to receive that size wire, the maximum wire size the terminals are intended to accept is to be used.

19.4 A magnetic trip protector shall be tested for calibration with the front face of the device in a vertical plane, unless it is intended in the end use to be mounted otherwise, in which case it shall be mounted in that position during all tests.

19.5 When a protector is constructed such that it can be modified or adjusted to provide different time delays, calibration tests are to be performed on the device with the longest time delay.

19.6 A multipole protector intended for poly-phase use shall be calibrated using one pole at a time for the 300 percent rated current test, and with all poles loaded equally for the 105 percent rated trip current test.

19.7 Calibration testing will be performed in a room ambient of 25 ±3°C (77 ±5°F), unless the protector is specifically designed to operate in other ambients. In the latter case calibration testing shall be performed at the specified ambient(s).

19.8 When a protector is ambient compensated, it shall perform as intended when subjected to the tests indicated in 19.1 in ambient temperatures of 25 ±3°C (77 ±5°F), 40 ±3°C (104 ±5°F), and 50 ±3°C (122 ±5°F).

19.9 To determine whether a protector complies with the requirements of 19.1 for operation at 105 percent of rated tripping current, starting with the representative device under test at the ambient temperature indicated in 19.7 or 19.8, a protector carrying 105 percent of its rated tripping current shall operate (open) within the limits specified by the manufacturer's curve.

19.10 To determine whether a protector complies with the requirements of 19.1 for operation at 300 percent of rated current, starting with the representative device at the ambient temperature indicated in 19.7 or 19.8, a protector carrying 300 percent of its rated current shall operate (open) within the limits specified by the manufacturer's curve.

19.11 To determine the type of trip-free, a protector shall be subjected to 19.10, except the closing command shall be maintained through the actuator for a period of time equal to at least five minutes. Reclosing of the protector during this time shall identify it as cycling trip-free. When it does not reclose, it shall be identified as trip-free.

20 Temperature

20.1 An overcurrent protector shall be capable of carrying 100 percent of its rated current continuously without tripping.

20.2 One representative device of the maximum ampere rating for a particular construction shall be subjected to the temperature test. It may be necessary to test lower current ratings, when it is determined by evaluating the design that the maximum current rating does not result in maximum heating of the device.

20.3 When a protector is constructed such that it can be modified or adjusted to provide different time delays, the temperature test shall be performed on the device with the shortest time delay to determine that tripping does not occur during the temperature test.

20.4 For the temperature test, a protector shall be placed in an enclosure. The enclosure is to be as small as would be practical in actual service.

20.5 The temperature of the ambient air surrounding the enclosure shall be 25 ±3°C (77±5°F), unless the device is intended to operate at a higher ambient in which case the specified higher ambient is to be used.

20.6 A protector shall be connected for the temperature test with 4 feet (1.2 m) of 14 AWG (2.1 mm^2) or larger wire, on both the line and the load side terminals. The wire size shall correspond to the rating of the protector. When the terminals of the device are too small to receive that wire size, the maximum wire size the terminal is intended to accept is to be used.

20.7 The protector shall carry its rated current until all temperatures become constant as indicated in 20.11.

20.8 An auxiliary switch incorporated in a protector shall carry its rated current during the temperature test.

20.9 A protector shall not attain a temperature at any point sufficiently high to constitute a risk of fire or be detrimental to any material used in the device or indicate temperature rises at specific points greater than as indicated in Table 20.1. All values given in Table 20.1 are based on an assumed ambient temperature of 25°C (77°F).

Table 20.1
Maximum acceptable temperatures rises

Part, material, or place of temperature measurement	Degrees C	Degrees F
Rubber or thermoplastic conductor insulation[a]	35	63
Field wiring terminals[b]	50	90
Factory wiring terminals[c]	65	117
Solid and built-up contacts, buses and connecting straps[c]	d	d
Contacts		
Solid and built-up silver, silver alloy, and silver faced	e	e
All other metals	65	117
Class 90 insulation systems		
Thermocouple method	50	90
Resistance method	70	126
Class 105 insulation systems		
Thermocouple method	65	117
Resistance method	85	153
Class 130 insulation systems		
Thermocouple method	85	153
Resistance method	105	189
Class 105 insulation systems on single layer coil with exposed surfaces either uninsulated or film-coated		
Thermocouple method	90	162
Phenolic composition[a]	125	225
On bare resistor material	375	675

Table 20.1 Continued on Next Page

Table 20.1 Continued

Part, material, or place of temperature measurement	Degrees C	Degrees F
[a] The limitation on phenolic composition and on rubber and thermoplastic insulation does not apply to compounds that have been investigated and found to have special heat resistant properties.		
[b] The temperature on a wiring terminal or lug is measured at the point most likely to be contacted by the insulation of a conductor installed in actual service.		
[c] The limit does not apply to connections to a source of heat, such as a resistor and a current element.		
[d] The maximum acceptable temperature rises are determined by the temperature limitations on the support material, adjacent part material, or 100°C (212°F) temperature rise on the copper material, whichever is lower. There shall be no structural deterioration of the assembly, loosening of parts, cracking or flaking of material, loss of temper of spring, annealing of parts, or other visible damage.		
[e] Temperature limited by the limitations on the material for adjacent parts. There shall be no structural deterioration of the contact assembly, loosening of parts, cracking or flaking of materials, loss of temper of spring, annealing of parts, or other visible damage.		

20.10 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.051 mm^2). When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to use thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument. Such equipment is to be used whenever referee-temperature measurements by thermocouples are necessary.

20.11 A temperature is considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 10-minute intervals, indicate no change. The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

20.12 The resistance method may be used for determination of the temperature rise of a copper or aluminum winding by comparing the resistance of the winding at the temperature to be determined with the resistance of the winding at the temperature to be determined with the resistance at a known temperature according to the formula:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt – is the temperature rise,

R – is the resistance of the coil at the end of the test,

r – is the resistance of the coil at the beginning of the test

t_1 – is the room temperature degree C at the beginning of the test,

t_2 – is the room temperature degree C at the end of the test, and

K – is 234.5 for copper, 225.0 for electrical grade aluminum.

Values of the constant for other grades must be determined.

21 Overload Test

21.1 A protector that has been previously subjected to the calibration tests shall perform as intended when subjected to an overload test consisting of making and breaking the test circuit for 50 cycles of operation. There shall be no electrical or mechanical malfunction of the protector nor any undue burning, pitting or welding of the contacts nor shall there be any arc over to the enclosure or mounting plate that causes the ground fuse in 21.7 to open.

21.2 The overload test current shall be determined as indicated in Table 21.1.

Table 21.1
Method of determining test current for overload tests

Device used for	Rated in	Test current	Power factor
Across the line motor starting	a-c hp	Six times full load current	0.40 – 0.50
	d-c	Ten times full load current	a
General-use or incandescent lamp control	a-c A	1.5 times rated current	0.75 – 0.80[b]
	d-c A	1.5 times rated current	a

[a] Noninductive, resistive load.
[b] When the device is marked "Resistance only", the test may be conducted using a noninductive, resistive load.

21.3 When a protector is constructed such that it is possible to manually open or close the circuit using the operating handle, it shall be operated for 50 cycles of operation with the first 35 operations performed manually at a rate of 1 second on, 9 seconds off, (unit may open automatically). The last 15 operations shall be performed with the device closed manually and opened automatically, with the operating handle held in the on position every third operation.

21.4 When a protector is constructed such that it is not possible to open the circuit manually using the operating handle, all 50 cycles of operation shall be performed by closing the device manually and allowing it to open automatically. The device shall remain in the off condition at least 9 seconds, or longer when it is not possible to reset the device, between operations.

21.5 The protector shall be mounted either within an enclosure or on a mounting plate during the overload test. The enclosure or mounting plate shall be metal unless the protector is restricted in its end use to a nonmetallic enclosure or nonmetallic mounting plate.

21.6 When the protector is mounted in an enclosure, the enclosure shall be as small as would be practical in actual service. When the enclosure is painted metal, the paint shall be scraped off the inside of the enclosure in areas where an arc is likely to strike.

21.7 A fuse shall be connected between the metal enclosure or mounting surface and unswitched line to indicate an arc over to the enclosure or mounting surface. When each line is switched, the fuse shall be connected between the enclosure or mounting surface and the live pole least likely to arc to ground. The fuse shall be a nonrenewable, nontime-delay, fuse having a voltage rating not less than the rated voltage of the protector. The fuse shall have an ampere rating of not more than the protector rated current but not less than 3 A nor greater than 30 A.

21.8 For the overload test the closed-circuit voltage shall not be less than 100 percent nor more than 110 percent of rated voltage of the protector; except for a protector rated more than 100 A, the closed-circuit voltage may be as much as 10 percent less than the rated voltage when the open-circuit voltage is not less than the rated voltage nor more than 110 percent of that voltage. The open-circuit voltage may be more than 110 percent of the rated voltage when agreeable to those concerned.

Exception No. 1: Where the test current is 150 amperes or more, the closed-circuit voltage shall be no less than 85 percent of rated voltage.

Exception No. 2: The closed circuit voltage shall be permitted to be less than 85 percent of rated voltage if the capacity of the supply circuit is at least equivalent to that of a circuit that is considered to be acceptable for the short circuit test as described in Short Circuit, Section 25.

21.9 A 2-pole protector intended for use on a direct-current or a single-phase alternating-current 3-wire system with grounded neutral shall be tested on a 3-wire supply circuit having the neutral grounded, with the protector poles connected to the ungrounded conductors of the circuit, with no connection to the midpoint of the load, and with the enclosure grounded as indicated in 21.7. A protector intended to control a 3-phase load shall be tested with three poles making and breaking the load, unless the use of two poles is considered as representative and is agreeable to all concerned. A multipole protector shall be tested with opposite polarity between poles, and a sufficient number of poles shall be used to represent conditions of use. See Overload and Endurance Test Connection Diagrams, Figure 21.1, for test connection configurations.

21.10 During the overload test on a protector incorporating an auxiliary switch, a potential of opposite polarity to that of the circuit of the protector shall be applied to the auxiliary switch, unless the protector is restricted in its end use application to the same polarity between the auxiliary switch and the protector circuit.

21.11 The overload test or tests are to cover the conditions of maximum voltage, power and current interrupted.

21.12 Reactive components of the load employed are capable of being in parallel when of the air-core type, but no reactances are to be connected in parallel with resistances, except that an air-core reactor in any phase may be shunted by resistance (R_{SH}) the loss in which is approximately 1 percent of the total power consumed in that phase calculated in accordance with the following formula:

$$R_{SH} = 100\left(\frac{1}{PF} - PF\right)\frac{E}{I}$$

in which:

PF is to power factor,

E is the closed-circuit phase voltage, and

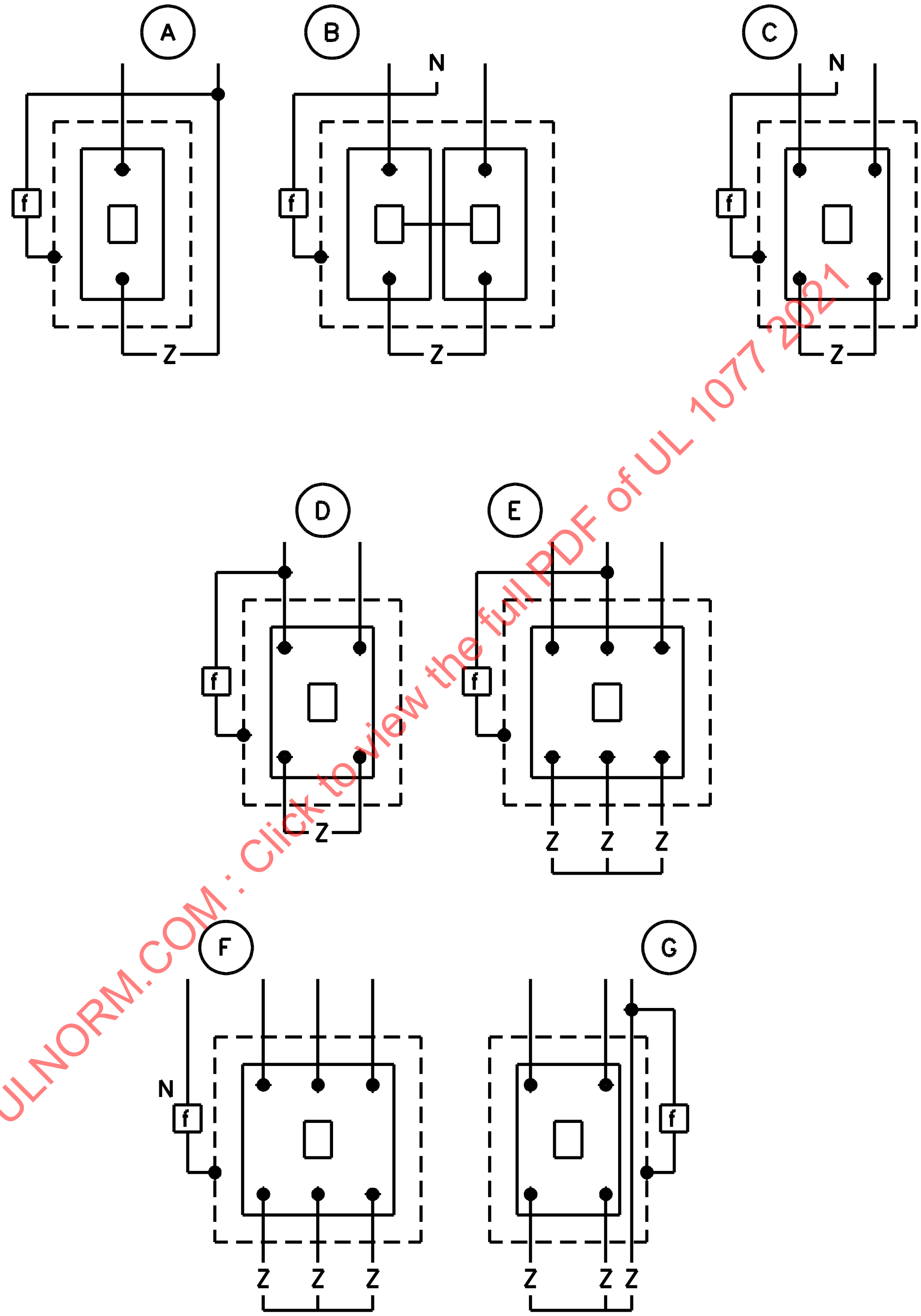
I is the phase current.

21.13 Circuit characteristics are normally determined using laboratory type meters. Where required because of high current conditions, the circuit is to be determined by oscillographic means as described in Short Circuit, Section 25. It is not necessary that a protector be in the circuit when making the circuit determination. The test current required is to be the root mean square (rms) symmetrical current value whether or not the protector to be tested trips instantaneously.

21.14 Table 21.2 and Table 21.3 give full-load currents for determining loads for tests specified for horsepower-rated protectors.

Figure 21.1

Overload and endurance test connection diagrams



SC0731A

A – 1-Pole

B – 1-Pole "Tested in Pairs"

C – 2-Pole Common-Trip "slant" (120/20, 125/250V) Rating

D – 2-Pole Common-Trip Rating Other Than C

E – 3-Pole

F – 3-Pole 480Y277 V or 600Y/3447 V Rating

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

N – Neutral

Z – Load Impedance

f – "Ground" Fuse – Enclosure

Table 21.2
Full-load motor-running currents in amperes corresponding to various alternating current horsepower ratings

Horse power	110 – 120 V			220 – 240 V[a,b]			440 – 480 V			550 – 600 V		
	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase	Single phase	Two phase	Three phase
1/6	4.4	–	–	2.2	–	–	–	–	–	–	–	–
1/4	5.8	–	–	2.9	–	–	–	–	–	–	–	–
1/3	7.2	–	–	3.6	–	–	–	–	–	–	–	–
1/2	9.8	4.0	4.0	4.9	2.0	2.0	2.5	1.0	1.0	2.0	0.8	0.8
3/4	13.8	4.8	5.6	6.9	2.4	2.8	3.5	1.2	1.4	2.8	1.0	1.1
1	16.0	6.4	7.2	8.0	3.2	3.6	4.0	1.6	1.8	3.2	1.3	1.4
1-1/2	20.0	9.0	10.4	10.0	4.5	5.2	5.0	2.3	2.6	4.0	1.8	2.1
2	24.0	11.8	13.6	12.0	5.9	6.8	6.0	3.0	3.4	4.8	2.4	2.7
3	34.0	16.6	19.2	17.0	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
5	56.0	26.4	30.4	28.0	13.2	15.2	14.0	6.6	7.6	11.2	5.3	6.1
7-1/2	80.0	38.0	44.0	40.0	19.0	22.0	20.0	9.0	11.0	16.0	8.0	9.0
10	100.0	48.0	56.0	50.0	24.0	28.0	25.0	12.0	14.0	20.0	10.0	11.0
15	135.0	72.0	84.0	68.0	36.0	42.0	34.0	18.0	21.0	27.0	14.0	17.0

[a] To obtain full-load currents for 200- and 208-V motors, increase corresponding 220 – 240-V ratings by 15 and 10 percent respectively.

[b] To obtain full-load currents for the 265- and 277-V motors, decrease the corresponding 220 – 240-V ratings by 13 and 17 percent respectively.

Table 21.3
Full-load motor-running currents in amperes corresponding to various direct-current horsepower ratings

Horsepower	110 – 120 V	220 – 240 V	550 – 600 V
1/4	3.1	1.6	–
1/3	4.1	2.0	–
1/2	5.4	2.7	–
3/4	7.6	3.8	1.6
1	9.5	4.7	2.0
1-1/2	13.2	6.6	2.7
2	17.0	8.5	3.6
3	25.0	12.2	5.2
5	40.0	20.0	8.3
7-1/2	58.0	29.0	12.0
10	76.0	38.0	16.0
15	110.0	55.0	23.0

22 Endurance

22.1 A protector that is capable of being manually operated to make and break the load it is controlling shall perform as intended when subjected to an endurance test at a rate of operation of 1 second on, 9 seconds off. There shall be no electrical or mechanical malfunction of the protector, or any undue burning, pitting or welding of the contacts. There shall not be any arc over to the enclosure that causes the ground fuse in 21.7 to open.

22.2 The test current, power factor, number of operations, and rate of operation for the endurance test shall be as indicated in Table 22.1.

Table 22.1
Method of determining test current for endurance test

Device rated in	Test current	Power factor	Cycles per minute	Number of cycles
a-c A	Rated current	0.75 – 0.80[a]	6	6000
d-c A	Rated current	b	6	6000

[a] When the protector is intended only to control a resistive load, the load for the endurance test shall be a non-inductive, resistive load.

[b] The load shall be a noninductive, resistive load.

22.3 The endurance test shall be performed on a representative device that has acceptably completed the calibration and overload tests.

22.4 A protector that is activated manually, but cannot be caused to open the circuit by manual means, is not subjected to endurance testing.

22.5 The conditions for the endurance test conducted on a protector shall be the same as those for the overload test specified in 21.5 – 21.14.

22.6 For a protector incorporating an auxiliary switch, a potential of opposite polarity to that of the protector circuit shall be applied to the auxiliary switch during the endurance test unless the protector is restricted in its end use application to the same polarity between the auxiliary switch and the protector circuit.

23 Dielectric Strength and Voltage-Withstand Tests

23.1 Dielectric strength test

23.1.1 A protector shall be capable of withstanding for 1 minute the application of a 60 Hz essentially sinusoidal potential of 1,000 V plus twice the maximum rated voltage between:

a) Live parts and the enclosure or mounting plate with the contacts open and closed.

b) Terminals of opposite polarity with the contacts opened and closed.

c) Live parts of different circuits.

23.1.2 A protector permitted to be marked as indicated in 34.6 (f)(4), (f)(5) or (f)(6), shall be subjected to 23.1.1. This test shall be conducted after both the short-circuit and overload/endurance tests.

23.2 Voltage-withstand test

23.2.1 A protector permitted to be marked as indicated in 34.6 (f)(4) or (f)(6), shall withstand, for 1 min without breakdown, the application of a 60 Hz essentially sinusoidal voltage between line and load terminals with the protector open and in the tripped and/or OFF position, in accordance with the test voltages specified in Table 23.1. This test shall be conducted after both the short-circuit and overload/endurance tests.

Table 23.1
Voltage-withstand test voltages

Rated voltage, V	Test voltage, V
V ≤ 50	500
50 < V ≤ 125	900
125 < V ≤ 250	1125
250 < V ≤ 440	1500
440 < V ≤ 600	1875

23.3 Details

23.3.1 To determine compliance with the requirements of 23.1 and 23.2, the protector is to be tested by a 500 VA or larger capacity transformer, whose output voltage is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test value 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 rapidly as is consistent with its value being correctly indicated by the voltmeter. A test transformer with a capacity of less than 500 VA may be used when provided with a voltmeter to directly measure the applied potential.

24 Recalibration

24.1 Following the Dielectric Strength Test of 23.1, a representative device that has completed the calibration, overload, and endurance test with acceptable results shall be subjected to a recalibration test.

24.2 The recalibration test shall be performed using the same method as the calibration test outlined in 19.9 and 19.10.

24.3 The trip times at 300 percent of rated current and at the manufacturer's specified value of trip current plus 5 percent of rated current shall be within the manufacturer's specified minimum and maximum trip curves.

24.4 An ambient–compensated protector shall be subjected to a recalibration test in a 40°C (104°F) ambient and the trip times at 300 percent and 100 percent of trip current shall be within ±15 percent of the trip times obtained from the manufacturer's trip curves at each level of current.

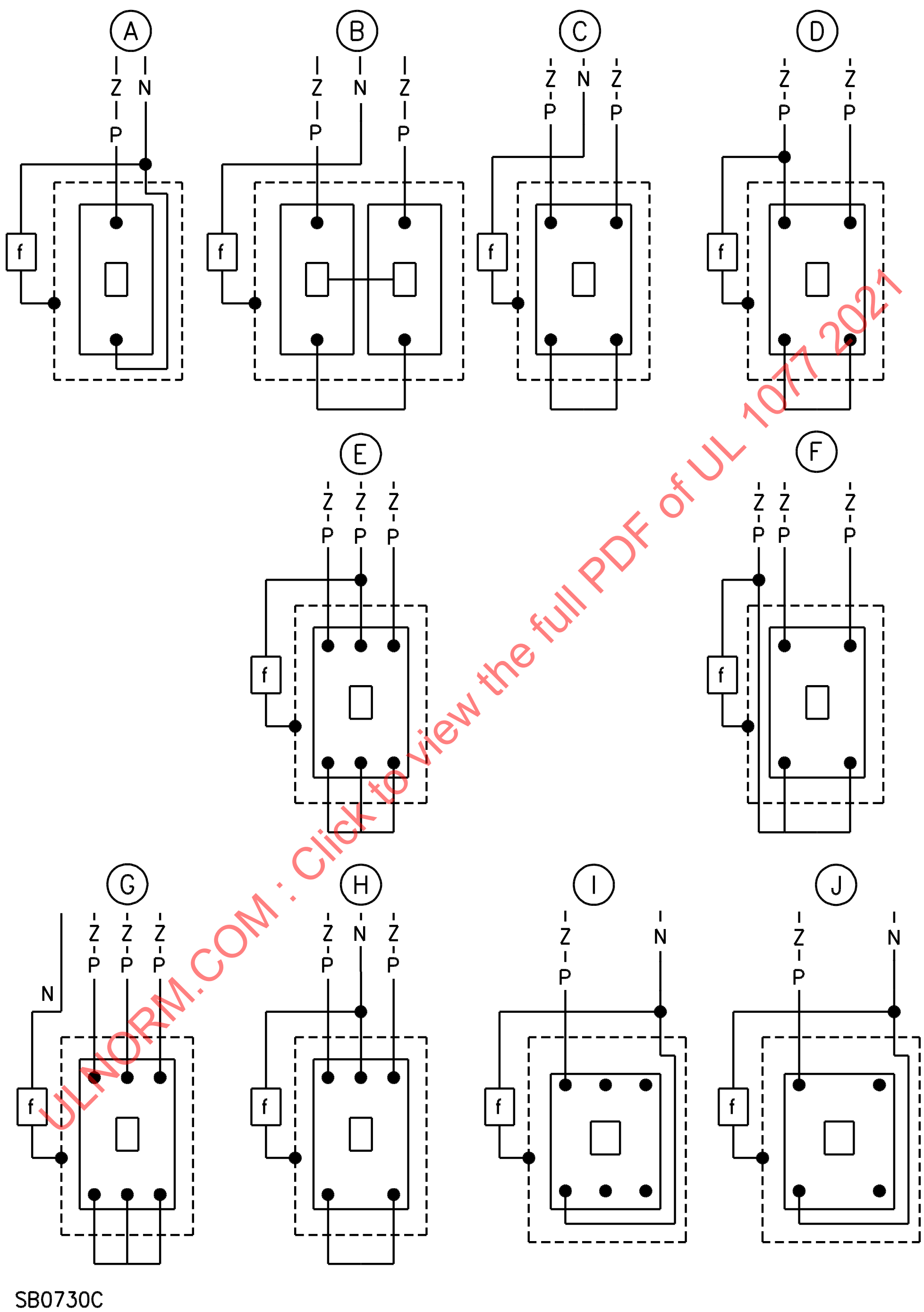
24.5 A protector permitted to be marked as indicated in 34.6 (f)(5) or (f)(6), shall be subjected to 24.1. This test shall be conducted after both the short-circuit and overload/endurance tests.

25 Short Circuit

25.1 A protector shall perform as intended when operated under short-circuit conditions. See Short-Circuit Ability Test Connection Diagrams, Figure 25.1, and Short Circuit Operations, Table 25.1.

Figure 25.1

Short circuit ability test connection diagrams



N – Neutral

Z – Limiting Impedance

f – "Ground" Fuse – Enclosure

P – Series Overcurrent Protective Device as required

Table 25.1
Short circuit operations

Poles	AC voltage ratings	Per pole operations[a]			Common operations[a]			Circuit used on[b]	Test voltage
		O	CO	CO	O	CO	CO		
1	120, 240, 277, 347, 480, 600	A	A	A				S	Rated
1	120/240				B	B	B	S	120/240
2	240, 480, 600				D	D	D	P	Rated
2	120/240				C	C	C	S	120/240
2	480Y/277, 600Y/347	J	J	J				S	277 or 347
2	480Y/277, 600Y/347				C	C	C	P	480 or 600
2	see note[c]				F	F	F	P	Rated
3	240, 480, 600				E	E	E	P	Rated
3	120/240				H	H	H	S	120/240
3	480Y/277, 600Y/347	I	I	I				S	277 or 347
3	480Y/277, 600Y/347				G	G	G	P	480 or 600

[a] See Figure 25.1 for short circuit ability test connection diagrams corresponding to A – J.

[b] The designation S indicates a supplementary protector intended for use on a single phase circuit; see 25.4 or 25.5. The designation P indicates a supplementary protector intended for use on a polyphase circuit; see 25.6.

[c] Indicates a two-pole common trip protector for a three phase rating.

25.2 The protector is to be mounted in an enclosure or on a plate as described in 21.5. A fuse shall be connected as described in 21.7 and shown in the test connection diagrams of Figure 25.1 to indicate an arc over to the enclosure or mounting plate.

25.3 A number of protector tripping elements, considered to be representative of the line, are to be subjected to the short-circuit test. In selecting the representative devices, consideration should be given to ratings, contacts, bimetals, and adjustable or replaceable trip assemblies.

25.4 Three representative single-pole protectors shall be subjected to the short-circuit test.

25.5 A multipole protector, intended for use on single-phase circuits, shall be tested applying the short circuit to one pole at a time. The total number of poles tested shall be three. Separate poles shall be used.

Exception: A multipole protector rated 120/240 volts shall be connected as shown in diagram b) of Short Circuit Ability Test Connection Diagrams, Figure 25.1 when it is a two pole device and as shown in diagram j) of Figure 25.1 when it is a three pole device.

25.6 A multipole protector intended for use on polyphase circuits shall be tested applying the short circuit to all poles at the same time. Three devices are to be tested.

25.7 Each pole of a protector shall be subjected to three operations except as noted in 25.30. The first operation shall be with the contacts of the protector closed and then the short circuit closed on the device.

The second and third operations shall be with the contacts of the protector open and then closed on the short circuit.

25.8 The wire size for the short-circuit test shall be the same as that outlined in 20.6.

25.9 Except as noted in 25.10, a fuse or a molded-case circuit breaker suitable for branch circuit protection shall be wired in series with the protector during the short-circuit test. A fuse shall be of the standard nonrenewable type, acceptable for branch-circuit protection. See Short-Circuit Ability Test Connection Diagrams, Figure 25.1.

25.10 Where the manufacturer specifies a short circuit rating that does not depend upon the use of a series connected protective device, the short circuit test shall be conducted without an overcurrent device connected in series with the supplementary protector.

25.11 The series fuse or molded-case circuit breaker shall be any size as specified for protection of the supplementary protector.

25.12 A protector intended for use with direct current shall be tested using a test circuit as nearly noninductive as possible, and with the metal mounting plate or enclosure at a positive potential with respect to the nearest arcing point.

25.13 A protector intended for use with alternating current shall be tested with an alternating current at rated frequency. The power factor of the circuit shall be 75 – 80 percent. A lower frequency of not less than 48 Hz or a lower power factor, or both may be used when agreeable to all concerned.

25.14 Reactive components of the impedance in the line are capable of being paralleled, when of the air–core type, but no reactance shall be connected in parallel with resistances, except that an air-core reactor(s) in any phase may be shunted by resistance, as long as the volt-ampere loss is approximately 0.6 percent of the reactive volt-amperes in the air-core reactor(s) in that phase. See 25.24.

25.15 The capacity of the supply circuit together with the total limiting impedance of the circuit shall be such as to limit the current to a value indicated in Table 25.2 or a value specified by the manufacturer where the end-use application of the protector is to be limited to a particular use. Any impedance that needs to be added to limit the current shall be connected in the circuit on the line side of the protector.

Table 25.2
Limited short-circuit test current

Appliance protector rating		
Horsepower[a]	**Voltage**	**Test current, amperes**
1/2 or less	250 or less	200
More than 1/2 up to 1	250 or less	1000
1 or less	More than 250	1000
More than 1 up to 3	250 or less	2000
More than 3 up to 7-1/2	250 or less	3500
More than 7-1/2	250 or less	5000
More than 1	More than 250	5000

[a] For the purpose of determining circuit capacity for a protector not marked in horsepower, a horsepower rating will be assumed on the basis of the marked rated amperes, Table 21.2 and Table 21.3

25.16 In order to determine that the specified current is available when the system is short-circuited at the test terminals, and that the circuit characteristics are those specified, an oscillograph or other acceptable metering equipment shall be used.

25.17 The open-circuit voltage of the circuit is not to be less than 100 percent nor more than 105 percent of the rated voltage of the unit under test, except that a higher voltage may be used when agreeable to all concerned. This measurement is to be determined by a voltmeter.

25.18 When the direct-current source is rectified alternating current, the requirements in 25.19 – 25.21 shall be applied.

25.19 The open-circuit voltage of the circuit is not to be less than 100 percent nor more than 105 percent of the rated voltage of the unit under test, except that a higher voltage may be employed when agreeable to those concerned. This measurement is to be determined by a voltmeter and, in addition, the open-circuit voltage, as determined by the arithmetic average of the maximum and minimum values of the voltage wave read from an oscillogram, is to be within 99 percent and 105 percent of the rated voltage of the protector, except that a higher voltage may be employed when agreeable to those concerned.

25.20 The minimum point on the voltage wave is not to be less than 90 percent of the rated voltage of the protector.

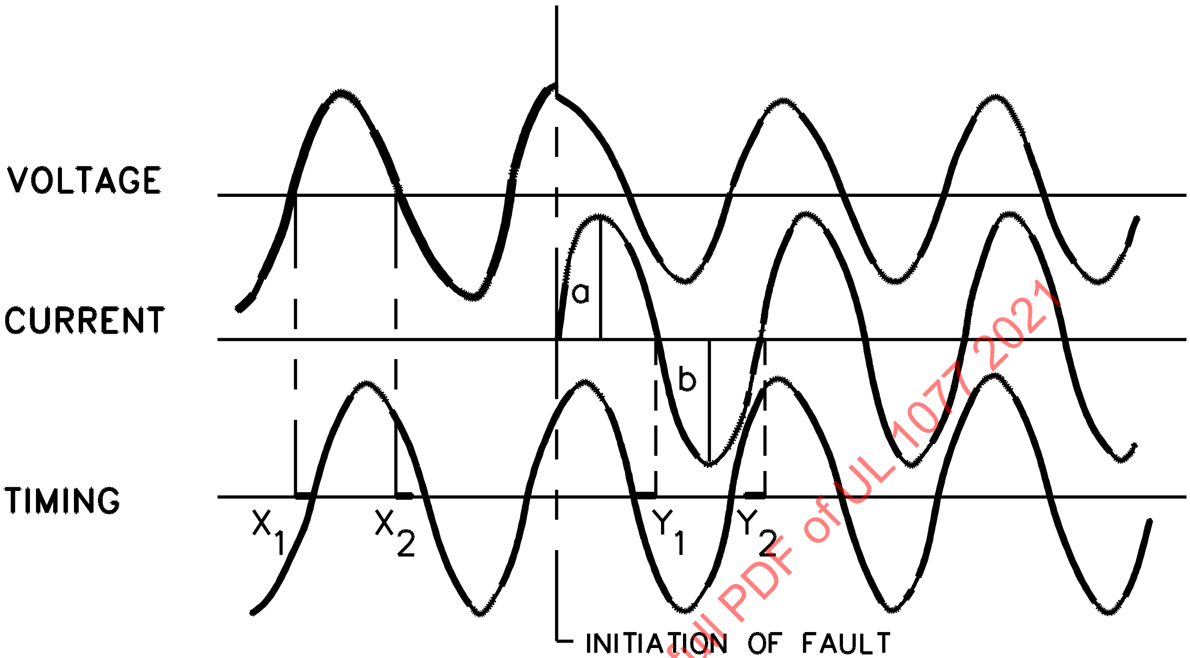
25.21 The available current capacity of the circuit is not to be less than the value that is required for the rating of the protector as indicated in Table 25.2. With the supply terminals short-circuited, the capacity is to be determined at the minimum point of the current wave closest to, but not less than, 1/2 cycle after circuit closure based on a 60 Hz timing wave.

25.22 For an alternating-current circuit the determination of current and power factor shall be in accordance with 25.23.

25.23 The current in a 3-phase test circuit is to be checked by averaging the rms values of the first complete cycle of current in each of the three phases. The current in a single-phase test circuit is to be checked by determining the rms value of the first complete cycle (see Figure 25.2), when the circuit is closed to produce an essentially symmetrical current waveform. The d-c component is not to be additionally added to the value obtained when measured as shown. In order to obtain the desired symmetrical waveform of a single-phase test circuit, random or controlled closing may be used. A waveform is considered to be essentially symmetrical when the difference between the deflection below and above the zero trace in the first full cycle is not greater than 7 percent of the smaller deflection. The power factor is to be determined by referring the open-circuit voltage wave to the two adjacent zero points at the end half of the first complete current cycle by transposition through an appropriate timing wave – the power factor to be computed as an average of the values obtained by using these two current zero points and the voltage to neutral to be used in the case of a 3-phase circuit.

Figure 25.2

Determination of current and power factor for circuits of 5000 amperes and less



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$$Current - \frac{a + b \times rms\ calibration\ of\ instrument\ element}{2}$$

$$Power\ Factor = \frac{Cosine[(Y_1 + X_1) \times 180] + Cosine[(Y_2 + X_2) \times 180]}{2}$$

Where X and Y values are fractions of the 1/2 cycle distance in which they occur.

25.24 With reference to 25.14, the shunting resistance used with an air core reactor having negligible resistance may be calculated from the formula:

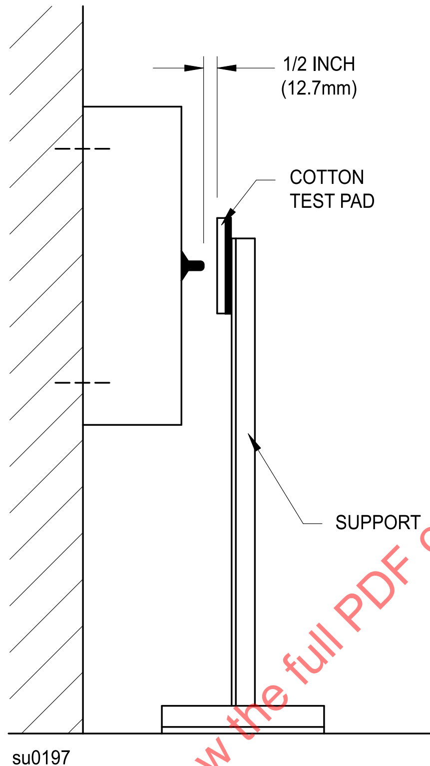
$$R = 167 \frac{E}{I}$$

where E is the voltage across the air-core reactor, with current I as determined by oscillographic measurement during the short-circuit calibration or by proportion, from meter measurements at some lower current.

25.25 A cotton pad at least 1/2 inch (12.7 mm) thick and having a length and width equal to four times the length and width of the handle opening, but not less than 3 inches (76.2 mm) for either dimension, is to be centered and placed 1/2 inch (12.7 mm) from the end of the protector handle. If agreeable to those concerned, the cotton pad may be placed closer to the end of the protector handle. The cotton pad is to be supported on either a solid surface or on a 1/2 inch (12.7 mm) mesh hardware cloth. A small opening is able to be provided in the cotton pad to pass a plunger to operate a push-type protector. See Figure 25.3.

Figure 25.3

Location of cotton pad for short-circuit test



25.26 The cotton used is to be surgical cotton, such as commonly used for medical purposes.

25.27 The protector shall complete the short-circuit test without igniting the cotton indicator. No breakage of the protector casing shall be apparent. There shall be no opening of the ground fuse described in 25.2, during the short-circuit test.

25.28 Where the manufacturer specifies that recalibration testing has been conducted after the short circuit test, the representative devices subjected to the short circuit test shall additionally be subjected to calibration testing as described in 19.9 and 19.10, and a dielectric strength test in accordance with 23.1.

25.29 The opening of the series fuse, welding of the contacts, inability of the device to be reset, inability of the device to indicate the circuit being open or closed, or the inability of the protector to trip the circuit shall not be considered unacceptable test results.

25.30 When the results of the first or second operation of the short-circuit test (see 25.7) are such that the device is rendered inoperable, but is otherwise intact as described in 25.27 and 25.29, the remaining operations need not be performed.

26 Strain Relief

26.1 The strain-relief means provided on accessory leads to which field connections are made, when tested in accordance with 26.2 shall be capable of withstanding for 1 minute, without displacement, the force as required in Table 26.1.

Table 26.1
Pull force

Wire size, AWG	Force, N (lb-f)
18 and larger	89 (20)
20 – 22	44.5 (10)

26.2 With the connections within the device disconnected and de-energized, the specified force shall be applied to the individual leads and so supported by the switch that the strain-relief means will be stressed from any angle that the construction of the switch permits. The strain relief is not acceptable if, at the point of disconnection of the conductors:

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 switch or electrical operator is impaired.

ACCESSORIES

27 All Accessories

27.1 General

27.1.1 A component part of an accessory shall comply with the requirements for that accessory.

27.2 Installation

27.2.1 A protector may have provision for separable accessories provided the following conditions are met:

a) The protector is acceptable for use with or without the accessory.

b) Each accessory is acceptable for the intended use.

c) Each accessory may be installed without the disassembly of factory-installed protector parts except parts that if omitted are considered not to affect the intended performance of the protector.

d) Instructions for the installation, operation, and necessary adjustments shall be available for each accessory.

e) The accessory is an essentially complete unit and does not require detailed assembly. Except as permitted in (f), 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 protector housing is not acceptable.

f) Except as noted in (g) and (h) 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.

g) Drilling, cutting, or filing is acceptable in the protector housing only to provide an opening for the accessory leads and the location of such openings is indicated by drill points or breakouts.

h) It is possible to accomplish the operation described in (g) in a manner so that debris does not accumulate inside the protector housing.

i) Strain or pushback relief, if required to meet the requirements of 27.5.1 and 27.5.2, 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.

j) The accessory complies with the marking requirements of 34.8.

k) The installation of the accessory does not inadvertently affect the performance of the protector.

27.3 Mounting

27.3.1 An accessory shall be securely mounted in position and prevented from loosening or turning if such motion may adversely affect the intended performance of the protector or reduce the minimum spacing to less than that indicated in 27.6.1.

27.4 Field wiring

27.4.1 An accessory shall be provided with means for the connection of wires having ampacity corresponding to the rating of the accessory. See Table 10.1 and Table 27.1.

Table 27.1
Ampacities of insulated conductors

Wire size		60°C (140°F)	
AWG	(mm^2)	Copper	Aluminum
22	(0.32)	3	-
20	(0.52)	5	-
18	(0.82)	7	-
16	(1.30)	10	-

27.4.2 Terminal leads of a protector accessory shall comply with Section 12.

27.4.3 A pressure connector provided for use with an accessory shall comply with Section 10.

27.5 Strain relief

27.5.1 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 Section 12.

27.5.2 Means shall be provided to prevent the accessory supply leads to which field connections are made from being pushed into the housing of a protector 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 protector or accessory is impaired.

27.5.3 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.

27.6 Spacings

27.6.1 With any combination of accessories installed, the protector spacings shall not be less than those required in Section 16.

27.6.2 The requirements in 27.6.1 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 protector or accessory on which the component is mounted in the intended manner.

27.6.3 The requirements in 27.6.1 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 protector or accessory, other than the dead metal surface on which the component is mounted.

27.6.4 The spacings at an accessory and its field-wiring terminals shall be in accordance with Table 16.1.

27.6.5 The spacing between the live part of the protector and an accessory or component of the same polarity shall be not less than 3.2 mm.

28 Auxiliary Switches

28.1 General

28.1.1 An auxiliary switch incorporated in a protector or mounted external to the protector shall be subjected to the performance tests in 28.2.1 – 28.5.1.

28.1.2 Auxiliary switch contacts shall be permitted to be designated as “a” or “b” as indicated below, but other contact arrangements shall be permitted to be used:

a) “a” contacts are opened when the protector contacts are opened, and are closed when the molded-case product contacts are closed.

b) “b” contacts are closed when the protector contacts are opened, and are opened when the protector contacts are closed.

28.2 Temperature

28.2.1 During the temperature test on the protector, an auxiliary switch shall carry its rated current and the temperature rises of the auxiliary switch shall be as outlined in Table 20.1.

28.3 Overload

28.3.1 The auxiliary switch of a protector shall be subjected to an overload test at the current specified in Table 28.1 or Table 28.2 or 28.3.5 for 50 cycles of operation. The test cycle is to be 1 second on, 9 seconds off. During the overload tests on the auxiliary switch, an opposite polarity potential shall be applied to the main contacts of the protector, unless the device is restricted to the same polarity between