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Underwriters Laboratories Inc. Standard for Safety

Supplementary Protectors for Use in Electrical Equipment

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

Fifth Edition, Dated June 3, 1999

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Recognition and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

This Standard consists of pages dated as shown in the following checklist:

Page	Date
1-40	June 3, 1999
A1-A2	June 3, 1999

UL 1077

Standard for Supplementary Protectors for Use in Electrical Equipment

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Revisions of this Standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction which conflict with specific requirements of the Standard cannot be judged to comply with the Standard. A product employing materials or having forms of construction not addressed by this Standard may be examined and tested according to the intent of the requirements and, if found to meet the intent of this Standard, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

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 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this Standard, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements to determine that the level of safety as originally anticipated by the intent of this Standard is maintained. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this Standard shall not be judged to comply with this Standard. Where appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this Standard.

1.4 revised June 3, 1999

2 Glossary

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

5.2 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 if 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 may be derived from the main contact circuit or from an independent source. The trip mechanism may be 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 may also 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 MECHANISM – The part of the protector that senses the abnormal condition in the circuit and causes the contact circuit to open.

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

2.14 UNDERVOLTAGE-TRIP PROTECTOR – A magnetic trip protector intended to trip the contact circuit if 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 need not comply with a specific requirement that:

a) Involves a feature or characteristic not needed 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 recognized rating established for the intended conditions of use.

3.4 Specific components are recognized as being 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 for which they have been recognized.

4 Units of Measurement

4.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

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 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 may be 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 the like, 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 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, 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 if 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 is otherwise acceptable 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 if:

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 Relative Thermal Indices Based Upon Past Field-Test Performance and Chemical Structure, Table 35.1 of 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 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 Voltage-Withstand, Section 23, 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 if:

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, may be 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 have acceptable mechanical strength and ampacity, and 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 the like.

9.2 Unplated iron and steel may be used in bimetallic elements and heaters.

9.3 Current-carrying parts, including terminals, shall be secured to their supporting surfaces so that they are prevented 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 shall be such as to provide for the continued alignment of contacts.

9.4 Friction between surfaces is not acceptable as a means to prevent turning of current-carrying parts. Turning is to be prevented 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 If current-carrying parts are held together by screws, a threaded part shall have not less than two full, clean-cut threads engaged in metal. If 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 If a wire-binding-screw construction or a pressure-wire connector is used as a terminating device, as pertains to 9.6, it shall be acceptable 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 provide good connections 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.

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 in 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 No. 14 AWG (2.1 mm^2).

12.2 Field wiring leads to be connected in a control circuit shall be No. 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 terminal shall be constructed so as to withstand the stress of normal handling without damage to itself or to the protector.

12.5 To determine compliance with 12.4, each field wiring lead is to withstand a tensile force increased gradually to 20 lbf (89N), and maintained at that value for 5 minutes.

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

12.7 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 No. 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 may be used for a terminal to which No. 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 No. 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 No. 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 if 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 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 on position when the protector is tripped automatically – that is, the protector shall be trip-free from the operating handle.

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 if this adjustment moves the trip current only towards the rated current.

15.6 An operating handle 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.

16.2 A live screw head or nut on the underside of an insulating base shall be prevented from loosening and shall be insulated or spaced from the mounting surface. This may 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 Test for Softening Point by Ring and Ball Apparatus, ASTM E28–1997.

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. If that barrier or liner is of other material of a type that is not acceptable 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 if 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 if, upon investigation, it is found to be acceptable for the particular application.

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 part and an uninsulated live part of uninsulated grounded dead metal part	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 if the bending of the quick connect terminals is likely to result in short circuiting of the terminals.

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: If 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 footnote c of Table 5.1, Minimum Clearances for Equipment, 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 if it is used as a direct support of current carrying parts and complies with Direct Support, Section 22 of 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 may be conducted in accordance with Section 4, Clearance A (Equivalency) of 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 Voltage - Withstand Test, Section 23;

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 if 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 samples to the tests specified in Table 18.1. The test sequence shall be as specified in Table 18.1. No conditioning of the protector shall take place during or between tests.

Table 18.1
Test sequence

	Tests applicable to				
Tests	**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
Overload	Yes	Yes	Yes	Yes	Yes
Endurance	Yes	Yes	Yes	Yes	Yes
Dielectric voltage-withstand	Yes	Yes	Yes	Yes	Yes
Recalibration	Yes	No	No	Yes	No
Short circuit	Yes	No	No	Yes	No

18.2 Overcurrent-, overvoltage-, undervoltage- and shunt-trip protectors may be constructed in such a manner that certain tests on one type can represent tests on other types. Once one type has been subjected to a complete test program, only those additional tests as may be necessary to determine the acceptability of the differences in construction need be conducted on other types.

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

Section	Test	Test sequence[a]		
		A	B	C
15	Calibration	X	X	X
16	Temperature and 100 percent calibration		X	
17	Overload		X	
18	Endurance		X	
20	Recalibration		X	
19	Dielectric withstand		X	
21	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 if 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.

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

18.4 In reference to 18.3, if 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. If the specified frequency is 60 Hz or if 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 as individual protectors. Protectors having two or more poles that are designed to trip independently (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 position of intended use and tested under conditions approximating those of intended operation, unless otherwise noted.

18.9 If a protector is not marked to indicate line or load connections, one additional sample shall be connected with the line and load terminals reversed during the overload, endurance, and short–circuit tests.

Exception: A protector that has only one arrangement for line and load connections need not comply with this requirement.

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.

19.2 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 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 No. 14 AWG (2.1 mm^2) or larger wire connected to each wiring terminal for thermal–trip devices. The length of wire may be shorter for magnetic–trip devices. The ampacity of the wire should be at least equal to the maximum rated current of the protector. If 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 tests.

19.5 If a protector is intended to be used with a number of different trip units 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.

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.

19.8 If a protector is ambient compensated, it shall perform acceptably 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.

20 Temperature

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

20.2 One sample 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, if it is determined by evaluating the design that the maximum current rating does not result in maximum heating.

20.3 If a protector is constructed for use with a number of different trip units to provide different time delays, the temperature test shall be performed on the device with the shortest time delay.

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 No. 14 AWG (2.1 mm^2) or larger wire per terminal. The wire size shall correspond to the rating of the protector. If 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.

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

Table 20.1 Continued on Next Page

Table 20.1 Continued

Part, material, or place of temperature measurement	Degrees C	Degrees F
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

[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 No. 24 AWG (0.21 mm^2) and not smaller than No. 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 No. 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 Initial Calibration Tolerances for Thermocouples table in the Standard for Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

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:

delta t – 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 acceptably 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 – 0.08[b]
	d–c A	1.5 times rated current	a

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

21.3 If 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 If 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, longer if not possible to reset, 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 If the protector is mounted in an enclosure, the enclosure shall be as small as would be practical in actual service. If 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. If 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 if 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 if agreeable to those concerned.

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

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 may be parallel if 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,

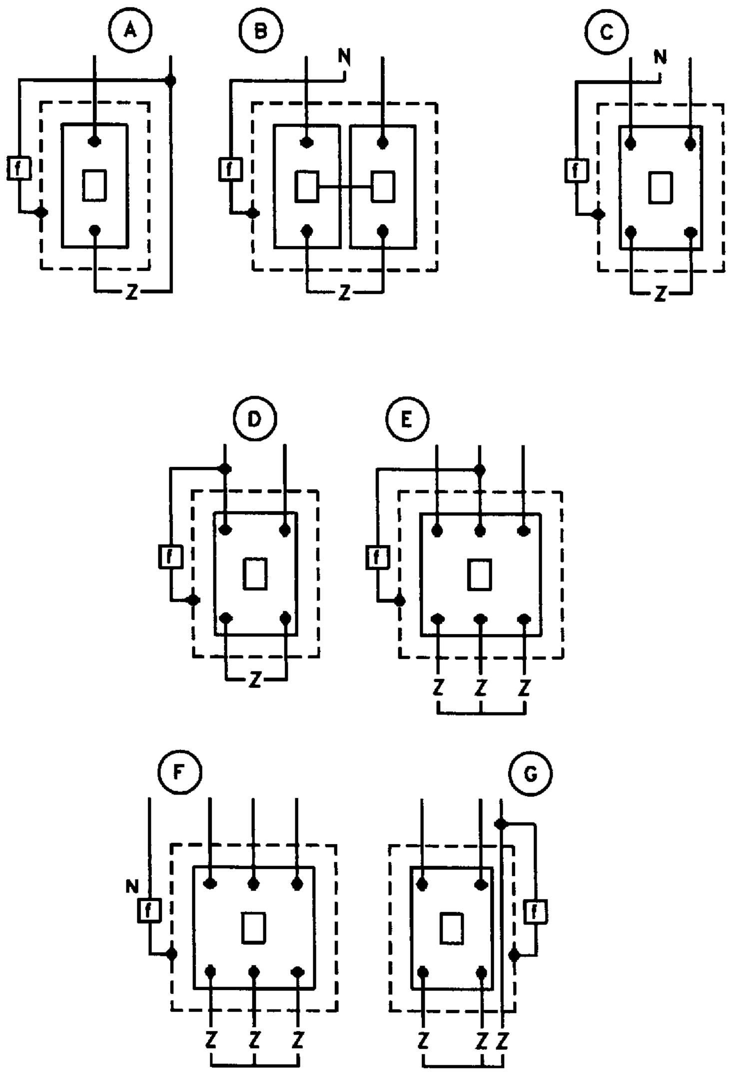
E is the closed–circuit phase voltage, and

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 Tables 21.2 and 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 – 30 A "ground" Fuse – Enclosure

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

Horsepower	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 may be manually operated to make and break the load it is controlling shall perform acceptably 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] If 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 sample 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 Voltage-Withstand

23.1 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.

23.2 To determine compliance with the requirements of 23.1, 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 if provided with a voltmeter to directly measure the applied potential.

24 Recalibration

24.1 Following the Dielectric Voltage-Withstand Test, a sample 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 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.

25 Short Circuit

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

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 samples, consideration should be given to ratings, contacts, bimetals, and trip units.

25.4 Three samples of a single-pole protector shall be subjected to the short-circuit test.

Table 25.1
Short circuit operations

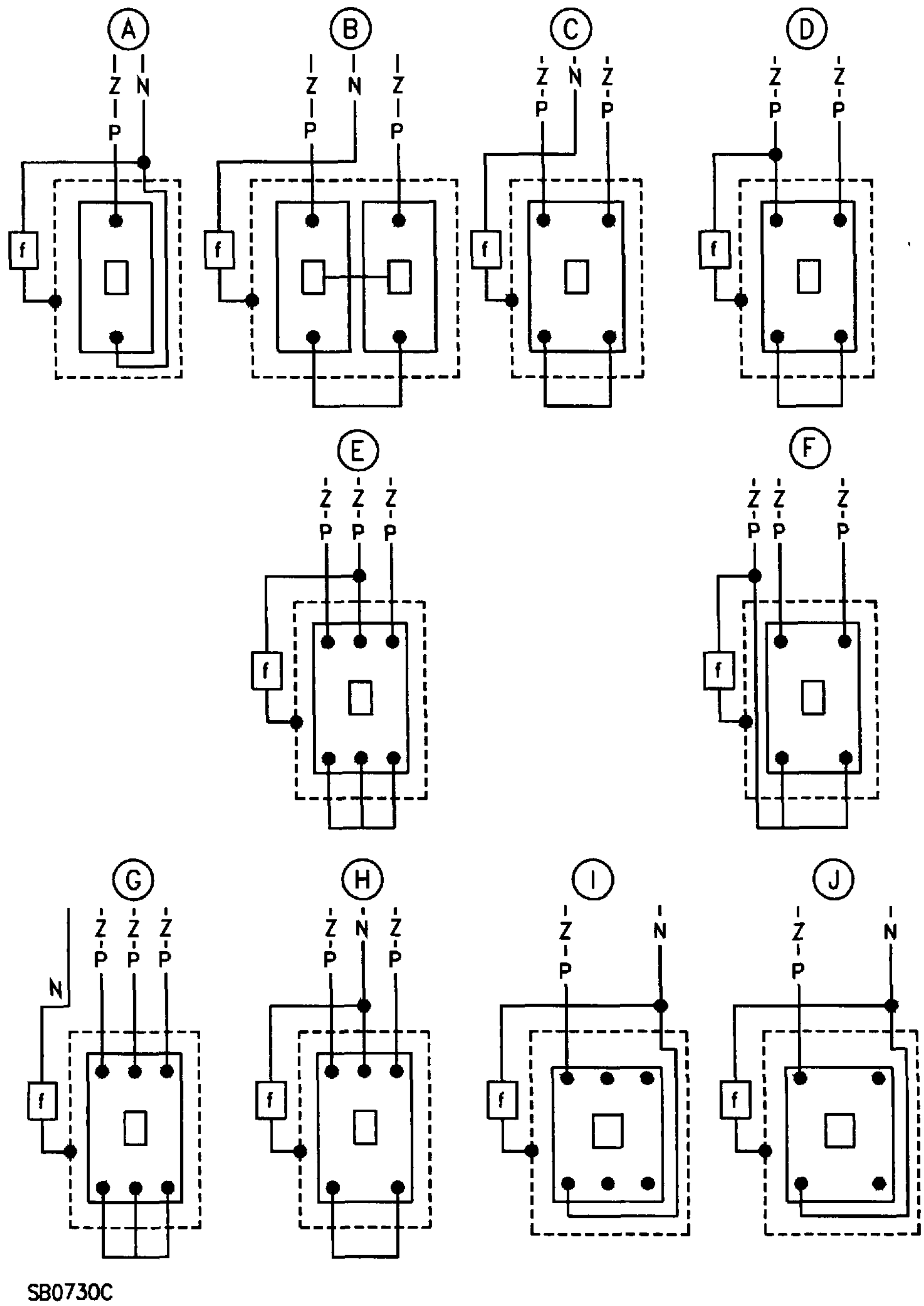
Poles	AC voltage ratings	Per pole operations[a]			Common operations[a]			Circuit used on[b]	Test voltage
		O	CO	CO	O	CO	CO		
1	120, 240, 277, 347, 480, 600	A	A	A				S	Rated
1	120/240				B	B	B	S	120/240
2	240, 480, 600				D	D	D	P	Rated
2	120/240				C	C	C	S	120/240
2	480Y/277, 600Y/347	J	J	J				S	277 or 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				K	K	K	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.

Figure 25.1
Short circuit ability test connection diagrams



N - Neutral

Z - Limiting Impedance

f - 30 A "ground" Fuse - Enclosure

P - Series Overcurrent Protective Device as required

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 if it is a two pole device and as shown in diagram j) of Figure 25.1 if 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 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.

Exception: The short-circuit test may be conducted without a fuse or molded-case circuit breaker wired in series with the supplementary protector at the request of the manufacturer.

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 if agreeable to all concerned.

25.14 Reactive components of the impedance in the line may be paralleled, if 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 may need 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, Tables 21.2 and 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 if 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 if 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 if agreeable to those concerned.

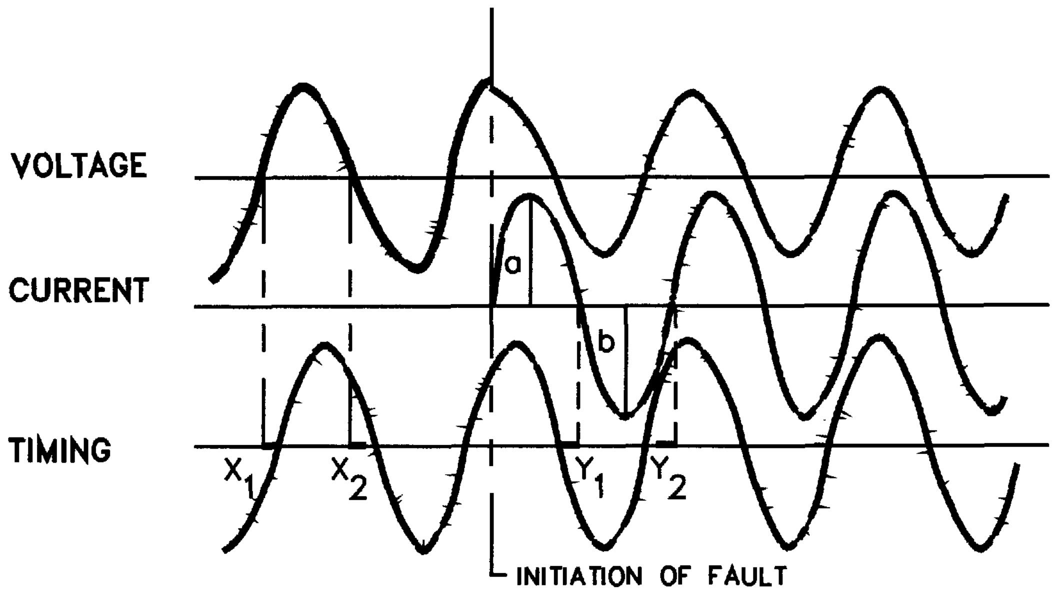
25.20 The minimum point on the voltage wave is not to be less than 90 percent of the rated voltage of the protector.

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

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

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:

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

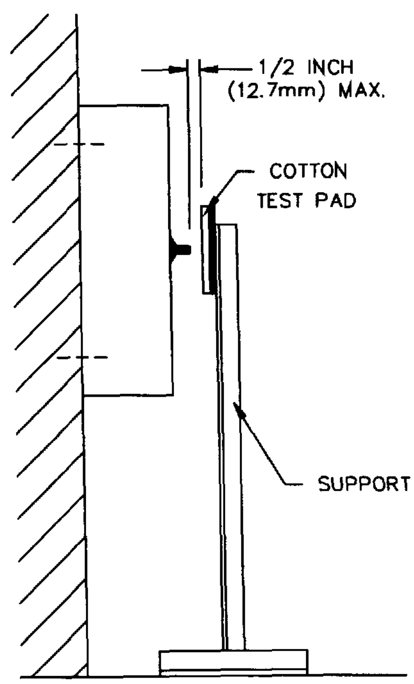
where E is the voltage across the air-core reactor, with current I as determined by oscillographic measurement during the short-circuit calibration or by proportion, from meter measurements at some lower current.

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 secured not more than 1/2 inch (12.7 mm) from the end of the protector handle. The cotton pad may be supported on either a solid surface or on a 1/2 inch (12.7 mm) mesh hardware cloth. A small opening may be provided in the cotton pad to pass a plunger to operate a push-type protector.

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.

Figure 25.3
Location of cotton pad for short-circuit test



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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 voltage-withstand test in accordance with Dielectric Voltage-Withstand, Section 23.

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 If 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.

OTHER PROTECTORS

26 Auxiliary Switches

26.1 General

26.1.1 An auxiliary switch incorporated in a protector or mounted external to the protector shall be subjected to the performance tests in 26.2.1 – 26.5.1.

26.2 Temperature

26.2.1 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 Temperature, Section 20.

26.3 Overload

26.3.1 The auxiliary switch of a protector shall be subjected to an overload test at the current specified in Table 26.1 or Table 26.2 or 26.3.5 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 the protector circuit and the auxiliary switch circuit in its end use application. The auxiliary switch may be tested in conjunction with the overload test of the protector.

26.3.2 An auxiliary switch intended for across-the-line motor starting or general use shall be capable of performing acceptably when subjected to an overload test consisting of 50 operations of making and breaking a circuit at rated voltage. The load controlled shall be as specified in Table 26.1. See 21.14.

26.3.3 An auxiliary switch intended for pilot duty – that is, to control the electromagnet of a contactor, a relay, or other magnetically operated device – shall be capable of performing acceptably when subjected to an overload test consisting of 50 operations of making and breaking a circuit of 110 percent of the rated voltage. The load controlled shall be as specified in Table 26.2 or 26.3.5.

Table 26.1
Method of determining test current for overload test on auxiliary switches

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 hp[a]	ten times full load current	
General use	a–c A	1.5 times rated current	0.75 – .080b
	d–c A	1.5 times rated current	b

[a] For devices rated in full load and locked rotor current, the locked rotor current shall be used as the test current.
[b] Noninductive resistive load.
[c] If the device is intended only to control a resistive load, the test may be conducted with a noninductive, resistive load.

Table 26.2
Electromagnet loads

Normal potential	Standard duty		Heavy duty	
	Normal current	Current inrush	Normal current	Current inrush
110 – 120 a–c[a] V	3.0	30	6.0	60
220 – 240 a–c[a]	1.5	15	3.0	30
440 – 480 a–c[a]	0.75	7.5	1.5	15
550 – 600 a–c[a]	0.6	6	1.2	12
115 – 125 d–c	1.1	–	2.2	–
230 – 250 d–c	0.55	–	1.1	–
550 – 600 d–c	0.2	–	0.4	–

[a] Power factor 0.35 or less.

26.3.4 A device that has been found to be acceptable for across-the-line motor starting of an alternating-current motor is acceptable for alternating-current pilot duty without further tests provided that the overload test current is at least 150 percent of the pilot duty inrush current at the same voltage and the power factor is 0.50 or less.

26.3.5 A load other than one as specified in Table 26.2 may be used when the device is intended to control an electromagnet having other characteristics.

Table 26.3
Method of determining test current for endurance test

Device used for	Device rated in	Test current	Power factor	Cycles per minute	Number of cycles
Across the line motor starting	a–c hp[a]	Rated full–load current	0.75 – 0.80	6	6000
	d–c hp[a]	Rated full–load current	b	6	6000
General	a–c A	Rated current	0.75 – 0.80[c]	6	6000
Use	d–c A	Rated current	b	6	6000

[a] Test current values for devices rated in full-load and locked rotor amperes shall be the full-load current. See 21.14

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

[c] If the auxiliary switch is intended only to control a resistive load, the load for the endurance test shall be a noninductive, resistive load.

26.3.6 There shall be no electrical or mechanical malfunction of the auxiliary switch, nor any undue burning, pitting, or welding of the contacts as a result of the overload test, nor shall there be any arc-over to the main contacts of the protector.

26.4 Endurance

26.4.1 The auxiliary switch of a protector shall be subjected to an endurance test at rated voltage as described in 26.4.2 – 26.4.4. During the endurance test, an opposite polarity potential shall be applied to the protector circuit, unless the device is restricted in its end use to the same polarity between the protector circuit and the auxiliary switch circuit. This test is to be made only if the protector is subjected to an endurance test. See Endurance, Section 22.

26.4.2 An auxiliary switch intended to control a motor, a resistive load, or a general purpose load shall be tested in accordance with Table 26.3.

26.4.3 An auxiliary switch intended to control the electromagnet of a contactor, a relay, or other magnetically operated device shall be capable of performing acceptably when subjected to an endurance test consisting of 6000 cycles of making and breaking a circuit of rated voltage and frequency. The rate of operation shall be 6 cycles per minute with the contacts closed for approximately 1 second each cycle. The load shall consist of an electromagnet representative of the load that the device is intended to control. The load characteristics shall be as specified in Table 26.2 or 26.3.5.

26.4.4 There shall be no electrical or mechanical malfunction, nor shall there be any undue burning, pitting, or welding of the contacts during the endurance test. There shall be no arc-over between the auxiliary switch and the circuit of the protector.

26.5 Dielectric voltage-withstand

26.5.1 An auxiliary switch shall be subjected to the dielectric voltage-withstand test outlined in Dielectric Voltage-Withstand, Section 23.

27 Overvoltage-Trip Appliance Protectors

27.1 General

27.1.1 The trip coil of an overvoltage protector may or may not be in the same circuit as the contacts.

27.2 Temperature

27.2.1 An overvoltage-trip protector shall be subjected to a temperature test as outlined in Temperature, Section 20.

27.3 Overvoltage

27.3.1 The coil of an overvoltage-trip protector shall be capable of withstanding continuously, without damage, 100 percent of its trip voltage, if it may be continuously energized at the trip voltage.

27.4 Operation

27.4.1 An overvoltage-trip protector shall operate within ±5 percent of the rated trip voltage, and shall not trip at the rated voltage of the protector.

27.5 Overload

27.5.1 An overvoltage-trip protector shall be subjected to the overload test outlined in the Overload Test, Section 21.

27.6 Endurance

27.6.1 An overvoltage-trip protector shall perform acceptably when subjected to the endurance test outlined in Endurance, Section 22, if capable of being operated manually to open-circuit.

27.7 Dielectric voltage-withstand

27.7.1 An overvoltage-trip protector shall be subjected to the dielectric voltage-withstand test outlined in Dielectric Voltage-Withstand, Section 23.

28 Undervoltage-Trip Protectors

28.1 General

28.1.1 The trip coil of an undervoltage protector may or may not be in the same circuit as the contacts.

28.2 Temperature

28.2.1 An undervoltage-trip protector shall be subjected to a temperature test as outlined in Temperature, Section 20.

28.3 Overvoltage

28.3.1 The coil of an undervoltage-trip protector shall be capable of carrying continuously, without damage, 110 percent of its rated voltage.

28.4 Operation

28.4.1 An undervoltage-trip protector shall operate within ±5 percent of its rated trip voltage, and shall not trip at the rated voltage of the protector.

28.5 Overload

28.5.1 An undervoltage-trip protector shall be subjected to the overload test outlined in the Overload Test, Section 21.

28.6 Endurance

28.6.1 An undervoltage-trip protector shall perform acceptably when subjected to the endurance test outlined in Endurance, Section 22, if capable of being operated manually to open-circuit.

28.7 Dielectric voltage-withstand

28.7.1 An undervoltage-trip protector shall be subjected to the dielectric voltage-withstand test outlined in Dielectric Voltage-Withstand, Section 23.

29 Shunt-Trip Protectors

29.1 General

29.1.1 A shunt-trip protector contains a trip mechanism that is energized by either overcurrent or by voltage, which may be either from a separate source or the same source as the contact circuit. A shunt-trip protector that is actuated by an overcurrent-trip mechanism shall be subjected to the same test program as an overcurrent protector, Sections 19 – 25. A protector that has a voltage-sensitive trip mechanism shall be subjected to the tests described in 29.2 – 29.7.

29.2 Temperature

29.2.1 A voltage-type shunt–trip protector shall be subjected to a temperature test as outlined in Temperature, Section 20.

29.3 Overvoltage

29.3.1 The coil of a voltage-shunt-trip protector intended for continuous duty shall be capable of withstanding continuously, without damage, 110 percent of its rated voltage.

29.4 Undervoltage

29.4.1 A voltage-shunt-trip protector shall operate at 85 percent of its rated voltage.

29.5 Overload

29.5.1 A voltage-shunt-trip protector shall be subjected to the overload test outlined in the Overload Test, Section 21.

29.6 Endurance

29.6.1 A voltage-shunt-trip protector shall perform acceptably when subjected to the endurance test described in Endurance, Section 22, when capable of manually opening the circuit.

29.7 Dielectric voltage-withstand

29.7.1 A voltage-shunt-trip protector shall be subjected to the dielectric voltage-withstand test outlined in Dielectric Voltage-Withstand, Section 23.

RATINGS

30 Details

30.1 A protector shall be rated in amperes and volts. It may be rated for alternating or direct current or both. The frequency or number of phases for an alternating-current device shall be included in the rating. The protector may also be rated in horsepower or volt-amperes.

30.2 The auxiliary switch of a protector may be rated in amperes and volts, horsepower and volts, or full-load and locked-rotor amperes and volts. If the auxiliary switch is intended to control an electromagnet of a contactor, a relay, or other magnetically operated device, it shall be rated standard or heavy pilot duty at a specified voltage; inrush current and normal current in amperes at a specified voltage; or a specified volt-ampere pilot-duty rating at a specified voltage.

30.3 The rating of a protector shall include the trip current or voltage. This may be indicated as a percent of the rated current or voltage, or shown on the delay curve to which the protector was calibrated.

MARKING

31 Specifics

31.1 A protector shall be marked with the manufacturer's name or trademark and type or catalog number of the device.

31.2 A protector shall be separately marked with its rated current and voltage, or the catalog number shall indicate the rated current and voltage of the protector. A separate marking indicating the delay-curve identification number to which the protector was calibrated shall be provided on the device, or the catalog number shall indicate the delay-curve identification number.

31.3 The marking of a protector shall be durable and legible.

31.4 If a manufacturer produces or assembles protectors at more than one factory, each finished protector shall have a distinctive marking, which may be in code, by which it may be identified as the product of a particular factory.

31.5 Unless the construction intends only one arrangement of line and load connections, or tests indicate that connections can be reversed, the terminals of a protector shall be marked "Line" and "Load", unless positive identification is obtained by marking only one terminal "Line" or "Load" or one set of terminals "Line" and "Load".

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APPENDIX A

Standards for Components

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard – UL Standard Designation

Title of Standard – UL Standard Designation

Insulating Materials – General, Systems of – UL 1446
Marking and Labeling Systems – UL 969
Plastic Materials for Parts in Devices and Appliances, Tests for Flammability of – UL 94
Polymeric Materials – Fabricated Parts – UL 746D
Polymeric Materials – Long Term Property Evaluations – UL 746B
Polymeric Materials – Short Term Property Evaluations – UL 746A
Polymeric Materials – Use in Electrical Equipment Evaluations – UL 746C
Printed–Wiring Boards – UL 796
Sleeving, Coated Electrical – UL 1441
Switches, Special–Use – UL 1054
Tape, Polyvinyl Chloride, Polyethylene, and Rubber Insulating – UL 510
Terminals Blocks – UL 1059
Terminals, Electrical Quick–Connect – UL 310
Wire Connectors and Soldering Lugs for Use With Copper Conductors – UL 486A
Wire Connectors for Use With Aluminum Conductors – UL486B
Wires and Cables, Thermoplastic-Insulated – UL 83
Wires and Cables, Thermoset–Insulated – UL 44

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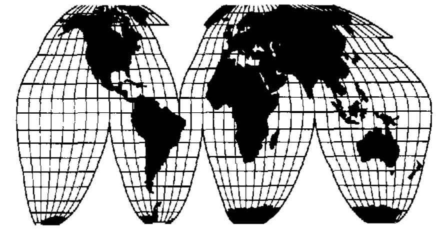

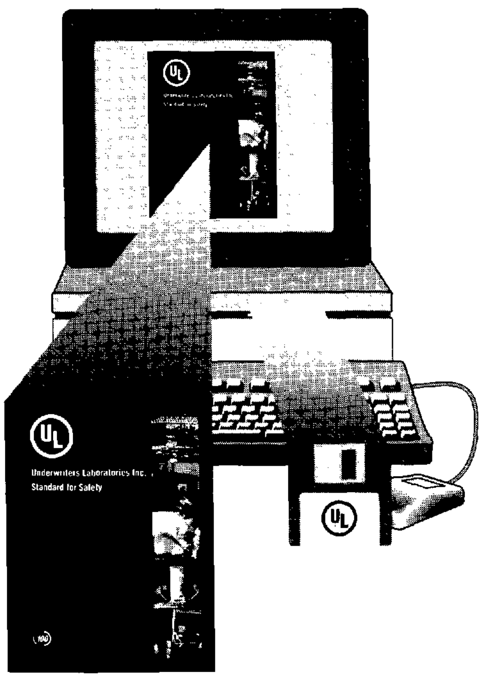

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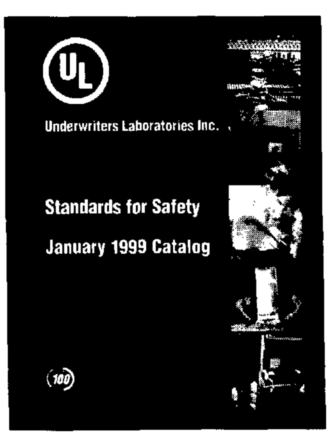

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