UL 497A

STANDARD FOR SAFETY

Secondary Protectors for Communications Circuits

UL Standard for Safety for Secondary Protectors for Communications Circuits, UL 497A

Third Edition, Dated March 20, 2001

Summary of Topics

This reaffirmation of ANSI/UL 497A dated December 3, 2024 is being issued to update the title page to reflect the latest ANSI approval date as a Reaffirmed American National Standard (ANS). No changes in requirements are involved.

Text that has been changed in any manner or impacted by ULSE'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 October 4, 2024.

No Text on This Page

MARCH 20, 2001
(Title Page Reprinted: December 3, 2024)

UL 497A

Standard for Secondary Protectors for Communications Circuits

First Edition – January, 1990
Second Edition – January, 1996

Third Edition

March 20, 2001

This ANSI/UL Standard for Safety consists of the Third Edition including revisions through December 3, 2024.

The most recent designation of ANSI/UL 497A as a Reaffirmed American National Standard (ANS) occurred on December 3, 2024. 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 ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at https://csds.ul.com.

No Text on This Page

CONTENTS

INTRODUCTION

1 Scope 5
2 General 5
2.1 Components 5
2.2 Units of measurement 6
2.3 Undated references 6
3 Glossary 6

CONSTRUCTION

4 General 9
5 Product Assembly 9
6 Enclosures 10
6.1 General 10
6.2 Enclosure top openings 13
6.3 Enclosure side openings 13
6.4 Enclosure bottom openings 16
7 Internal Materials 16
8 Accessibility and Electric Shock 17
9 Mechanical Assembly 23
10 Protection Against Corrosion 23
11 Cords 24
11.1 Strain relief 24
11.2 Bushings 24
12 Current-Carrying Parts 25
13 Internal Wiring 25
13.1 General 25
13.2 Splices and connections 25
14 Interconnecting Cords and Cables 26
14.1 General 26
14.2 Separation of circuits 26
14.3 Terminal and connectors 27
15 Insulating Material 27
16 Printed-Circuit Board 27
17 Overcurrent (Overload) Devices 28
18 Spacings 28

RISK OF INJURY TO PERSONS

19 General 29
20 Modular Jacks 29
21 Sharp Edges 30
22 Stability 30
23 Protection of Service Personnel 31

PERFORMANCE

24 General 31
25 Breakdown Voltage Measurement Test 35
26 Impulse Voltage Measurement Test 36
27 Overvoltage Test 36

27.1 General....36
27.2 Test method....40
28 Endurance Conditioning....42
29 Component Temperature Test....43
30 Drop Test....45
31 Impact Test....46
32 Crush Test....46
33 Strain Relief Test....46
34 Leakage Current Test....47
35 Dielectric Voltage-Withstand Test....48
36 Rain Test....49
37 Maximum Moment Measurement Test....52
38 Weatherometer and Micro Tensile Strength Test....52
39 Thermal Aging and Flame Test....53
40 Electric Shock Current Test....53

MANUFACTURING AND PRODUCTION-LINE TEST

41 Dielectric Voltage-Withstand Test....57

MARKING

42 General....59
43 Installation Instructions....60
44 Instruction Manual....60

APPENDIX A

Standards for Components....65

APPENDIX B – INFORMATION RELATING TO THE TESTING LABORATORY DIELECTRIC VOLTAGE-WITHSTAND TEST (TYPE TEST) AND THE PRODUCTION-LINE DIELECTRIC VOLTAGE-WITHSTAND TEST (ROUTINE TEST)

B1 Purpose....66
B2 Testing Laboratory Dielectric Voltage-Withstand Test (Type Test)....66
B3 Production-Line Dielectric Voltage-Withstand Test (Routine Test)....66
B4 Production-Line Dielectric Voltage-Withstand Tester Performance (Sensitivity)....67
B4.1 General....67
B4.2 Voltage Regulation (For the 1-Second Factory Test Only)....68

INTRODUCTION

1 Scope

1.1 These requirements cover secondary protectors for use in single- or multiple-pair-type communications circuits that are intended to be installed in accordance with Article 800 of the National Electrical Code, ANSI/NFPA 70.

1.2 Secondary protectors are intended to be used in the protected side of telecommunications networks that have an operating rms voltage to ground less than 150 volts and installed or used in accordance with the National Electrical Code, NFPA 70.

1.3 These requirements do not cover telephone protectors that are covered by the Standard for Protectors for Paired-Conductor Communications Circuits, UL 497. These requirements do not cover telephone equipment such as telephone answering devices, residential telephone instruments, telephone dialers, cordless telephones, key systems, and private-branch exchange equipment that is covered by the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

1.4 These requirements do not cover cellular telephones or other receiver/transmitter-type devices. Equipment of this type is covered by one of the following Standards:

- Standard for Audio, Video and Similar Electronic Apparatus – Safety Requirements, UL 60065
- Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1; or
- Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

1.5 These requirements may be used, directly or by reference, to investigate portions of other equipment not classified as telecommunications equipment accessories and that may be connected to a telecommunications network, insofar as they may be applicable to such equipment.

1.6 These requirements do not cover wires and cables intended to be permanently installed in a building in accordance with Article 800 of the National Electrical Code, NFPA 70.

1.7 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 or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, 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 used in the products covered by this standard.

2.1.2 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.

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

2.1.4 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.

2.2 Units of measurement

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

2.2.2 Unless otherwise indicated, all voltage and current values specified in this standard are root-mean-square (rms).

2.3 Undated references

2.3.1 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.

3 Glossary

3.1 For the purpose of this standard the following definitions apply.

3.2 EARTH GROUND – A conducting connection, whether intentional or unintentional, between an electrical circuit or electrical equipment and the earth, or to some conducting body that serves in place of the earth.

3.3 ELECTRICAL ENERGY – HIGH CURRENT LEVELS (POWER SUPPLIES) – Electrical energy that is capable of causing damage or risk of injury to persons (other than by electric shock) is determined to exist when, between a live part and an adjacent dead-metal part or between live parts of opposite polarity, there exists a potential of not less than 30 volts rms or 42.4 volts peak (AC or DC) and either:

a) An available continuous power level of not less than 250 volt-amperes or

b) A reactive energy level of not less than 20 joules.

For example, a tool or other metal short-circuiting a component can cause a burn or a fire when enough energy is available at the component to vaporize, melt, or more than warm the metal.

3.4 ENCLOSURE – The word "enclosure" refers only to parts that house or cover:

a) Uninsulated live parts that involve a risk of electric shock or

b) Parts that involve a risk of fire, electrical energy/high-current levels, or injury to persons.

An enclosure may be an integral part of a component, a separate item or part of an outer cabinet.

3.5 FIELD-WIRING TERMINAL – A terminal to which a telephone circuit may be connected by an installer in the field. A field-wiring terminal may consist of a screw-type terminal, quick-connect insulation stripping system, or plug/jack arrangement.

3.6 FIXED OR STATIONARY EQUIPMENT – Equipment that is not easily moved, and is intended to be moved from one place to another only when de-energized. Fixed equipment is usually fastened or secured to a building.

3.7 GROUNDING – Establishing an intentional electrically conductive connection between an electrical circuit or electrical equipment and the earth ground or to some conducting body that serves in place of the earth.

3.8 LONGITUDINAL VOLTAGE – (May also be called Common Mode Voltage) When applied to telecommunications conductors, the voltage common to both tip and ring conductors or the connection points of such conductors, as measured with regard to earth ground.

3.9 METALLIC VOLTAGE – (May also be called Differential Mode Voltage) When applied to telecommunications conductors, the voltage as measured between tip and ring conductors, of the same telecommunications pair, or the connection points of such tip and ring conductors, with no reference to earth ground.

3.10 NETWORK OPERATING VOLTAGES – Telecommunications networks normally operate at voltages of 56.5 volts DC or less, unless the source impedance is over 1600 ohms. For equipment connected to a single tip and ring pair, alerting and test voltages higher than 56.5 volts are intermittent and will be present over less than 1 percent of the usage of the equipment. Some telecommunications equipment, such as PBX and Key systems, may have a greater percentage of usage or operate at a higher voltage (such as T type lines). Maximum ringing voltages may not exceed 150 volts as defined by Article 725 of the National Electrical Code for Class 2 and 3 circuits.

3.11 NONPROTECTED SIDE – The portion of the loop circuit that rests on the central office or outside plant side of the primary telephone protector installed by the operating telephone company. The fault current limitation is subject to the breakdown voltage characteristics of the primary protector and its coordinated fusing system with the bridle or fuse wire with which the protector is intended to be used.

3.12 PORTABLE EQUIPMENT – Equipment that is easily moved and can be carried or conveyed by hand. Portable equipment is usually hand-held or hand-supported.

3.13 PRIMARY PROTECTOR – A voltage-limiting protector complying with the Standard for Protectors for Paired-Conductor Communications Circuits, UL 497.

3.14 PRODUCT – This term refers to all types of telephone equipment and appliances that will be used in residential, commercial, and industrial environments.

3.15 PROTECTED SIDE – Refers to that portion of the loop circuit that rests on the customer premises side of the primary telephone protector and is limited to short and long term current requirements for secondary protectors.

3.16 RISK OF ELECTRIC SHOCK – The risk that a person encounters when exposed to uninsulated live parts of a product that have a voltage and current sufficient to cause an electric shock, as defined in Accessibility and Electric Shock, Section 8.

3.17 RISK OF FIRE – The risk that a fire may occur as a result of equipment or component failure or the application of specified test conditions. A risk of fire is determined to exist at any component unless an

investigation of the circuit delivering power to that component complies with the power limitations criteria cited in this standard.

3.18 RISK OF INJURY TO PERSONS – A condition that is capable of occurring when one or more of the following exist:

a) When power-operated moving parts such as gears and linkages are accessible during intended operation and are capable of causing a cut or laceration.

b) When sharp edges, burrs, or projections are present that results in injury during use or servicing.

c) When the stability of a product is such that it results in injury to persons. See Stability, Section 22.

d) When there is risk that a part of the body could become endangered or that clothing could become entangled by a moving part resulting in an injury.

e) When uninsulated live parts involving risk of electrical-energy/high-current levels are accessible to personnel. See Accessibility and Electric Shock, Section 8.

f) When contact with accessible live parts can cause an involuntary reaction where the consequence of the reaction is a high risk of injury. See Accessibility and Electric Shock, Section 8.

g) When, during operation, the product propels missiles or other objects that may result in injury to persons.

3.19 TELECOMMUNICATIONS – Any transmission or reception of information such as signals, images, written text, or sounds, by electronic means.

3.20 TELECOMMUNICATIONS LINE CORD – The flexible cord used to connect a telephone set or other telecommunications devices to the telecommunications line at the network interface or modular jacks within the loop circuit. The cord may have male locking-type modular connectors on one or both ends for a plug-in arrangement or may have spade terminals on either or both ends for screw-type connections.

3.21 TELECOMMUNICATIONS LINE CORD EXTENSION – A telecommunications line cord that has a male connector on one end and a female connector on the other end.

3.22 TELECOMMUNICATIONS NETWORK – The interconnection of communications lines and switching equipment for providing communications service.

3.23 TELECOMMUNICATIONS NETWORK INTERFACE DEVICE – A piece of equipment that provides a point of interconnection between the telephone company communications facilities and terminal equipment, wiring, and protective apparatus at a subscriber's premises. The network interface or demarcation point is located on the subscriber's side of the telephone company's protector, or the equivalent thereof in cases where the protector is not employed, as provided under local telephone company's reasonable and nondiscriminatory standard operating practices. Network interface devices may contain the telephone primary protector within the unit.

3.24 TELECOMMUNICATIONS (TELEPHONE) EQUIPMENT – A device intended to be connected to a telecommunications network and used for receiving or transmitting information, or both, along the network.

3.25 TELEPHONE BRANCH CIRCUIT – The circuit that consists of a single pair conductor wire run in parallel with the main loop circuit. The junction point of the two circuits is usually contained in a cross-connect terminal block, network interface device assembly, or multi-output RJ11 type jack assembly.

3.26 TIP AND RING WIRES (TELEPHONE SWITCHING SYSTEMS) – A pair of conductors associated with the transmission portions of circuits and apparatus. Tip or ring designation of the individual conductors may be arbitrary except when applied to cord-type switchboard wiring in which case the conductors are designated according to their association with tip or ring contact of the jack and plug.

3.27 TOOL – Any means, other than manual manipulation, required to open an enclosure of a device.

3.28 USER SERVICING – Any form of servicing that can be performed by personnel other than those who are trained to maintain the equipment. User servicing is limited to user's access area. Some examples of user servicing are:

a) The installation of accessories by means of separable connectors such as modular connectors, attachment plugs and receptacles and

b) The changing or replacement of accessory boards, lamps, fuses and resetting of circuit breakers.

3.29 USER'S ACCESS AREA – All external surface areas and all internal areas that can be entered without the use of a tool, and all areas that the user is instructed to enter whether or not tools are required to gain access.

CONSTRUCTION

4 General

4.1 A secondary protector shall be constructed so that it will be durable for its intended installation and use, as determined by compliance with the performance requirements of this standard.

4.2 A secondary protector shall include overcurrent protection which will fuse, limit, or extinguish at currents less than the current-carrying capacity of indoor communications wire, cable or terminal equipment. Any overvoltage protection or grounding connection shall be connected on the equipment terminal side of the secondary protector overcurrent protection system.

4.3 A product shall employ materials that are intended for the particular use, as determined by the performance requirements of this standard.

4.4 Metals shall not be used in such combination as to cause galvanic action that will result in a risk of fire, electric shock, or injury to persons.

4.5 When breakage or deterioration of a part such as an enclosure, a frame, a guard, or the like can result in a risk of injury to persons, the part shall be constructed to meet the demand of expected loading conditions.

5 Product Assembly

5.1 A product shall be factory-built as a complete assembly and shall include all the essential components required for its intended function when installed (used) as intended. The product may be shipped from the factory as two or more subassemblies.

5.2 A product may be shipped from the factory unassembled, or disassembled to the degree required to facilitate shipment, when all of the following conditions are met:

a) All of the parts are furnished by the manufacturer;

b) Upon assembly, grounding continuity is provided where required between the field-assembled components;

c) The product is constructed so that field assembly can be accomplished without requiring drilling, cutting, threading, or any alteration other than the attachment of field-installed electrical conduit or raceway;

d) The relationship between separate parts is established at the time of manufacture, and is not dependent upon installation personnel;

e) Detailed step-by-step installation instructions are packaged with the product; and

f) All protective guards and other features intended to reduce the risk of fire, electric shock, or injury to persons are factory installed wherever possible.

6 Enclosures

6.1 General

6.1.1 An enclosure shall have the strength and rigidity required to resist the abuses to which the product will be subjected during intended use, without resulting in:

a) A risk of fire, electric shock, or injury to persons due to total or partial collapse, with resulting reduction of spacings to less than required or

b) Loosening, displacement or exposure of parts or other defects.

6.1.2 An enclosure or guard of sheet metal shall have a minimum thickness in accordance with Table 6.1 or Table 6.2, whichever applies.

Table 6.1
Minimum thickness of sheet metal for electrical enclosures carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness uncoated,		Minimum thickness metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch [MSG]	(mm)	inch [GSG]	(mm)
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited		0.020	(0.51)	0.023	(0.58)
4.75	(12.1)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	[24]		[24]	
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited		0.026	(0.66)	0.029	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	[22]		[22]	
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited		0.032	(0.81)	0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	[20]		[20]	
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited		0.042	(1.07)	0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	[18]		[18]	
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited		0.053	(1.35)	0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	[16]		[16]	
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited		0.060	(1.52)	0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	[15]		[15]	

Table 6.1 Continued on Next Page

Table 6.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness uncoated,		Minimum thickness metal coated,	
inches	(cm)	inches	(cm)	inches	(cm)	inches	(cm)	inch [MSG]	(mm)	inch [GSG]	(mm)
25.0	(63.5)	Not limited		39.0	(99.1)	Not limited		0.067	(1.70)	0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	[14]		[14]	
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited		0.080	(2.03)	0.084	(2.13)
38.0	(96.5)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	[13]		[13]	
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited		0.093	(2.36)	0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	[12]		[12]	
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited		0.108	(2.74)	0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	[11]		[11]	
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited		0.123	(3.12)	0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	[10]		[10]	

NOTE – Sheet steel for an enclosure intended for outdoor use (watertight) shall be at least 0.036 inch (0.91 mm) thick when zinc-coated and at least 0.032 inch (0.81 mm) thick when uncoated.

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments that may be applied via the enclosure surface when it is deflected. A structure that is as rigid as one built with a frame of angles or channels is considered to have equivalent reinforcing. Constructions considered to be without supporting frames include:

1) A single sheet with single formed flanges (formed edges),

2) A single sheet that is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame, such as by spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels that are not supported along one side (for example, side panels of boxes) the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a continuous flange at least 1/2 inch (12.7 mm) wide.

Table 6.2
Minimum thickness of sheet metal for electrical enclosures aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)	
Maximum width[b], inches	(cm)	Maximum length[c], inches	(cm)	Maximum width[b], inches	(cm)	Maximum length,[c] inches	(cm)		
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023	(0.58)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)		
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(0.74)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)		
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(0.91)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)		
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(1.14)

Table 6.2 Continued on Next Page

Table 6.2 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness in inches (mm)	
Maximum width[b], inches	(cm)	Maximum length[c], inches	(cm)	Maximum width[b], inches	(cm)	Maximum length,[c] inches	(cm)		
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)		
12.0	(30.5)	Not limited		42.0	(106.7)	Not limited		0.058	(1.47)
14.0	(35.6)	16.0	(40.6)	45.0	(114.3)	55.0	(139.7)		
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(1.91)
20.0	(50.8)	25.0	(63.5)	45.0	(114.3)	55.0	(139.7)		
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095	(2.41)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)		
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(3.10)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)		
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(3.89)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)		

NOTE – Sheet copper, brass, or aluminum for an enclosure intended for outdoor use (watertight) shall not be less than 0.029 inch (0.74 mm) thick.

[a] A supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has sufficient torsional rigidity to resist the bending moments that may be applied via the enclosure surface when it is deflected. A structure that is as rigid as one built with a frame of angles or channels is considered to have equivalent reinforcing. Constructions considered to be without supporting frames include:

1) A single sheet with single formed flanges (formed edges),

2) A single sheet that is corrugated or ribbed, and

3) An enclosure surface loosely attached to a frame, such as by spring clips.

[b] The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

[c] For panels that are not supported along one side (for example, side panels of boxes) the length of the unsupported side shall be limited to the dimensions specified unless the side in question is provided with a continuous flange at least 1/2 inch (12.7 mm) wide.

6.1.3 Conductive coatings applied to nonmetallic surfaces such as the inside surface of an enclosure, shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, unless it can be determined, by investigation, that flaking or peeling of the coating would not result in a reduction of spacings or the bridging of live parts that may present a risk of electric shock or fire.

6.1.4 A secondary protector intended for outdoor use shall be provided with a rain resistant cover or enclosure. When constructed of a polymeric material, the unit shall comply with the requirements in the Weatherometer and Micro Tensile Strength Test, Section 38.

6.1.5 A door or cover that is accessible from the outside of the enclosure and that gives access to a resettable or replaceable overload protective device shall be hinged or secured so that it will not be detached during servicing.

Exception No. 1: A door or cover that, by its function or size, obviously must be in place when the product is to operate as intended, is not required to be hinged or secured.

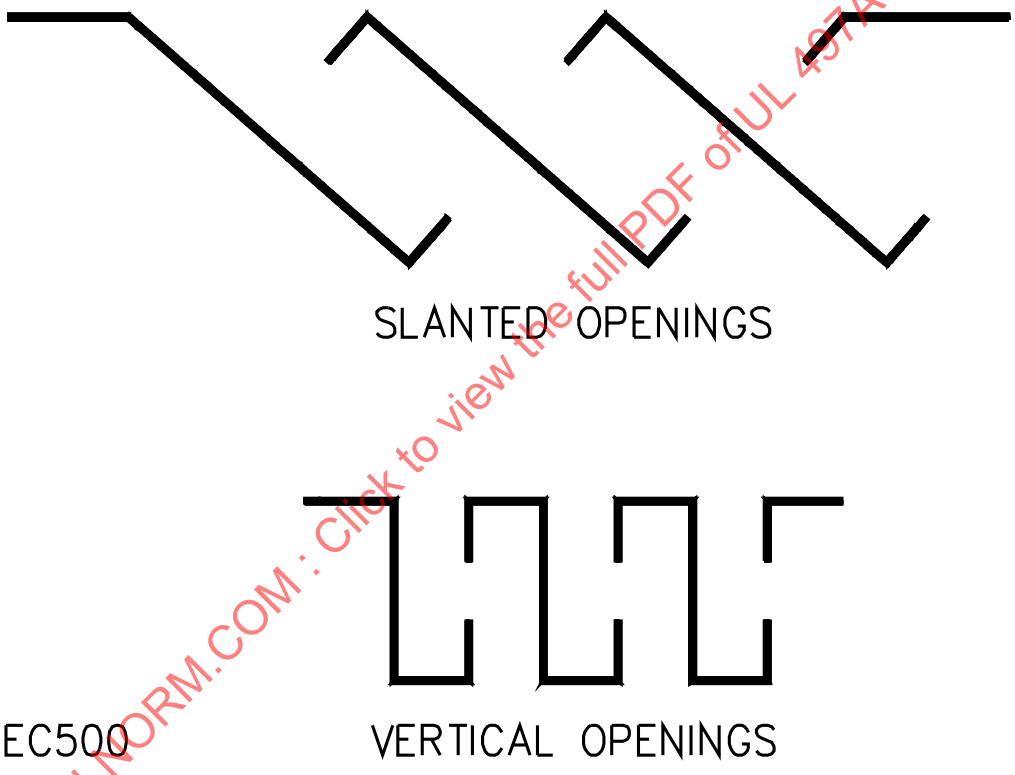
Exception No. 2: A product complying with the requirements in Accessibility and Electric Shock, Section 8, with the door or cover removed is not required to be hinged or secured.

6.2 Enclosure top openings

6.2.1 An enclosure top opening or an opening directly over an uninsulated live part involving a risk of fire, electric shock, or electrical-energy/high-current levels, shall not exceed 4.8 mm (0.19 inch) for any dimension unless the configuration is such that a vertically falling object cannot fall into the unit and contact an uninsulated live part. See Figure 6.1 for cross-section examples of enclosure top-cover designs.

Figure 6.1

Cross-sections of top-cover designs



6.3 Enclosure side openings

6.3.1 An opening in the side of an enclosure shall:

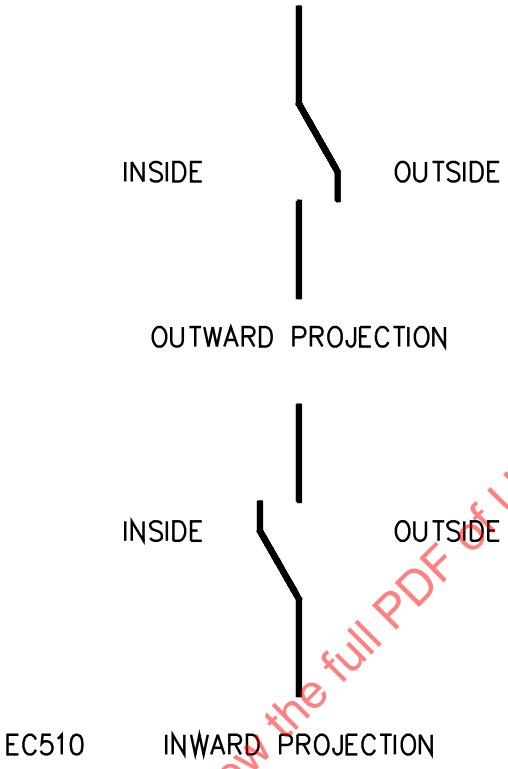
a) Not exceed 4.8 mm (0.19 inch) in any direction; or

b) Be provided with louvers shaped to deflect an external falling object outward. See Figure 6.2 for examples of louver designs; or

c) Be located and of such size so that an object that may be present cannot fall into the unit and drop (with no horizontal velocity) onto an uninsulated live part involving a risk of fire, electric shock, or electrical-energy/high-current levels or parts involving injury to persons.

Figure 6.2

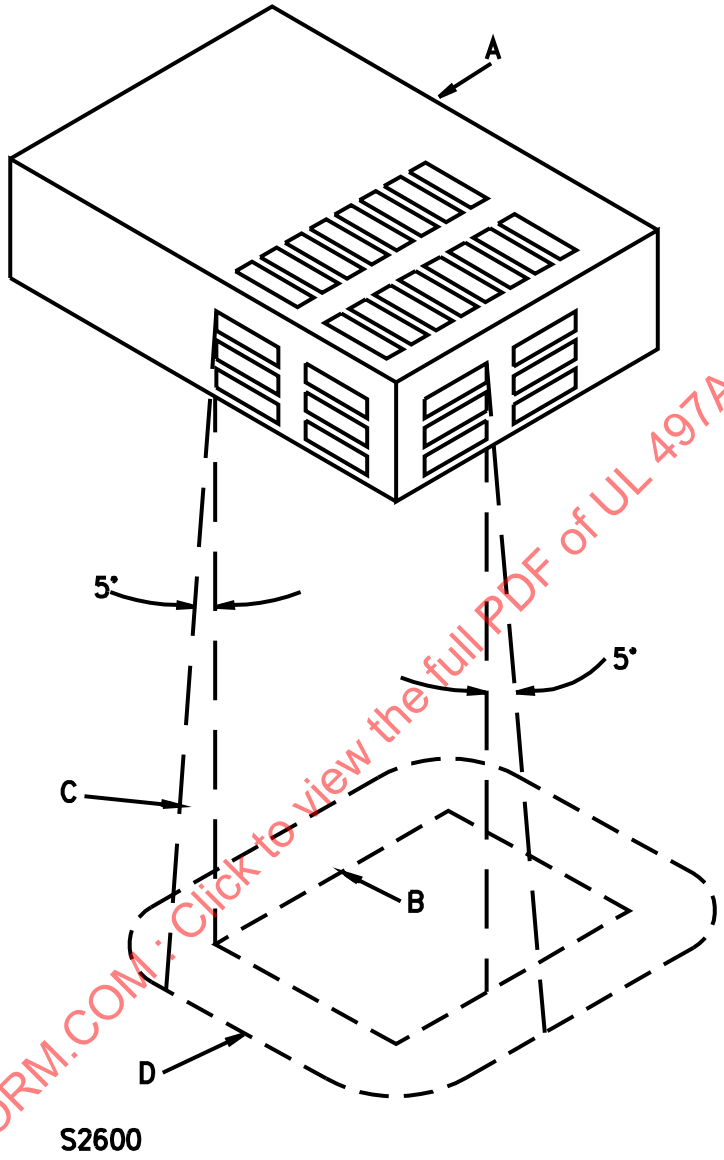
Louver designs



6.3.2 When a portion of a side panel falls within the area traced out by the 5-degree angle in Figure 6.3, that portion of the side panel shall be investigated as a bottom enclosure in accordance with 6.4.1 and 6.4.2.

Figure 6.3

Enclosure bottom



A – The entire component under which an enclosure (flat or dished with or without a lip or other raised edge) of noncombustible material is to be provided. The sketch is of an acceptably enclosed component with ventilation openings showing that the enclosure is required only for those openings through which flaming parts may be emitted. When the component or assembly does not have its own noncombustible enclosure, the area to be protected is the entire area occupied by the component or assembly.

B – Projection of the outline of the area of A that requires a bottom enclosure vertically downward onto the horizontal plane of the lowest point on the outer edge D of the enclosure.

C – Inclined line that traces out an area on the horizontal plane of the enclosure. Moving around the perimeter of the area B that requires a bottom enclosure, this line projects at a 5 degree angle from the line extending vertically at every point around the perimeter of A and is oriented to trace out the largest area; except that the angle may be less than 5 degrees when the enclosure bottom contacts a vertical enclosure or side panel, or when the horizontal extension of the enclosure B to D exceeds 152 mm (6 inches).

D – Minimum outline of the enclosure, except that the extension B to D need not exceed 152 mm (6 inches), flat or dished with or without a lip or other raised edge. The bottom may be flat or formed in any manner when every point of area D is at or below the lowest point on the outer edge of the enclosure.

6.4 Enclosure bottom openings

6.4.1 The bottom of an enclosure shall consist of a complete or partial bottom enclosure under a component, groups of components, or assemblies, as shown in Figure 6.3, and shall comply with the ventilation opening requirements in 6.4.2 unless a test demonstrates that the bottom enclosure provided will contain flames, glowing particles, and the like when all combustible material in the interior is ignited. The test procedure shall be conducted in accordance with the Overvoltage Test, Section 27.

Exception: A product intended to be mounted on a concrete floor or other noncombustible surface is not required to be provided with a bottom enclosure when marked in accordance with 42.12.

6.4.2 Ventilation openings may be provided in the bottom of an enclosure under materials that are not rated V-1 or less flammable in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, when the openings are constructed so that the materials do not fall directly from the interior of the unit. Other bottom opening constructions capable of being used are those that incorporate a perforated metal plate as described in Table 6.3, or a galvanized or stainless steel screen having a 14 by 14 per 25.4 mm (1 inch) mesh constructed of wire with a diameter of 0.4 mm (0.018 inch) minimum. Other constructions are not prohibited from being used when they comply with the Overvoltage Test, Section 27.

Table 6.3
Perforated metal plates

Minimum thickness,		Maximum diameter of holes,		Minimum spacing of holes center-to-center,	
mm	(inch)	mm	(inch)	mm	(inch)
0.66	0.026	1.14	0.045	1.70	0.067
				36 holes per cm^2	233 holes per $inch^2$
0.66	0.026	1.19	0.047	2.36	0.093
0.81	0.032	1.91	0.075	3.18	0.125
				11 holes per cm^2	72 holes per $inch^2$
0.91	0.036	1.60	0.063	2.77	0.109
0.91	0.036	1.98	0.078	3.18	0.125

7 Internal Materials

7.1 Polymeric materials used to enclose, support, or indirectly support current-carrying parts of a secondary protector shall comply with the requirements for the following flame classes in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

a) An enclosure used to enclose secondary protector components shall comply with the requirements for the 5V flame class.

b) Current-carrying parts employed within an enclosure, regardless of the enclosure use (protected or unprotected side of a primary protector) shall comply with the requirements for the V-2 flame class.

c) Current-carrying parts such as terminal cross connect assemblies used without an enclosure and located on the protected side of a primary protector in a user's access area shall comply with the requirements for the V-0 minimum flame class.

d) A decorative part or indirect support of a current carrying part shall comply with the requirements of the HB flame class.

7.2 When the material does not comply with the requirements of the specified flame class, it shall comply with the requirements in the Thermal Aging and Flame Test, Section 39.

8 Accessibility and Electric Shock

8.1 An uninsulated conductive part of a product that, during operation, is accessible to contact by the probe in Figure 8.1, shall comply with either (a) or (b).

a) Maximum Rated Voltage.

1) For combinations of direct voltage and sinusoidal alternating voltage at frequencies not greater than 100 hertz, the peak value of the composite voltage on the part with regard to ground or any other part that the probe in Figure 8.1 is able to contact, shall not be more than 42.4 volts peak where wet contact will not occur, and 21.2 volts peak where wet contact will occur.

2) For direct voltage interrupted at a rate of 10 – 200 hertz so that the duty cycle is 50 percent, the voltage on the part with regard to ground or any other part that the probe in Figure 8.1 is able to contact, shall not be more than 24.8 volts peak where wet contact will not occur, and 12.4 volts peak where wet contact will occur.

3) Limits for voltages of other frequencies and waveforms are to be determined by an investigation.

b) Maximum Rated Current.

1) For products other than those described in the following subitems 2, 3, or 4, the meter indication shall not be more than 0.5 milliampere when measurements are made in accordance with the Leakage Current Test, Section 34.

2) Product that comply with the criteria in items (a) – (c) shall produce a meter indication not more than that specified in 8.2.

i) The product requires an electromagnetic interference filter for functional performance or for compliance with other requirements (for example, FCC Regulations).

ii) The consequence of involuntary reaction does not result in a risk of injury. This involves a consideration of the risk of injury resulting from an involuntary reaction during use of the product; for example, heights, such as use on a ladder or a roof top; and moving parts, such as tools.

iii) There is a risk that a path for available current through the body will exist in the expected environment. When the available current is from the grounded supply, this will involve consideration of the risk that the user will be grounded during use of the product.

3) When all of the following specifications are met, the leakage current to ground for a product may be greater than 1.0 milliampere, but not more than 5.0 milliamperes, and the leakage current to ground for a system of products may be greater than 3.5 milliamperes, but not more than 5.0 milliamperes. The leakage current is to be measured with the equipment grounding conductor open, but otherwise in accordance with the Leakage Current Test, Section 34:

i) The product is not intended for household use.

ii) Provision is made for bonding together and grounding all metal frames of all the units in the system that are not identified as being double insulated.

iii) The marking and installation instructions comply with the requirements in 42.10.

iv) The meter indication does not exceed 0.5 milliampere when the current is measured from point-to-point on the product (or among simultaneously accessible parts or products in a system), and for current measured to ground, when the equipment grounding conductor is connected to the grounded supply conductor.

4) When a product complies with all of the following specifications, the leakage current to ground may be greater than 5.0 milliamperes. The leakage current is to be measured with the equipment grounding conductor open, but otherwise in accordance with the Leakage Current Test, Section 34:

i) The product is not intended for household use.

ii) Provision is made for bonding together and grounding all metal frames of all the units in the system that are not identified as being double insulated.

iii) Provision is made for the termination of a second equipment grounding conductor.

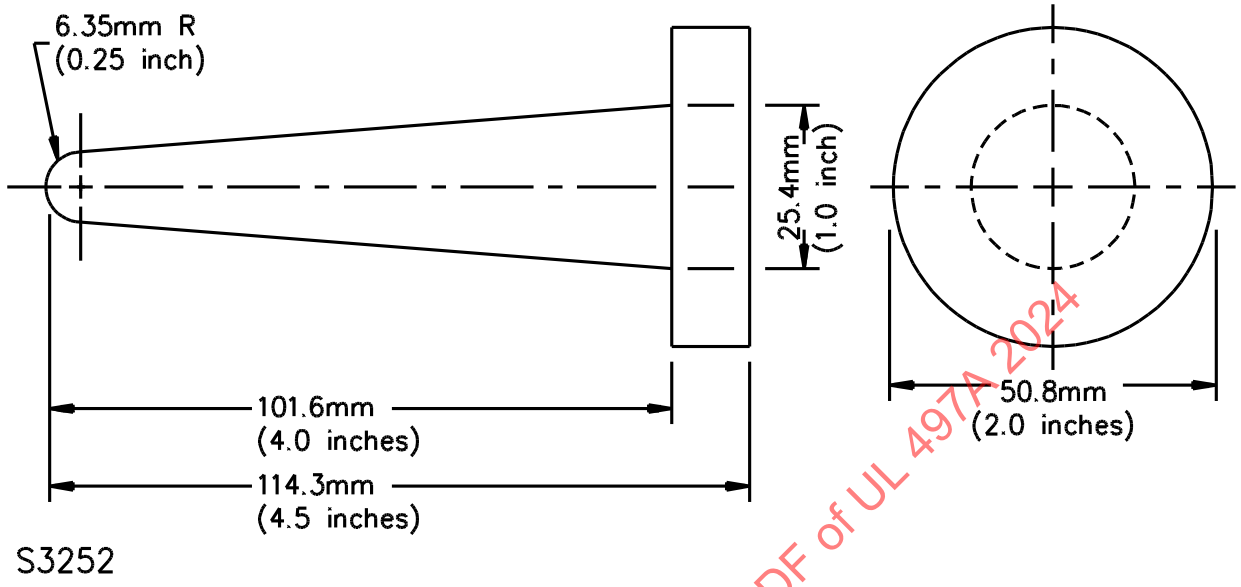
iv) The marking and installation instructions comply with the requirements in 42.10.

v) The meter indication does not exceed 0.5 milliampere when the product current is measured from point-to-point on the product (or among simultaneously accessible parts of products in a system), and for current measured to ground, when the equipment grounding conductor is connected to the grounded supply conductor.

Exception: An uninsulated conductive part that is accessible to the probe in Figure 8.1 but is located during intended use so that it will not be contacted, need not comply with the requirements in 8.1, but shall comply with the requirements in 8.4 (a) or (b).

Figure 8.1

Blunt-end accessibility probe



A – The surface of the conical body is tangent to the surface of the spherical tip.

B – The probe is to be used only as a gauge and inserted with minimal force. When the minor dimension of the opening is larger than 50.8 mm (2 inches), and the part is located at least twice the minor dimension from the opening, the part need not comply with 8.1. The minor dimension of the opening is identified as being the diameter of the largest sphere that will pass through the opening.

8.2 Current measurements are to be made in accordance with the Leakage Current Test, Section 34. For products that comply with 8.1(b)(2), the measured current to ground shall not produce a meter indication greater than 1.0 milliampere for a single product or 3.5 milliampere for a system of products.

8.3 For determining compliance with 8.1(a) or 8.4(a), the input impedance of the instrument for measuring the voltage is to be as close to 1 megohm as feasible, but not more than 1 megohm.

8.4 An uninsulated live part of a product that during operation is accessible to contact by the probe in Figure 8.2, but not accessible to the probe in Figure 8.1, or a part of a product that only during user servicing is accessible to contact by the probe in Figure 8.2, shall comply with either (a) or (b):

a) Maximum Rated Voltage.

1) For combinations of direct current voltage and sinusoidal alternating current voltage at frequencies not greater than 100 hertz, the peak value of the composite voltage on the part with regard to ground or any other part that the probe in Figure 8.2 is able to contact, shall not be more than the values shown in Figure 8.3. In no case shall the peak voltage be more than 60 volts when wet contact will not occur, and 30 volts when wet contact will occur.

2) For direct current voltage interrupted at a rate of 10 to 200 hertz so that the duty cycle is 50 percent, the voltage on the part with regard to ground or any other part that the probe in Figure 8.2 is able to contact, shall not be more than 24.8 volts peak where wet contact will not occur, and 12.4 volts peak where wet contact will occur.

b) Maximum Rated Current – When measured in accordance with the Leakage Current Test, Section 34:

1) The continuous current shall not be more than the values specified in Table 40.1.

2) The combination of magnitudes and durations of current shall not be more than those specified in Table 40.2.

3) The combination of capacitance and voltage values shall not be more than those specified in Table 40.3.

Exception: A part of a product that during operation is accessible to the probe in Figure 8.2 but not accessible to the probe in Figure 8.1, or a part of a product that only during user servicing is accessible to the probe in Figure 8.2, is not prohibited from exceeding the values specified in both 8.4(a) and (b)(1), when all of the following conditions are met:

a) The voltage does not exceed 150 volts, as measured by a voltmeter having input impedance as close as feasible to 1 megohm but not more than 1 megohm.

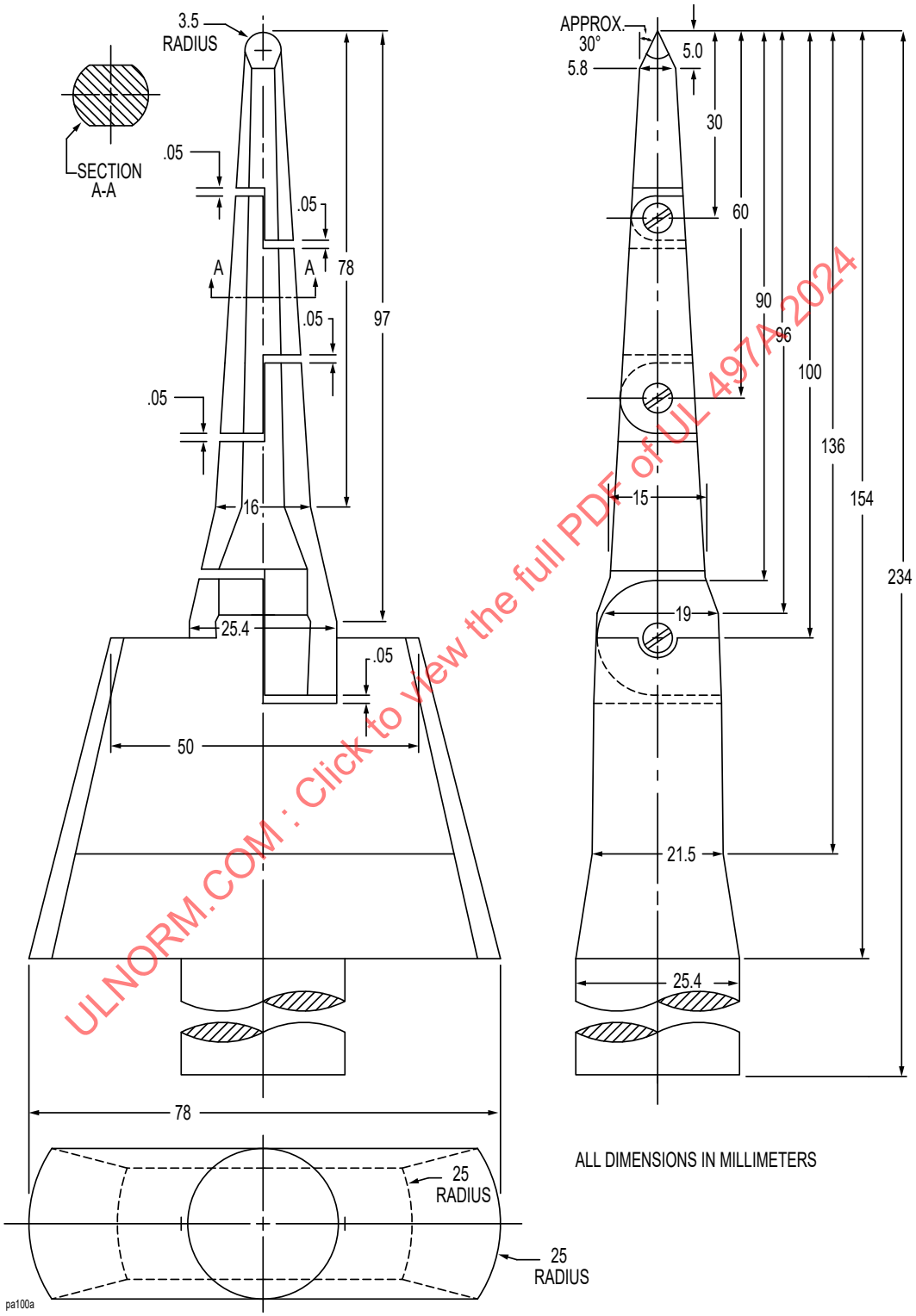
b) The occurrence of the periods in which the limits of 8.4(a) and (b)(1) are exceeded does not exceed a cumulative time of more than 2 percent of a 24-hour period (such as signal periods used for telephone ringing).

c) For a product that is intended for residential use only, the part that is accessible to contact by the probe illustrated in Figure 8.2 has an effective surface area not greater than 6.0 mm^2 (0.0093 square inch). For a product that is intended only for commercial or industrial use, the part, or combination of parts accessible to contact by the probe illustrated in Figure 8.2 has an effective surface area not greater than 12.0 mm^2 (0.0186 square inch). The effective surface area is that area of the part that would be contacted by a compliant finger able to conform to the shape of the surface. For example, a wire that is accessible to only one side is identified as being accessible to contact by a compliant finger on one-half of its circumference. The effective surface area on the wire is then equal to 1/2 times pi times the wire diameter times the length that is accessible to contact by the probe. When two or more such parts are located so that they will be touched simultaneously, and when they, in combination, will exceed the limits of 8.4 (a) and (b), the parts are determined to be a single part.

d) Each contact in a modular telephone jack or plug that exceeds the limits in (a) and (b)(1), has a companion contact in the same jack or plug that is connected to the return conductor (for example, the tip of a tip and ring pair). The return contact and the contact that exceeds the limits in 8.4(a) and (b)(1) shall be simultaneously contactable, independent of the locations in the plug and jack of the tip and ring conductors, including reversed polarity.

Figure 8.2

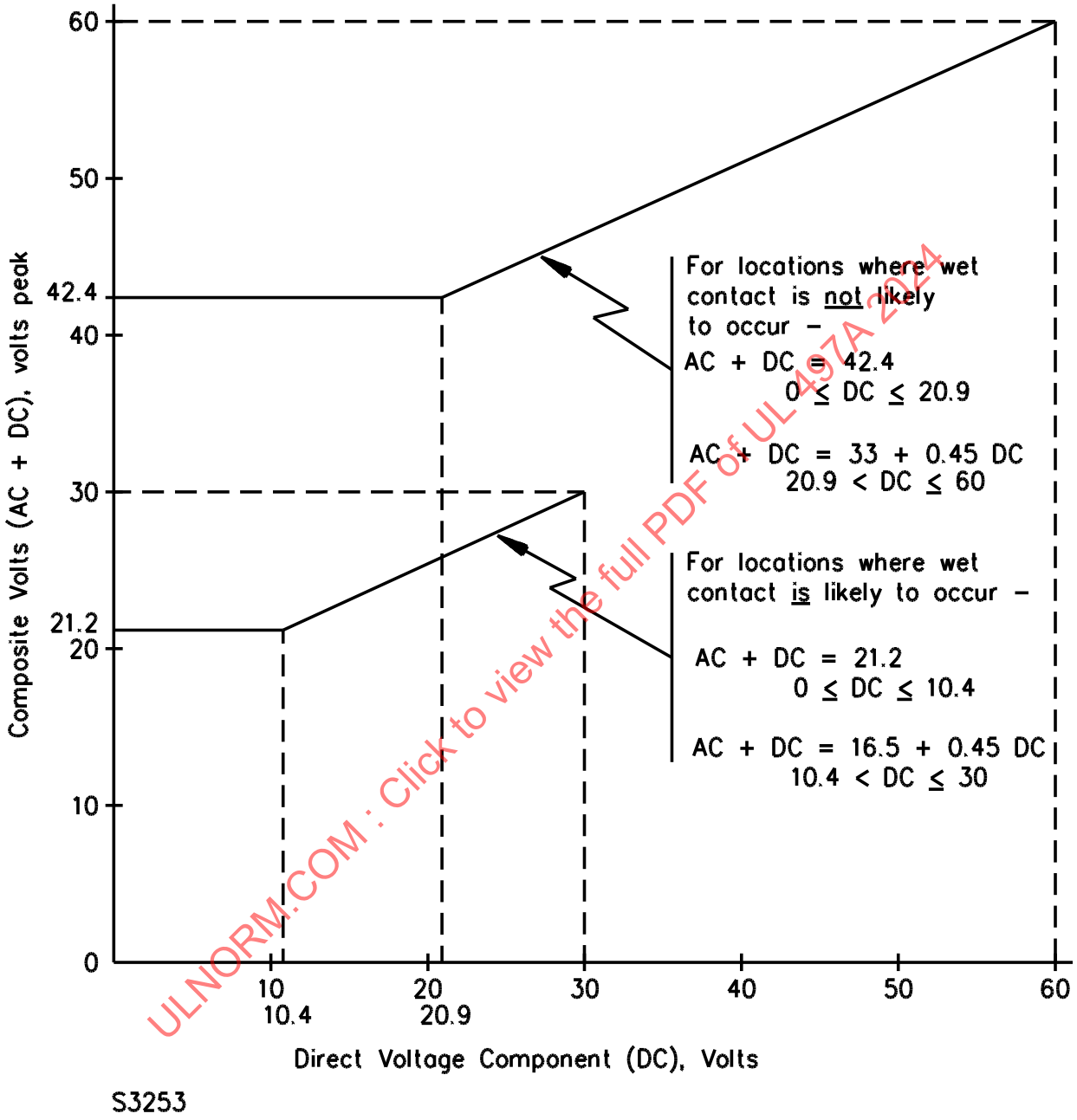
Articulate probe with web stop



The probe is to be inserted with a force not exceeding 25 N (5.62 lbf) through any opening in the enclosure of the product. The probe shall be rotated with the movable sections straight or in any possible position resulting from bending one or more sections in the same direction.

Figure 8.3

Maximum rated voltage



9 Mechanical Assembly

9.1 A product shall be assembled so that it is not adversely affected by vibration resulting from intended operation, such as vibration from operation of motors or similar products.

9.2 A switch, fuseholder, lampholder, attachment-plug receptacle, motor-attachment plug, or other similar component is to be mounted securely and shall not turn.

Exception No. 1: Turning of a switch is not prohibited when all of the following conditions are met:

a) The switch is of a plunger, slide, or other type that does not tend to rotate when operated. A toggle switch is subject to forces that tend to turn the switch during intended operation of the switch.

b) The means for mounting the switch will not loosen the switch upon operation.

c) The spacings are not reduced below the minimum identified values when the switch rotates.

d) The intended operation of the switch is by mechanical means rather than by direct contact by persons.

Exception No. 2: A lampholder of the type in which the lamp cannot be replaced (such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel) is not prohibited from turning when rotation does not reduce spacings below the minimum intended value.

9.3 Friction between surfaces is not intended for securing the position of the parts specified in 9.2. A lock washer is to be used as a means to secure the position of a device having a single-hole mounting means.

9.4 A rotating part that, by loosening, presents a risk of fire, electric shock, electrical-energy/high-current level, or injury to persons shall be assembled so that the direction of rotation tends to tighten the means that hold the rotating part in place.

Exception: A keyed part, a press fit, a part locked in place with a pin, or other means determined to be equivalent is to be used to hold a rotating part in place.

10 Protection Against Corrosion

10.1 Iron and steel parts shall be protected against corrosion by enamelling, galvanizing, plating, or other means determined to be equivalent, when corrosion or unprotected parts can result in a risk of fire, electric shock, or injury to persons.

Exception No. 1: Surfaces of sheet-steel and cast-iron parts within an enclosure are not required to be protected against corrosion when oxidation of the metal due to exposure to air and moisture does not result in a risk of fire, electric shock, or injury to persons. The thickness of metal and temperature are also to be identified.

Exception No. 2: Bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like, are not required to be protected against corrosion.

11 Cords

11.1 Strain relief

11.1.1 Means shall be provided so that a flexible cord cannot be pushed into the product through the cord-entry hole when such displacement could:

a) Result in damage to the cord;

b) Expose the cord to a temperature higher than that for which the cord is rated; or

c) Reduce spacings below the minimum intended values, such as to a metal strain-relief attachment.

11.1.2 A power supply cord shall be provided with strain relief means to keep tension on the cord from being transmitted to terminals, splices, or internal wiring. The strain relief means provided shall comply with the Strain Relief Test, Section 33.

11.1.3 A knot shall not be used to provide strain relief.

11.2 Bushings

11.2.1 At the point where a flexible cord passes through an opening in a wall, barrier, or the overall enclosure, there shall be a smooth, rounded bushing or the equivalent that shall be secured in place, or shall have a smooth, rounded surface against which the cord can bear. When other than a jacketed cord is used, and the wall or barrier is of metal, an insulating bushing shall be provided.

11.2.2 When the cord hole is in porcelain, phenolic composition, soft rubber, neoprene, or nonconducting material determined to be equivalent, a smooth, well-rounded surface is determined to be equivalent to a bushing.

11.2.3 Ceramic materials and some molded compositions are capable of being used for insulating bushings.

11.2.4 Vulcanized fiber may be used, when the bushing is not less than 1.2 mm (3/64 inch) thick and is formed and secured in place so that it will not be adversely affected by conditions of moisture.

11.2.5 A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be used on a cord where the cord enters the frame or enclosure if:

a) The bushing is not less than 1.2 mm (3/64 inch) thick and

b) The bushing is located so that it will not be exposed to oil, grease, oil vapor, or other substances that can have a deleterious effect on the compound employed.

11.2.6 A bushing of any of the materials specified in 11.2.2 may be used on a cord anywhere in a product when it is used in conjunction with a type of cord for which an insulating bushing is not required. The edges of the hole in which such a bushing is used shall be free from burrs, fins, and other conditions that could damage the bushing.

11.2.7 An insulated metal grommet may be used in place of an insulating bushing when the insulating material used is not less than 0.8 mm (1/32 inch) thick and completely fills the space between the grommet and the metal in which the grommet is mounted.

12 Current-Carrying Parts

12.1 Current-carrying parts shall be of silver, copper, a copper alloy, stainless steel, aluminum, or other material capable of being used for the application.

12.2 Bearings, hinges and the like are not to be used as current-carrying parts.

13 Internal Wiring

13.1 General

13.1.1 The wiring and connections between parts of a product shall be protected or enclosed or shall be in an intended cord or cable.

13.1.2 Internal wiring shall be routed and secured so that the wires and electrical connections will not be subjected to stress or mechanical damage.

13.1.3 A hole through which insulated wires pass through a sheet-metal wall within the overall enclosure of a product shall be provided with a bushing having a smooth, rounded surface upon which the wires may bear.

13.1.4 Internal wiring shall be capable of being used for the application, with regard to temperature, voltage, and exposure to oil, grease, solvents, acids and other conditions of service to which the wiring will be subjected.

13.1.5 Flexing, vibration, impact, or other movement of wiring and any supplementary wire insulation during intended use, including user servicing, shall not reduce the wire insulation or the wire termination integrity.

13.1.6 Metal clamps and guides used for routing stationary internal wiring shall be provided with smooth, rounded edges. Auxiliary nonconducting mechanical protection shall be provided under a clamp at which pressure is exerted on a conductor and no overall braid, and on any wire or wires that are subject to motion.

13.1.7 Wires shall be routed away from sharp edges such as those found on screw threads, burrs, fins, moving parts, and the like, that can damage the wire insulation.

13.1.8 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of the product.

13.1.9 Supplementary insulation shall be applied to internal wiring that involves a risk of electric shock and is exposed during user servicing.

13.2 Splices and connections

13.2.1 All splices and connections shall be mechanically secure and shall be bonded electrically. A soldered connection shall be made mechanically secure before being soldered, when breaking or loosening of the connection may result in a risk of fire or electric shock. Consideration shall be given to vibration when investigating electrical connections. Pressure wire connectors may be used.

13.2.2 A splice shall be provided with insulation equivalent to that of the wires involved when permanence of spacing between the splice and other metal parts cannot be maintained.

13.2.3 In determining whether or not splice insulation consisting of coated-fabric, thermoplastic, or other type of tape or tubing is capable of being used, consideration is to be given to factors such as mechanical strength, dielectric properties, and heat- and moisture-resistant characteristics.

13.2.4 When stranded internal wiring is connected to a wire-binding screw, there shall be no loose strands of wire that can contact other uninsulated live parts or dead-metal parts. This may be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other means determined to be equivalent.

14 Interconnecting Cords and Cables

14.1 General

14.1.1 Flexible-cord or -cable assemblies used for external interconnection between sections of a product or between products shall be provided with strain relief and bushings in accordance with Cords, Section 11.

14.1.2 Inserting a male connector in a female connector other than the one intended to receive it; misalignment of male and female connectors; and other manipulations of parts that are accessible to the user, shall not result in a risk of fire, electric shock, or injury to persons.

14.1.3 Connectors provided on interconnecting cords and cables shall comply with the accessibility requirements in Accessibility and Electric Shock, Section 8, with the connector out of its receptacle.

14.1.4 Interconnecting cables and external wiring containing Class 3 circuits provided as part of a system shall be capable of being used for the application.

14.1.5 Interconnecting cables and external wiring containing telephone circuits shall be rated for the use.

14.2 Separation of circuits

14.2.1 Field-wiring terminals and external circuit connectors for Class 2, Class 3, or communications circuits shall not be in a wiring compartment, box, or other area with conductors or terminals for other circuits. Field-installed conductors shall be secured so that they cannot contact uninsulated live part, field-installed wiring, and factory-installed wiring of any other circuit.

Exception No. 1: This requirement does not apply when a solid (unpierced) partition, permanently secured in place, is provided to separate field-installed conductors from field- and factory-installed conductors and live parts of any other circuit.

Exception No. 2: In units for which field connections for some applications are different from the connections for other applications, a removable solid partition or a permanent partition in which there are holes for the passage of conductors may be used. Instructions for use of a removable or pierced partition are to be a permanent part of the unit.

Exception No. 3: Instead of a partition, a wiring diagram may be provided on or with the unit when provision is made for routing all conductors and such routing is clearly and completely shown by the diagram, and complete wiring instructions accompany the diagram.

Exception No. 4: Separation of some field-installed conductors from others and from uninsulated live parts connected to different circuits may be accomplished by arranging the location of openings in the enclosure for the various conductors (with regard to the terminals or other uninsulated live parts) so that there is no risk that the conductors or parts of different circuits can be intermingled. When no more openings than are

required are provided in the enclosure for wiring of the unit and, when each such opening is opposite a set of terminals, it is to be assumed for the purpose of determining compliance that conductors entering the enclosure through any such opening will be connected only to the terminals opposite that opening. When more openings than are required are provided in the enclosure for wiring the unit, it is to be assumed in determining compliance that conductors will enter the enclosure through openings that are not opposite the terminals to which they are intended to be connected and touch insulated conductors and uninsulated live parts of other circuits.

14.2.2 In determining whether a unit complies with the requirements in 14.2.1, the unit is to be wired as intended in the field. Slack is to be left in each conductor within the enclosure, and care is to be used in stowing the slack in the compartment.

14.3 Terminal and connectors

14.3.1 External circuit connectors provided as part of the equipment shall be rated for their intended use with regard to the applicable requirements in Accessibility and Electric Shock, Section 8. Connectors intended to be connected to the telecommunications network shall comply with the requirements for communications circuit accessories.

15 Insulating Material

15.1 Uninsulated live parts involving a risk of fire, electric shock, or electrical-energy/high-current levels, shall be mounted on porcelain, phenolic composition, or other material having insulating characteristics determined to be equivalent.

15.2 Vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts when shrinkage, current leakage, or warpage may introduce a risk of electric shock or fire. A thermoplastic material used for the direct or indirect support of uninsulated live parts involving a risk of fire, electric shock or electrical-energy/high-current level shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

15.3 Molded parts shall have the mechanical strength and rigidity to withstand the stresses of actual service.

15.4 An insulating liner shall be capable of being used for the purpose. Barriers shall be held in place by a means more secure than friction between surfaces. The elasticity of tubing shall not be depended upon to hold the tubing in place. Heat shrink tubing may be used where a sharp edge or point is not involved.

16 Printed-Circuit Board

16.1 A printed-circuit board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796.

16.2 A resistor, capacitor, inductor, or other part that is mounted on a printed-circuit board to form a printed-circuit assembly shall be secured so that it cannot be displaced to result in a risk of electric shock or fire by a force that will be exerted on it during assembly, intended operation, or servicing of the board.

16.3 Consideration is to be given to a barrier or a partition that is part of an enclosure assembly and that provides mechanical protection and electrical insulation of a component connected to the printed-circuit board.

16.4 A printed-circuit board shall comply with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, for the applicable flame class as follows:

a) V-0 for a printed-circuit board that contains telecommunications (telephone) network circuits where the power capable of being delivered to an external resistor connected in parallel to the circuit load is 15 watts or more.

b) V-2 minimum for a printed-circuit board operating at normal telecommunications network voltage and current level and contained in a complete metal enclosure or a complete plastic enclosure that complies with the requirements of the 5V flame test.

17 Overcurrent (Overload) Devices

17.1 An overcurrent device shall have a current and voltage rating not less than the load it controls, and shall not open the circuit during intended use of the unit.

17.2 A protective device, the normal functioning of which requires renewal, replacement, or resetting, shall be in a readily accessible location.

Exception: The requirement does not apply when the presence of the protective device would be unknown to the user of the product because of its location and the omission of reference to the device in the operating instructions, circuit diagrams, and the like, provided with the product.

18 Spacings

18.1 The spacings between field-wiring terminals of opposite polarity and the spacings between a field-wiring terminal and any other uninsulated metal part dead or live, not of the same polarity, shall not be less than 1/8 inch (3.2 mm). Telephone network circuit terminals are not considered to be field-wiring terminals.

18.2 In all circuits other than at field-wiring terminals, the acceptability of spacings between an uninsulated live part and any other uninsulated metal part, dead or live, not of the same polarity shall be determined by the Dielectric Voltage-Withstand Test, Section 35.

18.3 At terminal screws and studs that are factory-installed and to which connections may be made in the field by means of wire connectors, eyelets, and the like, spacings shall not be less than 3.2 mm (1/8 inch) when such connectors, eyelets, and the like, are in such position that minimum spacings – opposite polarity and to dead-metal parts – exist.

18.4 An insulating lining or barrier of vulcanized fiber or similar material used where spacings would otherwise be unintended shall not be less than 0.8 mm (1/32 inch) thick, and shall be located or of such material so that it will not be adversely affected by arcing.

Exception No. 1: Vulcanized fiber not less than 0.4 mm (1/64 inch) thick may be used in conjunction with an air spacing of not less than 50 percent of the through spacing required.

Exception No. 2: An insulating line or barrier may be less than 1/32 inch thick when the material is capable of being used for the application in accordance with Insulating Material, Section 15.

18.5 When an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces, or when a movable dead-metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum spacings shall be maintained with the part in any position.

18.6 Snap or plug-in type connectors such as RJ-11 type jacks shall maintain a spacing between live conductors or parts of opposite polarity of not less than 0.76 mm (0.030 inch).

18.7 Wire insulation piercing terminals such as quick-connect-type terminals requiring insertion tools shall maintain a minimum 1.2 mm (3/64 inch) spacing between terminals.

RISK OF INJURY TO PERSONS

19 General

19.1 When the operation and maintenance of a product by the user involves a risk of injury to persons, means shall be provided to reduce the risk.

19.2 When investigating a product with regard to the requirement in 19.1, consideration shall be given to foreseeable misuse of the product.

19.3 An accessory that is made available or recommended by the manufacturer for use with the basic product shall be included in the evaluation of the product.

19.4 The capability of a guard, a safety release, an interlock and the like, and whether such a device is required, is to be determined from an investigation of the complete product, its operating characteristics, and the risk of a risk of injury to persons. The investigation is to include consideration of the results of breakdown or malfunction of any one component; but not more than one component at a time, unless one event contributes to another. When the investigation shows that breakdown or malfunction of a component can result in a risk of injury to persons, the component shall be investigated for reliability.

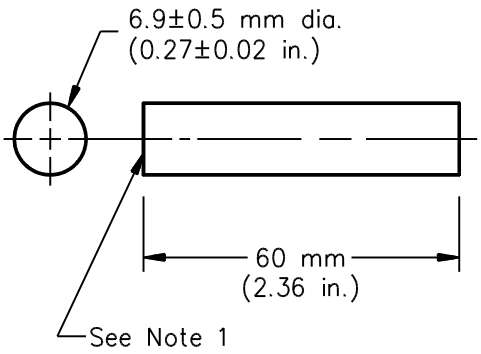
20 Modular Jacks

20.1 The contact pins of a modular-type jack that are accessible without the use of a tool and can be contacted by the probe in Figure 8.2, shall be positioned, shaped, recessed, or the like, to reduce the risk of injury to persons.

20.2 Compliance with the requirements in 20.1 is determined by inserting the probe in Figure 20.1, with a force not exceeding 4.45 N (1 lbf), and a distance not exceeding 4.5 cm (1.77 inches), into the opening of the jack. The results are not capable of being used when the probe cannot be withdrawn from the opening without rotating it or applying a force to the probe of more than 4.45 newtons.

Figure 20.1

Rubber accessibility probe



Note 1: Material: Soft Rubber Compound
Tensile strength: 80–100 psi
% Elongation: 36–50
Hardness[a]: 56–76

a Hardness as determined by a Type A Shore Durometer for rubber hardness–ASTM D2240–86.

S3262

21 Sharp Edges

21.1 An enclosure, edge, frame, projection, guard, opening, handle, or the like shall be smooth and not sharp enough to constitute a risk of injury to persons during intended maintenance and use.

Exception: A sharp edge that must be exposed to enable the product to perform its intended function is capable of being used.

21.2 For edges where the degree of sharpness cannot be determined by inspection, compliance with the requirement in 21.1 is determined by the test procedure in the Standard for Test for Sharpness of Edges on Equipment, UL 1439.

22 Stability

22.1 Under all conditions of servicing and intended use after installation, a fully assembled product shall not become physically unstable to the degree that it could result in a risk of injury to the user or service personnel.

22.2 The requirements in 22.3 – 22.7 apply to all free-standing products. A free-standing product is defined as one that is floor-standing and not intended to be secured to other units or to the floor or other part of the building.

22.3 In conducting the tests described in 22.4 – 22.7, all casters and jacks, when provided, are to be placed in their most favorable positions and wheels are to be locked or blocked. However, when casters are being used only to transport the product and jacks are lowered after installation, then the jacks (and

not the casters) are to be used in their most unfavorable position for the test, consistent with reasonable leveling of the product.

22.4 A freestanding product that has an external surface (work top or edge) at a height not exceeding 1 m (39-3/8 inches) from the floor, and that will be stepped or sat upon, shall not tip over when a continuous downward force of 800 N (179.8 lbf) is applied to that surface at the point of maximum moment. For this test all doors, covers, gates, drawers, and the like are to be in place and closed.

22.5 With regard to the requirement in 22.4, parts such as keyboards, control panels, spools, and the like are not considered parts that will be stepped on or sat upon.

22.6 A freestanding product more than 1 m (39-3/8 inches) high and weighing more than 25 kg (55.1 pounds) shall not tip over when a force equal to 1/5 the weight of the unit but not more than 250 N (56.2 lbf) is applied in any direction except upward at a height not exceeding 2 m (78-3/4 inches) from the floor. For this test, all doors, drawers, frames, and the like that can be opened are to be opened and placed in the most unfavorable position. Separate tests may be performed when user and service extensions are different or when stabilizers are used in accordance with 22.7.

22.7 A stabilizing means may be used to improve stability when doors, drawers, and the like are opened. The stabilizing means shall be automatic in operation or interlocked when associated with user use. For service personnel where it is not automatic in operation, a conspicuous marking shall be provided to caution the personnel on its use.

23 Protection of Service Personnel

23.1 Equipment operating at telecommunications network voltages higher than the typical voltages specified in 3.10 (for example, T type lines) shall be provided with a marking as specified in 42.13 to alert service personnel of the risk of electric shock.

23.2 A required guard or barrier shall be capable of being removed and replaced with a minimum of effort when removal is required for servicing the protected parts.

PERFORMANCE

24 General

24.1 The performance of secondary protectors for data communications circuits is to be investigated by subjecting representative samples of each rating to the tests indicated in Figure 24.1 – Figure 24.4 and described in Sections 25 – 40.

Figure 24.1

Test program sequence

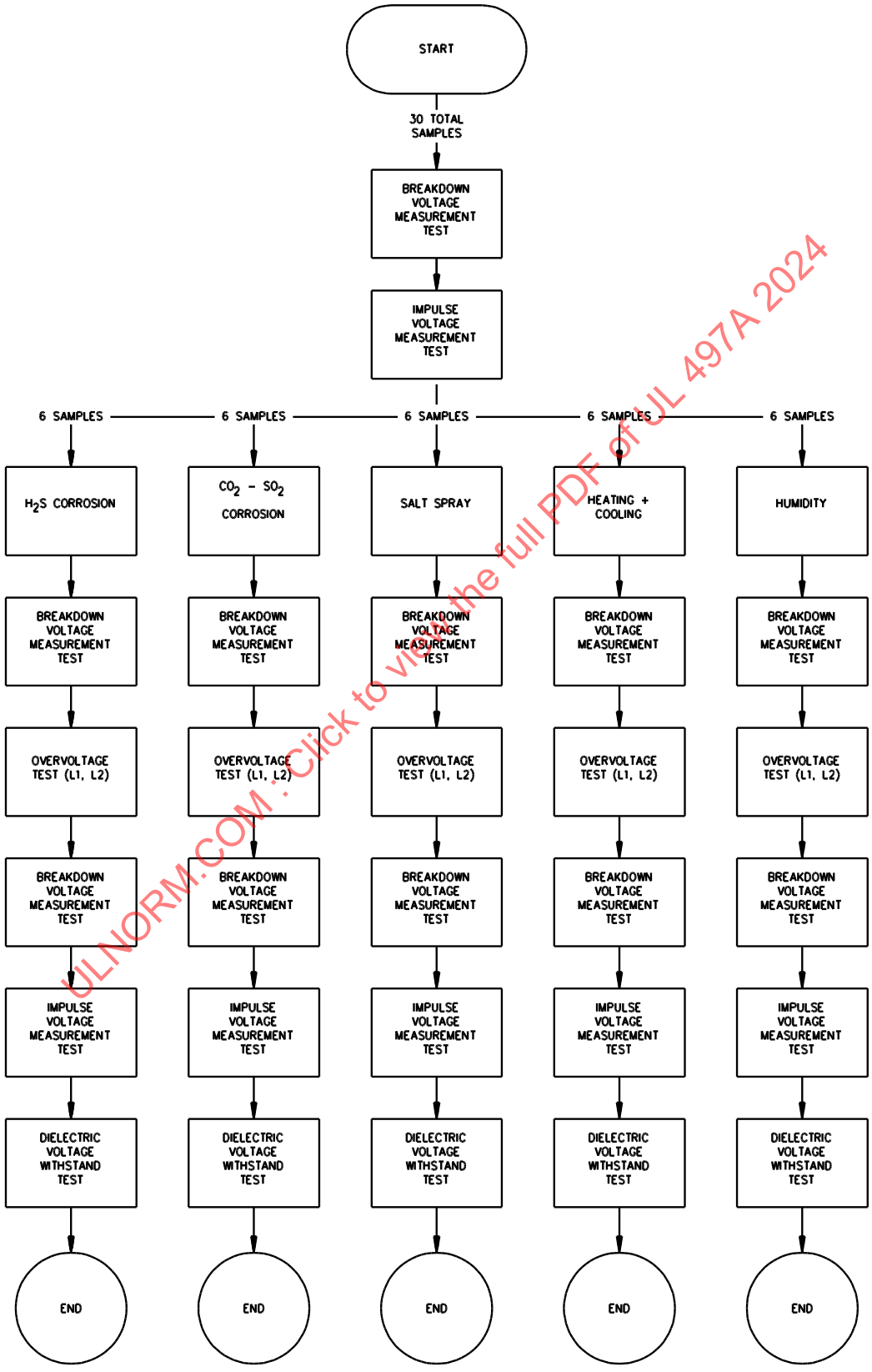


Figure 24.2

Test program sequence

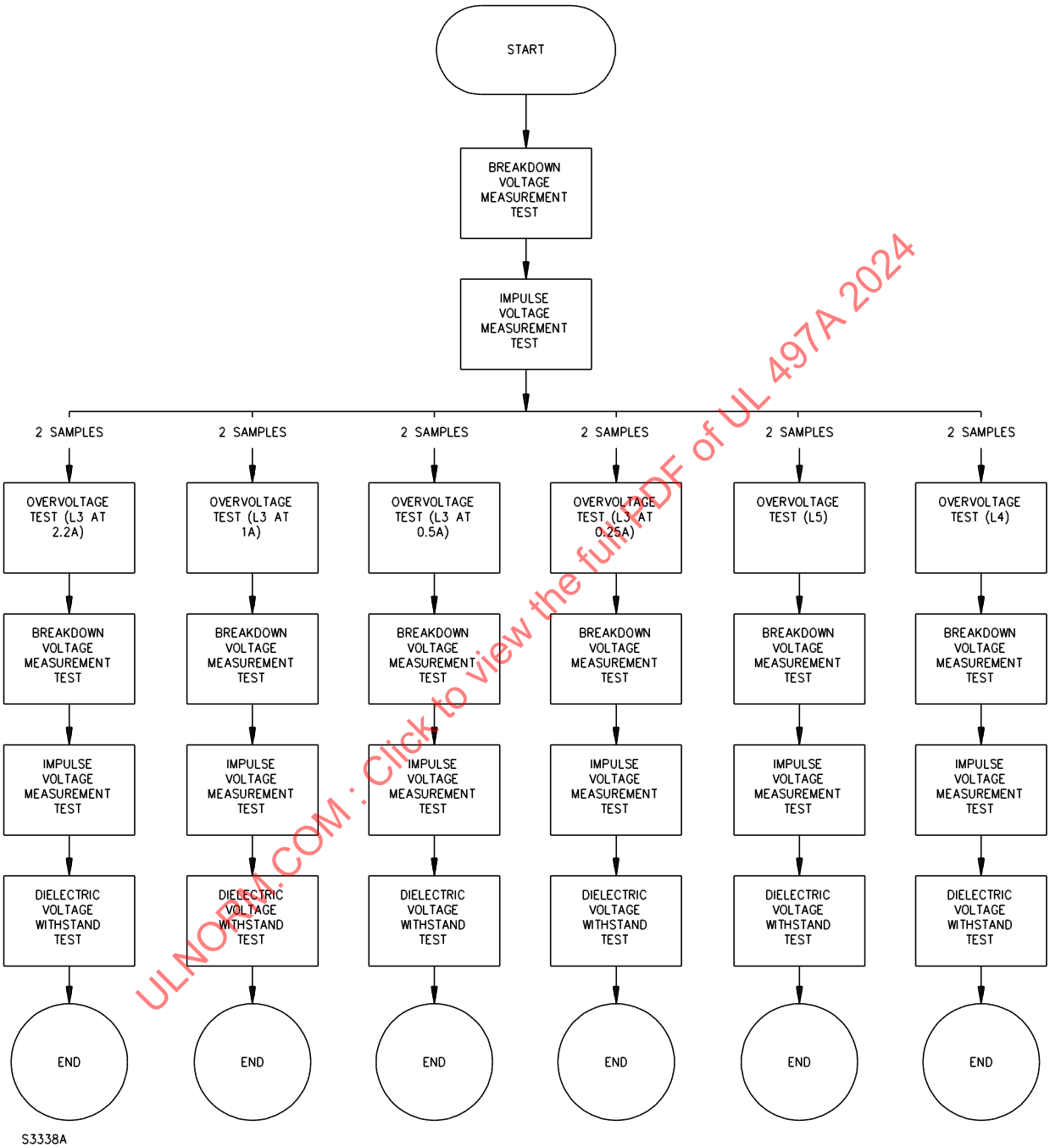


Figure 24.3

Test program sequence

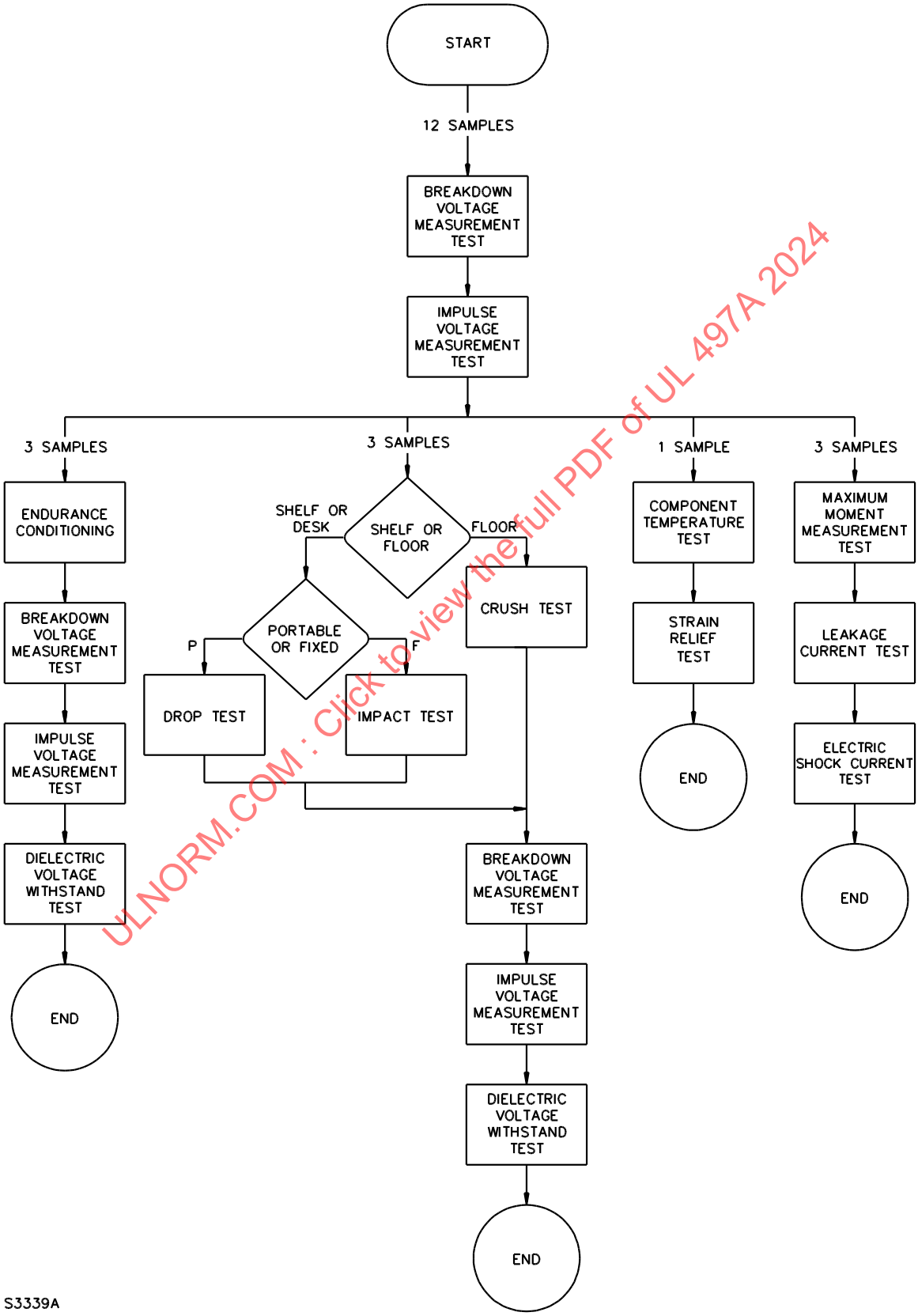
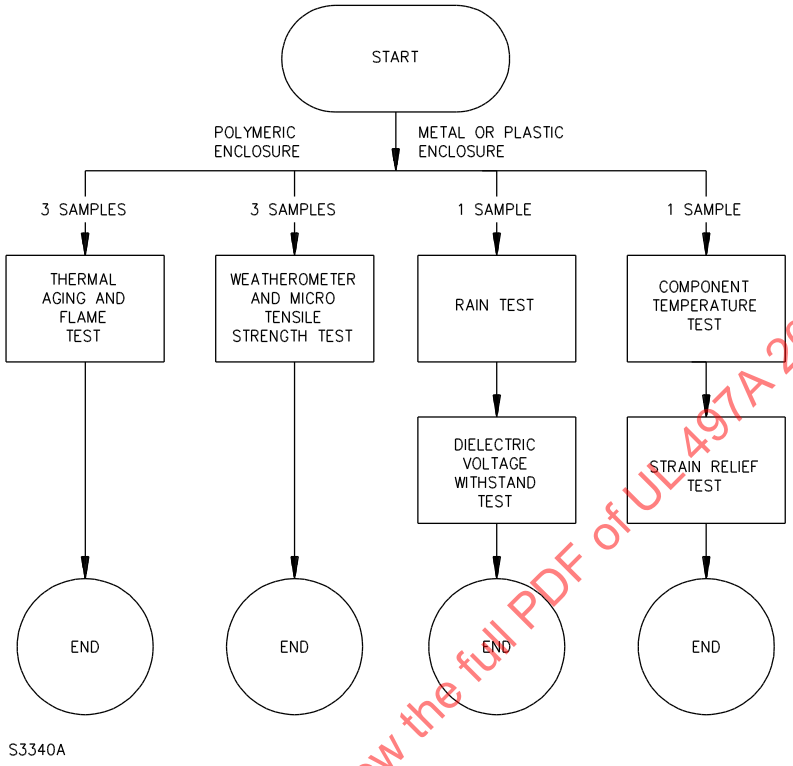


Figure 24.4

Test program sequence



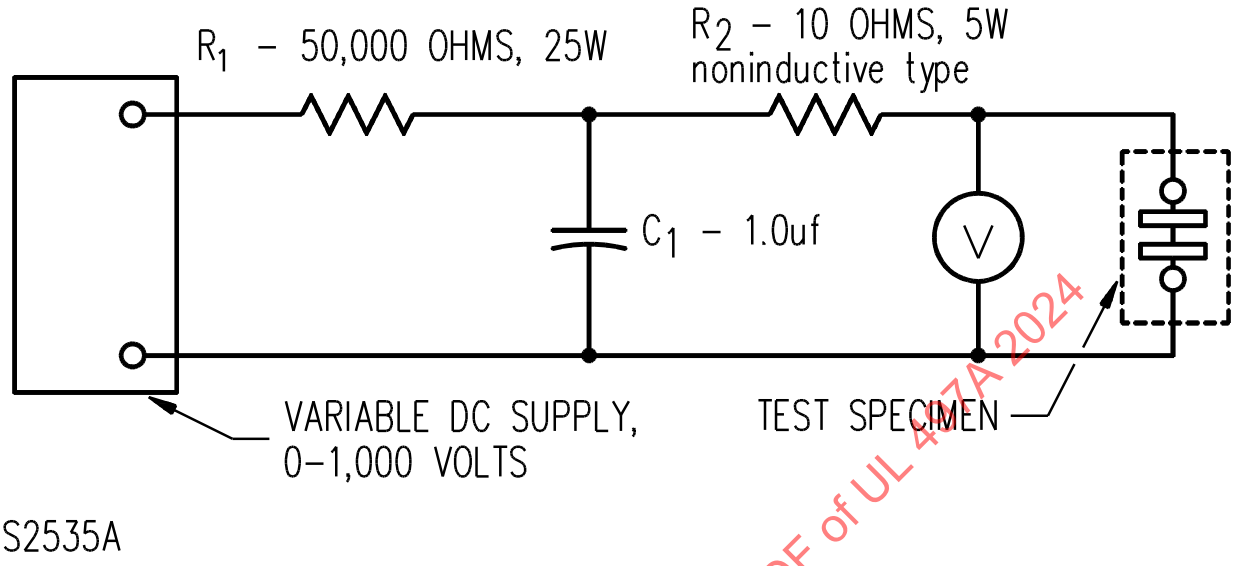
25 Breakdown Voltage Measurement Test

25.1 An overvoltage device or circuit of a secondary protector shall break down within ±25 percent of the manufacturer's rating or within the upper and lower limits of a rated voltage range when subjected to the conditions specified in 25.2 and 25.3. This requirement applies to overvoltage protection devices that connect between earth or system ground and the telephone line, and devices that connect between "tip" and "ring" lines of the telephone loop circuit.

25.2 The secondary protector is to be mounted in accordance with the manufacturer's installation instructions for connecting the unit to a standard telephone circuit, and the overvoltage device or circuit of the secondary protector is to be connected, in turn, to the circuit shown in Figure 25.1.

Figure 25.1

Breakdown voltage measurement test



25.3 The supply voltage is to increased at a rate no higher than 2000 volts per second. The voltage across the secondary protector overvoltage device is to be monitored using a meter or oscilloscope. The maximum peak voltage at breakdown is to be recorded for each test sample.

26 Impulse Voltage Measurement Test

26.1 An overvoltage device or circuit of a secondary protector shall break down within ±25 percent of the manufacturer's rating or within the upper and lower limits of a rated voltage range when subjected to the conditions specified in 26.2. This requirement applies to overvoltage protection devices that connect between earth or system ground and the telephone line, or devices that connect between "tip" and "ring" lines of the telephone loop circuit. The manufacturer may assign separate breakdown voltage ratings for the Breakdown Voltage Measurement Test, Section 25, and this test when the marking requirements in 42.3 are met.

26.2 Each test sample is to be mounted in a position of normal use and connected to a pulse generator that will produce a rate of voltage rise of 100 volts per microsecond. The exponential voltage rise shall remain within ±10 percent of the 100 volts per microsecond voltage rise-rate. The discharge current shall be sufficient to cause operation in the arc mode but not exceed 10 amperes.

27 Overvoltage Test

27.1 General

27.1.1 A secondary protector shall limit current, current extinguish, or open the telephone loop circuit without loss of its voltage protection, or indication of a risk of fire or electric shock (see 27.1.2) when

subjected to the conditions specified in Table 27.1 and 27.1.5 – 27.2.5. Following the overvoltage test, the samples shall comply with the Dielectric Voltage-Withstand Test, Section 35. When, during the test, the protector does not fuse open the telephone loop circuit, it shall comply with the Breakdown Voltage Measurement Test, Section 25, and the Impulse Voltage Measurement Test, Section 26.

Table 27.1
Test sample conditioning

Conditioning[a]	Indoor use only	Indoor/outdoor use only
0.1% H_2S	X	
1.0% H_2S	X	
0.5% SOH_2– 1.0% CO_2	X	
1.0% SO_2	X	
Salt spray	X	
85% humidity	X	
95% humidity	X	
Heating and cooling	X	X

[a] See 27.2.5 for details on conditioning.

27.1.2 Compliance with the test requirements specified in this section is based on the following conditions being met:

a) There shall be no ignition or charring of the cheesecloth indicator. Charring is deemed to have occurred when the structural integrity of the threads has been destroyed due to the temperature rise.

b) Based on the wiring simulator that is used:

1) The fuse or device used as the wiring simulator shall not interrupt the current during the test; or

2) The heating characteristic (integral I^2t), measured with the current probe, shall be compatible with the intended region noted in 27.2.3; or

3) When a No. 26 AWG (0.13 mm^2) solid copper wire is used as the wiring simulator, it shall not fuse open and shall not cause ignition or charring of the cheesecloth indicator.

c) The secondary protector shall comply with the Dielectric Voltage-Withstand Test, Section 35, after the completion of the overvoltage test.

27.1.3 A line cord is to be prepared for testing as follows: a 25 mm (1 inch) inside diameter circular loop is to be formed 76 mm (3 inches) from the end of the cord connected to the telecommunications network, restrained with a nonmetallic fastener such that the sections of the cord do not cross within the loop. The loop is to be mounted in a vertical plane and draped with two single plies of the cheesecloth. The cloth is to be bleached cotton cheesecloth running 28 – 30 m/kg (14 – 15 yards per pound), and having a "count of 13 by 11 (32 by 28)." This "count" means that for any square centimeter there are 13 threads in one direction and 11 threads in the other direction, or for any square inch, there are 32 threads in one direction and 28 threads in the other direction.

27.1.4 A coiled cord is to be prepared for testing as follows: the cord is to be laid flat and then extended to twice its normal length at rest. The ends are to be restrained using nonmetallic fasteners. A long cord may be looped around a nonmetallic cylinder such that adjacent coils do not touch. The cord is to be draped with two single plies of the cheesecloth described in 27.1.3.

27.1.5 To determine the effect of the overvoltage on the secondary protectors, each test sample is to be connected to the test circuit shown in Figure 27.1. One test sample at a time is to be subjected to the test. Three different samples are to be subjected to each L1 and L2 test condition as shown in Figure 24.1 and in 27.1.6. Two different samples are to be subjected to each L3, L4, and L5 test current condition shown in Figure 24.2. When conducting test L1, L2, or L5, test voltages are to be applied between tip and ground or ring and ground, except both circuits shall be tested when dissimilar components or circuits are used to make up the two protector circuits. When conducting test L3 or L4, each of the test currents noted for the test is to be applied simultaneously to both tip to ground and ring to ground. The test voltages noted in this section are open circuit test voltages. Test currents are adjusted to the indicated values with the samples under test shorted or bypassed out of the test circuit. Once calibration has been completed, the test circuit is de-energized and the sample connected into the circuit. Time duration of the test is started upon re-energization of the test circuit. The current and voltage parameters of L1 – L5 longitudinal voltage tests are as follows:

a) Test L1 – This test is to be conducted using 40 amperes at 600 volts AC for 1-1/2 seconds.

b) Test L2 – This test is to be conducted using 7 amperes at 600 volts AC for 5 seconds.

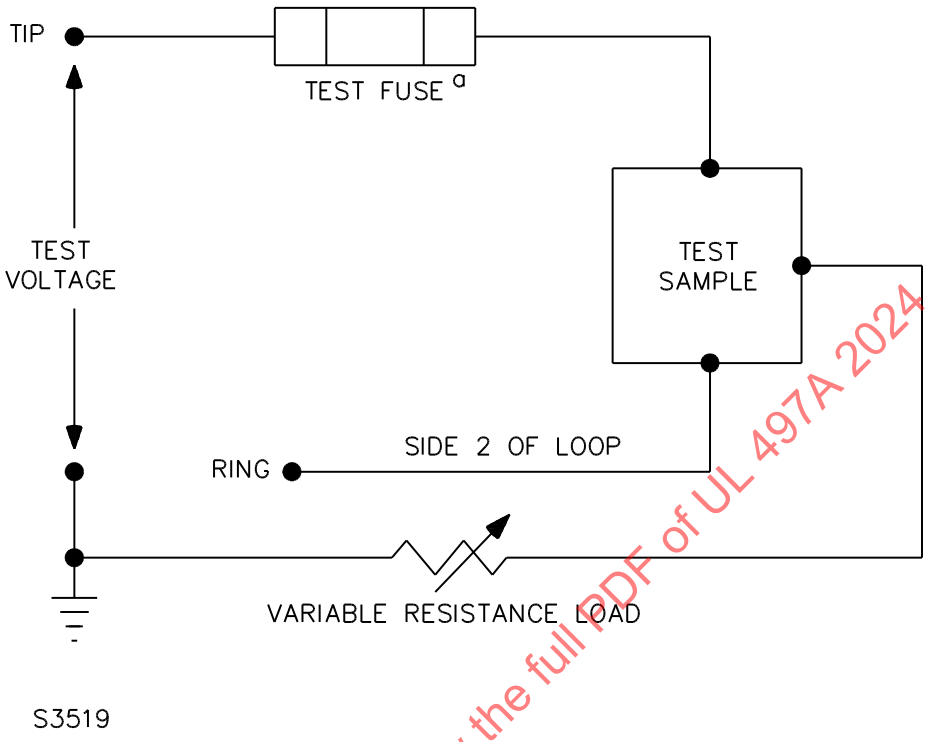
c) Test L3 – This test is to be conducted using 2.2, 1.0, 0.5, and 0.25 amperes through each side (tip and ring) at 600 volts AC for a minimum of 30 minutes at each current trial. The test may be ended when during the trial it can be verified that the samples have mechanically disconnected the simulated current-fault condition from the ground reference and output circuit, terminals and/or connectors.

d) Test L4 – This test is to be conducted using 2.2 amperes through each side (tip and ring) at 200 volts AC; or, when the equipment contains voltage-limiting devices operating between 200 and 600 volts AC, and the secondary protector employs other components that can be affected by the fault, a voltage value just below the breakdown point of the overvoltage device is to be used. When the secondary protector contains current interrupting devices operating below 2.2 amperes, a current value just below the interrupting point of such device is to be used. This test is to be conducted for a minimum of 30 minutes. The test may be ended when during the trial it can be verified that the sample has mechanically disconnected the test current as described for Test L3.

e) Test L5 – This test is to be conducted using 24 amperes at 240 volts for a minimum of 30 minutes. The test may be ended when during the trial it can be verified that the sample has mechanically disconnected the test current as described for Test L3.

Figure 27.1

Longitudinal voltage test



[a] Test fuse – see 27.2.3.

27.1.6 As indicated in 27.1.1, the samples are to be subjected to various conditionings and to the Breakdown Voltage Measurement Test, Section 25. These conditionings are to be as follows:

a) Hydrogen-Sulfide (H_2S) Conditioning – Representative samples are to be placed in a circulating-air chamber containing a hydrogen-sulfide atmosphere with air saturated with water vapor at room temperature. When the protector is intended for indoor use only, the percent concentration is to be 0.1 percent of the total volume of the test chamber. When the protector is intended for indoor and outdoor use, the concentration is to be 1.0 percent. The samples are to be subjected to this exposure for 10 days.

b) Carbon Dioxide-Sulfur Dioxide (CO_2-SO_2) Conditioning – Representative samples are to be placed in a circulating-air chamber containing a carbon dioxide and sulfur dioxide atmosphere with air saturated with water vapor at room temperature. When the protector is intended for indoor use only, the percent concentration is to be 0.5 percent of the total volume of the test chamber for sulfur dioxide and 1.0 percent of total volume for carbon dioxide. When the protector is intended for indoor and outdoor use, both concentrations are to be 1.0 percent. The samples are to be subjected to this exposure for 10 days.

c) Salt Spray Conditioning – The salt spray conditioning only applies to protectors intended for outdoor use. The apparatus for salt-spray (fog) testing is to consist of a fog chamber having inside dimensions of 1.22 by 0.76 by 0.91 m (48 by 30 by 36 inches); a salt-solution reservoir; a supply of suitably conditioned compressed air; one or more atomizing nozzles; and a dispersion tower constructed in accordance with the Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117, for producing a salt fog. The apparatus is also to include sample supports, provision for heating the chamber, and the required means of control. The samples are to be subjected to this exposure for 10 days.

d) Humidity Conditioning – Representative samples are to be placed in a humidity chamber for 3 hours. When the protector is intended for indoor use only, the samples are to be subjected to a relative humidity of 85 percent at 30 ±2°C (86 ±3°F). When the protector is intended for indoor and outdoor use, the relative humidity is to be 95 percent at 30 ±2°C.

e) Heating and Cooling Conditioning – Representative samples are to be subjected to 50 cycles of heating and cooling where each cycle consists of exposure to minus 34.5°C (minus 30°F) for 15 minutes followed by exposure to 67°C (152°F) for 15 minutes.

27.2 Test method

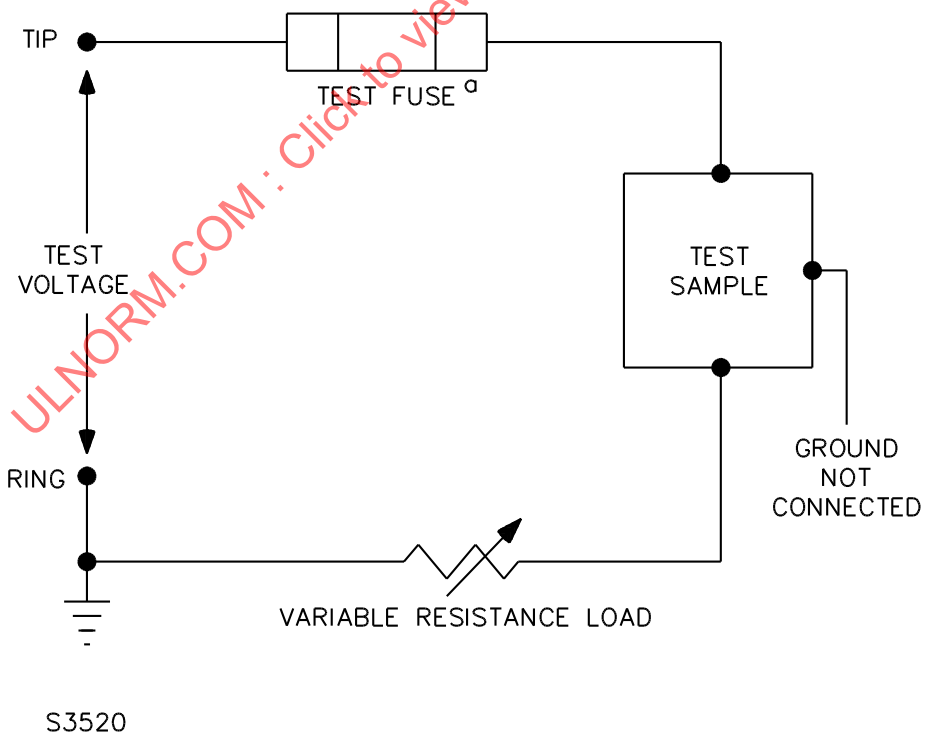
27.2.1 When the secondary protector employs tip-to-ring overvoltage protection or other electronic circuitry that connects between the tip and ring lines of the telephone loop circuit, Tests L1 – L4 are to be repeated using different samples and the metallic voltage test apparatus shown in Figure 27.2.

Exception No. 1: The metallic voltage test is not required to be conducted when the tip-to-ring overvoltage protection device and the current limiting is the same type device that is tested in the longitudinal voltage test specified in Figure 27.1.

Exception No. 2: The metallic voltage test is not required to be conducted when the secondary protector when subjected to breakdown voltage measurement and impulse voltage measurements is found to break down at higher than 1000 volts.

Figure 27.2

Metallic voltage test



[a] Test fuse – see 27.2.3.

27.2.2 A secondary protector that consists of series connected components located in either tip or ring lines and located at the output, user, or equipment side of the secondary protector is also to be tested metallically (Figure 27.2) with its output terminals (terminal equipment connections) both open-circuited and short-circuited. The current and voltage parameters are to be as specified in 27.1.5(c).

27.2.3 Two different types of test fusing elements, Figure 27.3 and Figure 27.4, are to be used in the evaluation of a secondary protector. When the secondary protector can be used in a circuit employing RJ11 type jacks or plugs or tinsel cord wire or the equivalent, the test fuse element used is to be a Type MDQ 1-6/10 ampere fuse by Bussmann Mfg. Co. or equivalent. The test fuse is to be replaced with a suitable resistor and oscilloscope to measure the resistor voltage and the conduction time. The resulting value of I^2t shall not be greater than 50.

Figure 27.3

MDQ 1-6/10 ampere fuse with typical fuseholder

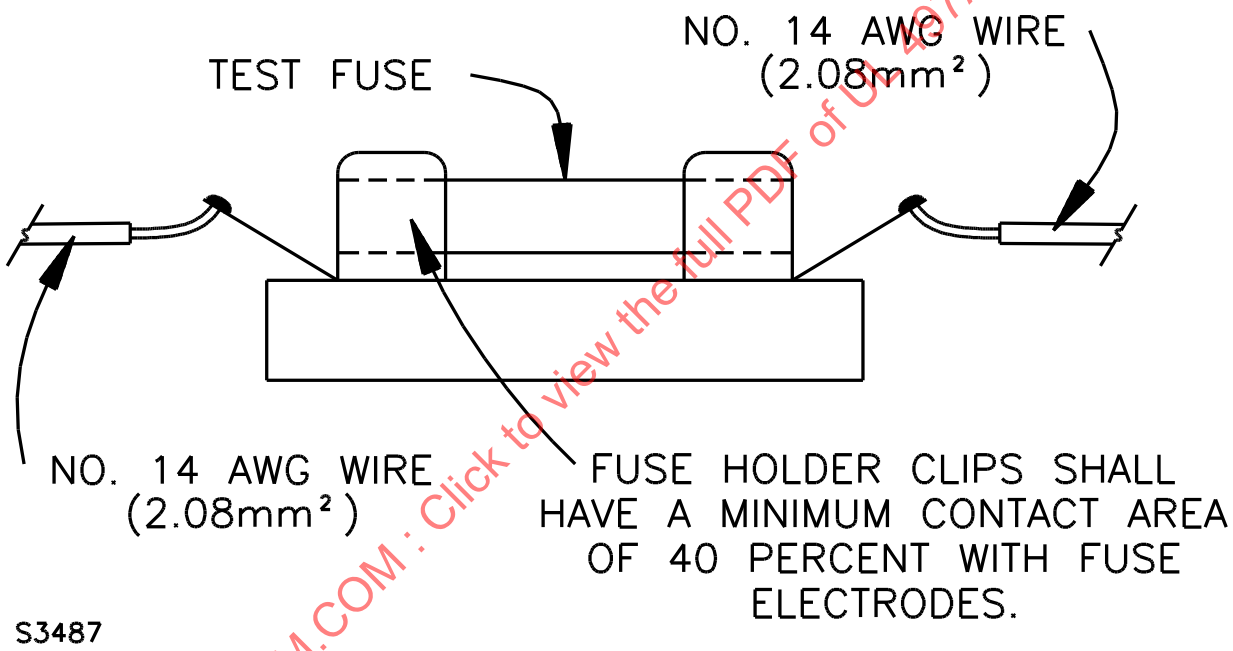
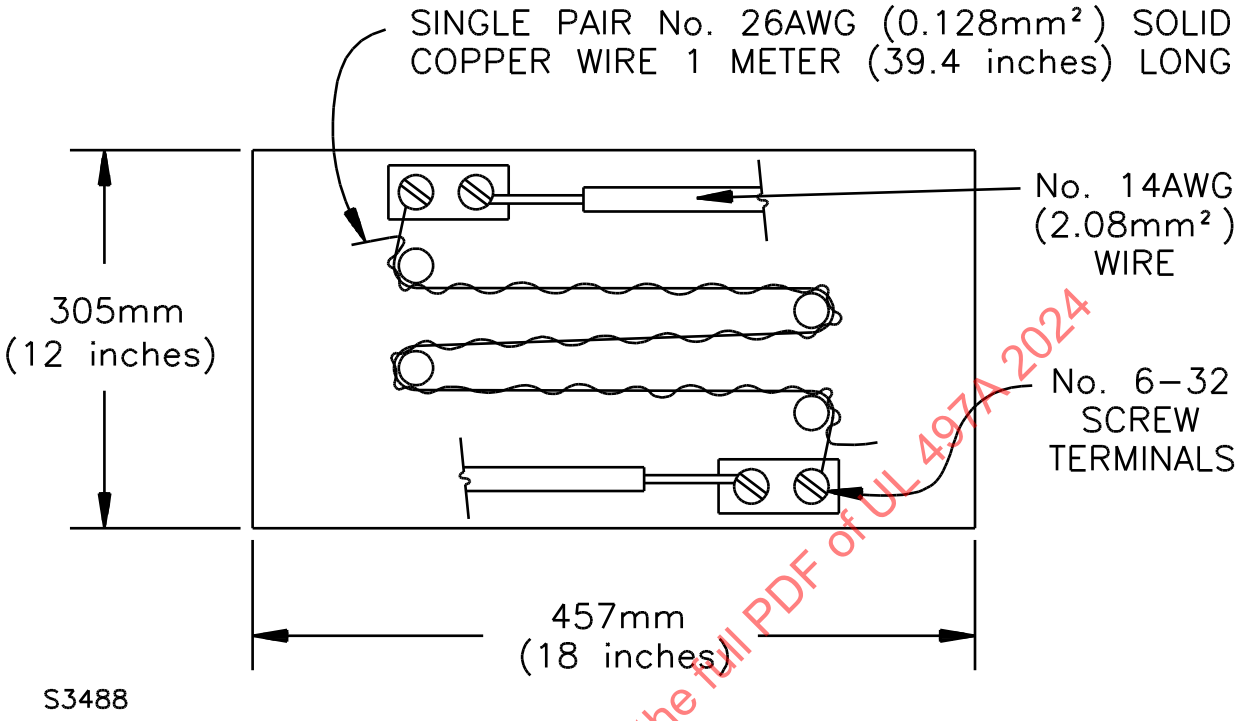


Figure 27.4

No. 26 AWG fuse wire test



27.2.4 When a secondary protector is intended to employ a direct cable system that connects from the primary-input side of the secondary protector, the test fuse of Figure 27.3 is to be replaced with the No. 26 AWG (0.13 mm^2) solid copper fuse wire shown in Figure 27.4. When testing is to be conducted using the No. 26 AWG solid copper fuse wire, the manufacturer shall provide an installation drawing and instructions in accordance with 44.3.

27.2.5 During each test trial, the sample is to be covered with a single layer of cheesecloth and visually monitored by the test operator for indication of a risk of fire as would be indicated by the charring or burning of the cheesecloth or the emission of molten metal or flame from any part of the test circuit including the test sample. Each trial is to be conducted with an unused fuse element. When conducting the test with the No. 26 AWG (0.13 mm^2) solid copper fuse wire described in 27.2.4, the fuse wire shall also be covered with a single layer of cheesecloth.

28 Endurance Conditioning

28.1 A secondary protector shall comply with the requirements of the Breakdown Voltage Measurement Test, Section 25; the Impulse Voltage Measurement Test, Section 26; and the Dielectric Voltage-Withstand Test, Section 35, after being subjected to 100 pulses as described in 28.2. The overcurrent protection component shall not open during this test.

28.2 Three samples are to be mounted, each in a position of intended use, and subjected to 50 surges of the following current waveform: short circuit peak current – 14 amperes, waveform – 10/1000 microseconds. Each pulse is to be applied at a rate of 1 pulse every 10 seconds. The 50 pulses are then to be repeated, except using opposite polarity.

29 Component Temperature Test

29.1 The materials used in the construction of a secondary protector shall not be adversely affected by the temperatures attained under any condition of the intended operation.

29.2 A material will be considered as being adversely affected when it is subjected to a temperature rise greater than that indicated in Table 29.1 during this test.

Table 29.1
Maximum temperature rises

Device or material	Normal standby, °C	Normal standby, (°F)	Ring condition, °C	Ring condition, (°F)
A. COMPONENTS				
1. Capacitors[a]	25	45	40	72
2. Fuses	25	45	25	45
3. Rectifiers – at any point				
a) Germanium	25	45	50	90
b) Selenium	25	45	50	90
c)Silicon	25	45	75	135
4. Relays, transformers, and other coils with:				
a) Class 105 insulated windings[b]				
Thermocouple method	65	117	65	117
Resistance method	75	135	75	135
b) Class 130 insulated windings[b]				
Thermocouple method	85	153	85	153
Resistance method	95	171	95	171
5. Resistors[c]				
a) Carbon	25	45	25	45
b) Wire wound	50	90	325	585
6. Sealing compounds	See note (f)			
7. Solid-state devices	See note (a) or (d)			
B. INSULATED CONDUCTORS[e]				
1. Appliance wiring material (AWM)	25°C (45°F) less than the established temperature rating of the wire			
2. Flexible cord – Types SJD, SJT	35	63	35	63
C. ELECTRICAL INSULATION – GENERAL				
1. Fiber used as electrical insulation or cord bushings	25	45	65	117
2. Phenolic composition used as electric insulation or as a part whose deterioration will result in a risk of fire or electric shock	25	45	125	225
3. Printed-circuit boards	Based on maximum use temperature rating of printed-circuit board			
D. GENERAL				
1. Mounting surfaces	25	45	65	117
2. Wood or other combustible material	25	45	65	117

Table 29.1 Continued on Next Page

Table 29.1 Continued

Device or material	Normal standby, °C	Normal standby, (°F)	Ring condition, °C	Ring condition, (°F)
3. Enclosure surfaces	40	72	40	72

[a] In lieu of complying with these temperature limits, these components may be evaluated in accordance with the appropriate sections of the parts stress derating method, Level 3, in the Reliability Engineer's Toolkit, April 1993, Rome Laboratory.

[b] See 29.3 for types of materials used for electrical insulation.

[c] In lieu of complying with these temperature limits, a resistor is considered capable of being used when it dissipates not more than one-half of its maximum power rating under the test conditions specified.

[d] The temperature of a solid-state device (that is, transistor, SCR, integrated circuit) shall not exceed 50 percent of its rating during the normal standby condition. The temperature of a solid-state device shall not exceed 75 percent of its rated temperature under the alarm condition or any other condition of operation that produces the maximum temperature dissipation of its components. For reference purposes 0°C (32°F) shall be considered as 0 percent. For integrated circuits the loading factor shall not exceed 50 percent of its rating under the normal standby condition and 75 percent under any other condition of operation. Both solid-state devices and integrated circuits may be operated up to the maximum ratings under any one of the following conditions:

1) The component complies with the requirements in MIL-STD.883C.

2) A quality control program is established by the manufacturer consisting of inspection and test of 100 percent of all components, either on an individual basis, as part of a subassembly, or equivalent.

3) Each assembled production unit is subjected to a burn-in test, under the condition that results in the maximum temperatures, for 24 hours while connected to a source of rated voltage and frequency in an ambient of at least 49°C (120°F) followed by an operation test for normal signaling performance.

[e] For standard insulated conductors other than those specified, reference should be made to the National Electrical Code, NFPA 70, the maximum allowable temperature rise in any case is 25°C (45°F) less than the temperature limit of the wire in question.

[f] Unless a thermosetting material, the maximum sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined by the Standard Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

29.3 The classes of material used for electrical insulation referred to Table 29.1 include materials as follows:

a) Class 105 – Impregnated cotton, paper, and similar organic materials when impregnated, and film coatings as applied to coil windings.

b) Class 130 – Inorganic materials, such as mica.

29.4 The temperature of a component exceeding that indicated in Table 29.1 is not prohibited from being reached when reliability data is provided by the manufacturer to justify its use.

29.5 Temperature rises are based on an assumed ambient temperature of 25°C (77°F). When a product is intended specifically for use with a prevailing ambient temperature constantly more than 25°C, the product is to be tested using the higher ambient temperature, and the allowable temperature rises specified in Table 29.1 are to be reduced by the amount of the difference between that higher ambient temperature and 25°C.

29.6 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 5-minute intervals, indicate no change.

29.7 Table 29.1 indicates two operating conditions; these are identified as "normal standby" and "ring". During the "normal standby" condition, the simulated telephone circuit employing the protector is to be energized at 56.5 volts DC until constant temperatures of the unit under test are recorded. During the "ring" condition, the telephone circuit is to be energized at 100 milliamperes, 150 volts AC, 60 hertz ring

frequency adjusted for a ring duty cycle of 25 percent (1 second) over every 4 seconds. The repetitive ring cycle is to be maintained for 15 minutes.

29.8 Temperature measurements on equipment intended for recessed mounting shall be made with the unit installed in an enclosure made on 19.1 mm (3/4 inch) thick wood having clearances of 50.8 mm (2 inches) on the top, sides and rear, and the front extended to be flush with the control unit cover.

29.9 Regarding coils, temperatures are to be measured by thermocouples consisting of wires not larger than No. 24 AWG (0.21 mm^2) or by the change-in-resistance method. The thermocouple method is not to be used for a temperature measurement where supplementary thermal insulation is employed.

29.10 Thermocouples consisting of No. 30 AWG (0.06 mm^2) iron and constantan wires and a potentiometer-type indicating instrument are to be used whenever referee temperature measurements by thermocouples are required.

29.11 The temperature of a copper coil winding is determined by the change-in-resistance method, wherein the resistance of the winding at the temperature to be determined is compared with the resistance at a known temperature by means of the formula:

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

in which:

T is the temperature to be determined in degrees C;

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

r is the resistance in ohms at the known temperature; and

t is the known temperature in degrees C.

29.12 As it is required to deenergize the winding before measuring R, the value of R at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time may be plotted and extrapolated to give the value of R at shutdown.

29.13 The circuit of a current-regulating resistor or reactor provided as a part of a control unit is to be adjusted for the maximum resistance or reactance at normal current.

29.14 The duration of the test is to be not less than:

a) Operation until constant temperatures are attained during the normal DC voltage (56.5 volts DC) condition.

b) Operation for 1 hour during the normal ring cycle of a telephone loop circuit. The ring voltage shall be adjusted to 200 volts peak to ground, 60 hertz, 1 second ring – 2 seconds off for each ring cycle.

30 Drop Test

30.1 A product intended to be mounted atop a desk or shelf and not secured in place by mechanical means shall show no signs of excessive damage that results in exposure of live parts and shall not produce a risk of electric shock when subjected to the tests specified in 30.2 and 30.3.

30.2 Three "as-received" samples of the assembly are to be subjected to a total of nine drops (three series each) from a height of 0.91 m (3 feet) onto a hardwood surface. The test is to be conducted so that for each drop, the sample strikes the surface in a different position.

30.3 Upon completion of the test specified in 30.2, the samples shall comply with the applicable requirements in the Breakdown Voltage Measurement Test, Section 25, Impulse Voltage Measurement Test, Section 26, and the Dielectric Voltage-Withstand Tests, Section 35.

31 Impact Test

31.1 Products intended to be fixed in place by a mechanical means or plugged into place such as an AC wall receptacle shall show no signs of excessive damage that results in exposure of live parts and shall not produce a risk of electric shock when subjected to the tests specified in 31.2 and 31.3.

31.2 Three "as-received" samples of the assembly are to be used for this test. Each test sample is to be held in a fixed position. A smooth steel sphere, 50.8 mm (2 inches) in diameter and weighing 0.54 kg (1.18 pound) is to be allowed to fall from rest through a distance of 1.31 m (51-3/4 inches) as required to cause the sphere to strike the sample with an impact of 6.8 J (5 foot-pounds).

31.3 Upon completion of the test specified in 31.2, the samples shall then comply with the applicable Breakdown Voltage Measurement Test, Section 25, the Impulse Voltage Measurement Test, Section 26, and the Dielectric Voltage-Withstand Test, Section 35.

32 Crush Test

32.1 Products that may be located a horizontal work plane of 762 mm (30 inches) or may rest upon the floor shall show no signs of excessive damage that results in exposure of live parts and shall not produce a risk of electric shock when subjected to the tests specified in 35.2 and 35.3.

32.2 Three "as received" samples of the assembly are to be used for this test. The sample is to be tested between two parallel, flat, maple blocks, each not less than 12.7 mm (1/2 inch) thick. A steady crushing force of 334 N (75 lbf) is to be applied at right angles to the surface of the test sample for a period of 1 minute. The crushing force is to be applied gradually in a direction normal to the sample surface.

32.3 Upon completion of the test specified in 32.2, the sample shall comply with the applicable requirements in the Breakdown Voltage Measurement Test, Section 25, the Impulse Voltage Measurement Test, Section 26, and the Dielectric Voltage-Withstand Test, Section 35.

33 Strain Relief Test

33.1 A cord splice lead shall not pull out of the plug, connector or jack of the secondary protector to the extent that bare conductors are exposed when subjected to the tests specified in 33.2. When the assembly is otherwise damaged and still operational, it shall comply with the applicable requirements in the Dielectric Voltage-Withstand Test, Section 35, after this test.

33.2 The secondary protector is to be mounted in accordance with the manufacturer's installation instructions, with the cord hanging in a vertical position. A force of 50 N (11.25 lbf) is to be gradually applied to the cord. The direction of application of the force is to be varied from directly downward to an angle of 45 degrees from the vertical in all directions. The force is to be applied for a period of 1 minute in each direction.

33.3 When the strain relief means utilizes a plastic part, the test shall be repeated on an "as-received" sample after oven aging for 7 days at 70°C (158°F).

34 Leakage Current Test

34.1 When the open circuit potential is greater than 42.4 volts peak as measured between any accessible part and earth ground or any other accessible part, the leakage current at any accessible part shall not be more than the following values when tested in accordance with 34.2 – 34.7.

a) 0.5 milliampere for an ungrounded product operating from rated voltage not exceeding 200 volts peak to ground (141.4 volts rms).

b) 5.0 milliamperes for an ungrounded product operating at a maximum fault voltage of 600 volts rms. Also refer to the requirement in 8.4(b).

34.2 With reference to the requirements of 34.1, leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of the equipment and ground, or between exposed conductive surfaces of the equipment.

34.3 Leakage currents from all exposed surfaces are to be measured to the grounded supply conductor individually as well as collectively where exposed surfaces are simultaneously accessible, and from one exposed surface to another where the exposed surfaces are simultaneously accessible. A part is considered to be an exposed surface unless it is guarded by an enclosure considered to reduce the risk of electric shock.

34.4 Surfaces that can be readily contacted by one or both hands of a person at the same time are considered to be simultaneously accessible. For the purpose of these requirements, one hand is considered to be able to contact parts simultaneously when the parts are within a 102 by 203 mm (4 by 8 inch) rectangle; and two hands of a person are considered to be able to contact parts simultaneously when the parts are not more than 1.8 m (6 feet) apart.

34.5 When all accessible surfaces are bonded together and connected to the grounding conductor of the system, the leakage current may be measured between the grounding conductor and the grounded supply conductor.

34.6 When a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil having dimensions 10 by 20 cm (3.9 by 7.9 inches) in contact with the surface. When the surface is less than 10 by 20 cm, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the product.

34.7 The measurement circuit for the leakage current test is to be as shown in Figure 34.1. The measurement instrument is defined in (a) – (c). The meter used for a measurement need only indicate the same numerical value for the particular measurement as would the defined instrument; it need not have all of the attributes of the defined instrument.

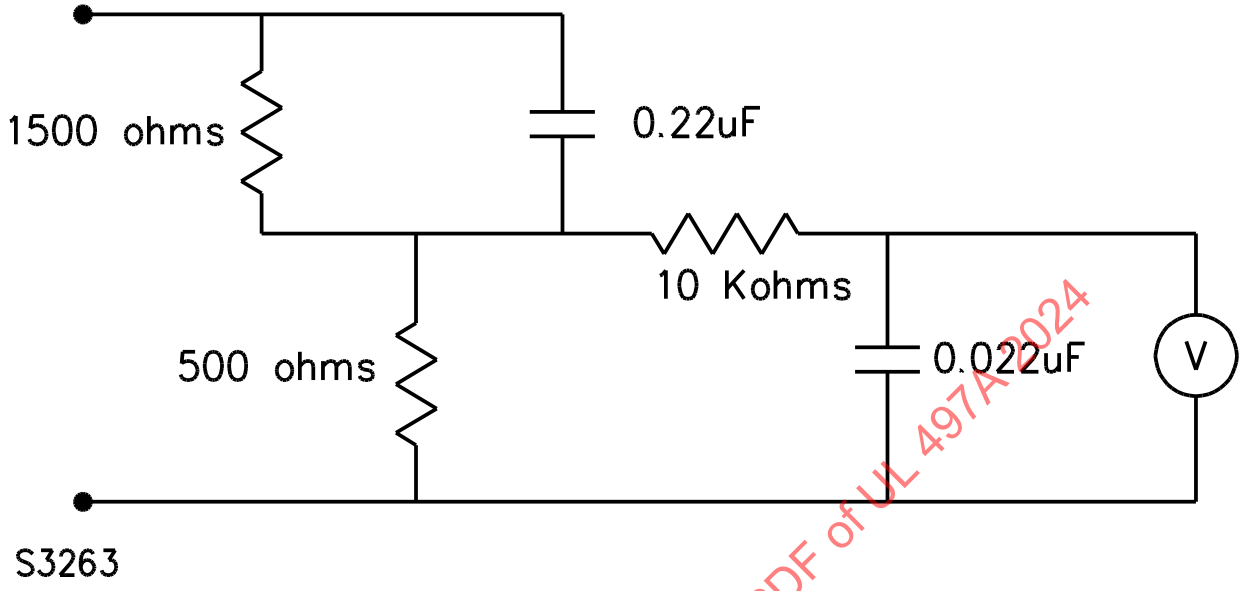
a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.22 microfarad.

b) The meter is to indicate 1.11 times the average of the full-wave rectified waveform of the voltage across the resistor or current through the 500-ohm resistor.

c) Over a frequency range of 0 – 100 kilohertz the measurement circuitry is to have a frequency response (ratio of indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.22 microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milliampere, the measurement is to have an error of not more than 5 percent at 60 hertz.

Figure 34.1

Leakage current measurement circuit



34.8 Unless the meter is being used to measure leakage current from one part of a product to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

35 Dielectric Voltage-Withstand Test

35.1 A secondary protector shall withstand for one minute, without breakdown, the application of an essentially sinusoidal AC potential of a frequency within the range of 40 – 70 hertz, or a DC potential, between live parts and the enclosure; live parts and exposed dead-metal parts; and live parts of circuits operating at different potentials or frequencies. The test potential shall be (also, see 35.3):

a) For a unit rated 30 volts AC rms (42.2 volts DC or AC peak) or less – 500 volts (707 volts, when a DC potential is used).

b) For a unit rated between 31 and 150 volts AC rms – 1000 volts (1414 volts, when a DC potential is used).

35.2 Exposed dead-metal parts are determined to be noncurrent-carrying parts that will become energized and accessible from outside of the enclosure of a control unit during operation with the door of the enclosure closed.

35.3 For the application of a potential between live parts of circuits operating at different potentials or frequencies, the voltage is to be the applicable value specified in 35.1(a) or (b), based on the highest voltage of the circuits under test instead of the rated voltage of the unit. Electrical connections between the circuits shall be disconnected before the test potential is applied. When a DC dielectric potential is used, the polarity of the applied test voltage shall be applied opposite to the normal operating voltage polarity.

35.4 When the charging current through a capacitor or capacitor type filter connected across the line, or from line to earth ground, is sufficient to prevent maintenance of the specified AC test potential, the capacitor or filter shall be tested using a DC test potential in accordance with 35.1.

35.5 The test potential may be obtained from any convenient source having sufficient capacity to maintain the specified voltage. The output voltage of the test apparatus is to be monitored. Starting at zero, the potential is to be increased at a rate of 200 volts per minute until the required test value is reached and is to be held at that value for 1 minute. Voltage breakdown occurs when the high voltage test equipment experiences a current flow between the test points greater than 0.5 milliampere.

35.6 A printed wiring assembly or other electronic circuit component that would be damaged by the application of, or would short-circuit the test potential, is to be removed, disconnected, or otherwise rendered inoperative before the test. A representative subassembly may be tested instead of an entire unit.

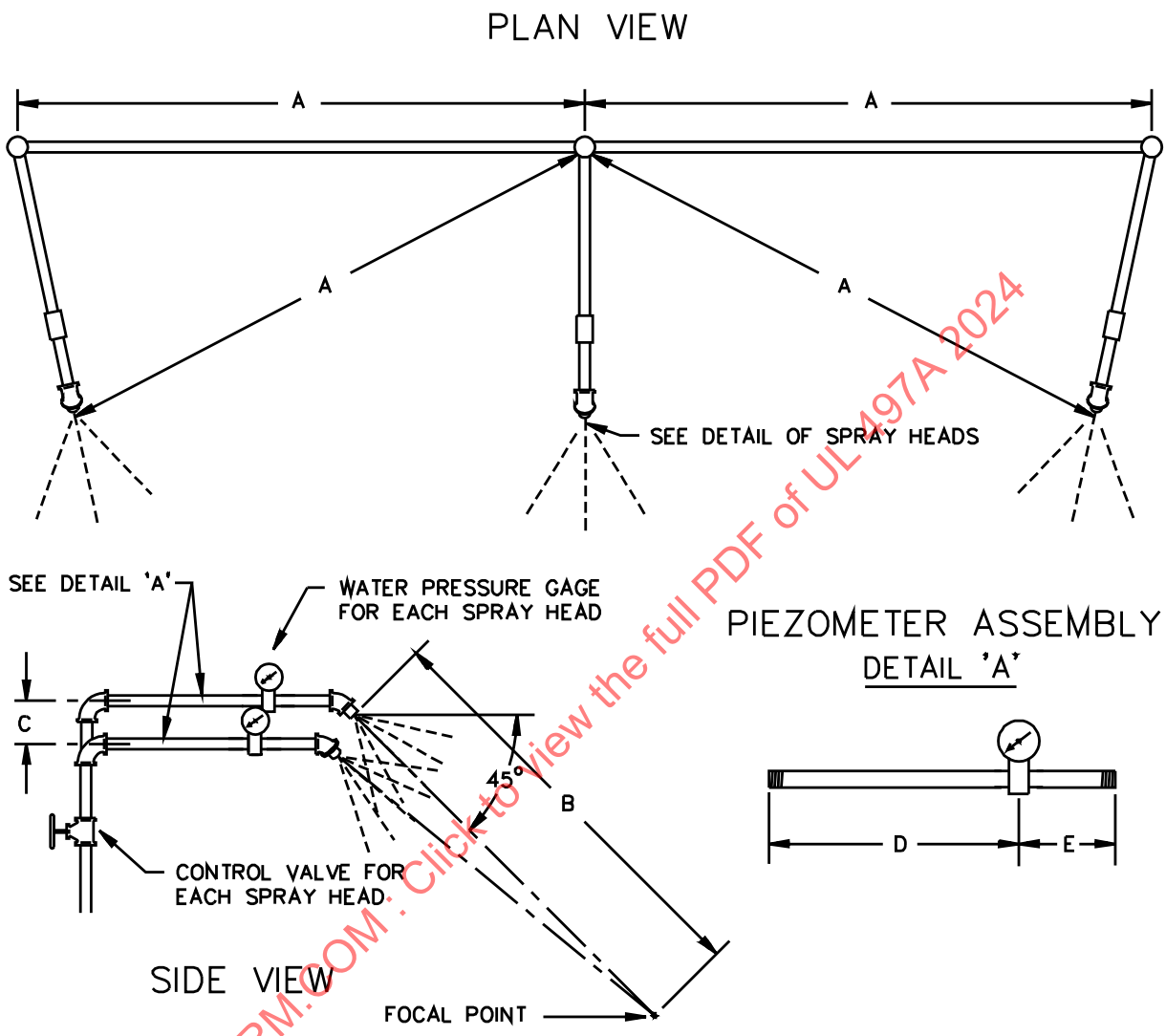
36 Rain Test

36.1 Secondary protectors intended for outdoor use shall be subjected to a rain exposure without wetting of electrical parts.

36.2 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure 36.1. Spray heads are to be constructed in accordance with the details shown in Figure 36.2. The water pressure for all tests is to be maintained at 5 psi (34 kPa) at each spray head. The distance between the center nozzle and the unit is to be 1.5 m (5 feet). The unit is to be brought into the focal area of the three spray heads in such a position and under such conditions that the greatest quantity of water will enter the unit while mounted on a vertical surface in a position of normal use. The cover is to be secured as intended. The spray is to be directed at an angle of 45 degrees to the vertical toward the unit or openings closest to current-carrying parts. The total exposure is to be for 1 hour. One sample is to be subjected to this test.

Figure 36.1

Rain test spray-head piping

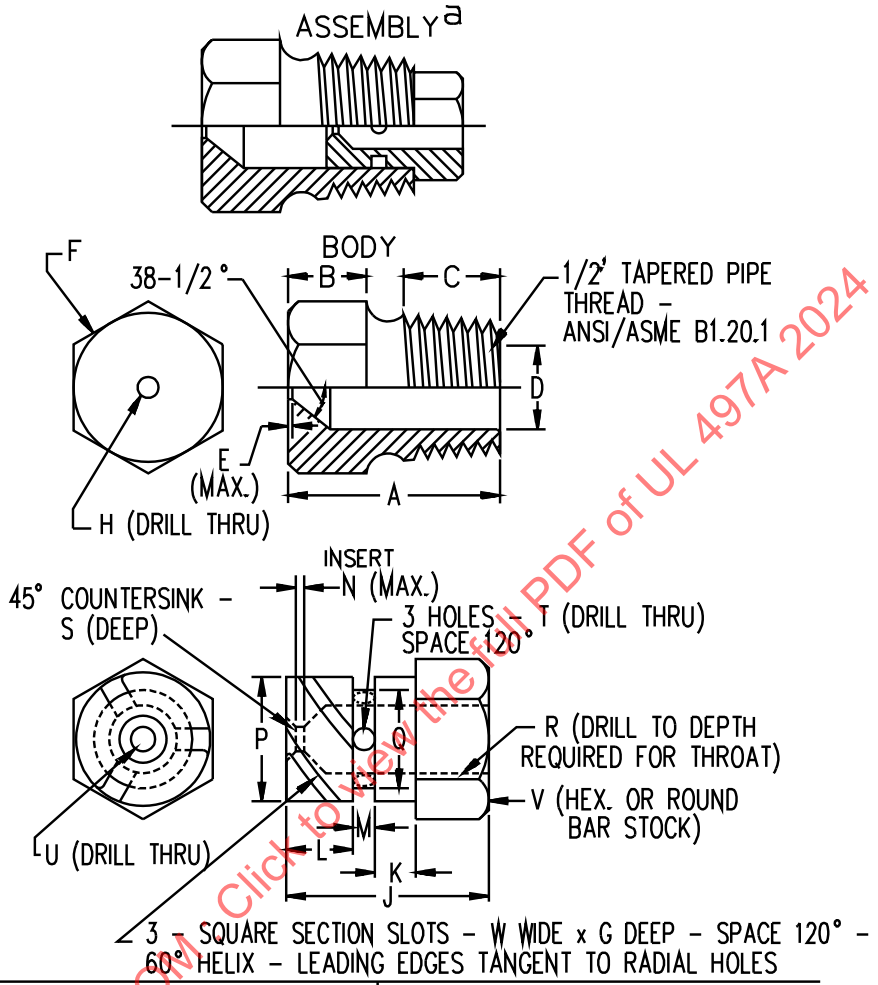


Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

RT101E

Figure 36.2

Rain test spray head



Item	inch	mm	Item	inch	mm
A	1 7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.80
H	(No.9)[b]	5.0	U	(No. 40)[b]	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

[b] ANSI B94.11M Drill Size

[c] Optional - To serve as a wrench grip.

RT100E

36.3 Following exposure, the outside of the sample is to be carefully wiped clear of water, the cover removed, and a visual examination made to determine when any water has entered and wetted current-carrying parts.

37 Maximum Moment Measurement Test

37.1 Secondary protectors intended to be plugged into an AC power wall receptacle shall comply with the requirements in 37.2 and 37.3. The actual moment of a plug-in protector shall not exceed the maximum calculated moment described in 37.2.

37.2 The weight of a plug-in type secondary protector (less the connecting telephone cord) is to be measured in ounces using a weight scale. The maximum allowable moment is to be determined by the following equation:

$$\text{Maximum Moment} = \frac{(18 - weight)}{2}$$

37.3 To determine the moment of a cordless secondary protector, the center of gravity of each sample is to be found experimentally and the actual moment calculated from the following equation:

$$\text{Moment} = D \times W$$

in which:

D is in inches for the dimension from front of secondary protector to center of gravity and

W is the weight in ounces of the secondary protector.

38 Weatherometer and Micro Tensile Strength Test

38.1 Secondary protectors intended for outdoor use and employing polymeric enclosures or covers shall show no visible signs of deterioration, such as crazing or cracking; and the tensile strength and ultimate elongation of specimens shall not be less than 65 percent of the corresponding properties of as-received samples, after exposure to ultraviolet light for 720 hours with intermittent water spray.

38.2 Five enclosure specimens are to be prepared in the same manner as specified in the Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension, ASTM D412, except for the 25.4 mm (1 inch) apart marks (for rubber specimens), which are to be placed on the specimens after the exposure to ultraviolet light. The five specimens are to be exposed to ultraviolet light from two enclosed carbon arcs formed between vertical electrodes, 12.7 mm (1/2 inch) in diameter, located at the center of a revolvable vertical metal cylinder 787 mm (31 inches) in diameter and 45 mm (17-3/4 inches) high. The cover specimens are to be mounted vertically on the inside of the cylinder in the ultraviolet light apparatus, with the width of the specimens facing the arcs, and held so that they do not touch one another. The arcs are to operate with 15 – 17 amperes, and the potential across the arcs is to be 120 – 145 volts AC. The arcs are to be enclosed by clear globes of heat-resistant glass.

38.3 The cylinder is to be rotated about the arcs at one revolution per minute, and a system of nozzles is to be provided so that each sample, in turn, is sprayed with water as the cylinder revolves. The temperature within the cylinder while the apparatus is in operation is to be 60°C (140°F).

38.4 During each 20-minute operating cycle of the apparatus, the cover specimens are to be exposed to light from the carbon arcs for 17 minutes and to water spray with light for 3 minutes. The test is to be continued until the samples have been exposed to ultraviolet light for a total of 612 hours, and to ultraviolet light and water for a total of 108 hours.

38.5 Three measurements for thickness are to be made in the constricted portion of the specimens using a dial micrometer graduated to 0.02 mm (0.001 inch) which exerts a load by means of an 85 gram weight. This load is applied through a round, flat contact for 6.35 ±0.25 mm (0.25 ±0.01 inch) in diameter, and amounts to a pressure of 26.2 kPa (3.8 psi) for this contact area. The minimum value obtained is to be used as the thickness of the specimen in calculating the tensile strength.

38.6 Two bench marks 25.4 mm (1 inch) apart are to be stamped centrally on the constricted portion of each specimen.

38.7 The elongation is to be measured by means of a scale or other device which is to be used in such a way as not to touch the specimen and is to be capable of indicating the elongation with an accuracy of 2.5 mm (0.1 inch).

38.8 When a dumbbell test specimen breaks outside the bench marks, or when the result of either tensile strength or elongation is below the requirements, an additional specimen shall be tested, the results of which shall be considered final. Results of tests of specimens which break in the curved portion just outside the bench marks may be accepted when within the minimum requirements.

39 Thermal Aging and Flame Test

39.1 Polymeric materials that have not already been investigated for 5V flame class shall comply with the requirements of this section. There shall be no warping of a polymeric material used to enclose, support, or indirectly support current-carrying or live parts, or impairment of the integrity of a cover as a water seal, when three representative samples are aged for 7 days in a circulating-air oven maintained at 70°C (158°F). Covers subjected to this test are to be installed as intended on the product. Following this exposure, representative samples shall comply with the requirements for the applicable flame class indicated in 7.1 and in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

40 Electric Shock Current Test

40.1 When the open-circuit potential between any part that is exposed only during user servicing and either earth ground or any other exposed accessible part exceeds 42.4 volts peak, the part shall comply with the requirements in 40.2 – 40.4, as applicable.

40.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 40.1 when the resistor is connected between any part that is exposed only during user servicing and either earth ground or any other exposed accessible part.

Table 40.1
Maximum current during user servicing

Frequency, hertz[a]	Maximum current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6

Table 40.1 Continued on Next Page

Table 40.1 Continued

Frequency, hertz[a]	Maximum current through a 500-ohm resistor, milliamperes peak
5000	22.0
6000	25.1
7000 or more	27.5

[a] Linear interpolation between adjacent values may be used to determine the maximum current corresponding to frequencies not shown. The table applies to repetitive nonsinusoidal or sinusoidal waveforms.

40.3 The duration of a transient current flowing through a 500-ohm resistor connected as described in 40.2 shall not exceed either of the following:

a) The value determined by the following equation:

$$T \leq \left(\frac{20\sqrt{2}}{I} \right)^{1.43}$$

in which:

T is the interval (in seconds) between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time; and

I is the peak current in milliamperes.

b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds when the current is repetitive. Typical calculated values of maximum rated transient current duration are shown in Table 40.2.

Table 40.2
Maximum transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.26 seconds
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	919 milliseconds
40.0	609
50.0	443

Table 40.2 Continued on Next Page

Table 40.2 Continued

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
60.0	341
70.0	274
80.0	226
90.0	191
100.0	164
150.0	92
200.0	61
250.0	44
300.0	34
350.0	27
400.0	23
450.0	19
500.0	16
600.0	12
700.0	10
809.0	8.3

40.4 The maximum capacitance between the terminals of a capacitor that is accessible during user servicing shall comply with the following equations:

$$C = \frac{88{,}400}{E^{1.43}(In\,E - 1.26)} \quad for\, 42.4 \le E \le 400$$

$$C = 35{,}288E^{-1.5364} \quad for\, 400 \le E \le 1000$$

in which:

C is the maximum capacitance of the capacitor in microfarads and

E is the potential in volts across the capacitor prior to discharge.

E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or the like. Typical calculated values of maximum capacitance are shown in Table 40.3.

Table 40.3
Electric shock – stored energy

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
1000	0.868
900	1.02
800	1.22

Table 40.3 Continued on Next Page

Table 40.3 Continued

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.6
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.0
45	150.0
42.4	169.0

40.5 With reference to the requirements in 40.2 and 40.3, the current is to be measured while the resistor is connected between ground and each accessible part individually, and all accessible parts collectively, when the parts are simultaneously accessible. The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, when the parts are simultaneously accessible.

40.6 With reference to the requirements in 40.5, parts are considered to be simultaneously accessible when they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is to be considered to be able to contact parts simultaneously when the parts are within a 102 by 203 mm (4 by 8 inch) rectangle; and two hands of a person are considered to be able to contact parts simultaneously when the parts are not more than 1.8 m (6 feet) apart.

40.7 Electric shock current refers to all currents, including capacitively coupled currents.

40.8 When the product has a direct-current rating, measurements are to be made with the product connected in turn to each side of a 3-wire, direct-current supply circuit.