UL 1492

STANDARD FOR SAFETY

Audio-Video Products and Accessories

UL Standard for Safety for Audio-Video Products and Accessories, UL 1492

Second Edition, Dated April 30, 1996

Summary of Topics

This revision to UL 1492 dated May 17, 2019 is being issued to add UL 62368-1 as an alternative to UL 60950-1 in paragraph 1.7.

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated March 8, 2019.

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UL 1492

Audio-Video Products and Accessories

Prior to the first edition, the requirements for the products covered by this standard were included in the Standard for Radio Receivers, Audio Systems, and Accessories, UL 1270; Low-Voltage Video Products Without Cathode-Ray-Tube Displays, UL 1409; and Television Receivers and High-Voltage Video Products, UL 1410. Prior to these standards, the requirements were included in UL 492.

First Edition – August, 1992

Second Edition

April 30, 1996

This UL Standard for Safety consists of the Second Edition including revisions through May 17, 2019.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover audio and video products intended for use on supply circuits in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements, where applicable, cover:

a) Audio products and accessories intended for household use and involved with the reproduction or processing of audio signals. Examples of such products include amateur radio products, amplifiers, intercommunicating devices, phonographs, radio clocks, radio-phonographs, radio receivers, record players, tape players, tape recorders, transceivers, tuners, tuner-amplifiers, and similar products.

b) Video products that are intended for household or commercial use, and that receive signals in ways such as off the air, through a CAT/MATV cable system, from a video-recorded medium, or from image-producing units. Examples of such products are video tape recorders; video-receiving, -processing, -recording, -producing, and -amplification products; television-antenna amplifiers; cable television (CAT) converters; television tuners; television receivers and monitors; television cameras; and similar products.

c) Auxiliary products and accessories intended for use with audio or video products wherein the auxiliary and accessory products are separate and do not perform the desired function, but are used in addition to or as a supplement to products according to (a) and (b). Examples of such products include character generators, editing controllers, video switches and encoders, CRT degaussers, video tape rewinders, head demagnetizers, tape erasers, and similar products.

d) Video products intended for entertainment purposes in ordinary locations of health-care facilities.

e) Cellular telephones and similar transceiving devices used on a vehicle, boat, or the like where the telephone interconnects to the telephone network through a radio transmitter and receiver.

f) Portable audio or video products of the types described in (a) – (c) and (e) that are intended for use with a marine or any other battery circuit as the power supply means.

1.3 Battery chargers and power supplies, whether portable or for permanent installation and not packaged with or specifically referenced in literature packaged with a product but intended for use with audio or video products, are categorized as battery chargers or power supplies and are not covered by these requirements.

1.4 These requirements do not cover products that are covered by the Standard for Commercial Audio Equipment, UL 813.

1.5 Audio or video products intended for use by children are covered by these requirements, but shall also comply with the applicable requirements in the Standard for Electric Toys, UL 696.

1.6 Video products intended for use at mercantile and banking premises to provide a means of recording holdup attempts or similar activities in the area shall also comply with the applicable requirements in the Standard for Surveillance Camera Units, UL 983.

1.7 Circuits in audio or video products intended to connect directly to a telecommunication network shall comply with the applicable requirements in 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.

1.8 A separately enclosed non-powered loudspeaker that is not intended for connection to a specific audio amplifying source shall comply with the requirements in the Electronic Industries Association (EIA) Interim Standard IS-33, Recommended Loudspeaker Safety Practices – An Industry Guideline, dated May 1987.

1.9 Deleted

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 Undated references

2.2.1 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 ACCESSIBLE PART – A part located so it can be contacted by a person, either directly or by means of the probe (see Figure 18.1 and 3.43) or a tool (see 18.4.1), or not recessed the required distance behind an opening (see 18.1.2).

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3.3 ADJUSTABLE CONTROL – A control provided for making adjustments necessary to render the product capable of performing its intended functions.

3.4 BARRIER – A part, usually an added part, that is required to comply with requirements involving accessibility, spacings, risk of fire, and the like.

3.5 BRANCH CIRCUIT – A branch circuit is that portion of the building wiring system beyond the final overcurrent device on the power-distribution panel protecting the circuit to the field-wiring terminals in a permanently connected unit or to the receptacle outlet for a cord-connected unit.

3.6 CART – A stand, as defined in 3.45, that is provided with casters, wheels, or rollers to make it mobile.

3.7 CASTER – Any roller or swiveled wheel attached to a stand or product that makes the stand or product mobile.

3.8 CHILD'S PRODUCT – A child's product is one that is decorated or specially constructed (pictures, color, or shape) so as to appeal to children or is advertised (on the product or shipping carton or in advertising literature) by the organization responsible for the product as being intended for use by children.

3.8A COIN/BUTTON CELL BATTERY – A small, single cell battery having a diameter greater than its height.

3.9 COMMERCIAL PRODUCT – A product intended for use in a commercial establishment such as a hotel, a motel, a house of worship, a school, or a business.

3.10 CONDITIONED LAMP – A lamp that has been operated for a minimum of 100 hours.

3.11 CONTAINED ATMOSPHERIC ENERGY (CAE) – The amount of energy resulting from the gas contained within a lamp. The CAE is calculated as follows:

$$CAE = 0.15 (PC - PE) V$$

in which:

PC is the contained pressure in atmospheres,

PE is the external pressure in atmospheres, and

V is the volume in cubic centimeters.

3.12 DEACTIVATED LAMP – A lamp end-of-life failure mode that is caused by the depletion of the filament emission material so that the lamp gasses cannot be ionized. A deactivated lamp may be simulated as follows:

a) For a rapid-start lamp, two lamps are utilized, each with one end connected to one of the lampholders, the other end open-circuited and

b) For an instant-start lamp using a circuit-interrupting lampholder, the lamp is removed and the circuit-interrupting lampholder terminals are short-circuited.

3.13 EXPOSED PART – A part that is subject to handling in normal use. Exposed parts include a phonograph pick-up arm and connections; antenna leads and terminals; grounding leads and terminals; metal parts on the back, top, sides, or front of the overall enclosure; and parts at or near operating controls.

3.14 FIBER – Where the term ″fiber″ is used in this standard to denote a material usually used as electrical insulation, vulcanized fiber is meant. Cellulose fiberboard, pressboard, fullerboard, or cardboard shall not be used in lieu of fiber. Fishpaper is a designation commonly used in the trade to refer to thin sheets of electrical grade vulcanized fiber.

3.15 FIELD-WIRING TERMINAL – Any terminal to which a supply or other wire can be connected by an installer in the field is a field-wiring terminal.

3.16 FLOOR-MOUNTED (CONSOLE) PRODUCT – A product that is intended to be used and supported on a floor one surface, generally the back, intended to be positioned adjacent to a wall or corner.

3.17 GROUND – Earth ground, unless otherwise specified.

3.18 HAZARD – The term hazard used alone is intended to be interchangeable with the phrase ″risk of fire, electric shock, or injury to persons.″ If used otherwise, it is intended to be interchangeable with the phrase ″risk of.″ For example, the phrases ″fire hazard″ and ″risk of fire″ are intended to be interchangeable.

3.19 HAZARDOUS ENERGY CIRCUITRY – Circuitry capable of:

a) Producing a voltage exceeding 42.4 V peak (21.2 V peak for an outdoor-use appliance and where wet contact is likely to occur) or

b) Delivering more than 15 W into an external resistor, as determined by the methods described in the Power Supply Tests, Section 77.

3.20 HEALTH-CARE FACILITY PRODUCT – product intended for entertainment purposes for use in a hospital, a nursing home, a medical-care center, or a similar health-care facility in which installation is limited to a nonhazardous area in accordance with the National Electrical Code, ANSI/NFPA 70. It is not intended for use in a critical-care area in which a patient may be treated with an externalized electrical conductor, such as a probe, a catheter, or other electrode, connected to the heart; however, the product is likely to be contacted by a patient during his stay in a health-care facility.

3.21 HIGH-PRESSURE LAMP – A lamp in which the contained atmospheric energy (CAE) equals or exceeds 5 Joules cold (de-energized 50°C or less). See 3.11 and 3.32.

3.22 HIGH-VOLTAGE PART – Any part that operates continuously at or above 2500 volts peak.

3.23 HIGH-VOLTAGE PRODUCT – A product that incorporates high-voltage parts.

3.24 HOUSEHOLD PRODUCT – A product intended for use in the home.

3.25 INSTANT-START LAMP CIRCUIT – A circuit that uses a high open-circuit voltage to start lamps that usually have a single contact at each end.

3.26 INTERLOCK – A mechanism that de-energizes parts involving a risk of electric shock or injury to persons before they become accessible to the user when the enclosure of the part is opened or a cover is removed.

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3.27 IN-WALL MOUNTED PRODUCT – A product that appears intended for in-wall mounting, has provisions for mounting ears or flanges, or is provided with in-the-wall mounting instructions. The product would be placed inside a wall cavity with some part of the product located behind the plane of the wall.

3.28 ISOLATING TRANSFORMER – A device containing two or more coils of insulated wire that transfers alternating-current energy by electromagnetic induction from one winding to another. The coil connected to the supply circuit is referred to as the primary. Any coil isolated from the primary is referred to as a secondary winding. The primary and secondary windings are not conductively connected and therefore the transformer provides electrical isolation of the secondary circuit or circuits from the primary circuit.

3.29 LAMP COMPARTMENT – A compartment that encloses a projection lamp. The housing may be metallic or polymeric, and include a glass diffuser or lens, a metal canopy, a screen, or the like.

3.30 LINE CONNECTED OR DIRECT CONNECTED – Generally used to mean that there is no electrical isolation (such as by an isolating power transformer) between any of the circuits of the product and the branch circuit supplying electrical energy to the product.

3.31 MAJOR ENCLOSURE PART – A part that:

a) Forms more than 50 percent of the area of any surface of an enclosure, such as the front, back, top, bottom, or either side and

b) Is needed to comply with the requirements to reduce the risk of fire, electric shock, or injury to persons, or to reduce the likelihood of mechanical damage to internal parts.

For the purpose of this definition, the surface area of a part is considered to be the surface area encompassed by the perimeter of the part, including the area composed of holes, perforations, and deletions within the boundaries of the part. If an enclosure surface is formed by separate sections, those sections that perform the same enclosure function are to be considered together; and both the evaluation of the part and the computation of the surface area are to be based on the composite surface. See Figure 3.1.

3.32 MEDIUM PRESSURE LAMP – A lamp in which the contained atmosphere energy (CAE) is greater than 0.5 Joule and less than 5 Joules. See 3.11 and 3.21.

3.33 MINOR DIMENSION OF OPENING – The diameter of the largest sphere that can pass through the opening.

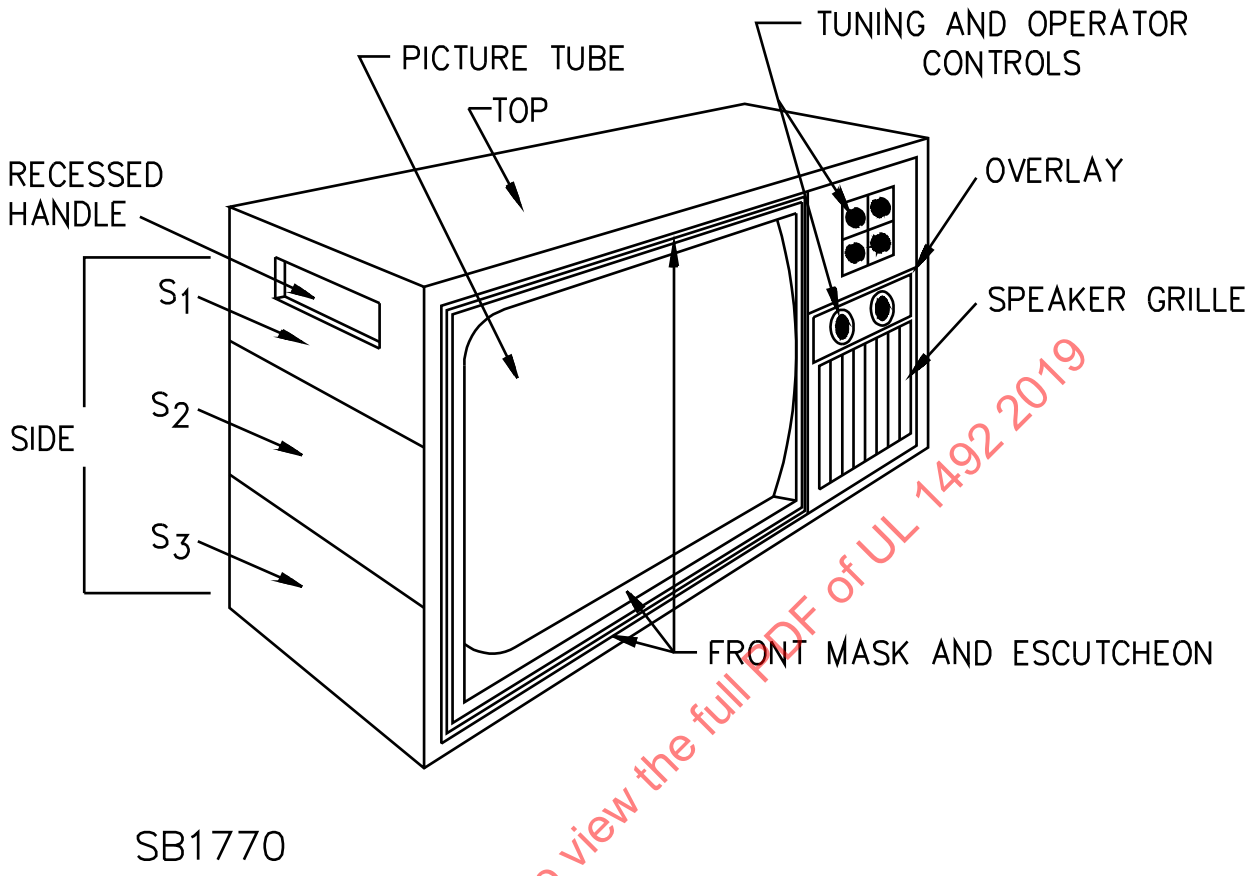
3.34 OPERATING CONTROL – A control, usually a knob, a pushbutton, or a lever, provided to enable the user to cause the product to perform its intended function, without the use of tools, when the product is in normal operating condition.

3.35 ORDINARY TOOLS – Flat-blade and cross-head screwdrivers, nut drivers, and pliers.

3.36 OUTDOOR LOCATION – An unprotected location exposed to weather.

3.37 PICTURE TUBE SIZE, DETERMINATION OF – The maximum dimensions of the bulb of the tube determine the tube diagonal, diameter, or equivalent area.

Figure 3.1
Examples of some major enclosure parts



MAJOR ENCLOSURE PARTS:

a) TOP – The top surface is a single continuous piece of material comprising 100 percent of the surface and is considered to be a required part of the enclosure. Therefore, it is a major enclosure part.

b) FRONT – The front surface is composed of several parts and materials, including the front mask and escutcheon, the tuning and operator controls, the speaker grille, the picture tube, and an overlay around the tuning and operator controls. The tuning and operator controls, overlay, and speaker grille are not major enclosure parts, even though they are required parts of the enclosure, because they do not form more than 50 percent of the front surface. The surface area is computed for each part individually because they do not perform the same enclosure function. The front mask and escutcheon is a major enclosure part because when computing the surface area encompassed by the perimeter of the part – including the area composed of openings for the picture tube, the tuning and operator controls, and the speaker grille– the resulting area comprises more than 50 percent of the front surface.

c) SIDE – The side surface is composed of several parts and materials, including the recessed handle and three panels (S_1, S_2, and S_3). The recessed handle is not a major enclosure part, even though it is a required part of the enclosure, because it does not form more than 50 percent of the side surface. The panels S_1, S_2, and S_3 are major enclosure parts, even though each panel by itself does not form more than 50 percent of the side surface, because the three parts perform the same enclosure function, and when taken together, they form more than 50 percent of the side surface.

3.38 PORTABLE HIGH-VOLTAGE PRODUCT – A high-voltage product that complies with one or more of the following:

a) It can be operated from self-contained batteries and is provided with a carrying handle or similar carrying means and has a mass less than or equal to 9 kilograms,

b) It can be operated from self-contained batteries and has no carrying handles or other similar carrying means and has a mass less than or equal to 1 kilogram when weighed without batteries, and

c) Any high voltage product that can be operated from self-contained batteries and might be held in one hand during any phase of normal operation regardless of mass.

3.39 PORTABLE PRODUCT – A product, other than a high-voltage product (see 3.38), that complies with one or more of the following:

a) It is provided with a carrying handle or similar carrying means and has a mass less than or equal to 18 kilograms.

Exception: Rack-mounted product handles are not considered to be carrying handles

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b) It has no carrying handles or other similar carrying means and has a mass less than or equal to 1 kilogram when weighed without batteries and is likely to be moved frequently.

c) Any product that might be held in one hand during any phase of normal operation regardless of mass.

Exception: Lightweight products such as preamplifiers, tuners, tape decks, decoders, or noise reduction units that depend upon connection to other products to be functional and by virtue of this are not frequently moved from one location to another are not considered to be portable.

3.40 POWER-SUPPLY CORD – The cord provided to connect the product to the supply circuit.

3.41 PREHEAT LAMP CIRCUIT – A lamp connected in series with a reactance ballast and the combination in parallel with a manual or automatic starter.

3.42 PRINTED-WIRING ASSEMBLY – A printed-wiring board on which separate components have been added.

3.43 PROBE – An instrument used to determine accessibility of a live part. See Figure 18.1.

3.44 RAPID-START LAMP CIRCUIT – A circuit using continuously heated lamp filaments, along with an open-circuit voltage for the ballast to start the lamp without a starter.

3.45 STAND – A structure intended to support a product.

3.46 SUPPLY CIRCUIT – The branch circuit supplying electrical energy to the product.

3.47 TABLE-TOP PRODUCT – A product that is intended to be used and supported on a table, a bench, a shelf, and the like, or mounted in a product rack. If provided with carrying handles or other similar carrying means, its mass is more than 9 kilograms for high voltage products or 18 kilograms for other than high voltage products; if no carrying handles or other similar carrying means are provided, its mass is more than 1 kilogram. Also includes products exempted in 3.38(a), 3.38(b), 3.39(a), and 3.39(b).

3.48 UNDERCABINET PRODUCT – A product intended to be secured to the bottom surface of a cabinet mounted over a countertop.

3.49 UNRELIABLE COMPONENT – Any rectifier, vacuum tube, transistor, electrolytic capacitor, integrated circuit (both true and hybrid), or similar electrical or electronic component.

3.50 USER-SERVICING – The replacing, cleaning, adjusting, and similar maintenance operations intended to be accomplished by the user. See User-Servicing, Section 15.

3.51 WET LOCATION – In direct contact with earth ground, and locations subject to saturation with water.

CONSTRUCTION

ALL PRODUCTS

4 General

4.1 The requirements in this Section apply to all products within the scope of this standard. They are supplemented by requirements in separate Sections that apply to a specific product.

4.2 The construction of the product shall be such that the product complies with each of the following:

a) The operation and user-servicing of the product does not result in a risk of fire, electric shock, or injury to persons;

b) The materials and components are used within their electrical, mechanical, and temperature limits; and

c) The assembly protects the components and wiring from being displaced or damaged.

4.3 The materials, components, and wiring referred to in 4.2 and elsewhere in this standard are to be those involving a risk of fire, electric shock, or injury to persons unless specifically indicated otherwise.

5 Combination Units

5.1 An audio or video product (such as a tuner, tape deck, phonograph, video camera, or the like) used as an integral part of a high voltage product is considered a combination unit and shall comply with all of the requirements for high voltage products.

Exception: An audio or video product used with a high-voltage product as part of a combination unit need only comply with the requirements for that particular product, if the combination complies with both of the following items:

a) The high-voltage product and the audio or video product are located in separate compartments of the combination unit and

b) The barrier or barriers that form the high-voltage product compartment are formed of a material and contain openings that comply with the requirements for a high-voltage product enclosure when judged as if the other compartments did not exist.

6 Double Insulated Products

6.1 A product that complies with the requirements in the Reference Standard for Double Insulation Systems for Use in Electronic Equipment, UL 2097, as well as the applicable requirements in this standard, may be marked in accordance with 127.12.1 and 127.12.2.

7 Undercabinet Products

7.1 In addition to the applicable requirements in this standard, an undercabinet product shall comply with all of the following:

a) It shall be provided with a power-supply cord in accordance with Table 24.1;

b) It shall comply with the enclosure impact tests described in Table 98.1;

c) It shall comply with the Temperature Test, Section 68, when mounted in accordance with 104.2 and 104.3;

d) It shall comply with the Undercabinet Elevated Ambient Test, Section 105;

e) It shall comply with the Undercabinet Increased Moisture Test, Section 106; and

f) It shall comply with the Undercabinet Mounting Security Test, Section 107.

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7.2 An undercabinet product shall be provided with all the necessary hardware for mounting the product using ordinary tools in accordance with the manufacturer's installation and operation instructions specified in Installation, Operation, and Other Instructions, Section 130. These installation and operation instructions are to be used to set-up the undercabinet product for the tests specified in 7.1.

7.3 An undercabinet product shall be provided with means for routing the power-supply cord and with cord storage or a means so that excess cord does not hang down.

8 Outdoor-Use and Wet-Location Products

8.1 A product intended for outdoor use or for use in wet locations shall:

a) Be provided with a Type SJ or heavier service power-supply cord, or a type determined to be equivalent, rated for outdoor use;

b) Be grounded as described in Grounding, Grounding Impedance, and Continuity, Section 28, or double-insulated as described in the Reference Standard for Double-Insulation Systems for Use in Electronic Equipment, UL 2097;

c) Withstand the Outdoor-Use Wetting Test, Section 103; and

d) Withstand the ultraviolet light exposure test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: Products not intended for outdoor use need not withstand the ultraviolet light exposure test described in UL 746C.

8.2 A product is considered to be intended for outdoor use or for use in wet locations if it complies with one or more of the following:

a) It is provided with a means (handles, wheels, rollers, or similar manipulatory devices) making it transportable;

b) Its mass is less than 35 kilograms;

c) It can be operated from a battery; and

d) The product-manufacturer's literature (instruction manual, use-and-care information, advertising or promotional material, or packaging) indicates or implies outdoor or wet location use of the product when connected to an AC source of supply.

Exception: A product as described in 8.2(a), 8.2(b), or 8.2(c) that is marked as specified in 128.3.1 (Outdoor use or wet location warning marking) is not intended for outdoor use or for use in wet locations.

8.3 A product that is connected to primary circuit power and is intended to be permanently installed and operated in an outdoor location shall comply with 8.1 (a) and (b) and employ an enclosure that complies with the requirements for Type 3 enclosures in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

9 Multiple-Supply-Circuit-Voltage Products

9.1 A product using a supply-circuit voltage selector shall be tested in accordance with the Multiple-Voltage Product Test, Section 80, without resulting in a risk of fire or electric shock. The product shall be provided with instructions and marked in accordance with 127.10.1 – 127.11.2.

9.2 A product that can be set to different rated supply-circuit voltages shall be constructed so that the indication of voltage to which the product is set is externally visible and preferably in the area adjacent to the rating information. See 127.11.1.

9.3 If the product is provided with more than one voltage-setting device or selector, it shall be made clear as to how all devices or selectors are to be set. See 127.11.2.

9.4 The construction of the supply-circuit voltage selector shall be such that the supply-circuit voltage setting cannot be unintentionally changed.

9.5 If the product is constructed so that the supply-circuit voltage selector setting can be changed by the user, the action of changing the voltage selector setting shall also change the supply-circuit voltage indication.

10 In-Wall Mounted Product

10.1 An in-wall mounted product shall be investigated for its suitability for the purpose and shall be provided with installation instructions in accordance with 130.6.1.

Exception: A product that by construction appears to be intended for in-wall mounting but that is not evaluated for the application shall be marked in accordance with 127.14.1 and need not comply with this requirement

10.2 An in-wall mounted product shall be provided with means for permanent connection to the primary circuit power in accordance with Supply Connections – Permanently Connected Products, Section 25.

11 Fire

11.1 A risk of fire is considered to exist if the open-circuit voltage between any two points in a circuit is equal to or greater than 2500 volts peak or if power of more than 15 watts can be delivered into an external resistor connected between the two points. See the Power Supply Tests, Section 77.

12 Electric Shock

12.1 Product leakage current

12.1.1 The leakage current at any accessible part shall not be more than 0.5 milliampere when tested in accordance with 67.1.1 – 67.2.3 if the open-circuit potential between the accessible part and earth ground or any other accessible part is more than 42.4 volts peak for an indoor product or where wet contact is not likely to occur and 21.2 volts peak for an outdoor product or where wet contact is likely to occur.

12.2 Electric shock during user-servicing

12.2.1 General

12.2.1.1 The risk of electric shock is considered to exist at any part exposed only during user-servicing if:

a) The open-circuit potential between the part and earth ground or any other simultaneously accessible parts (see 67.1.2) exceeds the value specified in Table 12.1 and

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b) Any one or more of the following conditions exist:

1) A continuous current flow through a 500-ohm resistor exceeds the limits specified in Table 12.2,

2) A combination of magnitude and duration of peak current flow through a 500-ohm resistor exceeds the limits specified in 12.2.2.1, and

3) A combination of capacitance and voltage exceeds the limits specified in 12.2.3.1 or 12.2.3.2.

12.2.2 Transient

12.2.2.1 The duration of a transient current– unidirectional or alternating – through a 500-ohm resistor, connected between any part exposed only during user-servicing and earth ground or any other accessible part, shall satisfy the following equation:

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

in which:

T is the duration, measured in seconds, from the time that the instantaneous value of the current first exceeds 7.1 milliamperes until the time that the current falls below 7.1 milliamperes and remains so for at least 1 second (typical calculated values appear in Table 12.3) and

I is the peak current in milliamperes– this current shall not exceed 809 milliamperes regardless of duration.

12.2.3 Stored-energy

12.2.3.1 The capacitance between capacitor terminals that are accessible during user-servicing shall satisfy the following:

$$C \leq \frac{88{,}400}{E^{1.43}(\ln E - 1.26)} \quad \textit{for E less than or equal to 400 volts}$$

$$C \leq 35{,}288E^{-1.5364} \text{ for E greater than 400 volts}$$

in which:

C is the 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 accessible by the removal or opening of an interlocked cover, or the like. Typical calculated values are shown in Table 12.4.

12.2.3.2 A part involving a potential of more than 40 kilovolts peak is to be investigated to determine whether or not it involves a risk of electric shock.

12.2.3.3 The blades of an attachment plug are considered to be accessible parts that may result in the discharge of a capacitor when short-circuited.

Table 12.1
Maximum voltages

Wave form		Fundamental frequency, hertz		Maximum volts[a]	
				Wet contact likely to occur,	
Alternating voltage, direct voltage, and combinations of both	**Polarity reversal**	**Greater than**	**But not greater than**	**no[b]**	**yes**
Where the change in instantaneous voltage for all durations equal to 5 percent of the period of the fundamental frequency of the wave form is not more than 20 volts for dry locations and 10 volts for wet locations[c]	Where the instantaneous voltage does not reverse in polarity	Any	Any	60 volts peak	30 volts peak
	Where the instantaneous voltage does reverse in polarity	Any	Any	60 volts peak and 84.8 volts peak-to-peak[d]	30 volts peak and 42.4 volts peak-to-peak[d]

Table 12.1 Continued on Next Page

Table 12.1 Continued

Wave form		Fundamental frequency, hertz		Maximum volts[a] Wet contact likely to occur,	
Alternating voltage, direct voltage, and combinations of both	Polarity reversal	Greater than	But not greater than	no[b]	yes
Where the change in instantaneous voltage for any duration equal to 5 percent of the period of the fundamental frequency of the wave form is greater than 20 volts for dry locations and 10 volts for wet locations[c]	Where the instantaneous voltage does not reverse in polarity	0	3	60 peak	30 peak
		3	4	55 peak	27.5 peak
		4	5	50 peak	25 peak
		5	6	45 peak	22.5 peak
		6	7	40 peak	20 peak
		7	8	35 peak	17.5 peak
		8	9	30 peak	15 peak
		9	10	25 peak	12.5 peak
		10	200	24.8 peak	12.4 peak
		200	300	26 peak	13 peak
		300	400	28 peak	14 peak
		400	500	31 peak	15.5 peak
		500	600	34 peak	17 peak
		600	700	37 peak	18.5 peak
		700	800	41 peak	20.5 peak
		800	900	46 peak	23 peak
		900	1000	51 peak	25.5 peak
		1000	1400	56 peak	28 peak
		1400	e	60 peak	30 peak

[a] The maximum output voltage regardless of load shall be measured with the input voltage applied per Table 63.1.

[b] Wet contact not likely to occur generally refers to indoor or sheltered locations that are not normally associated with water or other liquids

[c] The change in instantaneous voltage at any 5 percent of the period of the fundamental frequency of the wave form shall be determined by taking any 18-degree segment along the wave form and determining the change in instantaneous voltage in that segment. See Figure 12.1.

[d] For a sinusoidal wave, 84.8 volts peak-to-peak equals 30 volts rms.

[e] No upper limit.

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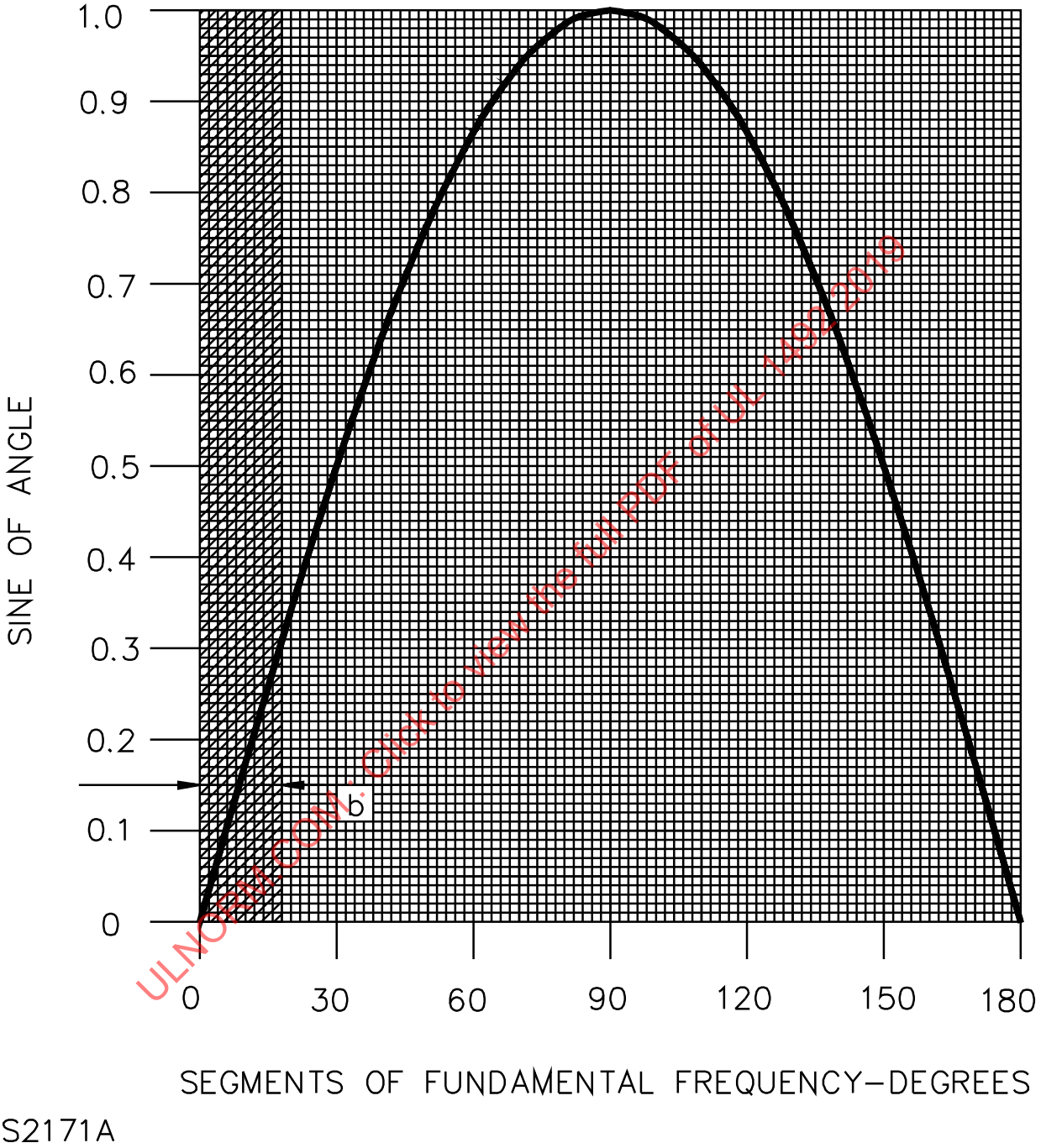
Figure 12.1
Sine wave[a]



[a]Values of the sine for angles from 0 – 180 degrees.

[b] Eighteen-degree (5 percent) segment if started at zero.

Table 12.2
Maximum current during user-servicing

Alternating voltage, direct voltage, and combinations of both	Fundamental frequency, hertz[a]		Maximum current in milliamperes through a 500-ohm resistor	
	Greater than	But not greater than	Where the instantaneous voltage does not reverse in polarity, peak	Where the instantaneous current does not reverse in polarity, peak-to-peak
Where the change in instantaneous voltage for all durations equal to 5 percent of the period of the fundamental frequency of the wave form is not more than 3.3 milliamperes	0	100	14.2	14.2
	100	500	18.8	18.8
	500	1000	22.0	22.0
	1000	2000	28.2	28.2
	2000	3000	34.6	34.6
	3000	4000	39.2	39.2
	4000	5000	044.0	44.0
	5000	6000	50.2	50.2
	6000	b	55.0	55.0
Where the change in instantaneous voltage for all durations equal to 5 percent of the period of the fundamental frequency of the wave form is more than 3.3 milliamperes	0	3	10.0	No values determined
	3	4	9.2	
	4	5	8.3	
	5	6	7.5	
	6	7	6.7	
	7	8	5.8	
	8	9	5.0	
	9	10	4.2	
	10	200	4.1	
	200	300	4.3	
	300	400	4.7	
	400	500	5.2	
	500	600	5.7	
	600	700	6.2	
	700	800	6.8	
	800	900	7.7	
	900	1000	8.5	
	1000	1400	9.3	
	1400	b	10.0	

[a] Straight line interpolation between adjacent values in the table shall be used to determine the maximum current values corresponding to frequencies not shown in the table.

[b] No upper limit.

Table 12.3
Electric shock transient

Maximum current in milliamperes peak through 500-ohm resistor	Maximum time in seconds of envelope containing excursions greater than 7.1 milliamperes peak
Less than 7.1	Not applicable
7.1	7.22
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
40.0	0.609
50.0	0.443
60.0	0.341
70.0	0.274
80.0	0.226
90.0	0.191
100.0	0.164
150.00	0.092
200.0	0.061
250.0	0.044
300.0	0.034
350.0	0.027
400.0	0.023
450.0	0.019
500.0	0.016
600.0	0.012
700.0	0.010
809.0	0.0083
Greater than 809.0	Not acceptable – see 12.2.2.1

Table 12.4
Electric shock – stored energy

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
40,000	0.0030
35,000	0.0037
30,000	0.0047
25,000	0.0062
20,000	0.0087
15,000	0.0135
10,000	0.0252
7,000	0.0437
5,000	0.0732
4,000	0.103
3,000	0.160
2,500	0.212
2,000	0.299
1,500	0.465
1,250	0.616
1,000	.0868
900	1.02
800	1.22
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

Table 12.4 Continued on Next Page

Table 12.4 Continued

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
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
45	150
42.4	169[a]
40	186[a]
35	239[a]
30	319[a]
25	452[a]
21.2	625[a]
Less than 21.2	Any[a]

[a] Any value is acceptable for indoor use. These values are only for outdoor-use or where wet contact is likely to occur.

13 Injury to Persons

13.1 General

13.1.1 A risk of injury to persons is considered to exist if one or more of the following conditions are present:

a) Power-operated moving parts, such as gears and linkages, are accessible during normal operation. See 13.2.1;

b) Sharp edges, burrs, or projections are present that can cause injury to persons during user assembly, operation of the product, or user-servicing. See the Sharp Edge Test, Section 97; and

c) The product, or the product on a cart or stand used with it, is unstable. See the Injury to Persons Tests, Section 96.

13.2 Power-operated moving parts

13.2.1 In applying the requirement in 13.1.1, accessibility of power-operated moving parts such as gears and linkages is to be judged using the articulated probe illustrated in Figure 18.1. The accessibility requirements are to be applied after the installation or assembly of parts provided by the manufacturer has been completed in accordance with the instructions provided by the manufacturer. The requirement does not apply to:

a) A pick-up arm assembly, turntable, or similar part on the top surface of a record changer or player;

b) A tape reel or tape drive mechanism that must be exposed for normal use. However, gears and linkages are to be judged for accessibility if the construction permits those parts to move with a tape reel, cartridge, or cassette removed from its operating position; or

c) Gears and linkages that are accessible only after lifting a side or corner of a spring-mounted motor (changer chassis) board. Accessibility to power-operated moving parts is to be judged with a record changer or a similar device in its normal playing position. Spring-mounted, suspended, or similarly mounted motor boards are to be held captive so they cannot be easily removed or lifted out from the mounting surface.

13.3 Carts

13.3.1 With regard to 13.1.1(c), a cart that has a shelf that is more than 1 m above the floor and that is intended for use in schools, institutions, health-care facilities, or like locations where children are likely to move the cart, shall comply with the Standard for Tall Institutional Carts for Use with Audio-, Video-, and Television-Type Equipment, UL 1667.

14 Product and Accessory Assembly

14.1 User-mechanical assembly (addition of legs, casters, decorative parts, and the like) of a product or accessory shall be such that all of the following requirements are met:

a) Assembly shall require one or more of the following:

1) No tools,

2) Only ordinary tools. See 3.35, and

3) Tools supplied with the assembly by the manufacturer

b) All parts required shall be provided.

c) Assembly instructions shall be provided. See Installation, Operation, and Other Instructions, Section 130.

d) Assembly instructions shall not cause the user to commit an act that in itself might result in a risk of fire, electric shock, or injury to persons.

14.2 Products or accessories intended to be installed by qualified service personnel need not comply with 14.1 (a) and (d). Such products or accessories shall be provided with the marking described in 130.1.3 and the installation instructions required in 130.1.1.

15 User-Servicing

15.1 User-servicing includes:

a) Replacement of a battery.

Exception No. 1: A battery that is intended to be and is soldered in place is not considered to be user-serviceable.

Exception No. 2: A battery intended to energize a memory circuit, or other similar use, when the product is not connected to a nominal 120- or 240-V supply circuit and that is not intended to be serviced by the user, identified on the outside of the product, or mentioned in the instruction manual or other user literature as being a part to be serviced by the user is not considered to be user-serviceable.

b) Replacement of a fuse or vacuum tube.

Exception No. 1: A fuse or vacuum tube that is intended to be and is soldered in place is not considered to be user-serviceable.

Exception No. 2: A fuse or vacuum tube that is not readily perceptible by the user is not considered to be user-serviceable. A fuse or vacuum tube is not readily perceptible if it is located within a chassis, compartment, or enclosure within the overall product. If the enclosure has a cover, it shall be one that does not need to be opened or removed in the operation or user-servicing of the product, can be opened or removed only with a tool, and cannot be discarded. A fuse or vacuum tube is readily perceptible if the fuse or vacuum tube can be ascertained visually or by touch during the operation or user-servicing of the product, or if the fuse or vacuum tube is cited either by information that appears on the outside surface of the product or by literature accompanying the product.

Exception No. 3: A plug-in vacuum tube or clipped-in-type fuse that is within a compartment provided with the marking described in 129.1.1 (No user-serviceable parts compartment warning) whether or not the fuse or vacuum tube is readily perceptible by the user is not considered to be user-serviceable.

c) Replacement of an incandescent lamp, whether it is a single lamp or one of a series or parallel string, intended for connection directly across the supply circuit that is a nominal 120 or 240 V, or replacement of a fluorescent lamp (for example, a low-pressure, mercury, electric-discharge lamp with a fluorescent coating), or a low-pressure or medium-pressure, electric-discharge lamp.

Exception No. 1: A lamp that is intended to be and is soldered in place is not considered to be user-serviceable.

Exception No. 2: A neon lamp (for example, an electric-discharge lamp with neon as the filling gas) is not considered to be user-serviceable.

Exception No. 3: A low-voltage (less than 30 V rms) vacuum-fluorescent (VF) display device is not considered to be user-serviceable.

Exception No. 4: A lamp that is located within a compartment bearing a marking described in Graphical Symbols and Supplemental Marking, Section 129, and the literature provided with the product does not instruct the user to service the lamp is not considered to be user-serviceable.

d) User adjustments that can be accomplished with the product in operation and without defeating the interlock or opening covers not intended to be opened by the user, such as:

1) Adjustment of a marked control or component with or without ordinary tools or

2) Adjustment of an unmarked control or component without a tool.

e) Any operation described or depicted in the operating instructions, or in any other literature accompanying the product.

f) Cleaning and demagnetizing of tape heads, as specified in the operating instructions.

g) Cleaning of lenses, cabinet, and the like.

h) Cleaning of a picture-tube face or window, if access to the parts to be cleaned can be gained using ordinary tools and without removing the chassis or the picture tube from the cabinet. During the cleaning operation, live parts are considered protected if the front cover of a picture-tube enclosure can be opened for cleaning or other user-servicing only after first opening an interlocked cover and, if the warning described in 135.1.1 (Removable front cover warning) is located on the cabinet where readily visible when the front cover is opened.

i) Setting a supply-circuit voltage mechanism.

j) Removing a cover.

k) Opening a door.

16 Spacings

16.1 General

16.1.1 A minimum spacing of 3.0 mm over surface and through air shall be maintained between uninsulated parts conductively connected to the supply circuit (for example, the primary circuit) and each of the following:

a) Uninsulated parts of opposite polarity,

b) Accessible conductive parts (includes pressed wood and similar material), and

c) An uninsulated part, in other than the supply circuit, where breakdown could result in a risk of electric shock.

Exception No. 1: This requirement does not apply if the location and relative arrangement of parts are such that permanent separation is provided such as on connectors, printed-wiring boards, and the like.

Exception No. 2: This requirement does not apply to the internal spacings of components but does apply to their external parts.

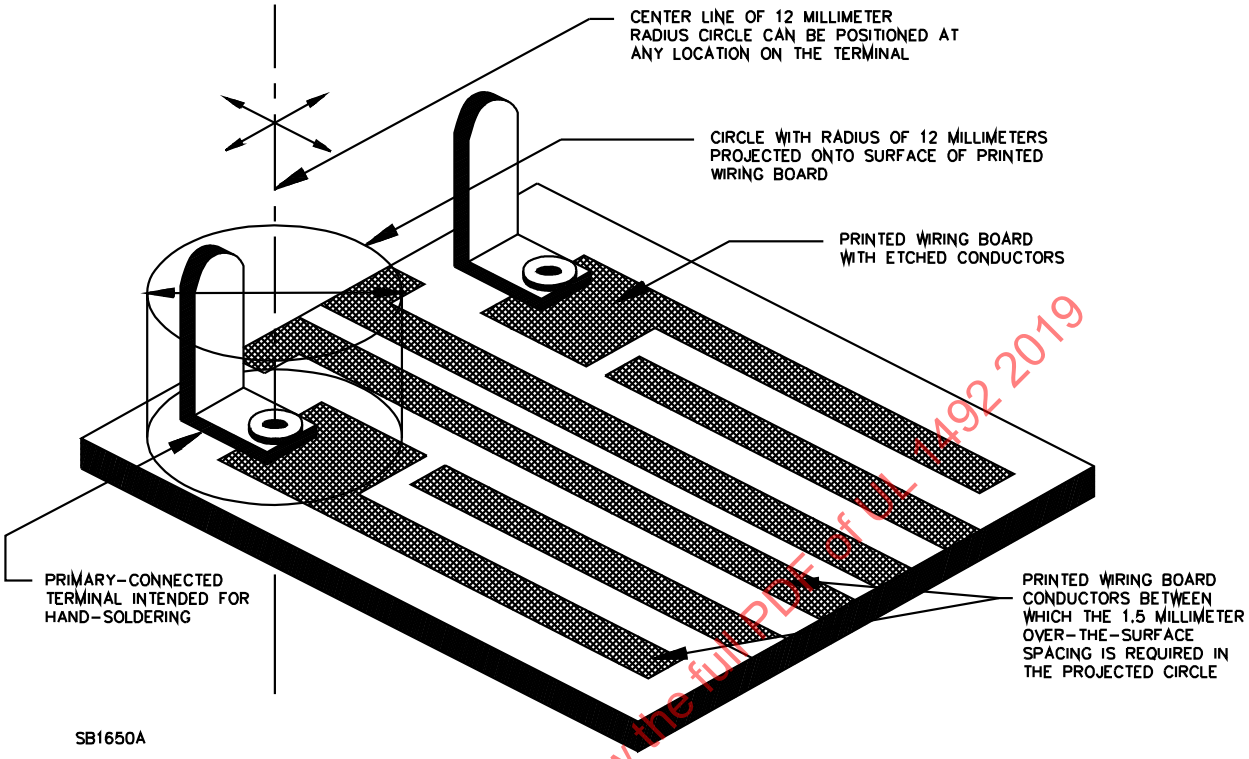
Exception No. 3: This requirement does not apply where a different spacing is required to comply with Double Protection, Section 44, or Double Protection for High-Voltage Products, Section 52.

16.1.2 If a printed-wiring board has primary-connected hand-soldered terminals, a 1.5-mm over-surface spacing shall be maintained between the printed-wiring conductors connected to the terminal and all other printed-wiring conductors located in the adjacent area (see 16.1.3).

16.1.3 For the purpose of 16.1.2, the adjacent area is that described by a 12-mm radius circle about the hand-soldered terminal. See Figure 16.1.

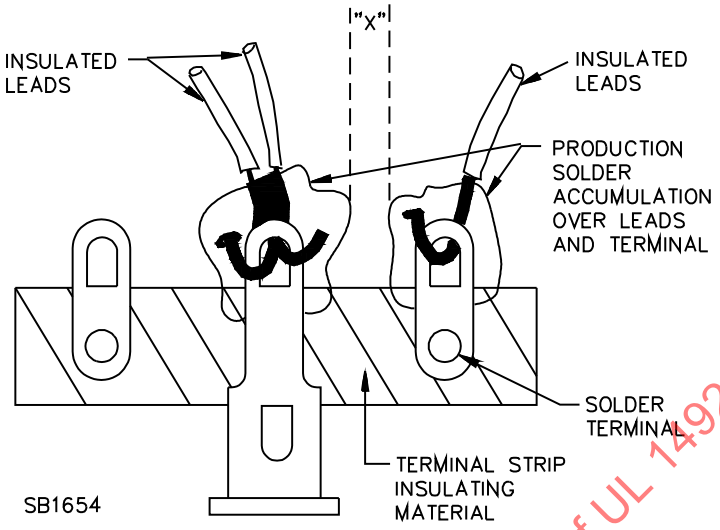
16.1.4 When measuring spacings through air or over surface between parts where hand soldering is involved, the spacing may need to be measured assuming production accumulations of solder on parts and lead connections as illustrated in Figure 16.2.

Figure 16.1
Measurement of over-surface spacings on printed-wiring boards with primary-connected, hand-soldered terminals



NOTE – Example only to illustrate 16.1.2 and 16.1.3.

Figure 16.2
Measurement of spacings between parts where hand-soldering is involved



NOTE – Example only to illustrate 16.1.4.

X = 3.0 mm spacing to be maintained between hand-soldered parts assuming production solder accumulations.

16.1.5 When determining the permanent separation between parts – for example, between a resistor and adjacent components – consideration shall be given to the location of the part, abuse during assembly and servicing, length and diameter of the integral leads, and consistency of positioning the part during factory assembly. If a question exists as to the part positioning, a force of 2 N is to be applied to the part in any direction permitted by the construction. The force is to be applied until there is no further movement during application of the force. The minimum spacing is to be measured after the force has been removed and the part has repositioned itself.

16.2 Insulating barrier in lieu of spacings

16.2.1 A barrier or liner of polymeric, fiber, or similar material (other than the enclosure), used where spacings would otherwise be unacceptable between uninsulated parts of opposite polarity or between such parts and accessible conductive parts, according to 16.1.1 and 16.1.2, shall comply with each of the following:

a) It shall be of a material complying with the requirements for insulating materials;

b) It shall be of a material that complies with the requirements in Table 20.1;

c) It shall comply with the applicable tests specified in the Strength of Enclosure Tests, Section 98, if it is likely to be handled during use or user-servicing of the products;

d) It shall be held in place by a means other than friction between surfaces;

e) It shall be located so that it is not likely to be damaged by operation of the product; and

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f) It shall have a minimum thickness of 0.70 mm; 0.35 mm when used in conjunction with an air space.

Exception: Insulation that is built into a component need not comply with 16.2.1.

16.3 Fuse and fuse clip

16.3.1 A minimum spacing of 3.0 mm over surface and through air shall be maintained between the uninsulated parts of a fuse and fuse clip that involve electric shock and each of the following:

a) Uninsulated parts of opposite polarity and

b) Accessible conductive parts.

The spacing shall be measured with the fuse in place.

Exception: The minimum spacing need not be maintained when a barrier that complies with 16.2.1 is provided.

16.4 Picture tube conductive coating

16.4.1 If a risk of electric shock results from an electrical connection between the external conductive coating of the picture tube and the picture-tube mounting means – straps, brackets, and the like – that contact the tube, there shall be a spacing of 12 mm minimum between the conductive coating and the mounting means. The spacing shall be measured over the surface of the tube.

16.5 Field-wiring terminals

16.5.1 The spacing between field-wiring terminals of opposite polarity, and the spacing between a field-wiring terminal and any other uninsulated metal part not of the same polarity, shall not be less than that specified in Table 16.1.

Table 16.1
Spacings at field-wiring terminals

Potential involved, volts	Minimum spacings		
	Between field-wiring terminals, through air or over surface, millimeters	Between field-wiring terminals and other uninsulated metal parts not always of the same polarity[a]	
		Over surface, millimeters	Through air, millimeters
250 or less	6.0	6.0	6.0
More than 250	12.0	12.0	9.0

[a] Applies to the sum of the spacings involved where an isolated dead-metal part is interposed.

17 Enclosures

17.1 General

17.1.1 A product shall be provided with an enclosure. The enclosure shall render parts involving a risk of electric shock or injury to persons inaccessible and shall protect the internal parts of the product from mechanical damage when such damage to parts might result in a risk of fire or electric shock. See Sections 97 – 99, 102, and 103.

17.1.2 A product enclosure that is comprised of two or more parts secured together solely by an adhesive shall be subjected to the Adhesive Securement Test, Section 100.

Exception: The test described in 100.2 does not apply to separately enclosed loudspeakers intended for connection to an audio amplifying source limited in accordance with 70.1.

17.1.3 A viewing screen that is integrally mounted to a projection-type television and that is not considered to be part of the required enclosure is to be removed when determining compliance with 17.1.

17.1.4 The enclosure of an in-wall mounted product shall not be provided with unused openings.

17.1.5 A metal enclosure for an in-wall mounted product shall have a minimum thickness of 1.35 mm uncoated.

17.2 Glass dial window

17.2.1 A glass dial window that covers live parts shall be of tempered glass not less than 4.8 mm thick, or shall withstand the impact test described in 98.11.1 – 98.11.4.

17.3 Polymeric enclosure

17.3.1 An enclosure of polymeric material shall comply with the requirements in Table 20.1.

Exception No. 1: A polymeric enclosure of a separately enclosed loudspeaker intended for connection to an audio amplifying source limited in accordance with 70.1 need only be rated HB, determined in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 2: For other than high voltage and in-wall mounted products, refer to the special construction option requirements in 17.4.1.

Exception No. 3: A polymeric enclosure of an in-wall mounted product shall have a minimum flammability rating of 5V.

17.3.2 A part, such as a control knob, a cover, a dial, a window, a switch casing, a handle, and the like, that is mounted in or over a cabinet opening and serves as a barrier to live parts, shall be considered as a part of the enclosure.

Exception: A control shaft is considered to be a barrier.

17.4 Special construction option for other than high-voltage products

17.4.1 If all those components that involve hazardous-energy circuitry as defined in 3.19, or involve the risk of injury to persons, or both, are individually or collectively enclosed in a material such as metal or one having a flammability classification of V-0 and the individual or collective enclosures comply with the appropriate mechanical strength tests in the Strength of Enclosure Tests, Section 98, the other components that in themselves do not involve hazardous-energy circuitry or the risk of injury to persons, and the overall enclosure of such components (which is not considered a required enclosure) need only have flammability characteristics of HB.

17.4.2 The individual or collective enclosures mentioned in 17.4.1 shall not be provided with holes or louvers that allow the circulation of air. Butt joints (where two surfaces are fastened together end-to-end) shall not be used unless joined by welding or equivalent means. See (a), (b), and (c) in Figure 17.1 for examples of unacceptable butt joints.

Exception No. 1: Holes for the entrance of wires only may be provided if the unused portion of any hole is no larger than 130 mm^2 in area. Any hole provided for lead wires, but not so used, shall be closed by metal or a material having a flammability classification of V-0.

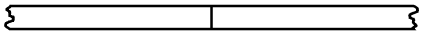
Exception No. 2: Butt joints provided with an overlap in contact with each other of at least 1.5 mm are acceptable. See (d), (f), and (g) in Figure 17.1 for examples of acceptable butt joints with overlap. See (e) in Figure 17.1 for an example of an unacceptable overlap construction.

Exception No. 3: Enclosure constructions other than the construction described in Exception No. 2 to 17.4.2 that meet the intent of the requirements by preventing the spread of fire to other areas of the product are acceptable.

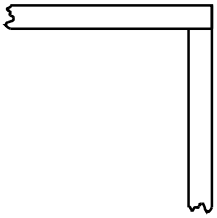
17.4.3 Hook-up wiring in hazardous-energy circuitry shall have mechanical protection in the form of an enclosure as described in 17.4.1; however, interconnecting wiring of Type SPT-2 or NISPT-2 or heavier flexible cord, or an appliance wiring material construction that has been determined to be equivalent to Type SPT-2 or NISPT-2 cord need not have additional mechanical protection if strain and push-back relief are provided.

17.4.4 For test requirements see Figure 17.2; the Special Option Tests, Section 73; and the Power Supply Tests, Section 77.

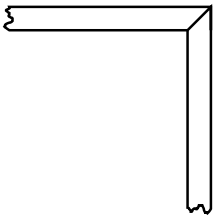
Figure 17.1
Some examples of butt joints



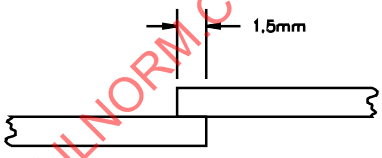
a) Unacceptable – Ends contact each other without additional joining means.



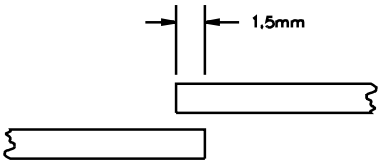
b) Unacceptable – End and surface contact each other without additional joining means. Vertical piece might contact horizontal piece any place along its surface.



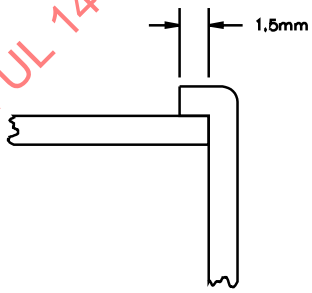
c) Unacceptable – Ends contact each other without additional joining means.
Note: (a), (b), and (c) would be acceptable if the ends and/or surfaces were joined by welding or other equivalent means.



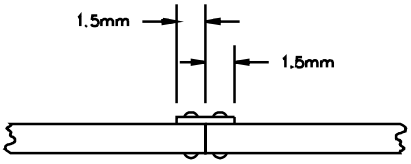
d) Acceptable – Surfaces overlap each other by at least 1.5 mm and are in contact.



e) Unacceptable – Surfaces overlap each other by at least 1.5 mm but are not in contact with each other.



f) Acceptable – See drawing (d).



g) Acceptable – Ends additionally secured together by piece which overlaps joint at least 1.5 mm.

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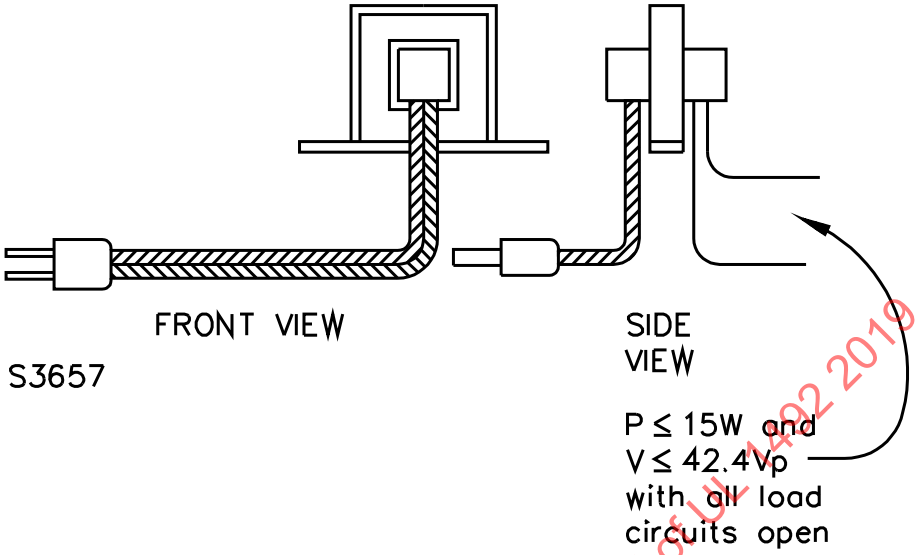
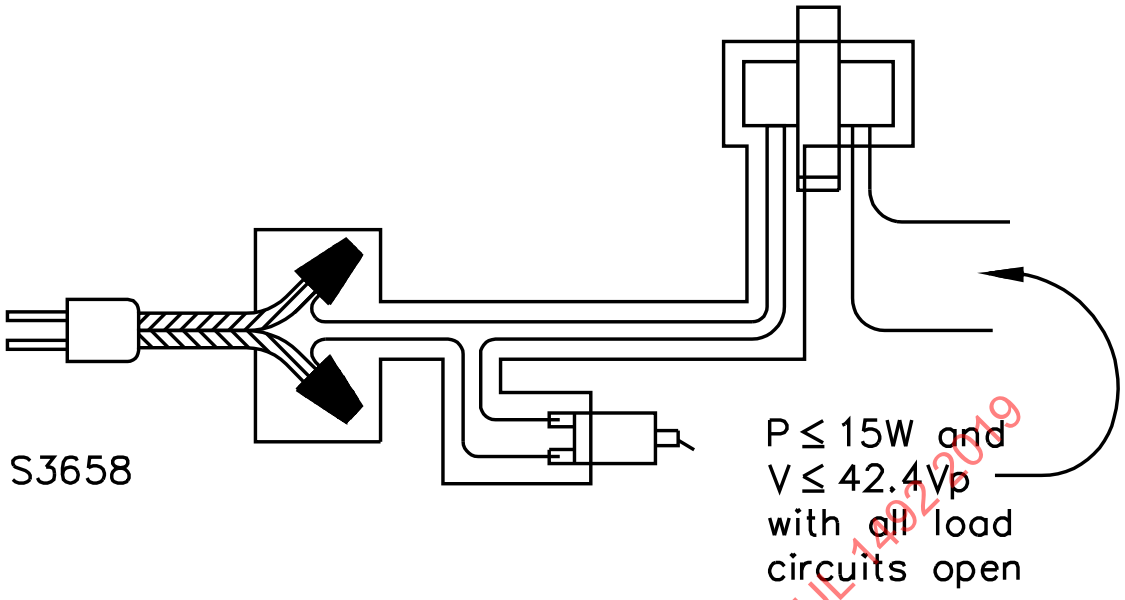
Figure 17.2
Enclosing of components (special construction option, 17.4.1)

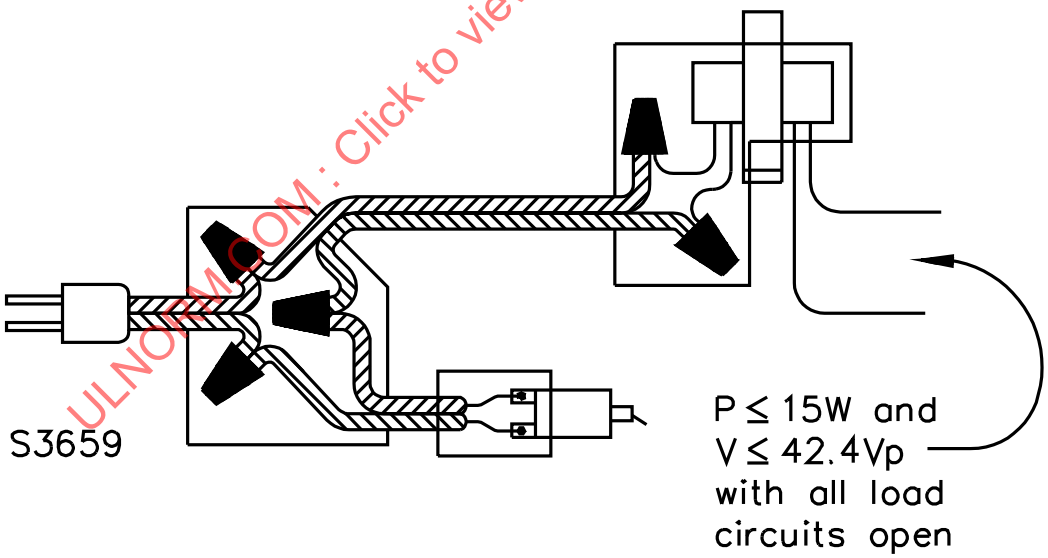


a) Power-supply cord terminates inside power transformer end bell; end bells over both sides of coil; secondary delivers less than or equal to 15 watts of power with load and less than or equal to 42.4 volts peak open circuit.

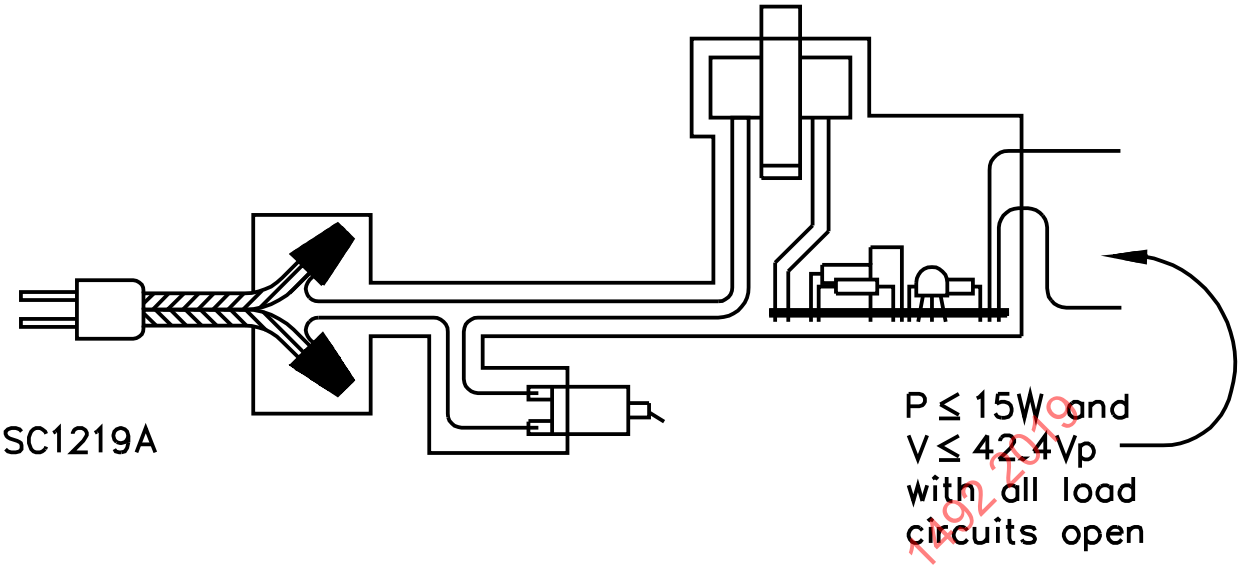


b) Power transformer without end bells; primary switch, connectors and primary connected appliance wiring material enclosed in metal or V-0 material; secondary delivers less than or equal to 15 watts of power with load circuit open and less than or equal to 42.4 volts peak open circuit.

Figure 17.2 (Cont'd)



c) Power transformer without end bells; primary switch, connectors and primary wiring of power transformer enclosed in metal or V-0 material; interconnecting wiring is SPT-1 cord; secondary delivers less than or equal to 15 watts of power with load circuit open and less than or equal to 42.4 volts peak open circuit.



d) Power transformer without end bells; primary switch, connectors, primary and secondary wiring of power transformer and printed-wiring board with hazardous components enclosed in metal or V-0 material, output delivers less than or equal to 15 watts of power with load circuit open and less than or equal to 42.4 volts peak open circuit.

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18 Accessibility of Parts

18.1 Articulated probe

18.1.1 An accessible part of a product shall not involve a risk of electric shock.

18.1.2 The accessibility of a live part shall be determined by Table 18.1.

Table 18.1
Recessing of live parts

Maximum width of slots[a] – millimeters	Diameter of round holes – millimeters	Minimum distance between opening and live part[b,c] – millimeters
Less than 25	Less than 25	Probe[d,e] + X – 3.0
	More than 25 but not more than 50	5D + X
25 but not more than 50	More than 50 but not more than 75	6D + X
More than 50 but not more than 75		7D + X
More than 75	More than 75	Not acceptable

[a] A high-voltage product enclosure shall have no opening that will accept the entrance of a 25-mm diameter sphere.
[b] D is the diameter of the largest sphere that passes through the opening.
[c] X is 3.0 mm for each 1000 V peak or fraction thereof at the live part. The voltage is to be measured with the product connected to a supply circuit as described in 63.5.1 and 63.5.2 and adjusted as described in 69.1.1.
[d] See Figure 18.1 for a description of the probe. No force is to be applied to the probe to determine accessibility.
[e] The tapered portion of the probe shall not contact a live part operating at a potential of 1000 V peak or less.

18.1.3 Friction-fit knobs, snap covers, and similar loose parts can be removed or opened when evaluating accessibility.

18.1.4 When using the probe shown in Figure 18.1, the probe is to be used only as a gauge and inserted with minimal force. The probe may be articulated to any position before, during, or after its full insertion into an opening by rotating the probe with the moveable sections straight or in any possible position resulting from bending one or more sections in the same direction.

18.2 Protective screens and barriers

18.2.1 Protective screens or barriers, openings larger than those covered in Table 18.1, irregular openings, and openings in flexible materials are to be given consideration with regard to the intent of the requirements.

18.3 Chassis-mounting bolts

18.3.1 Live parts are to be inaccessible after chassis-mounting bolts are loosened during installation as intended to reduce vibration. Chassis-mounting bolts not specifically intended to prevent further loosening, except by the use of a tool, are to be loosened the maximum amount likely to occur in service in determining the inaccessibility of live parts.

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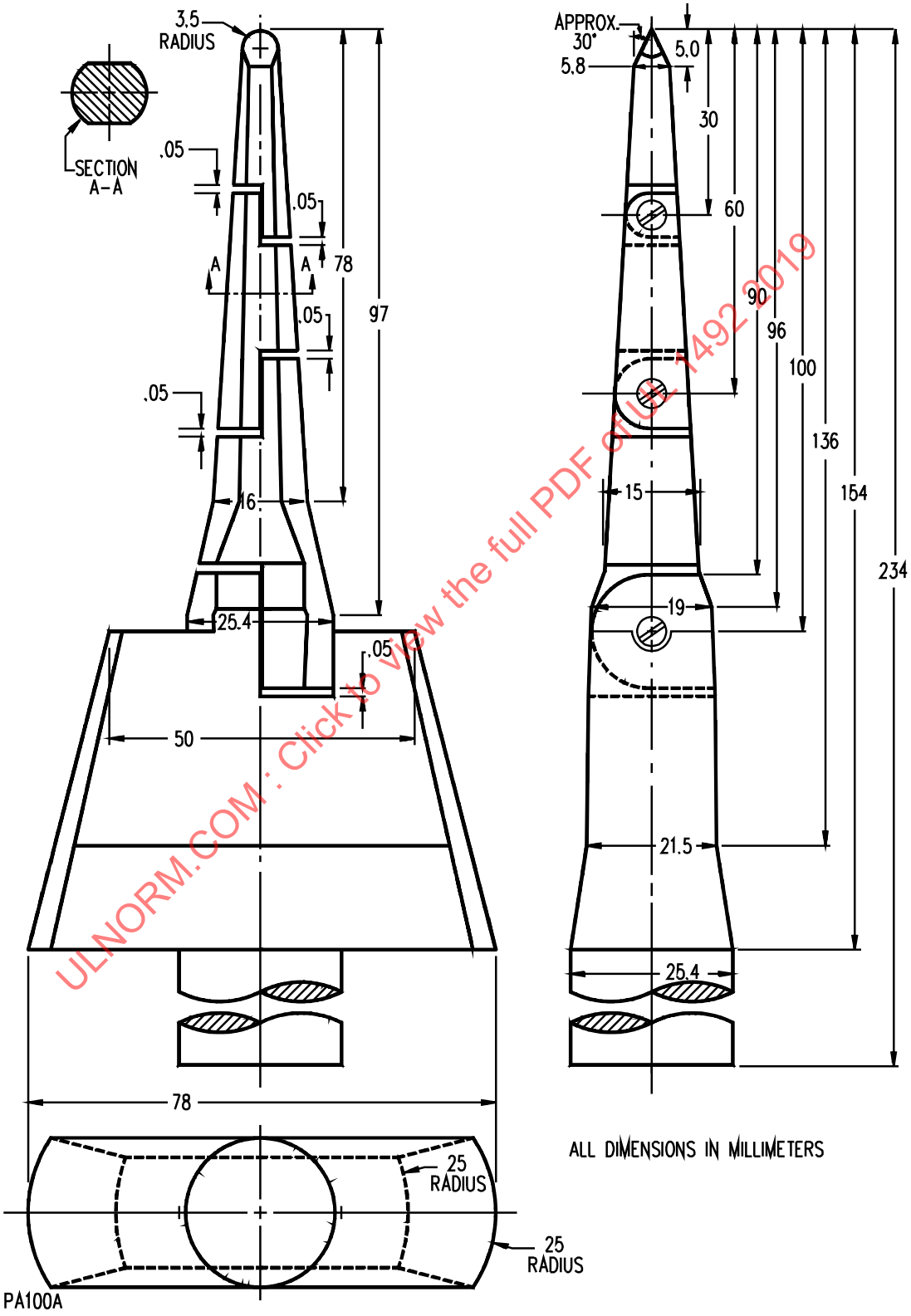
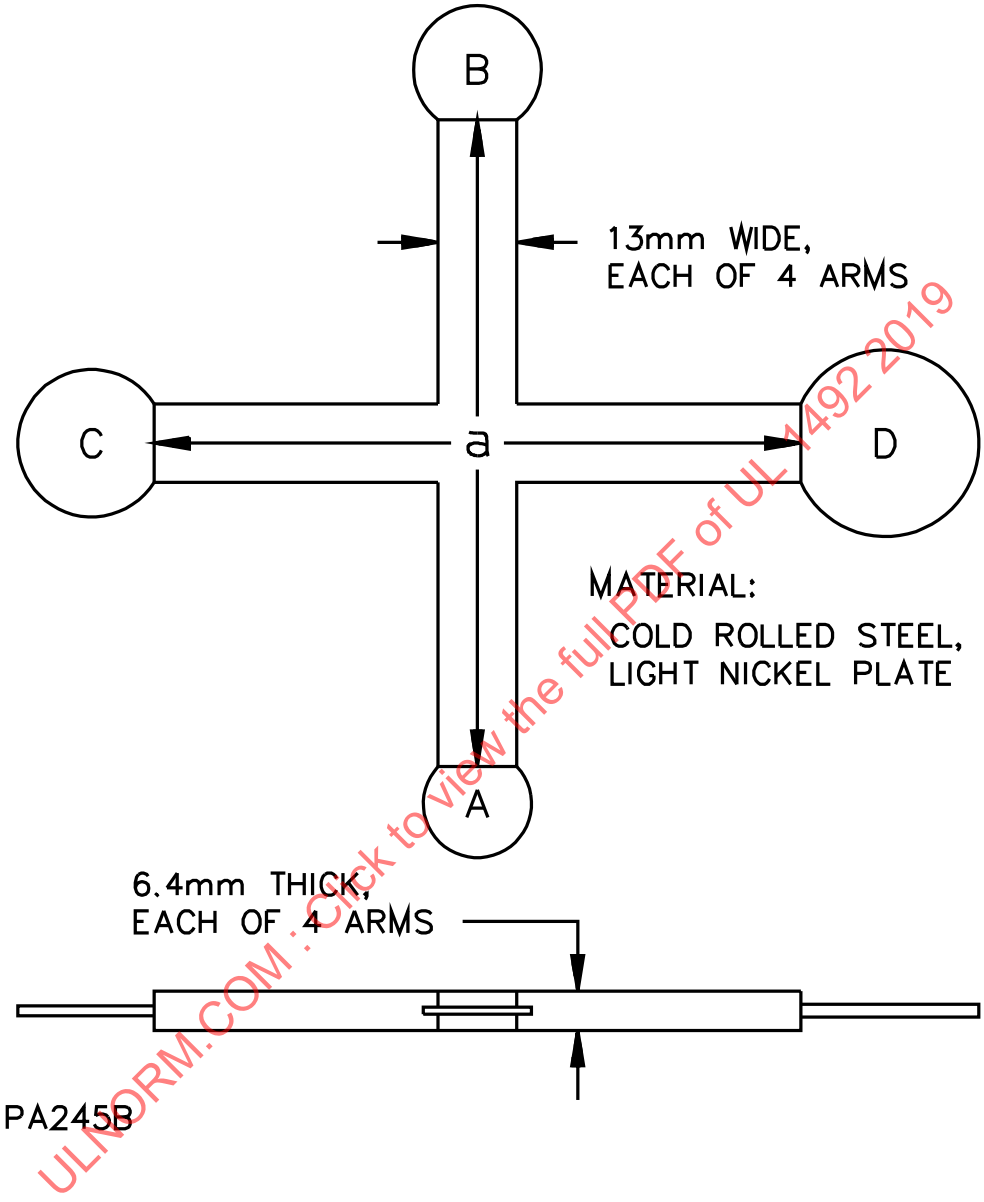
Figure 18.1
Articulated probe with web stop



18.4 Coin probe

18.4.1 The enclosure of a product, excepting the bottom, shall not have opening through which any of the four discs on the coin probe illustrated in Figure 18.2 can enter and contact any part involving a risk of electric shock. Additionally, while inserting the probe into the opening, the distance between any of the disc areas and any live parts shall not be less than 3.0 mm for each 1000 volts or fraction thereof in excess of 1000 volts peak. (For example, for 2500 volts peak the distance would be 6.0 mm.) No force is to be applied to the probe.

Figure 18.2
Coin probe



Dimensions of circular parts, millimeters			
Probe	Diameter	Thickness	Length[b]
A	17.5	1.12	15.9
B	20.6	1.88	19.1
C	23.8	1.63	22.2
D	30.2	2.06	28.6

[a] The arms of the probe provide a means of mounting the discs (circular parts). The lengths and arrangement of the arms are optional so long as they do not interfere with the use of the discs.

[b] Measured from the end of the arm to the outer end of the disc. The disc is to be inserted into the opening in question only up to its mounting arm to determine if it can contact a live part.

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18.5 Adjustment opening

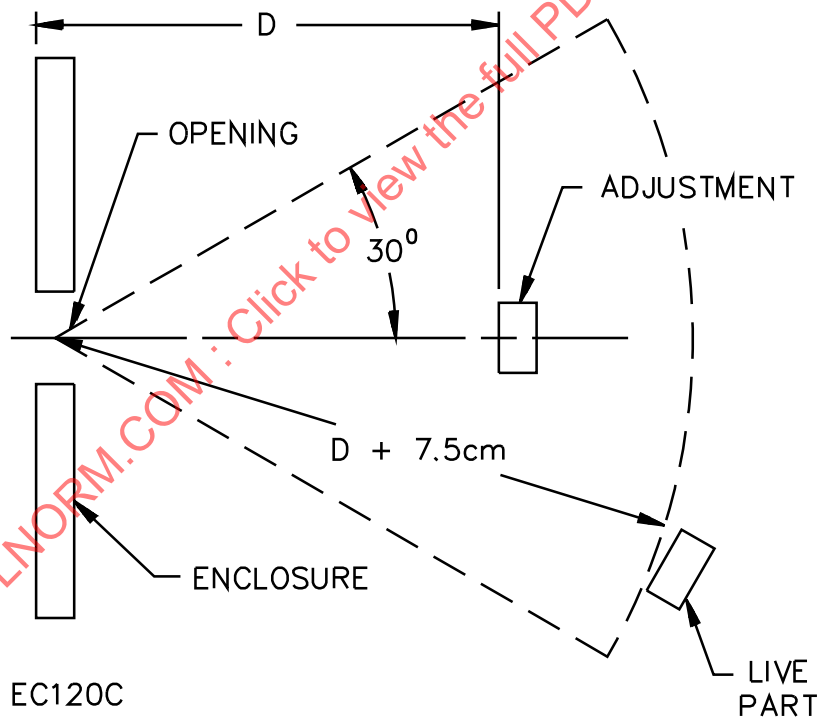
18.5.1 A part beyond an opening that might be used in making an adjustment that is considered a function of user-servicing is not considered to be accessible if a 3.0-mm diameter straight rod is prevented from touching the part when the rod is inserted through the opening and moved to all positions possible without producing an angle of more than 30 degrees between the rod and a line drawn between the center of the opening and the center of the face of the adjusting mechanism. The length of the rod beyond the opening is not to exceed the distance between the opening and the face of the adjusting mechanism by more than 7.5 cm. See Figure 18.3.

18.6 Control shaft

18.6.1 A control shaft that involves a risk of electric shock shall be rendered inaccessible by means of an interlocked compartment that complies with the requirements for Interlocks, Section 33, or by means of a captive insulating knob – an insulating knob that is not removable from the exterior of the enclosure.

18.6.2 Set screws, sealing compound, and devices that depend upon friction to prevent removal of a knob from the exterior of the enclosure are not considered acceptable.

Figure 18.3
Accessibility of live part through adjustment opening



19 Top Opening

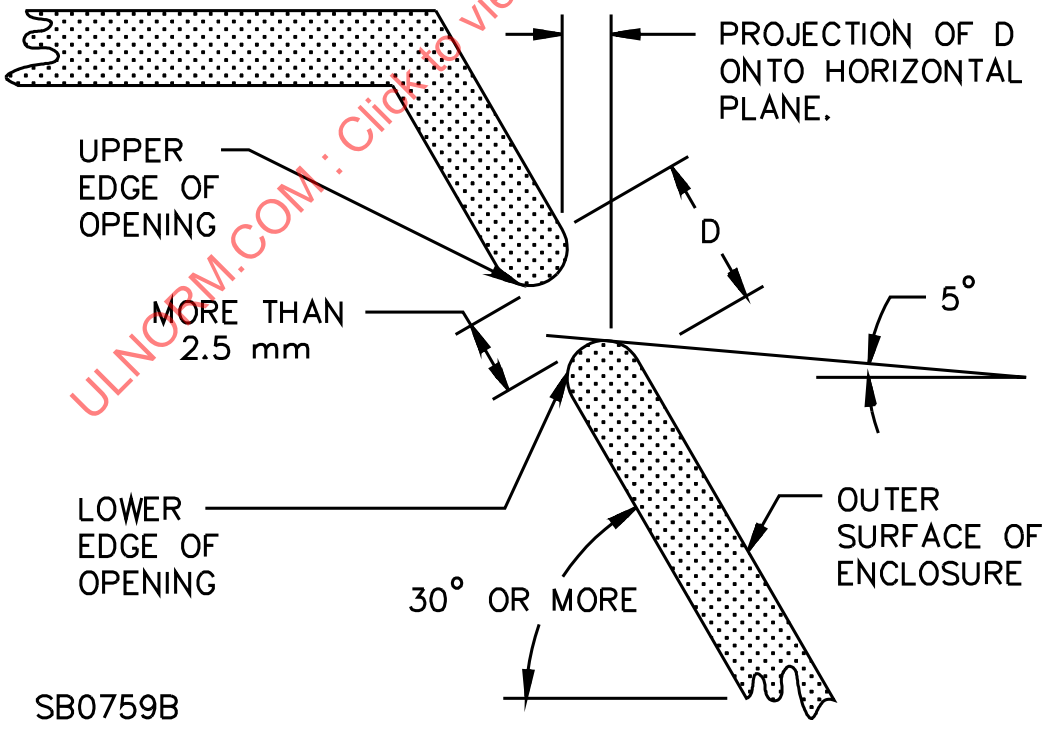
19.1 An opening in the top of the overall enclosure – see 19.2 – shall prevent passage of a sphere of more than 2.5 mm in diameter if the passage of an object through the opening results in risk of electric shock.

Exception No. 1: With regard to Figure 19.1, an opening "D" in the surface that makes an angle of 30 degrees or more with the horizontal is considered acceptable if the projection of "D" onto a horizontal plane does not exceed 2.5 mm when measured in the direction of the maximum slope of the surface in which the opening is located. The upper edge of the opening is the point of tangency between a vertical line and the enclosure above the opening. The lower edge of the opening is the point of tangency between the enclosure below the opening and a line that slopes downward away from the enclosure at an angle of 5 degrees to the horizontal.

Exception No. 2: An opening having a dimension larger than 2.5 mm and protected by a knob, handle, louver, or similar part is acceptable if a falling object cannot pass directly through the opening in a vertical direction and if the construction is such that an object placed at any point on the enclosure cannot slide or roll into the opening. This generally requires a 1.5-mm high lip on the surface surrounding the opening. A knob protecting an opening is to be on its shaft as far as possible without rubbing on the enclosure.

19.2 The top of the overall enclosure is considered that portion of the enclosure that is visible in a plan view when the product is resting on a horizontal surface, with all drawers and lids closed except a lid that must be detached for operation. Push buttons are to be in the maximum displaced position that the construction permits.

Figure 19.1
Cross-section of enclosure showing opening



20 Materials

20.1 General materials

20.1.1 Materials shall have properties as shown in Table 20.1.

Table 20.1
Requirements for materials

Application	Flammability classification[a,b]
Enclosure	
1. Polymeric– high-voltage products	
A. Major part[c]	V-0
B. Other part	V-1, V-0
2. Polymeric – other than high-voltage products[d]	V-2, V-1, V-0
3. Pressed wood or similar material	
A. Back cover of high-voltage products	V-1[e], V-0
B. Other[f]	None, HB, V-2, V-1, V-0
4. Outside surface of required enclosure of table-top or console products[g]	Tablet[h]
Barriers used in high-voltage products	
5. Internal barriers	V-2, V-1, V-0, VTM-2, VTM-1, VTM-0
Polymeric and fiber materials in contact with uninsulated live parts	
6. That involve a power greater than 15 W, see 35.1[i,j]	V-2, V-1, V-0, HF-2, HF-1, VTM-2, VTM-1, VTM-0
7. That involve a power equal to or less than 15 W, see 35.1[i,j]	HB, V-2, V-1, V-0, HBF, HF-2, HF-1, VTM-2, VTM-1, VTM-0
High-voltage parts	
8. Parts involving potentials equal to or greater than 2500 volts peak[k,l]	V-2, V-1, V-0, VTM-2, VTM-1, VTM-0
Sound-deadening and shock-absorption material	
9. In contact with live parts	
(specific gravity less than 0.6)	HF-1, HF-0
(specific gravity equal to or more than 0.6)	V-1, V-0
10. Not in contact with live parts	
(specific gravity less than 0.6)	HBF, HF-1, HF-0
(specific gravity equal to or more than 0.6)	HB, V-2, V-1, V-0
Other applications	
11. Grille covering material, cloth, and reticulated foam	Tablet[h]
12. Materials used in applications other than those specified in 1 – 11[i,j]	HB, V-2, V-1, V-0, HBF, HF-2, HF-1, VTM-2, VTM-1, VTM-0

Table 20.1 Continued on Next Page

Table 20.1 Continued

Application	Flammability classification[a,b]
NOTE – Covers insulation properties and stability. Mechanical strength is judged in the application. For enclosures see the Strength of Enclosure Tests, Section 98. [a] Flammability Classification – Determined by tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. For testing a material, the samples are to be flat stock – bar samples – sized in accordance with UL 94; for an assembly, the samples can consist of the assembly. High-voltage transformers, deflection yokes, printed-wiring boards, terminal strips, and the like can be tested as finished parts, or test samples can be cut from finished parts. In the case of small parts that might be consumed before the test is completed, large samples of the same material can be tested provided they represent the same or lesser thickness than the part in question. None of the larger samples is to be entirely consumed. Samples that consist of an assembly or a section thereof that are not flat stock samples are to be positioned in what is considered to be the worst position in the application. A material having a higher flammability classification than that specified in Table 20.1 is acceptable. See note c. [b] The parts evaluated by Table 20.1 and classified using 1.6-mm thick bar specimens may be accepted in lesser thicknesses in the end product. For polymeric enclosures, a material classified using 3.2-mm thick bar specimens may be accepted in lesser thicknesses in the end product. [c] See 3.31 for the definition of a major enclosure part. [d] See the special construction option and reference to a flammability classification of HB described in 17.4.1. [e] Does not apply to a pressed wood back cover that complies with the 746-5VS vertical flame test as determined by the test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. [f] Must be spaced at least 3.0 mm from uninsulated parts involving a risk of fire. [g] Applies only to surfaces constructed in accordance with all of the following: 1) The surface material is other than uncoated plastic; 2) The surface is covered with a material other than paint, silk-screening, hot-stamping, and paint-stenciling; 3) The surface lies in a plane within 10 degrees of horizontal; and 4) A 10-cm diameter circle can be projected in whole onto the surface. [h] The flammability test using a hexamethylene-tetramine tablet is described in the Tablet Flammability Test, Section 77. [i] Does not apply to the internal insulating systems of components or where component requirements exist (see 2.1.1 – 2.1.4). [j] Power measured in accordance with the Power Supply Tests, Section 77. [k] Mold-Stress-Relief – The part is required to withstand a temperature-stability test or an oven test as described in 98.3.1. There shall not be shrinkage, warpage, or other distortion that interferes with normal operation or servicing, results in accessibility of live parts, or reduces electrical spacings below the level necessary to comply with the applicable requirements pertaining to dielectric strength and leakage current. [l] Spacings – See 117.7 to determine acceptability of spacings.	

20.1.2 Cellulose nitrate or any comparably flammable material shall not be used for any part regardless of location, application, or function.

20.2 Small parts

20.2.1 The flammability and other requirements in Table 20.1 do not apply to small parts. For the purpose of these requirements, a small part is defined as one that complies with each of the following items:

a) Its volume does not exceed 2 cubic centimeters,

b) Its maximum dimension does not exceed 3 centimeters, and

c) Its location is such that it cannot propagate flame from one area to another or act as a bridge between a possible source of ignition and other ignitable parts.

20.3 Exempted parts

20.3.1 The parts listed in Table 20.2 are exempt from the requirements in Table 20.1.

20.4 Molded-material insulation

20.4.1 Major enclosure parts, as defined in 3.31, that are molded of polymeric material and that are not fabricated at the end-product manufacturing location shall be identified according with the Standard for Polymeric Materials – Fabricated Parts, UL 746D.

20.5 Insulation materials

20.5.1 Material used for the support of parts where shrinkage, current leakage, or warpage might result in a risk of fire or electric shock shall comply with both of the following:

a) The applicable requirements for insulating materials and

b) The appropriate material flammability classification in Table 20.1.

20.5.2 The laminate material in a printed-wiring board used in a circuit that involves a risk of fire or electric shock shall:

a) Comply with the direct support of current-carrying parts performance level requirements specified in the Standard for Printed-Wiring Boards, UL 796, and

b) Be marked with "▲" or a unique type designation that is limited to such printed-wiring boards to indicate compliance with the requirements in UL 796.

Table 20.2
Exempt parts list

All products	Specific products
1. External accessories that are not permanently attached to a product such as:	1. Loudspeaker parts not part of the required enclosure
a) 45 RPM adaptor	a) Cone
b) Bottle of lubricating oil	b) Dust cap
c) Cartridge	c) Spider
d) Earphone	d) Voice coils
e) Headphones	2. Camera
f) Microphone	a) Eye shield or sunshade
g) Phonograph record, compact disc, and other playback media	b) Lens cap
h) Remote control unit, not involving hazardous-energy circuitry	c) Shoulder strap and patch
i) Screwdriver	d) Seperable lens system
j) Signal level balancing mechanism	1. Lens
k) Tape	2. Filters
l) Tape cassette	e) Microphone windscreen
m) Tape reel	f) Shoulder pad
n) Batteries	3. Projection TV lenses
2. Fiber and similar material that is equal to or less than 0.25 mm thick	4. External thermoplastic feet having a maximum dimension of 6 cm in any direction and with a volume less than 10,000 mm^3 that are secured to the outside of the enclosure
3. Internal insulating systems of components or where component requirements exist (see 2.1.1 – 2.1.4)	
4. Paper marking lables, fiber, and similar materials less than 0.25 mm thick	
5. Parts segregated from parts in hazardous-energy circuitry such as:	
a) Dial strings	
b) Drive belts	
c) Felt	
d) Lacing thread	
e) Woven (cloth) materials	

20.6 Barrier insulating material

20.6.1 A barrier of insulating material used to render inaccessible those parts involving the risk of electric shock or injury to persons shall:

a) Be at least 0.70 mm thick and

b) Comply with item 5, 6, or 7 of Table 20.1, as appropriate.

Exception No. 1: Fiber, or the equivalent, that is at least 0.35 mm thick may be used to cover a splice in an inaccessible location.

Exception No. 2: Paper, waxed or otherwise treated to resist the absorption of moisture, that is at least 0.35 mm thick may be used to cover the crossover lead of a coil winding in an inaccessible location.

Exception No. 3: Paper that is at least 0.70 mm thick may be used to cover an electrolytic capacitor or similar part. Fiber that is at least 0.50 mm thick may be used to cover the shell of a metal-jacketed pilot lampholder.

21 Corrosion Protection

21.1 A metal part shall be protected against corrosion if corrosion of that part can contribute to or cause a risk of fire, electric shock, or injury to persons.

Exception: Metals that are inherently corrosion-resistant need not be further protected against corrosion.

22 Metallized Plastic Parts

22.1 Metallized plastic parts that utilize an electrically conductive material shall comply with the applicable requirements for such parts in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, if detachment of the conductive material from the plastic parts may result in a risk of fire or electric shock. (For example, metallized plastic parts that are located within the overall product enclosure that could peel and allow conductive material to contact uninsulated parts involving a risk of fire or electric shock.)

23 Conductive Internal Mechanical Parts

23.1 Conductive internal mechanical parts shall be assembled and secured so that such parts cannot become detached or displaced in a manner that may result in a risk of fire or electric shock.

23.2 The mechanical parts to which the requirements of 23.1 are intended to apply include:

a) Stationary parts such as subchassis assemblies, heat sinks, hum shields, mounting brackets, and retaining clips and

b) Moving parts such as springs, linkages, actuating arms, flywheels, and dial pointers.

23.3 Conductive mechanical parts of discrete electrical components shall also comply with the intent of 23.1 and 23.2 or with the separate requirements for that component, where such exist.

24 Supply Connections – Cord-Connected Products

24.1 Power-supply cord

24.1.1 The type and length of the power-supply cord shall be in accordance with Table 24.1 and shall have a flammability rating of VW-1. An equivalent or heavier type of cord may be used. For example, an appliance wiring material construction that has been determined to be equivalent to Type SPT-2 or NISPT-2 cord may be used in applications where Type SPT-2 or NISPT-2 cord is specified. The cord shall have an ampacity, as given in the National Electrical Code, ANSI/NFPA 70, not less than the current rating of the product. An integral grounding conductor, if provided, shall be at least the same size as the other conductors in the cord.

Exception: The length of a flexible cord on equipment intended for a special installation can be less than that specified in Table 24.1.

Table 24.1
Power-supply cords

Product type	Cord type	Minimum cord length, m
Portable, table-top, floor-mounted (console), and television cameras	SPT-2, NISPT-2, SV, SVT, SVE, SJ, SJT, SJE	1.5
Portable products with cord storage compartments	SPT-2, NISPT-2, SV, SVT, SVE	1.4
Coffee-table[a]	SV, SVT, SVE, SJ, SJT, SJE	3
Undercabinet	SPT-2, NISPT-2	1.4

[a] A coffee-table type product is a type that is finished on all four sides and intended for use in the center of the room

24.1.2 20 AWG conductors may be employed in appliance wiring material constructions as referenced in 24.1.1 provided that:

a) The appliance is rated 2.0 A or less,

b) The appliance does not employ a convenience receptacle, and

c) Overcurrent protection rated 2.0 A or less is provided in the attachment plug and connected so as to interrupt the ungrounded side of the supply circuit.

24.2 Power-supply-cord length measurement

24.2.1 The length of a power-supply cord shall be measured from the face of the attachment plug to the point where the cord emerges from the product.

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24.3 Attachment plug

24.3.1 A product intended for connection to a supply circuit by means of a power-supply cord or wiring harness shall be provided with an attachment plug that complies with one of the configurations covered in the Standard for Wiring Devices– Dimensional Requirements, ANSI/NEMA WD-6, and in the Standard for Attachment Plugs and Receptacles, UL 498. The attachment plug shall comply with the requirements in the Standard for Cord Sets and Power-Supply Cords, UL 817.

Exception: If the product is intended to be connected to supply circuits not defined in the National Electrical Code, ANSI/NFPA 70, or for connection to supply-circuit receptacles that are not defined in the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD-6, the configuration of the attachment plug is to conform to the applicable Standards of the country into which the product is intended to be shipped. This exception applies only when the product is set for use on the foreign supply circuit when leaving the factory.

24.3.2 The attachment plug of a product shall be a polarized (two-blade polarized or three-wire grounding) type. See 36.5.1 for convenience receptacle requirements. See also 27.1.1(d).

Exception No. 1: If the product is intended to be connected to supply circuits not defined in the National Electrical Code, ANSI/NFPA 70, or for connection to supply-circuit receptacles that are not defined in the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD-6, the configuration of the attachment plug is to conform to the applicable Standards of the country into which the product is intended to be shipped. This exception applies only when the product is set for use on the foreign supply circuit when leaving the factory.

Exception No. 2: Direct plug-in transformer units shall comply with the polarization requirements in the Standard for Class 2 Power Units, UL 1310.

24.3.3 The attachment plug shall have a current rating not less than 125 percent of the current rating of the product and a voltage rating appropriate for the rated voltage of the product. If the product is for use on two or more different values of supply-circuit voltage, the attachment plug provided with the product shall be the type intended for the voltage for which the product is adjusted when shipped from the factory. See 127.10.1 and 127.10.2.

24.4 Cord connector (appliance coupler)

24.4.1 An appliance coupler used as the load fitting of a detachable power-supply cord shall not be of a configuration that can mate with a conventional television interlock device, which has 2.4-mm diameter pins, spaced 7.9 mm apart, center-to-center.

24.5 Cord strain relief

24.5.1 The power-supply cord shall be attached to product so that the following requirements are met:

a) A mechanical strain on the cord leaving the overall enclosure cannot be transmitted to terminals, splices, or internal wiring;

b) A mechanical strain on the cord leaving the overall enclosure cannot detach an interlock connector (if provided) from the part of the product (cover) to which it is attached;

c) A mechanical strain on the cord leaving the overall enclosure cannot damage an interlock (if provided) so that it does not perform its intended function;

d) Externally applied casual twisting or rotational forces on the cord leaving the overall enclosure cannot be transmitted to terminals, splices, or internal wiring; and

e) The cord shall not come in contact with sharp edges or with moving parts that can damage the conductor insulation.

See the Strain Relief Test, Section 91.

24.6 Power-supply cord exit

24.6.1 A power-supply cord shall exit the product through an opening in the enclosure intended only for passage of the power-supply cord. The opening shall be free from projections such as sharp edges, burrs, and fins that might damage the conductor insulation.

24.7 Cord-bearing surface

24.7.1 If a knot in a power-supply cord serves as strain relief, the surface against which the knot can bear or with which it might come in contact shall be free from projections, sharp edges, burrs, fins, and the like that can cause abrasion of the coverings on the conductors.

24.8 Bushing

24.8.1 There shall be an insulating bushing that is secured in place:

a) Where the power-supply cord emerges from the enclosure and

b) Where the cord might be subjected to strain or motion.

Exception No. 1: An insulating bushing is not required with a Type SPT-2 or NISPT-2 cord, or an appliance wiring material construction that has been determined to be equivalent to Type SPT-2 or NISPT-2 cord, if the cord or appliance wiring material is built up with an additional 40-percent-rubber jacket that has a 0.70-mm minimum thickness at the point where it passes through an opening in conductive material, and if the hole through the metal is free of sharp edges, burrs, and fins. A smooth, metal bushing is acceptable if a Type SJ or heavier cord is used.

Exception No. 2: A smooth, metal grommet is acceptable as a bushing in an enclosure other than one made of metal, provided the inside diameter of the grommet is not less than 25 mm.

24.8.2 If the exit for the cord is in wood, porcelain, phenolic composition, or other insulating material, a surface free of fins, burrs, and similar imperfections is considered to be the equivalent of a bushing.

24.8.3 Fiber can be used if the finished bushing is minimum 1.2 mm thick and if it is formed and secured in place so that it cannot be adversely affected by conditions of ordinary moisture.

24.9 Cord push-back relief

24.9.1 The power-supply cord shall be provided with a means whereby the cord cannot be deliberately pushed inside the enclosure if, when it is pushed inside, one or more of the following unacceptable conditions can occur:

a) The cord insulation is subjected to temperatures or voltages above its assigned ratings,

b) The cord can come in contact with sharp edges or with moving parts that can damage the conductor insulation,

c) The cord displaces parts resulting in a reduction of required spacings,

d) The cord remains inside the product enclosure and cannot be retrieved when there are no user-serviceable parts and the product is marked in accordance with 129.1.1, and

e) The cord places strain on internal connections.

See the Power-Supply Cord Push-Back Relief Test, Section 92.

Exception: If an acceptable and separate cord-storage compartment is provided, (d) does not apply.

25 Supply Connections – Permanently Connected Products

25.1 General

25.1.1 Products intended for attachment to a structural part of a building or to other permanently located items that do not need to be removed for servicing shall be provided with means for permanent connection to the primary-circuit power. Products fastened in place shall be provided with means for permanent connection to the primary-circuit power unless connection by means of a supply cord is necessary to facilitate the interchange of units, or removal is necessary for maintenance and repair, in which case the shortest feasible length of cord shall be used.

25.1.2 A product intended for permanent connection to the branch circuit shall have provision for such connection.

25.1.3 A sheet-metal member to which a wiring system is to be connected in the field shall have a thickness not less than 0.81 mm, if of uncoated sheet steel; not less than 0.86 mm, if of galvanized sheet steel; not less than 1.11 mm, if of sheet aluminum; and not less than 1.09 mm, if of sheet copper or sheet brass.

25.1.4 A terminal box or compartment shall be provided in which branch-circuit connections to a permanently wired product are to be made and shall be such that these connections can be readily made and inspected without disturbing the wiring or the product after the product is installed as intended.

25.1.5 The volume of a field wiring compartment provided with pigtail leads for connection to the supply wiring shall not be less than indicated in Table 25.1.

Table 25.1
Minimum size of field-wiring compartment

Size of lead, AWG	Size of lead, (mm^2)	Wire space within compartment for each lead, cm^3
14	2.1	32.8
12	3.3	36.9
10	5.3	41.0
8	8.4	49.2
6	13.3	81.9

25.1.6 A pigtail lead shall not be more than two wire sizes smaller than the supply conductor (copper) to which it will be connected. For example, if 14 AWG (2.1 mm^2) supply conductors will be used, the pigtail leads provided shall not be smaller than 18 AWG (0.82 mm^2).

25.1.7 No electrical component shall be mounted on a part, such as the cover of a wiring terminal compartment, that must be removed to permit field-wiring connections to be made or inspected.

Exception: This requirement does not apply to a product in which it is intended that the power-supply circuit wires be connected to an attachment-plug receptacle into which the attachment plug blades to the product will be plugged.

25.1.8 A terminal compartment intended for connection of a supply raceway shall be attached to the product so that it is resistant to turning.

25.2 Separation of circuits

25.2.1 Field installation conductors of any circuit shall be separated by barriers:

a) From field installation and factory installed conductors connected to any other circuit, unless conductors of both circuits are insulated for the maximum voltage in either circuit and

b) From an uninsulated live part of any other circuit in the product, and from any uninsulated live part the short circuiting of which results in a risk of fire or electric shock.

25.2.2 Separation of some field installation conductors from others and from uninsulated live parts connected to different circuits can 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 likelihood that the conductors or parts of different circuits can be intermingled. If not more openings are provided in the enclosure than are necessary for proper wiring of the unit and each opening is opposite a set of terminals, it is to be assumed in determining compliance with 25.2.1 that conductors entering the enclosure through any such opening will be connected only to the terminals opposite that opening. If more openings are provided in the enclosure than are necessary for proper wiring of the unit, it is to be assumed

in determining compliance with 25.2.1 that conductors will enter the enclosure through openings not opposite the terminals to which they are intended to be connected and may touch insulated conductors and uninsulated live parts of circuits other than their own.

25.3 Wiring terminals

25.3.1 A permanently connected product shall be provided with wiring terminals or leads for the connection of conductors having an ampacity not less than the current rating of the product. A wiring terminal shall be provided with a soldering lug or an acceptable pressure wire connector, firmly bolted or held by a screw.

Exception: A wire-binding screw may be used at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor, if an upturned lug or the equivalent is provided to hold the wire in position. A fixed wiring terminal shall be prevented from turning.

25.3.2 A wire-binding screw shall not be smaller than No. 10 (4.8 mm diameter).

Exception: A No. 8 (4.2 mm diameter) machine screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor, and a No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.83 mm^2) conductor.

25.3.3 It should be noted that 14 AWG (2.1 mm^2) is the smallest conductor that is acceptable for branch-circuit wiring and thus is the smallest conductor that is to be anticipated at a terminal for connection of a branch-circuit conductor.

25.3.4 A terminal plate for a wire-binding screw shall be of metal not less than 1.3 mm in thickness and shall have not less than two full threads in the metal.

25.3.5 A terminal plate formed from stock having the minimum required thickness as given in 25.3.4 may have the metal extruded at the tapped hole for the binding screw so as to provide two full threads.

25.3.6 An upturned lug or a cupped washer shall be capable of retaining a supply conductor corresponding in size to that mentioned in 25.3.1, but not smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

25.3.7 The free length of a lead inside an outlet box or wiring compartment shall be 15 cm or more if the lead is intended for field connection to an external circuit.

25.3.8 A permanently connected product rated at 125 or 125/250 V (three-wire) or less and using a lampholder of the Edison screw shell type, a single-pole switch, or a single-pole automatic control shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. The identified terminal or lead shall be the one that is electrically connected to the screw shell of a lampholder and to which no switch or single-pole automatic control without a marked on or off position is connected.

25.3.9 If a product or chassis within a rack or similar enclosure is provided with an attachment plug for supply connection to a receptacle that is part of the product, and if the product or chassis has an Edison screw shell lampholder or a single-pole switch connected on the load side of the plug, the plug and receptacle shall be polarized.

25.3.10 A field-wiring terminal intended for the connection of a grounded neutral supply conductor shall be identified by means of a metallic coating that is substantially white in color and be easily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as an attached wiring diagram. If wire leads are provided instead of terminals, the identified lead shall have a white or gray color and shall be easily distinguishable from the other leads.

25.3.11 Wire-bending space shall be provided in accordance with the National Electrical Code, ANSI/NFPA 70.

26 Auxiliary Power Connections

26.1 An auxiliary power input connection provided for operation of the product from an alternative source of power, such as a Class 1, power-limited source, shall comply with the applicable portions of Supply Connections – Cord Connected Products, Section 24, and Supply Connections – Permanently Connected Products, Section 25, if the circuit involves a risk of fire or electric shock. See the National Electrical Code, ANSI/NFPA 70, which defines Class 1, power-limited sources.

26.2 An attachment plug provided for connection to the alternative power source shall not be of a type that is commonly used for line power.

26.3 If the auxiliary power source is not provided with overcurrent protection in accordance with the National Electrical Code, ANSI/NFPA 70, such protection shall be provided as part of the product.

26.4 Auxiliary power outlet connections provided as a power source for other products, charging of external batteries, and the like shall comply with one of the following if the circuit involves a risk of electric shock:

a) Means for connection of conduit complying with 25.1.2 – 25.1.6 and wire-binding screws, No. 6-32 (3.5 mm diameter) or larger, quick connect terminals, or leads. If wire-binding screws are provided, the terminals shall comply with 25.3.2 – 25.3.4;

b) A length of permanently attached Type SPT-2, NISPT-2, SV, SVE, SVT, SJ, SJE, or SJT flexible cord, an appliance wiring material construction that has been determined to be equivalent to Type SPT-2 or NISPT-2 cord, or the equivalent, and an acceptable cord connector body. The cord or appliance wiring material shall be provided with strain relief and a bushing complying with the requirements in 24.4.1 – 24.9.1;

c) An opening that will permit the field installation of a flexible cord and wire-binding screw, quick connect terminals, or leads as described in (a). Such an opening shall be provided with an insulating bushing as described in 24.8.1– 24.8.3; or

d) A receptacle for a plug-in connection.

Exception: The constructions described in (b) – (d) are not acceptable if the product is intended for supply connection by means of conduit.

26.5 Auxiliary input and output power connections shall be marked in accordance with 127.9.1.

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27 Polarization

27.1 General

27.1.1 A product that is provided with a polarized attachment plug of the two-wire, parallel-blade configuration or a three-wire grounding configuration shall comply with all of the following:

a) There shall not be risk of fire or electric shock with the attachment plug inserted in the supply-circuit receptacle and then with the supply circuit connections reversed.

b) When used in the primary circuit, a manual on-off switch, relay contacts, a solid state on-off switch, an automatic control with a marked on or off position, and an overload protective device shall be connected so as to interrupt the ungrounded side of the supply circuit (narrow blade on a two-wire plug or left-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down). An additional overload protective device if located in the grounded supply conductor shall be of equal or higher rating than the highest rated overload protective device located in the ungrounded supply conductor.

Exception: This requirement does not apply to a protective device that is an integral part of another component, for example, a nonreplaceable fuse in a power transformer.

c) The screw shell of a solitary plug fuseholder and the accessible contact of a solitary extractor fuseholder shall be connected toward the load. If a second fuseholder is located in the grounded side of the line, the screw shell or accessible contact shall be connected toward the grounded side of the supply circuit (wide blade on a two-wire plug or right-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down). See also (b).

d) Components connected between primary circuit and accessible conductive parts shall be connected to the grounded supply circuit conductor of the attachment plug (wide blade on a two-wire plug, right-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down). If identical components are connected in both side (poles) of the line, this requirement does not apply.

e) The screw shell of an Edison base lampholder and the identified contact (wide slot) of a parallel-slot receptacle mounted on the product shall be connected to the grounded supply circuit conductor of the attachment plug (wide blade on a two-wire plug or right-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down).

f) The peak voltage between any inaccessible structural part and the wide blade of the attachment plug shall not be more than the peak voltage between that structural part and the narrow blade of the attachment plug.

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g) If an interlock connector is mounted on a cover that can be applied so as to complete the enclosure in the intended manner but with the interlock connections reversed, the size, shape, or arrangement of the contacts shall be such that the connection of the two interlock parts can be effected in only one way.

h) Unless a capacitor is acceptable for the application as indicated in 39.1.1, it shall not be connected where breakdown can result in a risk of electric shock at an accessible metal part.

27.1.2 Except as required in 27.1.1(a), the conductor of the supply circuit that is connected to the grounded supply-circuit conductor of the attachment plug (wide blade on a two-wire plug, right-hand blade of a three-wire plug when looking at the face of the plug with the grounding pin down) is considered to be at grounded potential when evaluating the risk of electric shock.

27.2 Polarized product receptacle

27.2.1 Convenience receptacles provided on products that have a polarized attachment plug of the two-wire, parallel-blade type shall be of the polarized, two-wire, parallel, slot type.

28 Grounding, Grounding Impedance, and Continuity

28.1 General

28.1.1 If a grounding means is provided on a product, all accessible conductive parts that are likely to become energized and might cause a risk of electric shock as a result of:

a) Breakdown of a component or

b) A reduction in spacings due to user-servicing or handling of the product

shall be connected to the grounding means. The grounding means shall comply with the Grounding Path Test, Section 66. Also see 125.5.1 (Continuity of grounding connection).

Exception No. 1: An accessible conductive part need not be connected to the grounding means if an investigation, including short-circuiting of any component, determines that the accessible conductive part does not represent a risk of electric shock.

Exception No. 2: Accessible conductive parts connected to the secondary circuit of an isolating transformer need not be connected to the grounding means if all other components, component leads, and wiring, involving a risk of electric shock to ground, are separated or insulated from accessible conductive parts and secondary parts in accordance with 28.1.3 – 28.4.1, and:

a) The transformer secondary winding to which the ungrounded accessible part is connected is directly connected to the grounding means or

b) The transformer is provided with a conductive shield that is

1) Connected to the transformer core and the grounding conductor of a three-wire power-supply cord and

2) Located between the primary and secondary windings of the transformer; or

c) The transformer is a toroidal type where the primary and secondary windings are wound on separate legs of the core and where the core is grounded or is inaccessible and floating.

28.1.2 A component, as specified in 28.1.1, is considered to be any component (transformer, capacitor, wire insulation, and the like) unless the component has been investigated and determined to provide an insulation system equivalent to separate basic and supplementary insulation, reinforced insulation, or double insulation. See 28.2.1 – 28.4.1 for a definition of basic, supplementary, and reinforced insulation.

28.1.3 It is not practical to connect certain conductive parts – antennas, antenna terminals, control shafts, mounting screws, and the like, described in 28.1.1 – to the grounding means. Such parts are not considered likely to become energized if supplementary insulation is used in addition to the basic insulation provided. Where it is impractical to provide separate basic insulation and supplementary insulation, reinforced insulation can be used.

28.1.4 A grounded product having isolated accessible conductive surfaces other than those in 28.1.1 and 28.1.3 shall have provision for the grounding of such surfaces.

Exception: A small metal part (such as an adhesive-attached foil marking, a screw, and a handle) that is:

a) On the exterior of the enclosure and separated from all electrical components by grounded metal or

b) Electrically isolated from all electrical components in accordance with 28.2.1 – 28.4.1,

need not have provision for grounding.

28.2 Basic insulation

28.2.1 Basic insulation (with regard to 28.1.3) is the insulation necessary for the proper functioning of the product and for basic protection to reduce the risk of electric shock and shall have all of the following:

a) A dielectric voltage-withstand capability of 1000 V for 1 minute and

b) Minimum acceptable through-air or over-surface spacings of 1.5 mm in circuits of 125 volts or less.

28.3 Supplementary insulation

28.3.1 Supplementary insulation (with regard to 28.1.3) is independent insulation provided in addition to the basic insulation to protect against electric shock in case of breakdown of the basic insulation. When used in circuits involving 125 V or less, supplementary insulation shall comply with each of the following:

a) Supplementary insulation shall not be less than that required for the same material when used as basic insulation,

b) Supplementary insulation shall possess a minimum dielectric voltage-withstand capability of 2500 V for 1 minute, and

c) Supplementary insulation shall provide for spacings of:

1) 0.70 mm through the material and

2) 1.5 mm through air and over surface.

28.4 Reinforced insulation

28.4.1 Reinforced insulation (with regard to 28.1.3) is improved basic insulation with such mechanical and electrical qualities that it in itself provides the same degree of protection against electric shock as an insulation system comprised of basic insulation that is not reinforced and supplementary insulation. When used in circuits involving 125 V or less, reinforced insulation shall comply with each of the following requirements:

a) Reinforced insulation shall not be less than the total of that required for the combination of basic and supplementary insulation,

b) Reinforced insulation shall have a minimum dielectric voltage-withstand capability of 3500 V for 1 minute, and

c) Reinforced insulation shall provide for spacings of:

1) 2.0 mm through the material and

2) 3.0 mm through air and over surface.

28.5 Commercial products

28.5.1 A product intended only for commercial use and provided with a three-wire power-supply cord with a grounding conductor shall comply with the requirements in 28.1.1– 28.4.1 and 28.7.1 – 28.12.1 and be marked in accordance with 127.13.1.

28.6 Household or commercial products

28.6.1 A product intended for either household or commerical use and provided with a three-wire power-supply cord with a grounding conductor shall:

a) Comply with the requirements in 28.1.1 – 28.4.1 and 28.7.1 – 28.12.1 (Grounding Continuity) and

b) Comply with the requirements in Double Protection, Section 44, or Double Protection for High-Voltage Products, Section 52, as appropriate, with the grounding conductor disconnected.

28.7 Grounding interconnected products

28.7.1 When two or more products are electrically or mechanically connected to one another and one of them is grounded:

a) All accessible conductive parts according to 28.1.1 that might render an electric shock shall be grounded on all of the products and

b) Each unit of the system that has a separate power-supply cord shall have a grounding-type cord.

If the products are interconnected electrically and one of them is grounded, they shall be bonded together – such as by means of a conductor included in an interconnecting cable. When the cable involves supply-circuit (primary) voltage, the grounding conductor shall be at least the same size as the power-supply (primary) conductors in the cable.

28.8 Grounding conductor identification and connection

28.8.1 The grounding conductor in a flexible cord shall be green with or without one or more yellow stripes.

28.8.2 The grounding conductor shall be secured to the frame or enclosure of the product by a reliable means such as a screw. A screw, if used, shall be of corrosion-resistant metal, or shall be protected against corrosion in a manner that will not inhibit electrical conductivity between the screw and any other conductor. A lockwasher shall be used to prevent the screw from becoming loosened by vibration. The screw shall reliably penetrate any nonconductive coatings such as paint or vitreous enamel, over the part to be grounded. A connector that relies solely on friction shall not be used.

28.8.2.1 If a portion of the main ground is provided on the printed-wiring board trace, then compliance of the printed-wiring trace as a reliable means for main grounding shall be determined by the Ground Printed-Wiring Board (PWB) Trace Test, Section 90A.

28.8.3 A quick-connect terminal (both connector and tab) that complies with the requirements in the Standard for Electrical Quick-Connect Terminals, UL 310, is acceptable for connecting the grounding conductor of the power-supply cord to the frame or enclosure.

28.8.4 The grounding conductor shall be secured to the frame or enclosure of the product by a separate means such as a screw that is not likely to be removed during ordinary servicing not involving the supply cord.

28.8.5 Solder alone shall not be used for securing the grounding conductor.

28.8.6 The grounding conductor between parts of the product, in a supply cord, or in a cable shall not be less than the size of the current-carrying conductors between parts of the product, in the supply cord, or in the cable.

28.8.7 The grounding conductor shall be connected to the grounding pin or equivalent fixed contacting member of the attachment plug.

28.9 Grounding-type cord connector (appliance coupler)

28.9.1 The construction of a product or an appliance coupler shall be such that the grounding connection is made first and broken last with regard to the power-supply conductors.

28.10 Grounding adapters

28.10.1 Grounding adapters when packaged in conjunction with a product equipped with a three-wire supply cord shall be marked or tagged with instructions for their use. The adapter shall not be connected to the attachment plug before reaching the user.

28.11 Grounded product receptacle

28.11.1 Convenience receptacles provided on grounded products shall be of a grounding type and shall be grounded.

28.12 Permanently connected products

28.12.1 A field-wiring terminal or lead for the connection of an equipment grounding conductor shall be provided.

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28.12.2 A field-wiring terminal intended solely for connection of an equipment grounding conductor shall be a screw-type connector capable of securing a conductor of the proper size.

28.12.3 A wire-binding screw intended for the connection of the equipment grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A screw-type, pressure-wire connector intended for connection of such a conductor shall be plainly identified by the marking ″G,″ ″GR,″ ″GND,″ ″Ground,″ ″Grounding,″ or the symbol ⏚ (IEC Publication 417, Symbol No. 417-IEC-5019-a), or the like, or by a marking on a wiring diagram provided on the product. The wire-binding screw or screw-type wire connector shall be located so that it is unlikely to be removed during the normal servicing of the product, and the wire-binding screw shall have upturned lugs or the equivalent to retain the conductor.

28.12.4 The surface of an insulated lead intended solely for the connection of an equipment grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so color coded.

Exception: The requirements in 28.12.4 that cover the color coding of grounding leads apply to internal wiring that is visible in a wiring compartment in the area in which field connections are to be made. They do not apply to leads or wiring of low-voltage circuits intended to be field connected to Class 2 wiring and that are separated or segregated from high-voltage circuit, field-wiring connections by barriers. See the National Electrical Code, ANSI/NFPA 70, which describes Class 2 wiring.

28.13 Optional grounding

28.13.1 If a means for grounding is provided on the product even though it is not required, such grounding shall comply with all the grounding and polarization requirements.

Exception: A two-wire product with a performance ground – for example, a chassis ground terminal – need not comply with the requirements for grounding if reference is not made to the fact that the entire product is protectively grounded.

29 Current-Carrying Parts

29.1 General

29.1.1 A current-carrying part shall be of silver, copper, a copper alloy, stainless steel, aluminum, or other metal that is acceptable for the particular application.

29.1.2 Uninsulated current-carrying parts involving the risk of fire or electric shock shall be secured to the base or mounting surface so that they are not capable of turning or shifting in position, if such motion may result in a reduction of spacings below the minimum acceptable values.

29.1.3 In determining compliance with 29.1.2, friction between surfaces is not acceptable, but a properly applied lock washer is acceptable.

29.2 Contact material

29.2.1 Contacts of sockets, separable connectors, and the like, connected in circuits involving risk of fire shall be made of nonferrous, spring metal acceptable for the application.

30 Electrical Connections

30.1 General

30.1.1 If loosening or breaking of electrical connections involves a risk of fire or electric shock, the connections shall be soldered, welded, or otherwise securely connected. A soldered joint shall be mechanically secured before soldering.

30.1.2 A lead is considered to be mechanically secured when one or more of the following is provided:

a) At least one full wrap around a terminal,

b) At least one right-angle bend when passed through an eyelet or opening (except on printed-wiring boards where components are properly inserted and soldered), and

c) It is twisted with one or more conductors.

30.1.3 The placing of a lead along a flat surface and soldering (tack soldering) is not acceptable unless it can be demonstrated that a risk of fire, electric shock, or injury to persons is not likely to occur with the lead detached.

30.1.4 Tack soldering of a component is acceptable if, when any one of the component's leads is unsoldered, and the component and unsoldered lead are moved to any position, the component or unsoldered lead cannot contact any part involving a risk of fire or electric shock. If the tack-soldered component involves a risk of fire or electric shock when displaced, it shall not contact any other conductive part so as to increase the risk of fire or electric shock.

Exception: Tack soldering of a component weighing 2 grams or less is acceptable if when any one lead is unsoldered, and the component and unsoldered lead are moved according to (a) and (b), the component or unsoldered lead cannot contact any part involving a risk of fire or electric shock. The component and unsoldered lead shall be moved:

a) To any point along the arc caused by gravity as though the component were a free-swinging weight but not beyond the lowest point of the arc and

b) To any point within 15 degrees on either side of the arc formed by the movement described in (a).

30.1.5 Other means of securing integral leads (for example, spade-type connectors, wire wrapping, and the like) are acceptable if they provide equivalent mechanical security.

30.2 Misalignment of parts

30.2.1 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.

30.3 Wire-wrapped connections

30.3.1 Solderless, wrapped connections are not acceptable where subject to movement or flexure of the wires during conditions of intended operation or user-servicing.

30.4 Wire-wrapped wire

30.4.1 Copper wire – solid, pre-fused, stranded, overcoat stranded, or topcoat stranded – in 24, 22, or 20 AWG (0.21, 0.32, or 0.52 mm^2) may be used. Other sizes and types of wire may be subjected to special investigation.

30.5 Wire-wrapped terminals

30.5.1 Terminals shall be of copper, brass, or plated steel and have at least two sharp edges. Terminals of other materials may be subjected to special investigation.

30.5.2 The wrap shall:

a) Have at least 20 points on the corners of the terminal in contact with the wire and

b) Have at least 16 of the points closely wrapped with no overlapping.

See Table 30.1 (Typical number of wraps) and the Solderless Wire Wrap Connections Test, Section 95. A lesser number of wraps may be used if they provide an equivalent connection.

Table 30.1
Typical number of wraps

Number of sharp corners on the terminal	Number of closely wrapped turns	Total number of turns
4	4	5
2	8	10

30.5.3 The term ″closely wrapped″ in 30.5.2(b) means:

a) There shall not be gaps between adjacent turns greater than one half of the diameter of the wire exclusive of gaps on the first and last turns and

b) The sum of all gaps on any side of a connection shall not exceed the diameter of the wire exclusive of gaps on the first and last turns.

30.5.4 The requirements in 30.5.3 shall be applied only to the actual number of wraps that are tested. Therefore, gaps between any additional wraps that have been added at the manufacturer's option are not included when determining compliance with 30.5.3.

31 Securement

31.1 Friction-fit electrical connectors

31.1.1 A disconnecting part, such as an electrical connector, that is secured by friction-fit only, shall be investigated for risk of fire or electric shock in the extreme disconnected position.

Exception: Such an investigation is not required if the parts comply with one or more of the following:

a) The parts are capable of withstanding a separation force of 4.9 N after five insertions and withdrawals,

b) The parts are soldered together and need not be removed for user-servicing,

c) The parts are of such dimensions or are permanently routed or secured such that fire or electric shock will not result if the parts become disconnected,

d) A minimum, 0.70-mm thick insulating sleeve that has at least a 1.5-mm overlap is provided over the connector parts, and

e) The disconnection and displacement of parts resulting from shipping or moving of the product shall not result in a risk of fire or electric shock, as described in Component electric shock test, 67.7.1; the Dielectric Voltage-Withstand Tests, Section 71; and 81.1.

31.2 Component handling

31.2.1 Any handling, disconnection, or displacement, either intentional or unintentional, of a component of a printed-wiring assembly, a connector, lead, tube, shield, cover, or other similar part that is likely during normal operation or user-servicing shall not result in a risk of fire or electric shock, as determined in 67.7.1 (Component electric shock test); the Dielectric Voltage-Withstand Tests, Section 71; and the Part Disconnection and Component Handling Arcing Test, Section 81.

31.2.2 With regard to a risk of electric shock, a part that is within an enclosure having a cover with an acceptable interlock is not to be considered in its displaced or disconnected condition after the interlocked cover has been replaced if both of the following conditions exist:

a) Such displacement or disconnection is obvious prior to replacement of the interlocked cover and

b) An energized accessible part does not involve a potential of more than 150 volts with regard to ground or any other accessible part.

31.3 Evaluation consideration

31.3.1 Barriers, mechanical restraints, and the effect of gravity are to be given consideration when evaluating disconnection or displacement. A fastening means that relies solely on friction between parts is not acceptable unless investigated and found to be acceptable for the application. A fastening means is not to be removed if it cannot be removed inadvertently, and need not be removed during user-servicing. A flexible fastening means shall return to its original position and shape after flexing.

31.4 Adhesive securement

31.4.1 Barriers, wires, components, and leads that rely only on adhesive as a fastening means shall comply with the Adhesive Securement Test, Section 100.

31.4.2 A part or label of conductive material secured in place by an adhesive shall comply with the Adhesive-Backed-Parts Peel Test, Section 101, if, when dislodged, the part or label can act as a bridging agent and result in a risk of fire or electric shock.

31.5 Telescoping or rod antennas

31.5.1 With regard to 13.1.1(b), a telescoping or rod antenna terminating in an end that might constitute a risk of injury to persons shall be provided with a minimum 6.0-mm diameter button or ball on the end. See 96.10.1 – 96.10.3 for the antenna end piece securement tests.

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31.5.2 A telescoping or rod antenna that is an integral part of a product, and that is constructed so that any part of the antenna, either in its extended or unextended position, is within or, if broken, falls within the overall enclosure of the product, shall be provided with a mechanical guard or barrier that will prevent any part of the antenna from falling into the product and contacting live parts in the event the antenna or any part of it were to break.

31.5.3 To comply with 31.5.2:

a) An antenna and its mounting hardware may be mounted completely external to the enclosure;

b) The antenna may be mounted completely external to the enclosure and the mounting hardware, such as screws, nuts, bolts, or brackets, located within the overall enclosure, provided with a second means so that the hardware or the antenna cannot fall into the product and contact live parts. In determining compliance with the requirement, it is to be assumed that screws and nuts will loosen or be stripped, and the mounting hardware will be evaluated for contact with live parts in this condition;

c) The antenna and its mounting hardware may be surrounded with separate compartments that contain the antenna or its mounting hardware, if broken;

d) The antenna and its mounting hardware may be provided with supplementary insulation so that the antenna or its mounting hardware cannot contact live parts; or

e) The live parts within the enclosure may be provided with insulation so that the antenna or its mounting hardware, if broken, cannot contact them.

31.5.4 Mounting hardware refers only to those parts that are subject to stress when a telescoping antenna is subject to movement and that are used to mount the antenna itself. Those parts that may be connected to or are in contact with the telescoping antenna but do not serve as a mounting means for it are not subject to these requirements.

31.6 Lead-wire connection terminals

31.6.1 Lead-wire connection terminal assemblies such as those used for connection of external antenna lead wires, external speaker lead wires, and the like that are accessible to the user shall be anchored, fitted, or constructed so that they cannot work loose when the lead-wire connection means are tightened, loosened, or operated if any part of the assembly could fall inside the product and contact circuitry or parts involving a risk of fire or electric shock.

31.6.2 In applying 31.6.1, the construction of the connection terminal assemblies or their fastening means or both shall be evaluated by means of the impact test in 98.11.1; the pressure test in 98.5.1; and by tightening, loosening, and operating the connection means as would be encountered in attaching the lead wires in accordance with any procedure or instructions provided with the product.

31.6.3 Consideration shall be given to barriers and additional securing means that prevent the screw terminals or their fastening means from contacting live parts in the event of detachment.

32 Captive Parts

32.1 General

32.1.1 A part of the product that is essential for compliance with the requirements of this standard, such as the requirements described in Accessibility of Parts, Section 18, shall be made captive or otherwise arranged so that it cannot be deliberately or unintentionally discarded if all of the following conditions exist:

a) The part is subject to removal during user-servicing,

b) The part is not essential for the functioning of the product,

c) The part is not readily perceptible to the user during the use of the product (see Exception No. 2 to 15.1(b) for the definition of readily perceptible), and

d) The omission of the part might result in a risk of fire, electric shock, or injury to persons.

32.2 Captive knobs

32.2.1 A captive knob and shaft assembly shall withstand each of the following tests without exposing parts involving the risk of electric shock or injury to persons, or adversely affecting the captivating means:

a) The pressure test according to 98.5.1,

b) The impact test according to 98.11.1 – 98.11.3, and

c) The pull tests according to 98.4.1(c) or 98.4.2(b).

33 Interlocks

33.1 General

33.1.1 An interlock shall render parts that become accessible free from a risk of electric shock, excessive temperature, or driven movement (that could result in injury to persons).

33.1.2 An interlock shall be such that it cannot be defeated readily without resorting to one or more of the following procedures:

a) Damaging the product,

b) Making wiring connections or alterations,

c) Using other than ordinary tools, and

d) Using materials other than those readily available (adhesive tape, string, or conventional, extension-cord sets are considered readily available).

33.1.3 If two momentary-contact switches must be operated to energize the product, the arrangement shall comply with 33.1.2(d) and the operating means shall be spaced from each other and from uninsulated parts involving the risk of electric shock so that if they can be operated simultaneously (see 67.1.2) by one or both hands of a person, contact with uninsulated parts involving the risk of electric shock shall be unlikely.

33.1.4 The interlock device shall be such that during the operation and user-servicing of the product, all of the following requirements are met:

a) The interlock cannot be defeated by improper disassembly; for example, removal of the wrong screws during removal of the cover;

b) The cover in which the interlock is mounted shall not rotate by its own weight about the interlock axis perpendicular to the cover during any stage of its removal or replacement, if such rotation gives access to a part involving the risk of electric shock or injury to persons, or damages the interlock or the cover;

c) The act of removal or replacement of the interlocked cover shall not subject the user to unintentional contact with parts involving the risk of electric shock or injury to persons;

d) The interlocked cover cannot be readily misapplied to result in a risk of electric shock, unless such misapplication is obvious during and after replacement of the cover; and

e) An interlock using an appliance coupler and a motor attachment plug cap shall comply with the Interlock Strain Relief Test, Section 93.

33.2 User-servicing guard

33.2.1 A guard to prevent access to live parts through openings in an interlocked enclosure shall be hinged or otherwise prevented from being discarded if it must be removed for user-servicing. The guard shall not be rendered ineffective without being intentionally deformed or obviously misplaced.

33.2.2 A product incorporating an interlock intended to be functional during user-servicing shall be marked according to 128.10.1.

33.2.3 With regard to 33.1.4(c), parts that are recessed more than 6 cm from the edge of the cabinet opening, in the plane of the cover, are to be excluded when determining whether the act of removal or replacement of a cover subjects the user to unintentional contact with parts involving the risk of electric shock or injury to persons.

33.2.4 An interlock connector on a polarized or grounded product shall not be mounted on a cover that can be applied so as to complete the enclosure in what appears to be the intended manner but with the interlock connections reversed or without connection of the product to the grounding means.

33.2.5 If it is necessary to remove a chassis from the cabinet for user-servicing, the arrangement of the interlock assembly shall not be readily defeatable with the chassis out of the cabinet.

34 Electronic Components

34.1 Tube interchange and substitution

34.1.1 A risk of electric shock shall not result due to:

a) Interchange of any electron tube used in the product or

b) The substitution of a tube used in the product with its glass or metal equivalent of a like designation.

34.2 Standardized pin/socket arrangement

34.2.1 In addition to the evaluations of 34.1.1, certain industry-standardized electron-tube arrangements must be considered in cases where a risk of electric shock can result by placing potential and current on a socket pin to which a shield or an electron-tube metal envelope is likely to be connected.

Exception: Such arrangements need not be considered when there are no electron tubes with metal shields or metal electron tubes used in the product and there are no counterparts available where the shield or metal envelope is or might be connected to the particular pin reserved for such use.

34.3 Octal-base tube socket

34.3.1 An octal-base tube socket shall have its pin contacts recessed at least 1.4 mm so that a pin connected to any accessible metal part of a tube cannot contact any socket contacts that involve the risk of electric shock.

34.4 Picture-tube-base pins

34.4.1 Picture-tube-base pins not connected in the electrical circuit are considered as being at the highest voltage connected to the tube base.

35 Sleeving, Tape, Tubing, Wire Insulation, and Flexible Printed Wiring

35.1 General

35.1.1 Sleeving, tape, tubing, wire insulation, and flexible printed wiring shall be rated for the voltage involved and the temperature attained under any condition of actual use. Tape shall be flame-retardant. Sleeving, tubing and wire insulation shall have a flame retardant rating (VW-1). Flexible printed wiring that involves a power greater than 15 watts as measured in accordance with the Power Supply Tests, Section 77, shall be rated minimum V-2, HF-2, or VTM-2. Flexible printed wiring that involves a power less than or equal to 15 watts as measured in accordance with Section 77 shall be rated minimum HB, HBF, or VTM-2. Refer to 35.10.1 – 35.11.6 for interconnecting cables and speaker connection wires.

Exception: The following methods of construction need not comply with this requirement:

a) Insulated wire, sleeving, tape, and tubing used for bundling, routing, and lacing of wires if the overall length is equal to or less than 3 cm.

b) Spiralled insulated wire used for cabling routing and the like if the spiralled length is equal to or less than 3 cm.

c) Flexible printed wiring that does not involve a risk of fire or electric shock and that:

1) Has a maximum dimension equal to or less than 3 cm or

2) Is segregated from wiring and other parts involving the risk of fire or electric shock.

d) Sleeving, tape, tubing, and wire insulation that is used on parts that do not involve a risk of fire or electric shock and that is segregated from wiring and other parts involving the risk of fire or electric shock.

35.1.2 Combinations of insulated wire covered with sleeving, tape, or tubing where either the wire, sleeving, tape, or tubing is not classed as flame-retardant can be subjected to the flame test for VW-1 wire to determine if the combination can be classed as VW-1.

35.2 Primary wiring to convenience receptacle

35.2.1 A convenience receptacle of Type 5-15R (125-volt, 2-pole, 3-wire grounding), or 6-15R (250-volt, 2-pole, 3-wire grounding) in accordance with the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD-6, provided on a permanently connected product shall be wired to the supply circuit as indicated in Table 35.1.

Exception: Conductors of smaller, cross-sectional area than described in35.2.1 or other series devices such as printed-wiring board foils, switching contacts, or connectors may be used if the receptacle circuit complies with the Receptacle Overload Test, Section 76.

Table 35.1
Permanently connected product receptacle wiring

Size of supply circuit conductor,		Minimum size of lead to receptacle,	
AWG	(mm^2)	AWG	(mm^2)
14	2.1	18	0.82
12	3.3	16	1.3
10	5.3	14	2.1
8	8.4	12	3.3

35.2.2 A convenience receptacle of Type 1-15R (125-volt, 2-pole, 2-wire), 5-15R (125-volt, 2-pole, 3-wire grounding), or 6-15R (250-volt, 2-pole, 3-wire grounding) in accordance with the Standard for Wiring Devices – Dimensional Requirements, ANSI/NEMA WD-6, provided on a cord connected product shall be wired to the supply circuit with wiring at least the gauge of the power supply cord conductors but not less than 18 AWG (0.82 mm^2).

Exception: Conductors of smaller, cross-sectional area than described in 35.2.2 or other series devices such as printed-wiring board foils, switching contacts, or connectors may be used if the receptacle circuit complies with the Receptacle Overload Test, Section 76.

35.3 Small-gauge wire

35.3.1 Wire smaller than 24 AWG (0.21 mm^2) shall be used only if it is protected from damage due to the effects of vibration, impact, and handling during the operation and user-servicing of the product.

35.4 Wire handling

35.4.1 The conductor of a wire involving the risk of fire or electric shock shall not become exposed due to handling during user-servicing.

35.5 Accessibility of internal wiring

35.5.1 Wiring and connections inside the product enclosure that present a risk of fire or electric shock shall be made inaccessible.

Exception No. 1: Interconnecting wiring of Type SPT-2 or NISPT-2, or an appliance wiring material construction that has been determined to be equivalent to Type SPT-2 or NISPT-2 cord or heavier cord, as specified in 17.4.3 need not be made inaccessible.

Exception No. 2: Flexible cords and cables as specified in 35.10.1 – 35.10.3 need not be made inaccessible.

Exception No. 3: Appliance wiring material inside the overall enclosure that has a minimum, 0.70-mm thick insulation need not be made inaccessible.

35.5.2 With regard to the accessibility of internal wiring, the inaccessibility of such wiring required in 35.5.1 is considered to exist if, when judged as though it were an uninsulated live part, it is acceptable according to 18.1.1 – 18.1.4.

35.6 Low-energy circuit wiring

35.6.1 Low-energy circuit wiring (that is, wiring not involving the risk of fire or electric shock) that is not contained entirely within the enclosure and that might contact parts inside the enclosure that involve the risk of fire or electric shock shall be insulated (see 35.1.1) within the enclosure. Such wiring shall also be provided with a means of strain relief and push-back relief.

35.7 Cable and wiring subject to motion

35.7.1 Wires, cable, or cord subject to strain or motion, either within or outside the appliance enclosure shall comply with each of the following if damage to the insulation can result in a risk of fire or electric shock:

a) It shall be investigated to determine the effect of continued operation under the strain or motion to which it is subjected and

b) It shall be provided with:

1) Insulation at all points of strain or motion between conductors, and between conductors and adjacent conductive parts and

2) Strain relief (see 24.5.1) and a bushing (see 24.8.1).

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35.8 Wiring subject to handling

35.8.1 A lead that involves a risk of fire or electric shock and that may be flexed or handled during user-servicing shall be acceptably secured.

35.9 Openings in conductive material

35.9.1 An opening in a conductive material used for the passage of a wire connected to a circuit that involves the risk of fire or electric shock shall be free from sharp edges, burrs, fins, and the like that might damage the conductor insulation.

35.10 Remote or interconnecting cable

35.10.1 Each flexible-cord or -cable assembly used for external interconnection between sections of the product, or between products shall comply with all of the following requirements:

a) The assembly shall be of the type specified in 35.10.2 depending on the voltage, current, abnormal tests, and length;

b) The assembly shall have an ampacity rating not less than the current rating of the product, accessory, or product level it supplies; and

c) The assembly shall be provided with strain relief, cord exit, and push-back relief (as described in 24.5.1, 24.6.1, and 24.9.1) if the assembly is permanently attached to the product.

35.10.2 A flexible-cord or -cable assembly used as a remote cable shall comply with one or more of the following requirements:

a) The assembly shall be of or use a construction equivalent to Type SJ flexible cord and shall be marked ″VW-1.″

b) The assembly shall be of or use a construction equivalent to Type SV or Type SPT-2 or NISPT-2 flexible cord, or an appliance wiring material construction that has been determined to be equivalent to Type SPT-2 or NISPT-2 cord and shall be marked ″VW-1,″ if the length of the cord is equal to or less than 3 m.

c) The assembly shall be of or use a construction equivalent to Type SP-1 flexible cord, and shall be marked ″VW-1,″ if both of the following conditions are met:

1) The risk of electric shock is not involved.

2) The risk of fire is not involved following abnormal tests involving short circuits between conductors of the cord and any conductor of the cord and earth ground, or any other accessible part.

d) The assembly may be of any other type or construction of wire or cord when all of the following requirements are met:

1) The construction complies with the test conditions in 35.10.2(c)(1) and 35.10.2(c)(2);

2) An arcing test shows there is no risk of fire that might occur as a result of the test described in 82.1 and 82.2, conducted between the conductors involving risk of fire; and

3) The conductor insulation, and jacket if used, is marked ″VW-1.″

e) The assembly may be of any type or construction of wire when the voltage involved is less than 42.4 V peak and the power capability is less than 15 W. The power measurement shall be made in accordance with the Power Supply Tests, Section 77.

35.10.3 Products intended for connection to accessories by qualified service personnel and provided with external connections need not be provided with interconnecting cables. Instructions shall be included with the products to indicate type of wiring needed.

35.11 Audio amplifier circuit output connections– external speaker connection wire and terminals

35.11.1 Cables provided for connection of an external speaker to an audio amplifier circuit having an output limited in accordance with 67.3.1 and 70.1 shall have insulation with a flame retardant rating (VW-1).

Exception No. 1: Such insulation is not required if Type SP-1 or heavier flexible cord is provided.

Exception No. 2: Leads that are intended to be connected to audio output circuits when the voltage involved is less than 42.4 volts peak and the power capability is less than 15 watts need not comply with this requirement.

35.11.2 A product with an amplifier circuit having an output that is not limited in accordance with 67.3.1 or 70.1 shall be provided with one of the following to permit connections to the audio output circuit:

a) A length of permanently attached, Type SPT-2 or NISPT-2 cord, an appliance wiring material construction that has been determined to be equivalent to Type SPT-2, NISPT-2, or heavier cord, or equivalent flexible cord or cable complying with 35.10.1. An acceptable length would be that necessary for proper placement of the speaker system to achieve normally expected acoustic effects.

b) A receptacle on the product for a plug-in connection along with a mating plug and a Type SPT-2 or NISPT-2 cord, an appliance wiring material construction that has been determined to be equivalent to Type SPT-2, NISPT-2, or heavier cord, or equivalent flexible cord or cable complying with the requirements of 35.10.1. The arrangement shall comply with 30.2.1.

c) A connective device (such as a binding post, push-in terminal, and the like), the conductive parts of which are rendered inaccessible by inherent insulation of the device, by external barriers or covers over the device, or other equivalent insulating means. The materials used for the connecting parts (that is, the receptacle, the mating connection, and the like) shall comply with the following:

1) The material shall be at least 0.70 mm thick and

2) The material shall comply with Table 20.1.

35.11.3 When 35.11.2 (a) or (b) is selected, all necessary materials to make the connections and to insulate them shall be provided along with installation and connection instructions.

35.11.4 When a connective device according to 35.11.2(c) is selected, installation instructions that describe and depict the proper method(s) for making connections to the audio-output circuit by means of the particular connective device shall be provided with the product. The connective-device assembly, its inherent insulation, and any external barriers or covers shall be constructed so that, when connections are made according to the installation instructions, all of the following conditions are met:

a) The connections can be made without any preparation of the conductors other than the removing of wire insulation;

b) The uninsulated conductors are prevented from slipping out when the conductive device is tightened;

c) At least 1.5 mm of the wire insulation in addition to the bare conductor enters the assembly;

d) There are no openings in the insulated assembly that would allow:

1) The bare conductor to exit and

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2) Connections to be made in any manner not described in the installation instructions.

e) The accessibility probe illustrated in Figure 18.1 cannot contact:

1) Any conductive parts of the connection device with the terminal adjusted to any position (open, closed, and the like) without any connections made to it and

2) Any conductive parts of the connection device, as well as uninsulated conductors, parts of conductors, and the like, when connections have been made according to the installation instructions.

35.11.5 Amplifier output-circuit parts operating at a potential not limited in accordance with 67.3.1 or at power not limited in accordance with 70.1 shall be insulated or inaccessible.

35.11.6 A product with an amplifier circuit having an output that is not limited in accordance with 67.3.1 or 70.1, or both, shall be marked in accordance with 128.12.1.

36 Devices and Applications

36.1 Mounting

36.1.1 A user-accessible switch, lampholder, receptacle, or similar component shall be mounted securely so that it is not capable of turning.

Exception No. 1: The requirement that a switch cannot be turned can be waived if all of the following requirements are met:

a) The switch is a plunger or other type that does not tend to rotate when operated (a toggle switch is considered to be subject to forces that tend to turn the switch during its operation);

b) The means of mounting the switch make it unlikely that operation of the switch might loosen it;

c) The spacings are not reduced below the minimum values if the switch rotates; and

d) Operation of the switch is by mechanical means rather than by direct contact by persons.

Exception No. 2: A lampholder of a type in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in by a nonremovable jewel, need not be secured so that it cannot be turned, provided rotation of the lampholder cannot reduce spacings below the minimum acceptable values.

Exception No. 3: A user-serviceable lampholder intended to be readily removable without the use of a tool need not be secured so that it cannot be turned.

36.1.2 Inadvertent loosening of parts shall not reduce spacings below minimum values or cause accessible parts to render an electric shock.

36.2 Securing means

36.2.1 The means used for securement mentioned in 36.1.1 and 36.1.2 shall consist of more than friction between surfaces – for example, a properly applied lock washer is an acceptable means of securement for a device having a single-hole mounting means.

36.3 Unused receptacle

36.3.1 An unused receptacle, such as one provided for the attachment of an accessory, that involves a risk of electric shock shall comply with both of the following requirements:

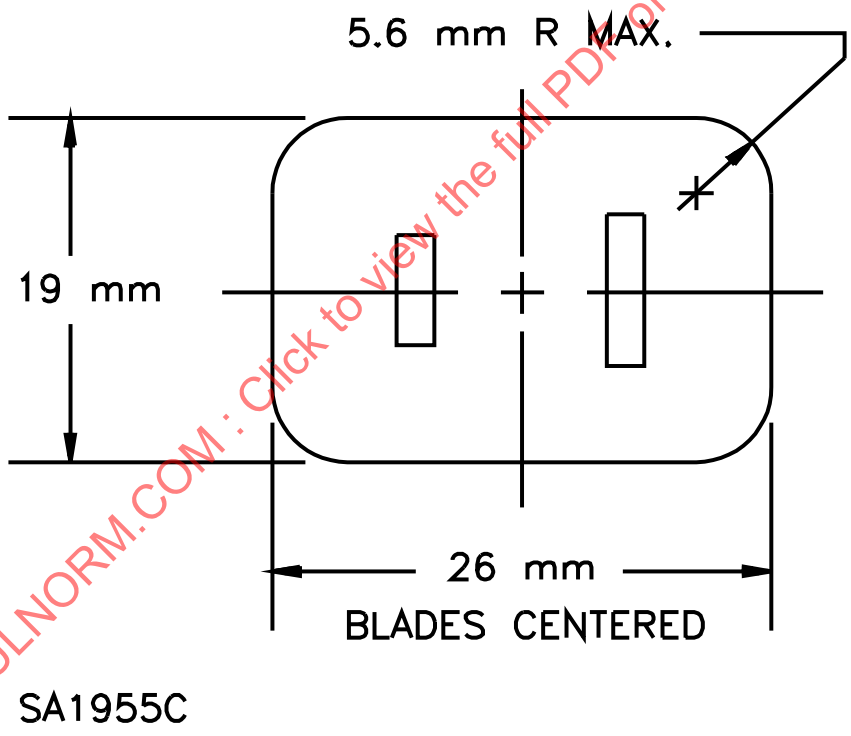
a) The unused receptacle shall not be of the type generally used as a receptacle for signal interconnection of products (for example, a single-prong, shielded-type phonograph plug) and

b) The unused receptacle shall involve 120-V, 60-Hz (supply-circuit) voltage only if it is of the conventional, parallel-slot type.

36.4 Receptacle separation

36.4.1 The spacing between any adjacent parallel-slot receptacles on a product shall provide for the simultaneous, full insertion of attachment plugs having the face size indicated in Figure 36.1 in all of the receptacles.

Figure 36.1
Plug-face dimensions for determining outlet separation



36.5 Receptacle configuration

36.5.1 The configuration of a convenience receptacle shall be of a type intended for the supply circuit to which the product is to be connected. In other words, supply-circuit connected receptacles provided on cord-connected products shall conform to the configuration applicable to the attachment plug on the supply cord.

Exception: If a receptacle is intended for an accessory that cannot be used separately (that is, must be used with the basic product), other configurations may be acceptable

36.6 Receptacle mounting clearance – conductive surface clearance

36.6.1 A receptacle mounted onto a conductive surface shall have the face of the receptacle mounted at least 2.4 mm from the conductive surface as shown in Figure 36.2.

36.7 Receptacle mounting clearance – small outlet surface clearance

36.7.1 A receptacle with face dimensions of less than 15.9 mm in width or 22.2 mm in length shall have the face of the receptacle mounted not more than 4.8 mm from the adjacent mounting surface as shown in Figure 36.3. The adjacent mounting surface is considered to be within a 22.2 mm long and 15.9 mm wide area symmetrically located about the receptacle contacts as shown in Figure 36.3.

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Figure 36.2
Minimum conductive surface clearance

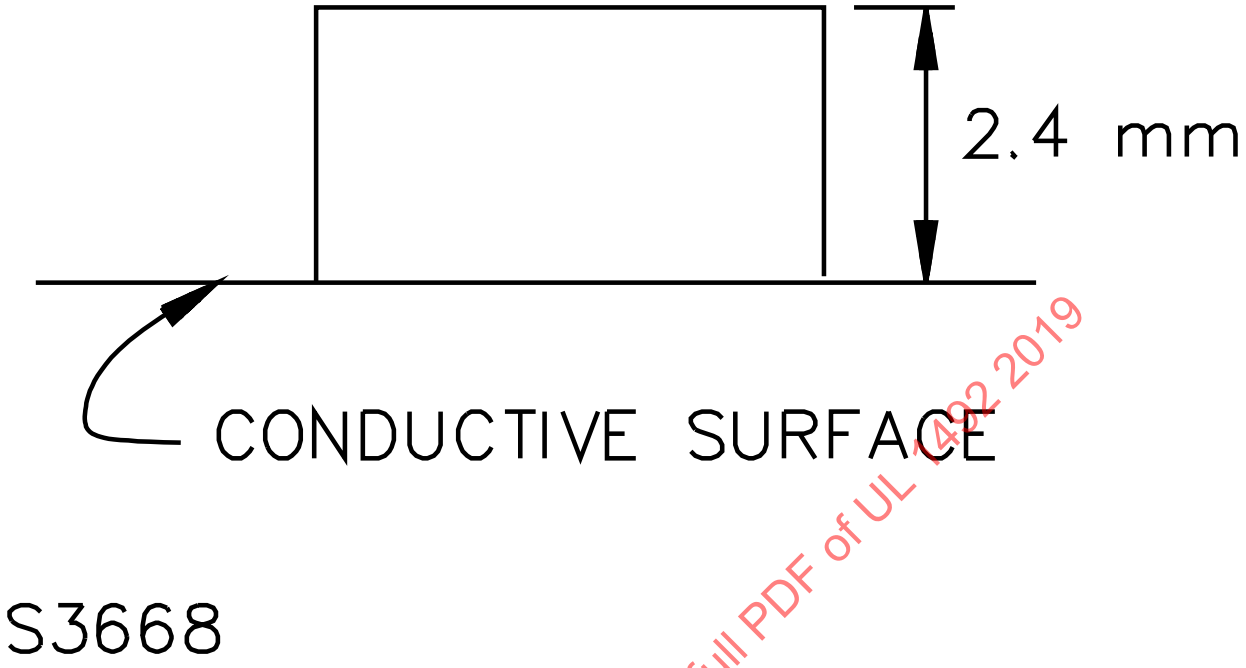
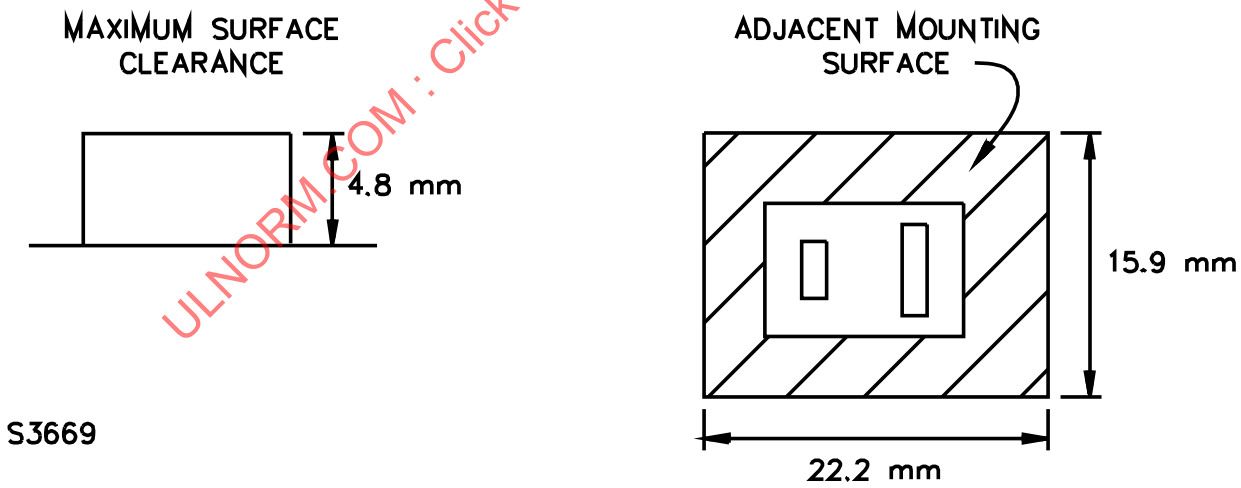


Figure 36.3
Small outlet



36.8 Receptacle insertion clearance

36.8.1 The area surrounding an unused attachment-plug receptacle shall be free of any projections that might interfere with the full insertion of the blades of a circular attachment plug having a face diameter of 30.2 mm.

Exception: This requirement does not apply if the projections are such that the blades of the attachment plug are obstructed from being inserted to make electrical contact with the female contacts of the receptacle.

36.9 Lampholder construction

36.9.1 Terminals, conductive parts, and contacts of a lampholder shall be securely riveted or otherwise secured with or without the lamp in place. The lampholder terminals and other parts involving the risk of electric shock, including the lamp base, shall be protected against the likelihood of grounding or of rendering an electric shock while in use or during user-servicing. Insulation of lampholder screw shells shall comply with 20.6.1.

36.10 General switch and relay applications

36.10.1 A switch or other current-interrupting device shall be tested in accordance with the requirements for that component. The actual load controlled in the product may be used in place of the artificial load specified in the requirement applicable to the component.

Exception: A switch or relay that is not connected to the supply circuit, controls a power of 50 watts or less during idle conditions, and is constructed and connected so that no risk of electric shock will result if the switch malfunctions need not be tested.

36.10.2 The current rating of a supply-circuit control switch shall not be less than the current that it controls when the product is adjusted as indicated in 68.5.1.

36.10.3 A supply-circuit control switch shall:

a) Satisfy Equation 36.1 or

b) Be TV-rated (see 36.10.4).

Exception No. 1: A keylock supply-circuit control switch need not be TV-rated if it is used in series with a main on-off switch in a commercial product to reduce the likelihood of unauthorized use of the product.

Exception No. 2: A vacation switch (a switch used to disconnect power from the product during long periods of non-use) that is not accessible on the front of the unit and is not operable from the remote control need not be TV-rated.

36.10.4 The current and voltage rating of a TV-rated switch shall not be less than the maximum steady-state rms current and voltage that it controls. A TV-rated switch is marked with the type designation TV-1 to TV-20. The suffix number in the type designation represents the maximum steady-state current (rms) in amperes.

36.10.5 The current and voltage rating of a supply-circuit relay shall be acceptable for the application. The current rating of the contacts of the relay shall be equal to or greater than the maximum steady state (rms) current that it controls.

Equation 36.1
Maximum current controlled by a non-tv-rated switch

$$I_p \leq 1.414\ A$$

in which:

I_p is the peak inrush current controlled by the switch, as determined by the Peak Inrush Current Test, Section 65, and

A is the switch current rms rating in amperes.

36.10.6 If the peak inrush current controlled by the supply-circuit relay exceeds the peak current corresponding to the relay contact rating – relay contact current rating in amperes, rms, times 1.414 – the relay is to be subjected to the Relay Endurance Test, Section 83.

Exception: Relay contacts with a suitable TV-rating need not be subjected to the relay endurance test.

36.11 Receptacle switch or relay

36.11.1 A switch or relay that controls a supply-circuit connected receptacle shall be TV-rated. The current and voltage rating of the switch or relay shall not be less than the maximum steady-state rms current and voltage that it controls based upon the marked receptacle rating.

Exception: A relay that complies with the Relay Endurance Test, Section 83, need not be TV-rated.

36.12 Double-pole, TV-rated switches controlling two circuits

36.12.1 A double-pole, TV-rated switch controlling two different circuits (for example, one pole controlling a 120-V AC circuit and the other pole controlling a DC circuit) shall be acceptable for the application. The current, frequency, and voltage rating for each pole shall not be less than the maximum steady-state current, frequency, and voltage that it controls.

Exception: An AC, TV-rated, double-pole switch controlling one AC circuit and one DC circuit may be accepted without further tests if:

a) The DC circuit voltage is 42.4 V or less,

b) The DC circuit power capability is 50 W or less, and

c) The DC current is 10 percent or less of the 120- or 240-V AC current rating of the switch.

36.13 Transfer switch

36.13.1 An AC/DC transfer switch that involves the risk of fire or electric shock, used in a combination supply-circuit and battery-operated product, shall be arranged so that it cannot be inadvertently operated.

36.14 Solenoids and motors

36.14.1 A solenoid or motor connected in the supply-circuit or in a circuit having a power capability of more than 50 W [see 77.1.2(b)] shall be investigated in accordance with 75.3.

37 Protective Devices

37.1 A protective device such as a fuse, manual-reset overcurrent device, or fusible resistor shall comply with the applicable protective-device component requirements.

37.2 Protective devices may be located in either, or both, of the following locations:

a) The circuitry inside the product (see the markings described in 128.4.1, 128.4.2, and 128.6.1) or

b) The attachment plug [see the markings described in 128.5.1, 128.6.1, 128.9.1, and 131.8(14)].

37.3 For purposes of overload protection, a printed wiring board conductor or any individual wire or wires is not considered to be a protective device.

38 Transformers

38.1 General

38.1.1 Isolating transformers shall comply with the construction and performance requirements in the standards indicated in Table 38.1.

38.2 Transformer enclosure

38.2.1 The enclosure of a transformer mentioned in test option 4 of Table 77.1 and note c of Table 38.1 shall comply with the following items:

a) The enclosure shall be of metal or the equivalent.

b) The enclosure shall completely and individually enclose the transformer windings.

Exception: A transformer need not be provided with an enclosure if it:

a) Is a high-frequency or signal and coupling type or

b) Has an input of 60 W or less, measured after 1 minute of operation, with all secondary windings short-circuited and complies with the Short-Circuit Test, Section 79.

c) The enclosure shall not be provided with holes or louvers that allow the circulation of air. Holes for the entrance or exit of wires may be provided if all of the following conditions are met:

1) An unused portion of any lead opening is not larger than 130 mm^2 in area;

2) The total unused portion of two or more lead openings is not more than 230 mm^2 in area; and

3) All openings provided for lead wires, but not so used, are effectively closed.

d) The enclosure shall not be larger than the transformer itself, unless the acceptability of the combination is investigated and determined to be acceptable.

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e) The enclosure shall not contain polymeric materials unless the specific combination of construction and materials is investigated and determined to be acceptable.

Exception: A small amount of phenolic composition, such as a terminal block, may be used without investigation.

Table 38.1
Isolating transformer requirements

Type of isolating transformer	Shall comply with all applicable UL 1411[a] requirements	Shall comply with all UL 1876[a] requirements
Power	Yes[b,c]	No
Motor	Yes[b,c]	No
High-frequency	Yes[d]	No
Signal and coupling	No	Yes

[a] UL 1411 is the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances and UL 1876 is the Standard for Isolating Signal and Feedback Transformers for Use in Electronic Equipment.

[b] Power Input, Temperature, and Abnormal Operation tests specified in UL 1411 may be conducted in the complete product.

[c] The 7-hour or 15-day abnormal operation tests required in UL 1411 need not be conducted if the total power output of the transformer is equal to or greater that 15 watts, and the transformer is provided with an enclosure that complies with 38.2.1.

[d] Only Sections 4 – 14, 22 – 25, 27, and 28 of UL 1411 apply to high-frequency switching transformers.

39 Capacitors, Varistors, and Suppressors

39.1 Isolating components

39.1.1 A component such as a capacitor, a combination capacitor and resistor, or a suppressor used for antenna blocking, line-by-pass, or metal-cabinet isolation; or between supply-circuit (line) connected parts and exposed metal parts (where the component is continually stressed) shall comply with the requirements in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

39.2 Across-the-line component

39.2.1 A component such as a capacitor, a combination capacitor and resistor, a varistor, or a suppressor connected across the supply circuit shall comply with the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

39.2.2 A component as described in 39.2.1, used in series with an impedance or a protective device in accordance with 39.2.2, rated more than 1 A, need not comply with the requirements for across-the-line capacitors if the combination of the component and impedance or the component and the protective device complies with the requirements for across-the-line capacitors in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

39.2.3 A component as described in 39.2.1 is also considered to be across the line under any of the following conditions:

a) The component is used for antenna blocking or line-by-pass isolation in a product provided with an external antenna terminal or terminals that might be grounded and

b) The component is used for line-by-pass isolation in a product provided with a terminal or connection intended to be grounded.

39.3 Electrolytic capacitor

39.3.1 A liquid-electrolyte, metallized-film, or conductive-foil type electrolytic capacitor connected in a circuit capable of delivering a power of more than 15 W as determined in the Power Supply Tests, Section 77, and having a diameter of more than 10.0 mm, shall be provided with a means of relieving excessive internal pressure.

39.3.2 A capacitor as described in 39.3.1 shall be positioned so that the pressure relief means is not obstructed. If obstruction of the pressure relief means cannot be determined by visual inspection, a suitable means shall be used to force the capacitor to vent in its intended manner.

39.4 Capacitor employing liquid or wax dielectric medium

39.4.1 A capacitor connected in a circuit having a power availability of more than 15 watts as determined in 77.2.1 – 77.2.4 and using a liquid or wax dielectric medium more combustible than askarel (polychlorinated biphenyl dielectric oil) shall comply with the Standard for Capacitors UL 810, covering protected oil-filled capacitors.

40 Line-Connected or Direct-Connected Series Resistors

40.1 A resistor connected in series with the line (supply) circuit input of a line-connected or direct-connected product or the primary of a power-transformer-isolated product, for the purpose of reducing the input surge current, the power-supply voltage, or both, shall comply with the requirements in the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

Exception No. 1: Resistors connected to the line at the load side of a fuse rated 1 A or less need not comply with the requirements in UL 1412.

Exception No. 2: Resistors connected to the line at the load side of a resistor rated 120 ohms or more need not comply with the requirements in UL 1412.

Exception No. 3: Line-to-chassis resistors used to comply with 43.1 need not comply with the requirements in UL 1412.

Exception No. 4: Gas discharge lamp series dropping resistors and resistor/capacitor combinations connected across primary switch contacts for the purpose of contact arc suppression need not comply with the requirements in UL 1412.

Exception No. 5: Other resistors that are not involved with the power supply of the product need not comply with the requirements in UL 1412.

Exception No. 6: Resistors that comply with test option 5 of Table 77.1 need not comply with the requirements in UL 1412.

No Text on This Page

41 Lasers

41.1 Products that use a laser shall comply with the current construction requirements of the Code of Federal Regulations, Title 21, Chapter I, Subchapter J, Sections 1010.2 and 1010.3 and Sections 1040.10 and 1040.11.

41.2 With reference to 41.1, compliance of laser products with the Code of Federal Regulations (CFR), Title 21, Part 1040, shall be determined by:

a) Determining the Class of laser (as defined in the CFR) from the manufacturer's required documentation, such as the Center for Devices and Radiological Health (CDRH) report, markings and labels, or similar documentation;

b) Verifying that the manufacturer's markings and labels having the information specified in the CFR are affixed on the laser product (as defined in the CFR);

c) Determining that the corresponding construction features, such as protective housing, interlocks, and similar features, are provided in accordance with the CFR; and

d) Determining that the resulting construction complies with the construction requirements of this standard.

42 Batteries and Battery Circuits

42.1 General

42.1.1 A battery shall comply with the requirements in this Section and with the Battery and Battery-Circuit Tests – Electrical, Section 88, and the Battery Tests– Mechanical, Section 89.

42.2 Battery connections

42.2.1 A battery used in a combination supply-circuit and battery-operated product shall not be connected to the supply circuit.

Exception: This requirement does not apply if current-carrying parts are insulated, arranged, or otherwise protected so that there is no risk of fire or electric shock.

42.3 Battery terminals

42.3.1 The terminals of a battery shall be protected or located so they cannot be inadvertently short-circuited during installation, replacement, or while in service.

42.4 Automotive or marine battery cord connections

42.4.1 The connecting means of a product cord intended for connection to a marine or automotive battery circuit shall be acceptable for the application.

42.4.1.1 The flexible cord used with an automotive type battery shall be Type SPT-2, non-integral SPT-2, or SVT.

42.4.2 A plug constructed to engage an automobile cigar-lighter receptacle is an example of an acceptable connecting means.

42.4.3 An AC/battery product that is intended to be powered from a separable battery-supply cord shall not use a connector on the product that has a configuration that engages the AC cord-connector described in 24.4.1.

42.5 Battery-circuit fuse

42.5.1 A product intended for use with a battery shall be provided with a fuse or protective device in the battery-supply circuit if the battery is external to the product and is capable of producing a power of more than 15 watts – see 90.1.

42.5.2 A fuse or protective device shall be located in or adjacent to the battery connecting means in the conductor electrically opposite to the circuit common conductor. (See 90.1, Battery Supply Short-Circuit Test, and 128.6.1, Protective device replacement marking).

Exception: The fuse may be in the battery-supply circuit common if equivalent protection is provided.

42.5.3 If the fuse or protective device is not located within the actual connecting means (connector plug or the like), the length of wire between the connecting means and the protective device shall not be greater than 13 cm.

42.5.4 The battery-connecting means mentioned in 42.5.2 is defined as the first point of electromechanical connection at the battery or battery cell.

Figure 42.1
Battery connecting means

Figure 42.1 deleted

43 Antenna Discharge Path

43.1 Each terminal or lead provided for the connection of an external antenna or cable-system input shall be conductively connected to the supply circuit. The conductive connection shall have a resistance of 12 megohms maximum; comply with the requirements in the Standard for Conductive-Path and Discharge-Path Resistors for Use in Radio-, Video-, or Television-Type Appliances, UL 1676; and the connection shall be effective with the power switch either on or off.

Exception No. 1: The conductive connection need not be provided if all of the following requirements are met:

a) Such a connection is established in the event of electrical breakdown of the antenna or cable-system input isolating means;

b) The breakdown mentioned in (a) does not result in a risk of electric shock and does not short-circuit any of the components necessary to comply with the requirements in Double Protection, Section 44, or Double Protection for High-Voltage Products, Section 52; and

c) The resistance of the conductive connection between the supply circuit and the chassis, which has a construction using an isolating power transformer, does not exceed 12 megohms.

Exception No. 2: A capristor (a capacitor with a built-in shunt resistor) that complies with the requirements for antenna isolating capacitors in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414, need not comply with this requirement.

44 Double Protection

44.1 A product intended to accept composite television signals – for example, a VCR, television tuner, cable converter, satellite receiver, audio/video receiver, or the like – shall comply with the requirements for double protection of antenna terminals, antenna connections, and integral antennas in Double Protection for High-Voltage Products, Section 52.

Exception No. 1: A 75-ohm, F-Type coaxial antenna connector need not comply with the requirements for double protection.

Exception No. 2: This requirement does not apply to a video product intended only for commercial use and provided with a grounding means in accordance with Grounding, Grounding Impedance, and Continuity, Section 28.

44.2 If a product is shipped from the factory with a separate 75-to-300 ohm coupling-transformer assembly, the 300-ohm terminals of this assembly shall be provided with double protection when the assembly is connected to the product.

45 Accessories

45.1 Accessory installation procedure

45.1.1 An accessory intended specifically for use with a product shall be investigated to determine that:

a) The accessory and

b) The combination of the accessory and the product

comply with applicable requirements.

Exception: The combination of the accessory and the product need not be investigated if the accessory complies with all of the following requirements:

a) The accessory is intended to be installed by qualified service personnel and is marked as required by 45.1.4;

b) The accessory or the product, or both, has auxiliary power connections marked in accordance with 127.9.1; and

c) The accessory is provided with installation instructions as required in 130.1.3.

45.1.2 An accessory is considered to be intended specifically for use with a product if one of the following requirements is met:

a) The accessory is packed with the product,

b) The accessory is referenced by manufacturer's name and catalog number in a product marking, or

c) The product manufacturer's literature (instruction manual, use-and-care information, advertising or promotional material) indicates or implies use of the accessory by manufacturer's name and catalog number with a product.

45.1.3 The installation or connection of an accessory that is intended to be installed or connected by the user shall not require the use of other than ordinary tools and shall not require any act that might involve the risk of fire, electric shock, or injury to persons (for example, reduction of spacings or damage to components).

45.1.4 An accessory that is intended to be installed or connected by qualified service personnel may be provided with external power connections (see 127.9.1) and shall be marked to indicate installation by qualified service personnel only (see 130.1.3).

45.1.5 The installation of accessory products by qualified service personnel shall be such that:

a) The mechanical positioning can be accomplished by means of regular tools normally available or by means of special tools provided by the organization responsible for the product as a part of the installation kit and

b) The electrical connections can be readily accomplished by making use of existing terminals and connections in the product or as a part of the building wiring.

45.2 Tripods

45.2.1 Tripods for use with cameras provided with a standard 1/4 – 20 threaded hole need not comply with 45.1.1 unless the tripod complies with 45.1.2 (b) and (c) and is provided with the manufacturer's name and catalog number.

45.3 Accessory jumper plug

45.3.1 If the use of a tool to remove a jumper plug provided in a receptacle that is intended for the connection of an accessory involves a risk of electric shock, the plug shall be of such size and shape that it can be removed readily by hand.

45.4 Accessory connection

45.4.1 A receptacle or connector, except as noted in 127.7.1, shall be a female type that requires that the accessory/connector have all contacts exposed. The receptacle or connector shall not involve energy that presents a risk of fire or electric shock, under normal operating conditions, or under any condition that includes the introduction of any one short circuit or any one open circuit in any one component that is not reliable, such as a vacuum tube or transistor and the connection of any connector terminal to the chassis, to ground, or to any other accessible part.

LIQUID CRYSTAL DISPLAY (LCD) VIDEO PRODUCTS

46 General

46.1 In addition to complying with all other applicable requirements in this standard, an LCD video product shall comply with the requirements in Sections 47 – 49, 108 – 115, 133, and 134.

No Text on This Page

47 Overtemperature-Protective Device

47.1 Overtemperature protection that is provided for compliance with the Abnormal Operation Tests, Section 115, shall consist of one of the following:

a) Thermal protection complying with the applicable requirements for fluorescent-lamp-ballast protectors in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements;

b) A thermal cutout complying with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691; and

c) Another protective device that is investigated and found to provide equivalent protection.

47.2 A thermal or overload protective device shall not function during normal operation of the product.

48 Lamp Compartment

48.1 An LCD video product intended for use with a medium or high pressure lamp shall be provided with a lamp compartment. The lamp compartment shall have no open holes greater than 3.0 mm diagonally or in diameter. Parts of the lamp compartment where particles from a ruptured lamp are likely to drop to and rest shall be of a material as specified in 48.2.

Exception: A lamp containment barrier at points other than where particles from a ruptured lamp are likely to drop to and rest may be provided with open holes greater than 3.0 mm diagonally or in diameter if additional barriers are located such that there is no line-of-sight opening between the arc tube of the lamp and any point external to the product.

48.2 With regard to 48.1, the surface of the lamp compartment, where particles from a ruptured lamp are likely to drop to and rest, shall be metal, minimum 3.0 mm thick tempered or borosilicate glass, or metal screen with open holes of maximum 3.0 mm diagonally or in diameter.

Exception No. 1: A lamp compartment of a polymeric material may be used if it complies with the Lamp Particle Ignition Test, Section 111.

Exception No. 2: A glass material other than tempered or borosilicate glass may be used if it complies with the Glass Thermal Shock/Containment Test, Section 112.

49 Ultraviolet Radiation Interlock

49.1 An interlock provided to reduce the risk of ultraviolet radiation shall comply with the requirements in Interlocks, Section 33, and be provided with a marking as indicated in 133.5.1.

HIGH-VOLTAGE PRODUCTS

50 General

50.1 Details

50.1.1 In addition to complying with all other applicable requirements in this standard, a high voltage product shall comply with the requirements in this Section and in Sections 51, 52, 116 – 119, 135, and 136.

50.1.2 In determining the acceptability of insulated high voltage conductors, refer to note a to Table 63.1 for test voltages.

No Text on This Page

50.2 Degaussing coil insulation

50.2.1 Insulation on a degaussing coil that involves a risk of fire or electric shock shall be of acceptable material that has a minimum thickness of 0.70 mm.

Exception: Degaussing coil insulation may be minimum 0.35 mm thick if it is located where it is not subjected to damage or displacement during factory assembly or user-servicing.

50.3 Picture-tube enclosure opening

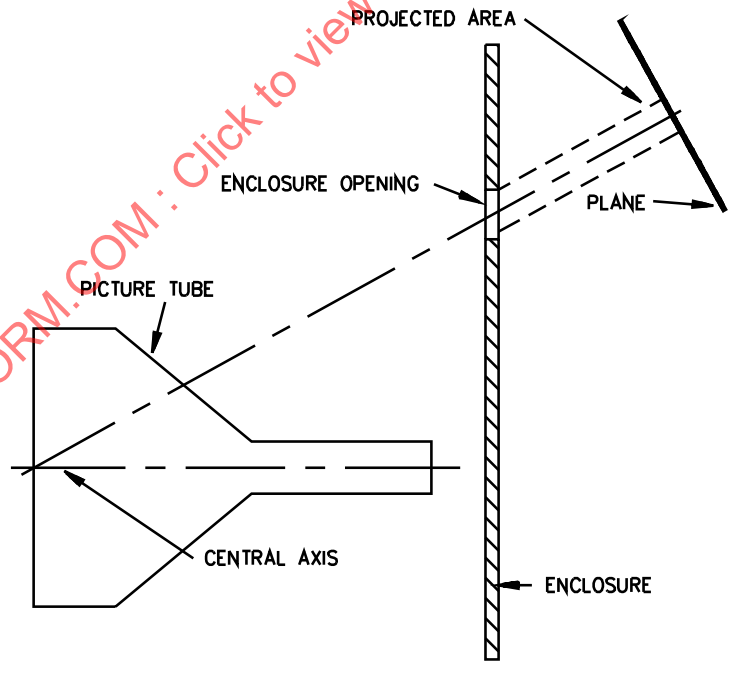
50.3.1 To reduce the risk of injury that may result from implosion of a picture tube having a diameter of 7.5 cm or more, or equivalent face area, the projected area of any opening in the top, back, sides, or front of the enclosure onto a plane perpendicular to a line passing through the center of the opening and any point on the central axis of the bulb section of the picture tube, shall not exceed 130 mm^2 unless the minor dimension of the projected area is not more than 10 mm. See Figure 50.1.

50.3.2 The use of a metal-cone picture tube and the presence of barriers are to be given consideration in applying 50.3.1.

50.4 Picture-tube neck protection

50.4.1 A picture-tube neck, socket, and leads shall have an enclosure or the equivalent that protects them from mechanical damage from the top and sides.

Figure 50.1
Picture-tube enclosure opening



50.5 Picture-tube implosion protection

50.5.1 A picture tube having integral implosion protection shall comply with the requirements in the Standard for Mechanical Safety for Cathode Ray Tubes, UL 61965.

Exception No. 1: This requirement does not apply to a picture tube having a diameter of less than 7.5 cm, or equivalent face area.

Exception No. 2: This requirement does not apply to a picture tube that is not directly viewed and is totally enclosed, including the face, as described in 50.3.1.

50.5.2 An enclosure using a picture tube not having integral implosion protection and using a separate window may be subjected to an investigation to determine that the window provides implosion protection equivalent to that afforded by a picture tube having integral implosion protection.

50.6 High-voltage component

50.6.1 A part used for insulation or in contact with live parts of a component in the high-voltage circuit and associated parts involving a potential of 2500 volts peak or more shall comply with the following:

a) The part shall be of a material classified at least as those shown in item 8 of Table 20.1 and

b) The part shall:

1) Comply with the Arcing Test, Section 117, or

2) Comply with the Component-Part Flame Test, Section 118.

50.6.2 In applying 50.6.1, a part is considered acceptable if it complies with the Component-Part Flame Test, Section 118, and a lead is considered acceptable if it has a flame-retardant rating (VW-1).

50.7 High-voltage part

50.7.1 A high-voltage part that is likely to be left in contact with accessible metal, a wooden cabinet, or a similar part having a relatively low level of insulation shall not involve risk of electric shock with regard to the chassis assembly or ground.

51 Overload-Protective Device for High-Voltage Products

51.1 A product shall be provided with an overload-protective device connected as specified in 51.4 and 51.5. The protective device may be either an overcurrent type or an overtemperature type rated as specified in 51.2 and 51.3.

Exception: A product powered by a direct plug-in transformer unit need not be provided with an overload-protective device in the supply circuit of the transformer unit if the direct plug-in unit uses a transformer that complies with the 7-hour abnormal temperature limits in the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411. See 128.7.1 for the plug-in power-supply replacement marking requirement.

51.2 An overcurrent-protective device connected in the power-supply circuit shall have a current rating not more than the current rating of the power-supply cord.

51.3 An overtemperature-protective device connected in the power-supply circuit shall be rated so that it opens the circuit within 4 minutes when four times the current normally drawn by the product is passed through the supply circuit.

51.4 The overload-protective device required by 51.1 may be located in one of the following:

a) The 120- or 240-volt supply circuit inside the product;

b) The attachment plug. See marking described in 128.5.1, 128.6.1, and 128.9.1 and in 131.8(14);

c) The 120- or 240-volt supply circuit inside a direct plug-in power supply that utilizes a step-down isolating transformer of the low-voltage secondary type, is provided with 15-ampere blade configuration, and is intended to be used on a nominal 120- or 240-volt branch circuit;

d) The isolating transformer of a plug-in power supply if an additional protective device is provided in the low-voltage power circuit inside the product and located as described in 51.5(b); or

e) The 120- or 240-volt supply circuit inside a separable, cord-connected power supply.

51.5 If the overload-protective device is located in the supply circuit as described in 51.4(a), it shall be:

a) A separate and distinct component that is replaceable by the user or service personnel without replacing other components. A protective device that is an integral part of another component, for example, a power transformer, is not an acceptable means of complying with 51.1.

Exception No. 1: An automatically- or manually-reset protective device need not be replaceable by the user or service personnel; however, a manually-reset protective device shall be resettable by the user or service personnel.

Exception No. 2: A protective device built into the supply circuit or into an isolating transformer of a plug-in power supply need not be replaceable by the user or service personnel. See 51.4 (c) and (d).

Exception No. 3: A protective device built into the supply circuit of a separable, cord-connected power supply need not be replaceable by the user or service personnel if the enclosure is secured in such a manner that it cannot be opened with ordinary tools. See 128.4.1 for replacement marking.

Exception No. 4: A protective device built into the supply circuit of a product complying with the construction described in the Exceptions to 129.1.1, 129.1.2, and 129.1.3 need not be replaceable by the user or service personnel. See 130.1.7 for marking requirement.

b) Connected in the circuit to provide protection for all components in the product.

Exception No. 1: Components normally used to prevent RF radiation, such as the across-the-line capacitor, line-by-pass capacitor, and the line-to-chassis or line-to-antenna resistor or capristor or line choke need not be protected by the protective device.

No Text on This Page

Exception No. 2: A component normally used to guard against transients coming into the product through the supply circuit, such as a spark-gap device or varistor, need not be protected by the protective device if it complies with the requirements for that component and is used in accordance with its recognized rating and other limitations of use.

52 Double Protection for High-Voltage Products

52.1 Double protection shall be provided between parts of a product that are specified in 52.2 and 52.3 and circuits directly connected to the AC power supply that involve a risk of electric shock – See Electric Shock, Section 12.

Exception No. 1: The requirement in 52.3 does not apply to a separate component– for example, a tuner or a record changer used in a combination unit but not located in the high voltage product compartment, see Combination Units, Section 5.

Exception No. 2: This requirement does not apply to high-voltage products intended only for commercial use and provided with a grounding means in accordance with Grounding, Grounding Impedance, and Continuity, Section 28.

Exception No. 3: The requirement in 52.3 does not apply to a separate component that has its own enclosure and that is intended for use with a high-voltage product as part of a system.

52.2 Double protection shall be provided for antenna terminals, antenna connections, and integral antennas. For the purpose of this requirement, a video input jack is not considered to be an antenna.

Exception No. 1: A 75-ohm, F-Type coaxial antenna connector need not be provided with double protection.

Exception No. 2: Antenna terminals, antenna connections, and integral antennas not intended to accept composite television signals need not be provided with double protection.

52.3 Double protection shall be provided for earphone and headphone jacks (see 52.5), major parts of a conductive enclosure as defined in 3.31, and those user-control buttons, knobs, and shafts that are:

a) Accessible without the use of a tool and

b) Located:

1) On the front, top, or sides of the high-voltage product enclosure or

2) On the back of the enclosure so as to be easily adjusted while the user is in front of the enclosure. Such a control is considered to be easily adjustable by the user if the shortest distance between the center of the face of the picture tube and the control is 1.0 m or less as measured over the top or around either side of the enclosure with a flexible tape measure stretched tightly over the surface of the enclosure.

52.4 If a high-voltage product is shipped from the factory with a separate 75-to-300 ohm coupling-transformer assembly, the 300-ohm terminals of this assembly shall be provided with double protection when the assembly is connected to the high-voltage product.

52.5 An accessory jack on a high voltage product that also has an earphone or headphone jack shall have double protection provided for the accessory jack if it is located on the same surface of the enclosure – top, front, sides, or back – as the earphone or headphone jack and is similar in construction so as to mechanically and electrically accommodate the earphone or headphone plug.

52.6 Double protection shall be provided by the use of:

a) Two independent levels of insulation or two isolating components or two insulating systems, examples of which are indicated by an X in Table 52.1, used so that breakdown of either one of the levels of insulation or isolating components or systems will not result in a risk of electric shock to ground. See Example No. 1 of 52.7 or

b) One level of insulation or one isolating component or insulating system, examples of which are indicated by an X in Table 52.2. See Example No. 2 of 52.7.

52.7 Double protection shall be considered with regard to all supply-circuit connected wiring, components, component leads, a direct-connected chassis, and the like, as illustrated in the following examples:

Example No. 1: Antenna terminals that are isolated from the supply circuit by means of an isolating power transformer as one level and a capristor as a second level would comply with 52.8(a) and 52.8(b); however, it is also necessary that the antenna leads be insulated from the supply circuit by means of the insulation on the antenna leads – one system of insulation – and by the insulation on the supply leads – second system of insulation – if physical contact between the two leads is possible. Additionally, bare leads of the capristor are to be provided with wire insulation, sleeving, tape, or tubing in accordance with 52.8(d) or are to be routed and secured so as to provide the minimum 1.5-mm spacing required by 52.8(f).

Example No. 2: An earphone jack that is isolated from a direct-connected chassis by means of an audio-output transformer that complies with the requirements in this standard as the only level of insulation would comply with 52.9(e); however, if the secondary leads of the audio-output transformer can contact the direct-connected chassis, a second system of insulation is to be provided for the leads unless the lead insulation complies with the requirements in 52.9(g).

Table 52.1
Double protection using two components or systems

Parts	Type	Item specified in 52.8 likely to be used							
		Isolating transformer, 52.8[a]	Capacitor or capristor, 52.8[b]	Component, 52.8[c]	Wire insulation, sleeving, tape, or tubing, 52.8[d]	Barrier or insulation, 52.8[e]	Spacing, 52.8[f]	Part insulation and performance tests, 52.8[g]	Equivalent, 52.8[h]
Integral antennas and antenna connections	UHF and VHF	X	X	X	X	X	X		X
	75-ohm coaxial connector				Exempt				
Earphone jacks	All	X	X		X	X	X		X
Control button[a]	Insulating	X		X	X			X[b,c]	X
	Insulating with conductive plating	X		X	X			X[b,c,d]	X
	Conductive	X		X	X				X
Control knob	Insulating	X		X	X			X[b,c]	X
	Insulating with conductive plating	X		X	X			X[b,c,d]	X
	Conductive	X		X	X			X[b,c] and either e, f, or g	X
Control shaft[a]	Insulating	X		X	X			X[b,c,h]	X
	Conductive	X		X	X			X[b,c] and either i or j	X
Conductive enclosure[k]	Major parts	X	X		X	X	X		X

[a] A noncaptive button, knob, or shaft is acceptable for only one level. For example, two concentric noncaptive knobs mounted on the same shaft are not considered to comply with 52.8.

[b] Capable of withstanding the 14 N pull test described in 98.4.1 before and after the complete product has been subjected to the temperature stability test required by 98.2.1.

[c] Capable of withstanding the 90 N pressure test described in 98.5.1 before and after the complete product has been subjected to the temperature stability test required by 98.2.1.

[d] Having a minimum spacing of 1.5 mm between the plating and the nearest conductive part to which the button or knob is mounted.

[e] Having an insert of insulating material with a thickness of not less than 0.70 mm.

[f] Mounted on a conductive shaft reliably covered with insulating material as described in note e.

[g] Mounted on a conductive shaft having an inaccessible shaft coupling as described in note j.

[h] Located so that any conductive parts at or near the control that would be made live by breakdown of the first level of insulation or isolating component or system cannot be touched by the probes illustrated in Figures 18.1 and 18.2.

[i] Reliably covered with insulating material having a thickness of not less than 0.70 mm. The form-fitted insulator may, at the manufacturer's option, be provided with a hole at the end of the insulator to allow for dielectric voltage-withstand testing of the other insulation further back on the shaft. This hole is not to exceed 1.5 mm in diameter.

Table 52.1 Continued on Next Page

Table 52.1 Continued

Parts	Type	Item specified in 52.8 likely to be used							
		Isolating transformer, 52.8[a]	Capacitor or capristor, 52.8[b]	Component, 52.8[c]	Wire insulation, sleeving, tape, or tubing, 52.8[d]	Barrier or insulation, 52.8[e]	Spacing, 52.8[f]	Part insulation and performance tests, 52.8[g]	Equivalent, 52.8[h]
[j] Having an inaccessible shaft coupling of insulating material having a thickness of not less than 0.35 mm, and having a spacing of not less than 1.5 mm over surface of the material and through air between the conductive parts of the shaft. [k] An insulating covering – for example, nonconductive paint, leatherette, and the like – over a conductive enclosure is not acceptable as reliable insulation unless it has been investigated and found to be acceptable as insulation.									

Table 52.2
Double protection using one component or system

Parts	Type	Item specified in 52.9 likely to be used								
		Resistor, 52.9[a]	Isolating power transformer coil or winding, 52.9[b,c,d]	Isolating output transformer, 52.9[e]	Component, 52.9[f]	Wire insulation, 52.952.9[g]	Barrier or insulator, 52.9[h]	Spacing, 52.9[i]	Part insulation and performance tests, 52.9[j]	Equivalent, 52.9[k]
Integral antennas and antenna connections	UHF and VHF	X	X		X	X	X	X		X
	75-ohm coaxial connector					Exempt				
Earphone jack	All	X	X	X		X	X	X		X
Control button[a]	Insulating	X	X		X	X			X[b,c,d,e,f]	X
	Insulating with conductive plating	X	X		X	X			X[b,c,d,e,f,g]	X
	Conductive	X	X		X	X				X
Control knob	Insulating	X	X		X	X			X[b,c,d,f]	X
	Insulating with conductive plating	X	X		X	X			X[b,c,d,f,g]	X
	Conductive	X	X		X	X			X[c,d] and either h, i, or j	X

Table 52.2 Continued on Next Page

Table 52.2 Continued

Parts	Type	Item specified in 52.9 likely to be used								
		Resistor, 52.9[a]	Isolating power transformer coil or winding, 52.9[b,c,d]	Isolating output transformer, 52.9[e]	Component, 52.9[f]	Wire insulation, 52.952.9[g]	Barrier or insulator, 52.9[h]	Spacing, 52.9[i]	Part insulation and performance tests, 52.9[j]	Equivalent, 52.9[k]
Control shaft[a]	Insulating	X	X		X	X			X[b,c,d]	X
	Conductive	X	X		X	X			X[b, l, or m]	X
Conductive enclosure[n]	Major parts	X	X	X		X	X			

[a] Captivation depending upon setscrews, cement, sealing compound, and devices that depend upon friction to prevent removal of a button, knob, or shaft from the exterior of the enclosure are not acceptable. A construction that requires the captivating means of a button, knob, or shaft to be destroyed or damaged during servicing of the product is not acceptable.

[b] Capable of withstanding the applicable pull test described in 98.4.1 or 98.4.2, depending on the protrusion length, before and after being subjected to the temperature stability test required by 98.2.1.

[c] Capable of withstanding the impact specified in Table 98.1 before and after the complete product has been subjected to the temperature stability test required by 98.2.1.

[d] Capable of withstanding the 90 N pressure test described in 98.5.1 before and after the complete product has been subjected to the temperature stability test required by 98.2.1.

[e] Capable of withstanding a 100,000-cycle endurance test without developing openings larger than those specified in the requirements to reduce the risk of fire and electric shock and without creating a risk of electric shock. The endurance test may be conducted at any convenient rate as it is a mechanical test only; the button contacts need not be electrically connected for the test. Following the endurance test, the dielectric voltage-withstand test described in note f is to be conducted.

[f] Having a dielectric voltage-withstand capability of 3500 volts, 60 Hz for 1 minute. The 3500-volt, 60-Hz potential is to be applied between metal foil placed over the accessible part of the control button, the knob, or the shaft and the part involving a risk of electric shock. The foil is to be pressed against the sides of, and into the 6 openings around the control button, the knob, or the shaft by means of the probe illustrated in Figure 18.1.

Exception: If the control button, the knob, or the shaft has a thickness of 1.5 mm or more, and its construction is such that it will maintain a spacing of not less than 3.0 mm through air and over surface between accessible parts of the control and the part involving a risk of electric shock, the 3500-volt dielectric voltage-withstand test may be waived. A control button is to be judged for spacings in both the normal and the depressed condition.

[g] Having a spacing of not less than 3.0 mm between the plating and the conductive part to which the button or knob is mounted.

[h] Mounted on a control shaft of insulating material that has an inaccessible length of 3.0 mm. See Figure 52.1.

[i] Mounted on a conductive control shaft capable of withstanding the applicable pull test described in 98.4.1 or 98.4.2, depending upon the protrusion length, before and after being subjected to the temperature stability test required by 98.2.1, and reliably covered with insulating material that:

a) Has a thickness of not less than 1.5 mm and

b) Has a dielectric voltage-withstand capability of 3500 volts, 60 Hz for 1 minute.

[j] Mounted on a conductive shaft capable of withstanding the applicable pull test described in 98.4.1 or 98.4.2, depending upon the protrusion length, before and after being subjected to the temperature stability test required by 98.2.1, and reliably covered with two layers of insulating material:

a) Each of which has a minimum thickness of 0.70 mm and

b) Having a dielectric voltage-withstand capability, across both layers taken together, of 3500 volts, 60 Hz for 1 minute.

[k] Covered with insulating material that has a thickness of not less than 1.5 mm and complies with the performance tests specified in notes b – d, and f.

Table 52.2 Continued on Next Page

Table 52.2 Continued

Parts	Type	Item specified in 52.9 likely to be used								
		Resistor, 52.9[a]	Isolating power transformer coil or winding, 52.9[b,c,d]	Isolating output transformer, 52.9[e]	Component, 52.9[f]	Wire insulation, 52.952.9[g]	Barrier or insulator, 52.9[h]	Spacing, 52.9[i]	Part insulation and performance tests, 52.9[j]	Equivalent, 52.9[k]

[l] Covered with two layers of insulating material each of which has a thickness of not less than 0.70 mm and that comply with the performance tests specified in notes b, c, and d.

[m] Having an inaccessible shaft coupling of insulating material that has a thickness of not less than 1.5 mm; has a spacing through air and over surface of at least 3.0 mm between conductive parts of the shaft; and complies with the performance tests specified in notes b, c, and d.

[n] An insulating covering– for example, nonconductive paint or leatherette – over a conductive enclosure is not acceptable as reliable insulation unless it has been investigated and found to be acceptable as insulation.

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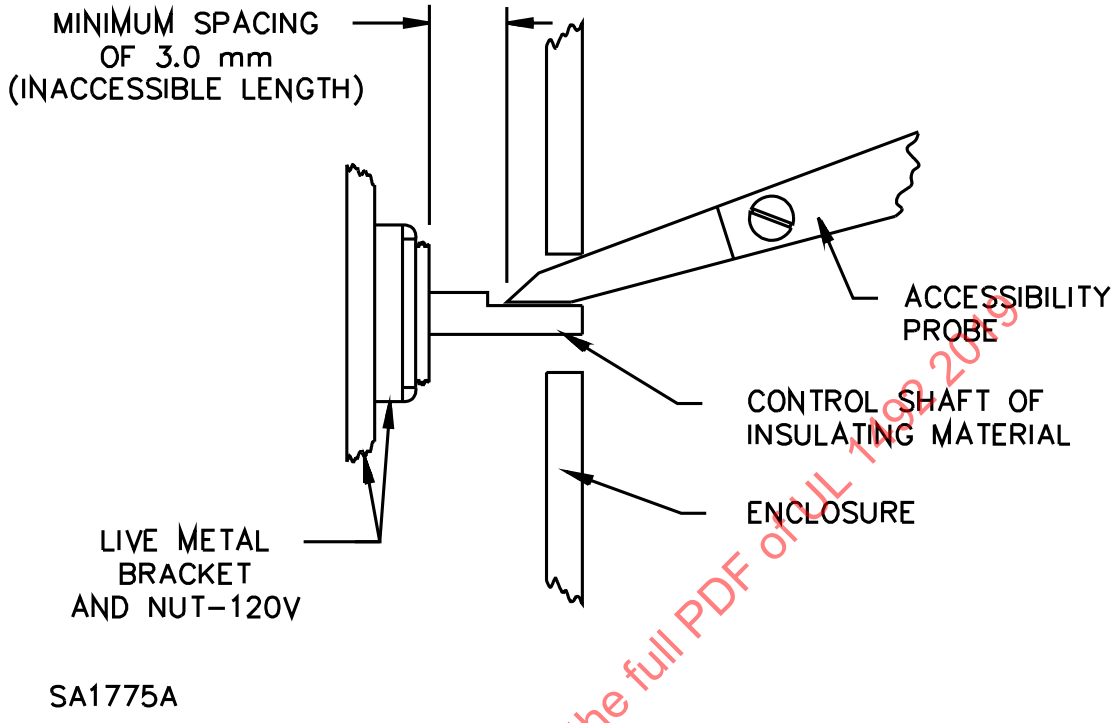
Figure 52.1
Control shaft of insulating material



52.8 Any two components or systems that are acceptable for the application may be used to provide double protection. Examples of acceptable components or systems that are considered likely to be used are described in 52.8 (a) – (h) and are indicated by an X in Table 52.1.

a) An isolating power transformer (see Transformers, Section 38), audio output transformer, coil, or winding. For a coil or winding operating at a peak voltage of more than 2500 volts, see 71.8.1 – 71.8.3. A coil or winding, such as a deflection yoke, operating at a peak voltage of 2500 volts or less is acceptable, if it:

1) Is made of insulating material complying with the applicable requirements in Table 20.1,

2) Complies with the spacing requirements in 52.8(f), and

3) Complies with the dielectric voltage-withstand requirements in 71.6.1.

b) A capristor or a capacitor – see 39.1.1 and 39.2.1. For antenna circuits, a conductive path in parallel with a capacitor is required by 43.1.

c) A component – switch, tuner, and the like – complying with the requirements for that component.

d) Sleeving, tape, tubing, or wire insulation rated in accordance with 35.1.1.

e) A barrier or insulator of insulating material complying with item 5 of Table 20.1, and having a minimum thickness of 0.70 mm.

Exception: A barrier or insulator may have a minimum thickness of not less than 0.35 mm in inaccessible locations where the barrier or insulator is protected against mechanical abuse during factory assembly or servicing – for example, a barrier inside a UHF or VHF tuner housing. Two separate 0.35-mm thick barriers or insulators are not considered acceptable to comply with the intent of this requirement; the 0.35-mm thick barrier or insulator shall be used in conjunction with some other acceptable level

f) A minimum spacing through air and over surface of insulating material of at least 1.5 mm where the location and relative arrangement of parts are such that a permanent separation will be maintained – see 16.1.5.

g) Insulation and performance tests on the part itself as described in the applicable notes to Table 52.1.

h) Any other level of insulation or isolating component or insulating system examined and tested according to the intent of the requirements and found to be substantially equivalent.

52.9 Any one component or system that is acceptable for the application may be used to provide double protection. Examples of acceptable components or systems that are considered likely to be used are described in 52.9 (a) – (k) and are indicated by an X in Table 52.2.

a) A resistor:

1) Mounted so that the resistor, or part of the resistive element, cannot be short-circuited by displacement of the resistor, resistor leads, or any adjacent component in accordance with 16.1.5;

2) Having a power dissipation rating that will not be exceeded as a result of any overload condition; and

3) Located away from all components that may overheat during any overload condition.

b) An isolating power transformer:

1) Complying with the requirements in Transformers, Section 38;

2) Having integral leads complying with 52.9(g); and

3) Having a dielectric voltage-withstand capability of 3500 volts, 60 Hz for 1 minute across the insulation providing double protection. Depending upon the construction used, the dielectric voltage-withstand potential may need to be applied between only one insulation system of the transformer; for example, the primary winding and secondary winding, or the primary winding and core, or the secondary winding and core; or it may need to be applied across two or all three of the insulation systems of the transformer.

c) A coil or winding, such as a deflection yoke, operating at a peak voltage of more than 2500 volts and complying with the requirements in 71.8.1 – 71.8.3;

d) A coil or winding, such as a deflection yoke, operating at a peak voltage of 2500 volts or less and:

1) Made of insulating material complying with the applicable requirements in Table 20.1,

2) Complying with the spacing requirements in 52.9(i), and

3) Complying with the dielectric voltage-withstand requirements in 71.6.1 except the test potential is to be a minimum of 3500 volts AC.

e) An isolating output transformer:

1) Complying with the requirements in this standard and

2) Having a dielectric voltage-withstand capability of 3500 volts, 60 Hz for 1 minute across the insulation providing double protection. See 52.9(b)(3).

f) A component – switch, tuner, or the like – that, in addition to complying with the requirements for that component, has been investigated for compliance with double-protection requirements.

g) Wire insulation rated in accordance with 35.1.1 and having either of the following constructions:

1) Two separate layers of insulation having a total thickness of not less than 0.65 mm, neither layer of which has a thickness of less than 0.18 mm or

2) A single layer of insulation having a thickness of not less than 0.70 mm.

h) A barrier or insulator of insulating material:

1) Having a thickness of not less than 1.5 mm;

2) Complying with 5 of Table 20.1; and

3) Having a dielectric voltage-withstand capability of 3500 volts, 60 Hz for 1 minute

i) A minimum spacing through air and over surface of insulating material of at least 3.0 mm where the location and relative arrangement of parts are such that a permanent separation will be maintained. See 16.1.5.

j) Insulation and performance tests on the part itself as described in the applicable notes to Table 52.2.

k) Any other level of insulation or isolating component or insulating system examined and tested according to the intent of the requirements and found to be substantially equivalent.

VIDEO PRODUCTS INTENDED FOR USE IN HEALTH-CARE FACILITIES

53 General

53.1 In addition to complying with all other applicable requirements in this standard, a video product intended for use in health-care facilities shall comply with the requirements in Sections 54 – 62 and 120 – 124.

54 Cords and Plugs

54.1 Attachment plug

54.1.1 Unless double insulation is provided, a product intended for use in a health-care facility shall be provided with a conventional, 2-blade with grounding-pin attachment plug designated ″Hospital Grade.″

54.2 Flexible cord

54.2.1 The flexible cord shall be Type SJ, SJO, SJT, SJTO, or an equivalent jacketed cord. An oil-resistant cord shall be provided if the product is likely to be subjected to grease or oil. It shall be of a type intended for use at a voltage not less than the rated voltage of the product and shall have an ampacity not less than the current rating of the product.

54.3 Supply cord length

54.3.1 The length of the supply cord, measured from the point where the cord emerges from the product enclosure to the plane of the face of the attachment plug, shall not be less than 1.5 m.

Exception: A product that is intended for use in a health-care facility and that is not intended to be moved in the expected use of the product, but which is not obviously intended to be permanently connected, may be acceptable if provided with the shortest feasible length of Type SJO, SJT, SJTO, or equivalent cord and an attachment plug for supply connection. The investigation of such a feature is to include consideration of the utility of the product and the necessity of having it readily detachable from its source of supply by means of the attachment plug.

55 Grounding

55.1 Product grounding

55.1.1 All products shall be provided with a means for grounding as described in this Section and in Grounding, Grounding Impedance, and Continuity, Section 28.

Exception: A product identified as being double insulated and having no accessible conductive surfaces shall not be provided with a grounding means.

55.1.2 An accessible conductive surface is not intended to include metal nameplates or handles, isolated metal frame of cabinets, or isolated screws or other hardware that are fastened into polymeric or otherwise nonconductive enclosures.

55.2 Double insulation

55.2.1 A product identified as being double insulated and having accessible conductive surfaces shall have a means for grounding such surfaces provided as part of the power-supply cord, or by a separate terminal consisting of a pressure-wire connector or wire-binding screw. The pressure-wire connector or wire-binding screw shall be capable of securing a 10 AWG (5.3 mm^2) or smaller grounding conductor.

55.2.2 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure-wire connector intended for connection of such a conductor shall be plainly identified such as by being marked ″G,″ ″GR,″ ″Ground,″ ″Grounding,″ or the like, or by a marking on a wiring diagram provided on the product. The wire-binding screw or pressure-wire connector shall be located so that it is unlikely to be removed during normal servicing of the product.

55.3 Accessible conductive parts

55.3.1 For a product not identified as being double-insulated, all accessible conductive parts that are likely to become energized from within and all dead-metal parts within the enclosure that are exposed to contact during any user-servicing operation and that are likely to become energized shall be connected to the grounding means that shall be a part of the flexible cord and attachment plug, or the detachable power-supply cord.

55.4 Isolated, accessible conductive parts

55.4.1 A grounded product and its auxiliary equipment also having isolated accessible conductive surfaces that are not likely to become energized from within shall have provision for the grounding of such surfaces by a separate terminal consisting of either a pressure-wire connector or wire-binding screw. The pressure-wire connector or wire-binding screw shall be capable of securing a 10 AWG (5.3 mm^2) or smaller grounding conductor. See also 55.2.1.

55.5 Grounding conductor

55.5.1 The surface of the insulation on the grounding conductor of a flexible cord shall be green with or without one or more yellow stripes. The grounding conductor shall be secured to the frame or enclosure of the product that is intended to be grounded by means of a screw that is not likely to be removed during any servicing operation not involving the power-supply cord, or by other equivalent means. A solder-only connection shall not be used for securing the grounding conductor. The grounding conductor shall be connected to the grounding blade or equivalent, fixed contacting member of an attachment plug.

56 Separation of Circuits

56.1 Parts touched by patient

56.1.1 Where one or more electrical insulation breakdowns between adjacent conductive parts – wires, terminals, structural metal, and the like – of a product results in available leakage current in excess of the limits outlined in 120.1, the construction shall comply with at least one of the following:

a) For insulated conductive parts, each insulation used shall be acceptable for the maximum voltage possible– for example, the highest voltage on a part with regard to ground or with regard to any accessible, conductive part either with or without the introduction of any random breakdown of an insulation involved. A spacing over surface or through air between parts that is not less than 1.5 mm for potentials of 125 V rms, or not less than 2.4 mm for potentials of 126 – 250 V rms, may be used in place of a single insulation.

b) For two uninsulated conductive parts a spacing between parts that is not less than twice that required in (a) may be used.

c) If not insulated or spaced apart as (a) or (b), the parts shall be separated by means of a solid insulating (unpierced) barrier, permanently secured in place, properly located, and of sufficient integrity that the barrier is acceptable as a supplement to conductor insulation, or in the case of a barrier between two uninsulated parts, satisfies the requirements for reinforced insulation thereby affording a degree of protection against the risk of electric shock equivalent to that afforded by double insulation.

56.1.2 In evaluating the required separation of the patient-touched parts from internal circuits in accordance with 56.1.1, consideration shall be given to the effects of deterioration of insulation, abnormal operation, overload, short-circuit, or component-breakdown conditions.

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56.1.3 The patient-touched parts mentioned in 56.1.1 and 56.1.2 are those parts that are likely to be contacted by the patient while the patient is in bed – for example, a pillow speaker or pendant control for a product that might be taken into the bed and operated by the patient, or a product that might be placed near or above the bed and operated by the patient.

57 Pendant Controls

57.1 Pendant-control enclosure

57.1.1 In a pendant control intended for patient use, current-carrying parts that involve a risk of fire or leakage current exceeding the limits specified in 120.1 shall be totally enclosed in an insulating material. The insulating material shall withstand the drop test specified in 124.4.1 and have a flammability classification of V-1 or better as described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. This requirement does not apply to the openings of the enclosure that accommodate functional devices such as switches, speakers, and control-switch knobs. The enclosure shall be marked to caution the user against using the product in an oxygen-enriched atmosphere unless it has been investigated and found acceptable for that use. See 138.2.1 for marking information.

57.2 Pendant-control cord strain relief

57.2.1 A pendant control cord shall be provided with strain relief at each end; for example, at the point of connection to the control and to the plug.

57.3 Holders and hooks

57.3.1 A hook or holder shall be provided on the plate to which the pendant control is connected for its support when not in use. An equivalent supporting arrangement shall also be acceptable. The hook or holder shall be located on the outside of the bed.

58 Switches

58.1 Any switch connected in the supply circuit and used as the on-off device shall open all supply circuit conductors simultaneously.

58.2 The equipment grounding conductor shall not be interrupted by a switch.

58.3 The on-off positions of the switch shall be clearly indicated.

59 Transformers

59.1 A transformer connected in the primary circuit intended to supply energy to the low-voltage pendant control shall comply with the requirements for transformers for use with hospital-product pendant controls in theStandard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411. The transformer core shall be grounded.

Exception No. 1: This requirement does not apply to two isolating transformers connected in series, where the primary winding of the second transformer is connected to the secondary winding of the first transformer. The core of the second transformer shall not be grounded. The first transformer shall comply with 38.1.1, and the second transformer's insulation system need only comply with the construction requirements in UL 1411.

Exception No. 2: The transformer core need not be grounded if the insulation between the primary winding and the secondary windings consists of basic and supplementary or of reinforced insulation and if the transformer core is electrically isolated from all secondary windings, secondary circuits, and conductive parts connected to secondary circuits (such as heat sinks and the like).

60 Products Having Signaling and Nurse-Call Feature

60.1 A signaling and nurse-call feature, if provided, shall comply with the applicable requirements in the Standard for Hospital Signaling and Nurse Call Equipment, UL 1069.

61 Wheels and Casters

61.1 The wheels or casters on a product or on a cart intended for use with a specific product shall have a minimum diameter of 10 cm.

62 Cleaning and Disinfecting

62.1 General

62.1.1 A product shall be constructed so that it can be cleaned or disinfected in accordance with the manufacturer's instructions (see 139.1) without increasing the risk of fire, electric shock, or injury to persons.

62.1.2 Unless it is obvious that the enclosure's construction and materials are acceptable for the cleaning and disinfecting operation called for, a sample of the product shall be subjected to the test described in 124.1.1.

62.2 Entry of spilled materials

62.2.1 Except for a wall- or ceiling-mounted type, a product shall be constructed to prevent the entry of spilled materials (for example, saline solutions, volatile liquids, and the like) that could result in a risk of fire or electric shock by coming into contact with live parts or parts operating at elevated temperatures.

62.2.2 To comply with the requirement specified in 62.2.1, there shall not be an opening in any nonvertical surface (top, sloping, and the like) unless the opening is protected by a barrier that prevents the entrance of a liquid that might fall on the area in question from a vertical direction.

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PERFORMANCE

ALL PRODUCTS

63 General

63.1 Details

63.1.1 Unless stated otherwise, values of voltage and current are root-mean-square (rms) values.

63.1.2 A product having both AC and DC ratings is to be tested with the product connected to an AC supply and again to a DC supply.

Exception: When it can be established that one type of supply connection results in the maximum operating conditions, the product can be tested with that type of supply.

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63.2 Voltmeters

63.2.1 Unless indicated otherwise, voltage measurements are to be made with a voltmeter having a resistance of 2000 ohms per volt minimum for potentials of 1000 V or less and 20,000 ohms per volt minimum for potentials of more than 1000 V.

63.2.2 The open-circuit-voltage measurement used in conjunction with a leakage- or shock-current determination is to be made with a measuring instrument that has an input impedance that does not significantly affect the circuit being measured. In general, a measuring instrument with a minimum input impedance of 1 megohm is to be used.

63.3 Leads, connectors, and components

63.3.1 When testing the complete product, a lead, connector, or component that is accessible during the operation or user-servicing of the product is to be:

a) In its intended position and

b) In any position likely after user-servicing.

63.4 Cheesecloth indicators

63.4.1 Cheesecloth used for tests is to be untreated cotton running 26 – 28 square meters per kilogram and having what is known to the trade as a count of 13 by 11 – that is, for any square centimeter, 13 threads in one direction and 11 threads in the other direction.

63.4.2 Tests involving cheesecloth are to be made in a room free of drafts.

63.5 Supply-circuit voltage and frequency

63.5.1 All operational tests are to be conducted with the product connected to a supply circuit of rated frequency and the voltage specified in Table 63.1.

63.5.2 A product that can be operated from alternate power supplies, such as DC adapters, car batteries, and the like, is to be tested with those supplies if such testing is considered necessary.

63.5.3 Table 63.1 indicates the various test voltages for products intended for use on the standard domestic supply circuits. It is not intended to provide the test voltages for multiple-voltage products intended for operation on other types of supply circuits such as those found in foreign countries.

63.5.4 Products for use on other than a standard domestic supply circuit are to be tested in accordance with Table 63.1, with the following modifications. Normal operation tests are to be conducted with the test-voltage indicated on the product or in the instruction manual for the particular voltage-selector-switch setting. Abnormal operation tests are to be conducted with the test-voltage supply adjusted to 110 percent of the maximum voltage indicated on the product or in the instruction manual for the particular voltage-selector-switch setting. All tests are to be conducted with the voltage-selector-switch setting and associated test voltage that represents the worst-case condition.

63.5.5 A product with one supply-circuit-frequency rating is to be tested at that frequency. A product with a multiple-frequency rating is to be tested at 60 Hz, if 60 Hz is included in the rating, and may also be tested at any of the other frequency ratings unless it can be established that testing at 60 Hz results in the maximum operating conditions.

Table 63.1
Operation test voltages

Section	Test	Marked voltage rating	Test voltages
	Normal operation tests		
64	Power input	105 – 130	Maximum marked voltage, but not less than 120 V
65	Peak inrush current	or	or
67	Product-leakage and shock-current	210 – 260	Maximum marked voltage, but not less than 240 V
68	Temperature		
69	Maximum voltage measurement[a]		
109	Electric shock		
113	Ozone		
114	Ultraviolet radiation		
116	X-radiation	105 – 130	130[b,c]
		or	or
		210 – 260	260[b,c]
	Abnormal operation tests		
76	Receptacle overload		
77	Power supply		
78	Picture-tube filament short-circuit		
81	Part disconnection and component handling arcing	105 – 130	130[b,c]
82	Cable arcing	or	or
88	Battery overcharge	210 – 260	260[b,c]
115	Abnormal operation		
117	Arcing		
98	Enclosure temperature stability	105 – 130	130[b]
		or	or
		210 – 260	260[b]

[a] In determining the acceptability of insulated high-voltage conductors, voltages are to be measured with the product connected to a 130-volt source of supply (260 volts for a product rated at a nominal 240 volts) and with all controls adjusted to give the maximum voltage possible with a useable picture or output.

[b] For a product intended to be operated at more than one given voltage, the test voltage is to be 130 V for the lower voltage, and 110 percent of the higher voltage, but not less than 240 V nor more than 260 V.

[c] The test voltage may be reduced to a lower value, but not less than 105 or 210 V, respectively. The lower test-voltage value may be used for abnormal-operation tests where the lower value represents a more severe condition or in cases where a higher voltage might cause a protective device to clear the circuit.

64 Power Input Test

64.1 The measured power input shall not exceed the marked input rating by more than 5 percent when the product is operated as indicated in 64.2 – 64.5 to produce maximum power input, or power input as indicated in 64.3(h)(4), whichever applies.

64.2 A product with multiple modes of operation, multiple signal input sources, or both, is to be operated using each mode of operation or signal input source separately, or in combination, according to the manufacturer's instructions to produce the maximum power input.

64.3 The power-input measurements are to be made under the following conditions:

a) Positions and Use – The product is to be connected, operated, and mounted according to the manufacturer's instructions.

b) Operating Controls – User controls are to be adjusted within the range of intended operation. For products with amplification circuits, tone controls, filters, and wave-shaping controls are to be set in the mid-range positions. The volume control is to be adjusted so as to produce maximum amplifier output [see (g) and (h)]. If there is more than one amplifier circuit, each amplifier is to be adjusted to produce maximum output simultaneously even if not equal. Supply-circuit voltage-setting devices are to be set according to the manufacturer's instructions.

c) Factory Controls – Factory-set controls that are not intended to be user adjustable are not to be readjusted from their factory setting.

d) Motors and Motor Drive Parts – Motors and motor-driven parts of the product are to be loaded according to the intended purpose. When testing involves motor-driven parts, other parts of the product that are intended to be operated at the same time are to remain connected.

e) Accessories – A product with an output connection intended to supply voltage and current to an accessory is to have the intended accessory:

1) Connected according to the manufacturer's instructions unless power consumption is greater with the accessory not connected and

2) Operated in such a way as to produce maximum power input to the product. A simulated load consuming power equivalent to the accessory may be used in place of the accessory.

f) Audio Output Circuit Loading – An audio-amplifying circuit intended to supply audio-signal voltage and current to a speaker is to have its output load adjusted according to one of the following:

1) If the product is provided with either internally or externally connected speakers, those speakers may be used as the load. Where the speaker action is not critical to proper loading or cooling of the product, demagnetized speakers may be used for this purpose;

2) If the product is provided with either internally or externally connected speakers, an audio load of equal impedance may be substituted for each speaker or assembly of speakers;

3) If the product is not provided with speakers but the speaker impedance rating is marked on the product, an audio load of impedance equal to that marked on the product is to be connected to the product output terminals according to the manufacturer's instructions; or

4) If the product is not provided with speakers and there is no speaker impedance rating marked on the product, an audio load that results in the highest audio output power per channel of amplification is to be connected to the product output terminals according to the manufacturer's instructions.

The audio load connected to each product is to be essentially resistive with not more than a 10-percent reactive component at any frequency up to 5 kHz. The audio load is to be capable of continuously dissipating the full output of the product while maintaining the resistance within 1 percent of its rated value.

g) Signal Level Not Affecting Power Input – A product need not be connected to an external input signal if the supply-circuit input power or current is not noticeably affected by signal level.

h) Signal Level Affecting Power Input – A product provided with circuits where the supply-circuit input power or current is noticeably affected by signal level is to be connected and tested as follows:

1) Audio Signal Level – The product is to be connected as illustrated in Figure 64.1.

i) A 1000-Hz sinusoidal signal is to be applied to the first audio stage of each preamplifier or amplifier circuit.

Exception: A sinusoidal signal of the geometric mean frequency of the upper and lower frequency limits of the circuit under test may be used if the amplifier has a limited bandwidth (for example, less than nominal 20 Hz – 20 kHz). The geometric mean frequency is equal to the square root of the product of the low frequency limit and the high frequency limit. The frequency limits may be specified by the manufacturer.

ii) If the power delivered to the audio loads depends on the phase difference between signals, the input signals are to be 90 degrees out of phase.

iii) If the power delivered to the audio loads depends on a special signal encoding method to activate amplifier circuits, the input signals are to be appropriately encoded so as to produce maximum undistorted audio output power at all loads. As an alternative to this method, a separate audio input signal may be injected at an appropriate point in each amplifier circuit so as to achieve the same results.

iv) After a 15-minute warmup period, the signal input level and the product operating controls are to be adjusted to produce one-eighth of the maximum, available, undistorted, sine wave output power or 0.5 W, whichever is greater. The maximum, available, undistorted, sine wave output power is considered to be the maximum attainable with no evidence of clipping or flattening of the sine wave as determined by viewing the waveform on an oscilloscope. If there is a question about clipping or flattening of the output sine wave, a distortion analyzer may be used to measure the total harmonic distortion (THD) present in the waveform. The THD is not to be greater than 1 percent.

2) Video Signal Level

i) A National Television System Committee (NTSC) television receiver is to be operated on-channel. The input signal is to be a composite, consisting of an RF carrier modulated with a standard NTSC split field color bar pattern, applied at the antenna input connection of the product. The top half of the color bar pattern is to consist of fully saturated 75 percent color bars and the lower half is to consist of I, Q and 100 percent white bars. The signal shall have a strength of approximately 10 mV.

ii) An NTSC monitor or television receiver with a video input connection is to be operated with a video input signal, consisting of a standard NTSC split-field, color-bar pattern, applied at the input connector of the product. The top half of the color-bar pattern is to consist of fully saturated, 75 percent color bars and the lower half is to consist of I, Q and 100 percent white bars. The signal shall have a strength of approximately 1 V peak-to-peak.

iii) Television receivers or monitors that use a different system, such as High Definition Television (HDTV), are to be operated with the appropriate signal that produces the maximum supply current input power.

64.4 When measuring the power input, increases in power having a duration of 5 seconds or less are to be discounted if the power increase does not occur more often than once a minute. Such increases may result from momentary operation of a motor, mechanical cycling of parts, or the like.

64.5 If an overload protection device opens during the power input test, the protective device is to be short-circuited when making the measurement.

65 Peak Inrush Current Test

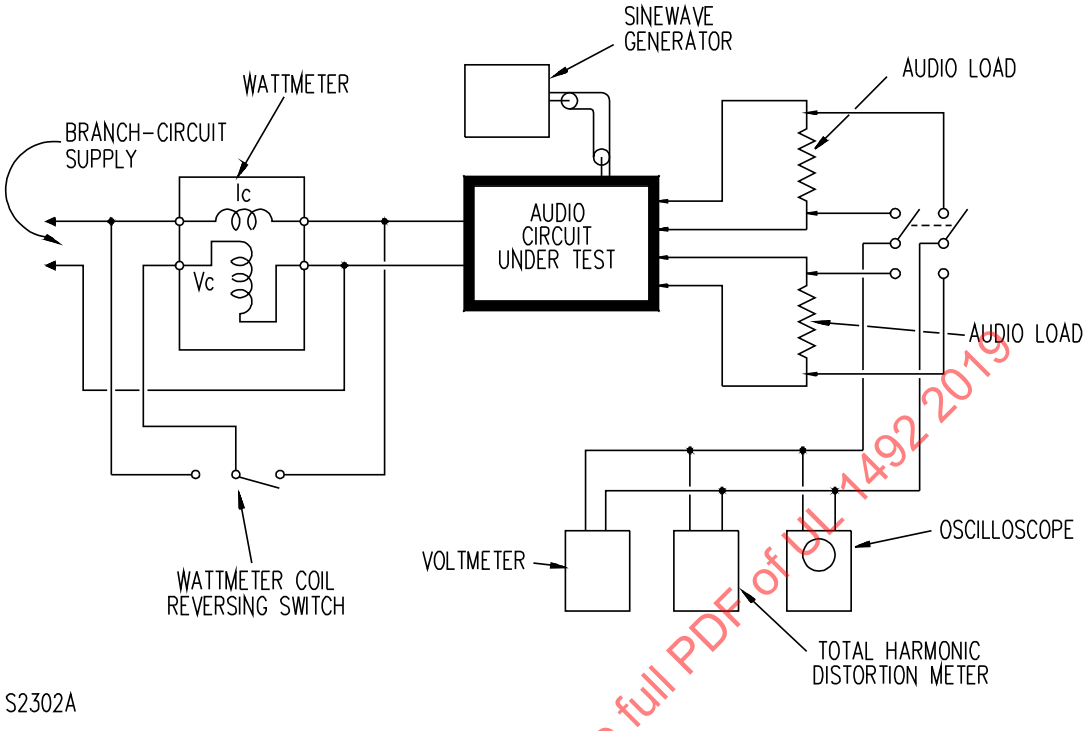
65.1 General

65.1.1 The peak value of inrush current controlled by contacts of a product supply-circuit control switch or relay shall not exceed the switch or relay current rating in amperes, rms, times 1.414.

Exception No. 1: A switch having a TV rating as described in 36.10.4 need not comply with this requirement.

Exception No. 2: A relay that has a TV rating or that has been tested for 25,000 cycles of operation with a tungsten load equal to or exceeding the load controlled by the relay need not comply with this requirement. See 83.1.

Figure 64.1
Typical input-power and input-current test circuit for an audio amplifier circuit



65.2 Test circuit

65.2.1 The product is to be connected to a 120-V, 60-Hz supply source calibrated to represent a 20-A household branch circuit having a momentary 1000-A, short-circuit current capability. For the purpose of these requirements, a circuit having a momentary 1000-A, short-circuit current capability is defined as one complying with the requirements of the qualification tests described in 65.6.1 – 65.6.3.2.

65.2.2 The following devices are to be part of the supply source defined in 65.2.1, as shown in the test circuit illustrated in Figure 65.1:

a) A single-pole, single-throw, bounce-free type switch. For example, a wiping-blade knife switch and

b) A 0.02-ohm, high-frequency, current-viewing, resistive shunt complying with the specifications given in Table 65.1.[a]

[a]The construction details of the 0.02-ohm shunt may be found in Appendix B.

65.3 Product operating condition

65.3.1 The product controls and switches are to be adjusted as indicated in the Power Input Test, Section 64. The thermal state of the product is to maximize the magnitude of the inrush current.

65.4 Test procedure

65.4.1 The 120-V, 60-Hz test circuit to which the product has been connected is to be momentarily energized by operating the test-circuit control switch asynchronously for 60 – 100 cycles of closure and opening. The waveforms of these events are to be displayed on a storage oscilloscope connected across the 0.02-ohm, high-frequency, current-viewing, resistive shunt.

Figure 65.1
Peak inrush-current measurement test circuit

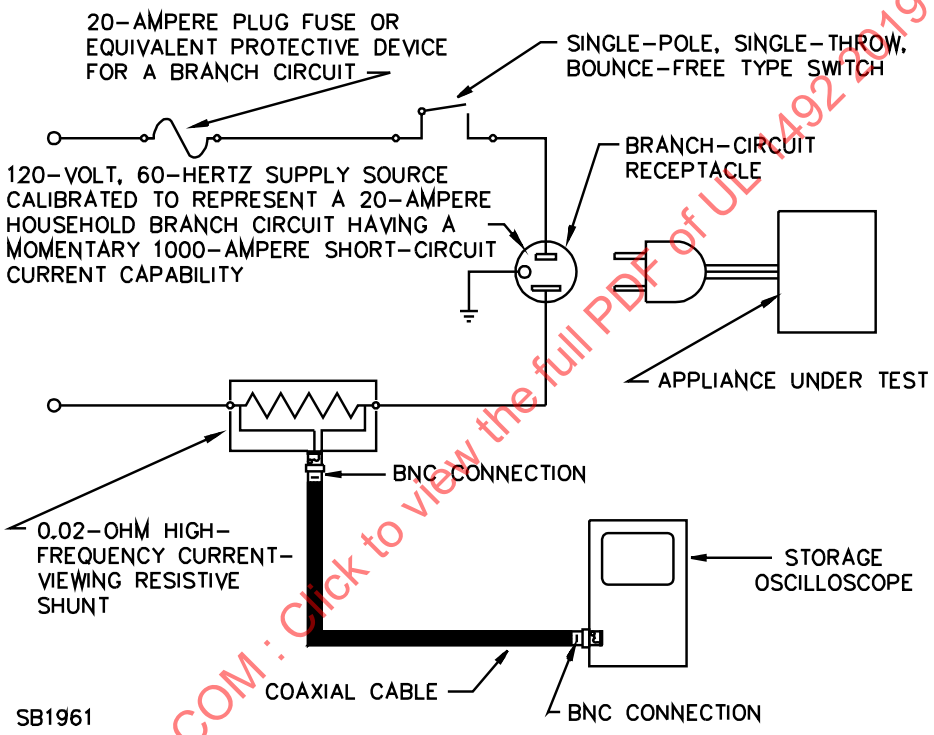


Table 65.1
Specifications for the high-frequency, current-viewing, resistive shunt used for measuring product peak inrush-current

Parameter	Specification	Tolerance
Resistance	0.02 ohms	±2.5 percent
Rise time	30 nanoseconds[a]	plus 0; minus not specified

[a] If a peak-to-peak pulse of any convenient value having a rise time of 30 nanoseconds or less is applied, there is not to be discernible rise-time degradation of the applied waveform when viewed from the current-viewing connector.

65.5 Calculation of peak inrush current

65.5.1 The peak inrush current is to be calculated according to the equation:

$$I_p = \frac{E_p}{R_s}$$

in which:

I_p is the calculated peak inrush current of the product being tested;

E_p is the maximum value of voltage measured across the 0.02-ohm, high-frequency, current-viewing, resistive shunt as displayed by the storage oscilloscope; and

R_s is the exact resistance of the high-frequency, current-viewing, resistive shunt.

65.5.2 The inrush current contributed by any product circuitry that is not controlled by the contacts of the supply-circuit control switch is to be deducted from the calculation described in 65.5.1 so as to determine the actual peak inrush current controlled by the switch contacts.

65.5.3 When observing the waveforms on the oscilloscope, narrow, low-energy-content spikes may be visible due to charging of stray wiring capacitance of the load wiring or to circuit inductance due to a component, such as a phonograph motor. These spikes, which may precede, follow, or both precede and follow the main transient after switch closing and opening, are to be disregarded provided the duration of each spike is 100 microseconds or less.

65.6 Qualification tests for peak inrush-current measuring circuit

65.6.1 General

65.6.1.1 To be considered acceptable for use in the peak inrush-current measurements described in 65.1.1 – 65.5.2, the supply capability at the branch-circuit receptacle shown in Figure 65.1 (the supply source in combination with all of the circuit elements depicted in that figure) shall be such that the following qualification tests are satisfied:

a) Static Load Regulation – The voltage measured at the receptacle shall not fall more than 2.4 V from the open-circuit value when loaded with a steady-state, 20.0-A rms resistive load. The test method and conditions are to comply with 65.6.2.1 and 65.6.2.2.

b) Dynamic Loading – The inrush current to the specified tungsten lamp test load shall achieve a value of 80 ±5 percent of the theoretical maximum inrush current which that tungsten lamp load could produce if it were to be placed across a source of zero-source impedance. The actual inrush current being produced is to be determined using the test methods and conditions described in 65.6.3.1 and 65.6.3.2.

65.6.2 Static load regulation

65.6.2.1 The static load regulation test evaluates the 60-Hz impedance of the supply source, including the inrush-current test equipment, by a measurement of the voltage drop under steady-state load conditions. Automatic voltage-regulation equipment in the supply source, which adjusts the supply voltage under load conditions, is to be connected to the supply circuit during these evaluation tests. However, the automatic voltage-control feature is to be disabled during the test in 65.6.2.2.

65.6.2.2 The open-circuit voltage at the supply receptacle of Figure 65.1 is to be adjusted to 120 V as measured with a voltmeter that has an accuracy of ±1 percent or better. For example, 120 V indicated on a 150-V, full-scale voltmeter requires an instrument accuracy of 3/4 percent full scale, or better. A resistive load is to be applied to the receptacle, and adjusted to 20.0 A rms as measured with an ammeter having an accuracy of ±1 percent – or better – at 20 A. The voltage across the receptacle is to be measured with the 20.0-A load applied, using the same instrument as for the open-circuit voltage measurement. The open-circuit voltage is to be rechecked. The difference between the open-circuit and load voltages is to be calculated. Refer to 65.6.1.1(a).

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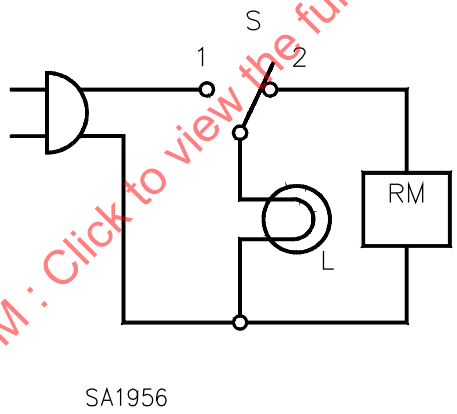
65.6.3 Dynamic loading

65.6.3.1 Prior to its use in the dynamic loading test, it is to be determined that the transient-current measurement instrumentation, which consists of an oscilloscope and high-frequency shunt, is reading the peak value of the 20.0-A rms, steady-state current used in the test in 65.6.2.2 within ±5 percent.

65.6.3.2 The test load in Figure 65.2 is to be prepared using the shortest possible, direct wiring of minimum 12 AWG (3.2 mm^2) copper wire. This test circuit is to be connected to the supply receptacle of Figure 65.1, and the receptacle voltage adjusted to 120 V using the voltmeter described in 65.6.2.2. The open-circuit voltage, Voc, is to be recorded. The maximum theoretical peak inrush current is to be calculated as Voc X 1.414/1.00. Lamp L is to be preheated by throwing switch S to position 1 briefly, then back to position 2. The cooling resistance of lamp L is to be followed to 1.00 ohm with resistance-measuring equipment. Immediately upon reaching 1.00 ohm (typically reached within 20 – 35 seconds after the last heat), switch S is to be rapidly transferred to position 1 briefly again, and then returned to position 2. The peak value of voltage measured for lamp L, except for the first cold start pre-heat cycle, is to be recorded by the use of the oscilloscope and high-frequency shunt. Closure of the 1.00 ohm tungsten load across the receptacle is to be repeated for a minimum of 60 – 100 cycles of operation of S. The value of the highest peak voltage measured during this sequence is to be noted. The highest peak inrush current is to be calculated using the equation in 65.5.1 and then its percentage of the maximum theoretical inrush current (determined by the equation above) calculated. Refer to 65.6.1.1(b).

Figure 65.2
Load for dynamic loading test



S – Single-pole, double-throw, bounce-free type switch (for example, wiping-blade knife switch) capable of rapid transfer between contacts.

L – No. 4 photoflood lamp, 1000 W at 120 V.

RM – Resistance-measurement equipment capable of accurately measuring 1.00 ohm (Wheatstone bridge, digital ohmmeter, or the like).

66 Grounding Path Test

66.1 The resistance or the impedance of the grounding path at 60 Hz shall not exceed 0.1 ohm when measured from the grounding means of the product to the conductive part that is required to be grounded. The resistance can be determined by any resistance-measuring equipment.

Exception: If a grounding-path resistance of more than 0.1 ohm is measured, the impedance is to be determined by measuring the voltage when a current of 20 A derived from a 60-Hz source with a no-load voltage not exceeding 12 V is passed between the product grounding means (point on the product where the cord grounding conductor is attached) and the grounded conductive part. The impedance in ohms is to be calculated by dividing the drop in potential in volts by the current in amperes passing between the two points. The power-supply cord is to be excluded when this measurement is made.

67 Product-Leakage and Shock-Current Test

67.1 General

67.1.1 All accessible parts are to be tested for leakage current. All parts accessible during user-servicing are to be tested for shock current. The currents from these parts are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible.

67.1.2 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 considered to be able to simultaneously contact parts that are within a 10 by 20 cm rectangle. Parts that can be contacted simultaneously by a person having a reach of 2 m are considered to be touchable by both hands.

67.1.3 Leakage or shock current refers to all currents, including capacitively coupled currents.

67.1.4 Unreliable insulation such as that usually used between the points specified in (a) – (g) is to be short-circuited or open-circuited during the test.

a) Between the voice coil and the frame of a speaker,

b) Between live parts and the metal frame of a phonograph pick-up cartridge,

c) Between the two channels of a stereophonic phonograph pick-up cartridge,

d) Between the plates of an adjustable or variable air-dielectric capacitor,

e) Between the heater and cathode elements of a vacuum tube,

f) Between any two adjacent elements of a vacuum tube, between the elements of an electrolytic capacitor, and

g) Between the elements of a solid-state component (diode, transistor, integrated circuit, and the like).

Exception: A solid-state component (diode, transistor, integrated circuit, and the like) that has been found reliable to not malfunction in such a mode as to result in a risk of electric shock need not be shorted or open-circuited during the test.

67.1.5 Current measurements are to be made with any operating control or adjustable control that is considered subject to user operation in all possible positions of contact and either with or without tubes, separable connectors, and similar devices in place.

67.2 Product leakage current

67.2.1 The leakage current shall not be more than that specified in 12.1.1 (Product leakage current).

67.2.2 The measurement circuit for the product leakage-current test is to be as shown in Figure 67.1. The ideal measurement instrument is defined in (a) – (d). The meter that is actually to be used for a measurement need only indicate the same numerical value for the particular measurement as would the ideal instrument. The meter used need not have all of the attributes of the ideal instrument.

a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 µF;

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

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response (a 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 0.15 µF capacitor to 1500 ohms. At an indication of 0.5 milliampere, the measurement is to have an error of not more than 5 percent at 60 Hz; and

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

67.2.3 A sample of the product is to be tested starting with the as-received condition with all of its switches closed, but with its grounding conductor, if any, open. The as-received condition is defined as the product not being energized for a minimum of 48 hours prior to the test, and with the product at room temperature. The supply voltage is to be the maximum voltage marked on the product, but not less than 120 (or 240) V. See Table 63.1. The test sequence, with regard to the measuring circuit in Figure 67.1, is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Immediately after connection, the current is to be measured using both positions of switch S2 and with the switching devices in the product in all of their operating positions.

b) Switch S1 is then to be closed, energizing the product, and immediately after closing the switch, the current is to be measured using both positions of switch S2, and with the switching devices in the product in all of their operating positions.

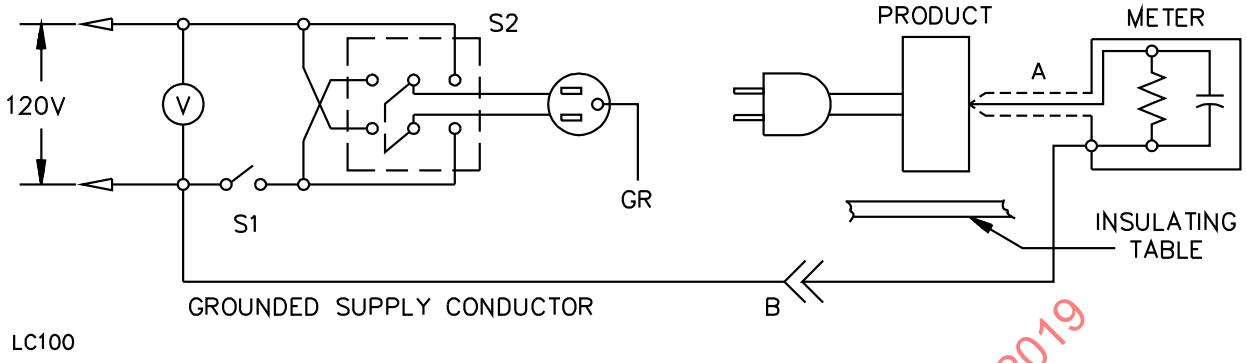
c) The current measurements of (a) and (b) are to be repeated after thermal stabilization of the product.

67.3 Electric shock at audio output circuit terminations

67.3.1 The audio output potential of an amplifier circuit having provision for connection of an external speaker or speakers shall be 100 V open circuit or less when tested as described in 67.3.2.

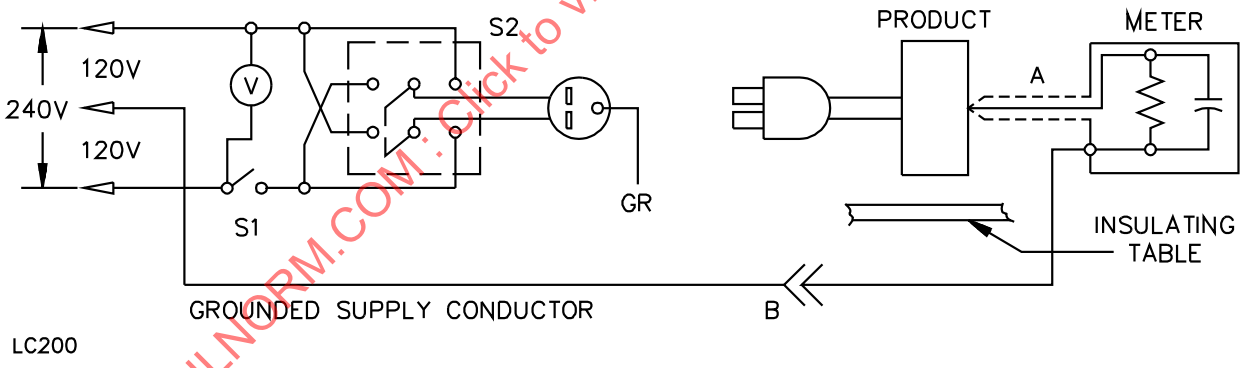
Exception: This requirement does not apply to a product that complies with the requirements in 35.11.2 – 35.11.6.

Figure 67.1
Leakage-current measurment circuit



LC100

NOTE – Product intended for connection to 120-V supply.



LC200

NOTE – Product intended for connection to a three-wire, grounded neutral power supply as illustrated above.

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of product to another.

67.3.2 A variable-frequency signal generator is to be connected to the input terminals and a matched load impedance connected across the output terminals. The input-signal voltage is to be adjusted to such a value that maximum, available, undistorted, sine-wave power is delivered to the load. The output circuit is then to be opened and the potential across the output terminals measured. The test is to be repeated over the range from 60 to 100 Hz in steps of 10 Hz by adjustment of the signal generator.

67.4 Electric shock at an audio output circuit under fault conditions

67.4.1 The voltage between:

a) Any accessible conductive part (see 18.1.2) of the audio-output circuit of an amplifier and

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b) Any other accessible conductive part (including earth ground or another accessible conductive part of the audio-output circuit)

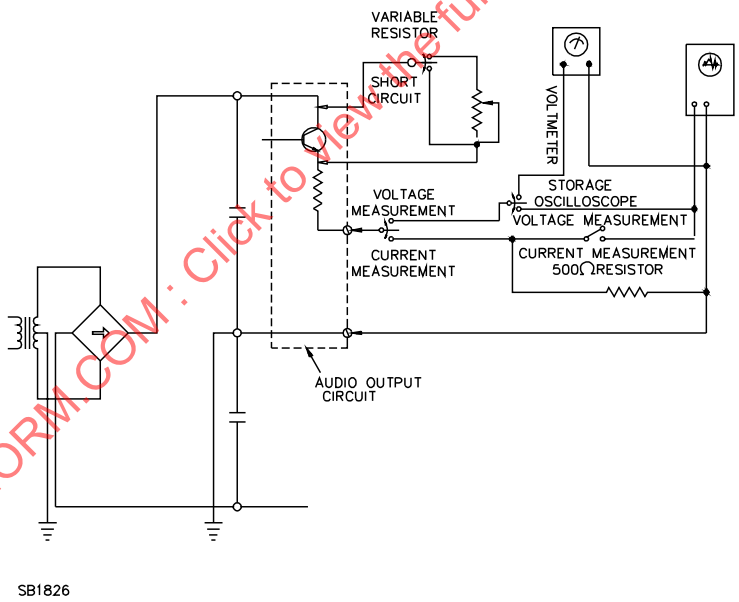
shall not exceed 60 V peak for potentials that do not reverse in polarity or 60 V peak and 84.8 V peak-to-peak for potentials that reverse in polarity when the amplifier audio-output circuit is tested as described in 67.4.2 – 67.4.5.

Exception: This requirement does not apply in those instances in which the duration of current through a 500-ohm noninductive resistor connected between the parts satisfies the equation in 67.4.7.

67.4.2 A variable resistor is to be connected between any two terminals of an unreliable component such as a vacuum tube, diode, electrolytic capacitor, transistor, or integrated circuit located in the audio-output circuit. See Figure 67.2 for an example of the test applied across the collector-emitter junction of an audio-output transistor. The amplifier circuit is to be operated under no-signal conditions without any load connected to the audio output circuit.

67.4.3 The variable resistor is to have a resistance value high enough that, when initially connected across the terminals of the component in the audio-output circuit being tested, there is no effect on circuit operation. The variable resistor is also to be capable of being reduced to zero resistance and of conducting large magnitudes of current.

Figure 67.2
Measurement-circuit connections



(Illustrated procedure for determining electric shock at an audio output circuit under fault conditions)

67.4.4 With the product connected to a supply circuit in accordance with 63.1.2 and Table 63.1 and operating normally under no-load conditions, the variable resistor is to be slowly reduced in resistance value and the voltage at the audio output circuit monitored. If the product ceases to function before the voltage at the audio output circuit exceeds the values specified in 67.4.1, the cause of the malfunction is to be determined. If a component other than a fuse, overload protector, or limiter has been damaged, it is to be replaced by either an open circuit or a short circuit, whichever produces the more unfavorable results. The test shall be continued until zero resistance of the variable resistor is reached, the maximum voltage is reached, or until the voltage is reduced or interrupted by the opening of a fuse, overload protector, or limiter.

67.4.5 Following the test procedure described in 67.4.4, a previously untested product or one repaired to original operating order is to be additionally tested by suddenly applying a short circuit across the same two terminals. The output-voltage waveform is to be recorded on a storage oscilloscope or by similar means.

67.4.6 If the maximum value of output voltage measured as described in either 67.4.4 or 67.4.5 exceeds the values specified in 67.4.1, a 500-ohm, noninductive resistor is to be connected between the parts. The test described in 67.4.4 or 67.4.5 (or both if the maximum value of output voltage exceeds the specified values when the product is tested according to both 67.4.4 and 67.4.5) is to be repeated; however, the current through the 500-ohm resistor instead of the open-circuit voltage is to be monitored.

67.4.7 The duration of the current through the resistor is to satisfy the equation:

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

in which:

T is the duration (in seconds) measured from the time that the instantaneous value of current first exceeds 7.1 milliamperes, until the time that the current falls below 7.1 milliamperes and remains so for at least 1 second and

I is the peak current (in milliamperes).

A current of less than 7.1 milliamperes peak is acceptable regardless of duration.

Exception: The peak current shall not exceed 809 milliamperes regardless of duration.

67.4.8 If a fuse, other circuit protective element, protector, limiter, and the like is relied upon to open the circuit, it shall be marked as described in 128.4.1– 128.6.1 and 128.9.1.

67.4.9 If the protective or limiting function is accomplished through the use of solid-state circuitry to provide sensing, cut-off, limiting, and the like, the product with protective or limiting circuitry shall complete 100,000 cycles of operation simulating the fault(s) that it is intended to interrupt, clear, or guard against to remove or preclude hazardous potentials appearing at the speaker terminals.

67.4.10 To determine compliance with 67.4.9, three samples of the product are to be subjected to the cycling test. Upon completion of the required number of cycles, the test in 67.4.6 or 67.4.7 is to be repeated with acceptable results.

67.5 Product shock-current

67.5.1 The shock current between parts accessible only during user-servicing and between such parts and earth ground shall not be more than that specified in 12.2.1.1 (Electric shock) for a continuous current; or more than that specified in 12.2.2.1(Transient electric shock) for a transient current.

67.6 Stored-energy electric shock

67.6.1 If the short-circuiting of accessible parts results in the discharge of a capacitor, thereby causing an instantaneous flow of current, the transient condition is to be considered with regard to 12.2.3.1 (Stored-energy electric shock).

67.6.2 Immediately – not more than 1 second – after the attachment plug has been removed from a source of supply, the blades of the plug are considered to be accessible parts that may result in the discharge of a capacitor when short-circuited.

67.7 Component electric shock

67.7.1 To determine if the connectors, components, and leads of a product comply with 31.1.1(e) (Part disconnection) and 31.2.1 (Component handling), disconnection is to take place while the product is operated under maximum-voltage conditions (see Maximum Voltage Measurement, Section 69). Current and voltage readings are to be taken during the initial 5 minutes of the test.

67.8 Picture-tube anode lead

67.8.1 Unless marked as described in 136.1.1 (Second anode voltage determination marking), electrical contact between the picture-tube anode lead and the chassis, earth, or other parts of the product that are likely to be brought into contact, either intentionally or unintentionally, with the anode lead during servicing shall not result in any of the following conditions:

a) An electrical breakdown that produces a permanent risk of electric shock and

b) Subjection of insulation and spacings, the deterioration or breakdown of which results in a permanent risk of electric shock, to a voltage of more than 1270 volts peak during a 5-minute period, if the arrangement of parts is such that the voltage is likely to cause an electrical breakdown.

67.8.2 Parts of the product with which contact by the anode lead is considered likely during servicing include the antenna terminals, control shafts, deflection-yoke bracket, and the like. It is to be assumed that professional service personnel might use jumper leads or disregard mechanical supports for the anode lead in order to make such contact.

67.8.3 The contact mentioned in 67.8.1 is to be made under the following conditions:

a) The product is to be operated as described in 69.2.2 and 69.2.3.

b) For a product using an isolating power-transformer supply, connection is to be established between the anode lead and the grounded conductor of the power-supply line at the attachment plug of the product by a 1.8-m jumper lead.

c) The chassis is to be insulated from ground.

d) A peak-reading voltmeter is to be connected between the chassis and each side of the power-supply line at the point where the line first enters the chassis.

e) The first 15 seconds of the test is to be conducted with the connection between the anode lead and the connection point established by means of arcing through air, with the distance of the arcing adjusted to produce the maximum voltage between the accessible metal part and the live part. The remainder of the 5-minute test period is to be conducted with a solid metallic connection established between the anode lead and the connection point.

f) The measurements are to be repeated with the attachment plug reversed in the power receptacle.

68 Temperature Test

68.1 General

68.1.1 A product, when tested according to the applicable conditions and procedures described in this Section, shall not attain a temperature that results in one or more of the following conditions:

a) The likelihood of ignition of materials or components.

b) An adverse effect upon materials or components.

c) The temperature limits of materials or components being exceeded.

d) Temperatures at specific points greater than the limits specified in Table 68.1.

68.2 Thermal equilibrium

68.2.1 Thermal equilibrium is considered attained when three successive readings taken at 15-minute intervals indicate that there is no temperature change of the part.

68.3 Ambient temperatures

68.3.1 The values in Table 68.1 are based on an ambient temperature of 25°C. However, a test may be conducted at any ambient temperature within the range of 10– 40°C. Each observed temperature shall satisfy Equation 68.1.

Equation 68.1
Correction of measured temperatures

$$T_m + (K - T_a) \leq T_1$$

in which:

T_m is the measured temperature of the material or component,

K is 25 when temperatures are measured in degrees Celsius,

T_a is the room ambient temperature, and

T_1 is the temperature limit according to Table 68.1.

68.3.2 If the ambient temperature is not 25°C, and the corrected temperature exceeds the value appearing in Table 68.1, the test may be repeated at an ambient temperature closer to 25°C.

Table 68.1
Maximum temperatures

Parts of product	Temperature, °C
1. Accessible parts[a]	
a) Surfaces of an enclosure	90
b) Small areas and easily discernible heat sinks	90
2. Handles or knobs that are grasped for lifting, carrying, or holding[a]	
a) Metallic	50
b) Nonmetallic	60
3. Accessible front panels, all accessible control panels, and handles or knobs that are contacted but do not involve lifting, carrying, or holding[a]	
a) Metallic	60
b) Nonmetallic	85
4. Enclosure interior surfaces	
a) Wood	90
b) Insulating material[c]	65
5. Insulating materials	
a) Polymeric	b
b) Varnished cloth	85
c) Fiber	90
d) Wood and similar material	90
e) Laminated phenolic composition[c]	125
f) Phenolic composition	150
6. Softening point of any sealing compound	d
7. Coil winding surfaces using impregnated organic insulation or enameled wire[e]	90
8. Capacitors[f]	
a) Electrolytic	65
b) Other types	90
9. Fuses[c]	90
10. Semiconductor devices	g
11. Selenium rectifiers[c]	75
12. Conductors with rubber or thermoplastic insulation[c]	60
13. Solderless wrapped connections	100

[a] Item 1 is concerned with ignition of materials that may contact the enclosure. Items 2 and 3 are concerned with skin-burn if contacted by the user. The lowest temperature limit on a given surface is the maximum temperature for that surface or part.

[b] Polymeric material shall be acceptable for the application when evaluated with regard to temperature.

[c] Does not apply if investigated and accepted for a higher temperature.

[d] The maximum sealing compound temperature, when corrected to 25°C ambient temperature, is 15°C 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.

[e] A hot-spot temperature not higher than 105°C on the surface of a coil winding is acceptable, provided the temperature of the winding does not exceed 100°C. The temperature limits of 90°C by the thermocouple method and 100°C by the resistance method are based on the standardized allowance for a maximum hot-spot temperature of 105°C.

[f] A capacitor operating at a temperature higher than 65°C is to be evaluated on the basis of its marked temperature rating, or if not marked with a temperature rating, can be investigated to determine its acceptability at the higher temperature.

[g] Temperature limits on solid-state components are not specified; however, adequate spacings shall be provided such that the operating temperature of the component does not adversely affect adjacent insulating materials or components, or result in the temperature limits of those materials or components being exceeded.

68.4 Product test conditions

68.4.1 The product is to be tested with the maximum projection on the back in contact with a flat vertical wall of wood or comparable heat-insulating material.

Exception: The spacing between the wall and the main surface of the back of the product is not to be less than 25 mm.

68.4.2 Covers and doors likely to be closed during operation are to be closed for the duration of the test.

68.4.3 Consideration is to be given to the actual conditions of intended operation.

68.4.4 Rubber-like and felt materials are to be removed from supporting feet to the extent that they are likely to be worn off in service.

68.4.5 Horizontal ventilating screens subject to the accumulation of dust and having openings that will not permit the passage of a 1.0 mm diameter sphere are to be covered with loose cotton.

68.4.6 A product that does not have a complete enclosure or that is intended for protected installation in home systems, or both, is to be provided with a built-up wood cover or enclosure, simulating installation in a cabinet. The cover or enclosure is to be constructed of wood nominally 19 mm thick, and arranged so as to expose user controls. Where clearances are not specified by the manufacturer, covers or enclosures are to provide a clearance of 5 cm from the four sides of the chassis, and from the top of the tallest component mounted above the chassis. If an enclosure bottom is required, the enclosure bottom is to provide a clearance of 25 mm from the bottom of the lowest component. In determining the chassis dimensions, extended flanges and feet are to be disregarded.

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68.5 Product operating conditions

68.5.1 The product is to be operated:

a) At the power input as described in the Power Input Test, Section 64, with the product connected as described in 63.5.1 – 63.5.5 (Supply-circuit voltage and frequency),

Exception: Pink noise as described in 68.5.2 may be used as an alternate signal if the sine wave does not represent loading of the amplifier. Each amplifier circuit shall be adjusted to deliver one-eighth maximum undistorted output as determined in the Power Input Test, Section 64. If the acceptability of a component or part is in question, sinusoidal signals at one-eighth maximum undistorted output shall be used.

b) With all unused receptacles at their maximum rating, and

c) As described in 68.4.1 – 68.4.6 to represent expected usage of the product.

68.5.2 A product intended to be operated with a pink noise input as specified in the Exception to 68.5.1(a) shall be operated with a pink-noise, audio-input signal (band-limited at 12 decibels per octave, 20 Hz to 20 kHz, equal energy per octave) connected to each input affecting the power consumption of the product, coupled through a filter circuit with a frequency roll-off of minimum 12 decibels per octave as follows. The amplitude-probability distribution shall be three standard deviations. The low- and high-frequency figures of the amplifier mentioned in (a) and (b) are those given by the manufacturer. The signal amplitude is to be adjusted to cause the product to deliver power equal to one-eighth of measured, maximum, undistorted, output power as described in the Power Input Test, Section 64, or one-eighth of the manufacturer's rated output power, whichever is greater, into the matching load impedance that produced the maximum, input power consumption when tested in accordance with 64.3. The output power is to be calculated using the relation $P = E^2/R$ in which E is the voltage measured by a true rms indicating voltmeter across the noninductive, resistive output load R.

a) Low Frequency – Corner frequency (point where audio signal is down 3 decibels) of high-pass filter set at 50 Hz or as close as practicable to twice the low-frequency response figure, whichever is greater and

b) High Frequency – Corner frequency of low-pass filter set at 20 kHz or as close as practicable to one-half the high-frequency response limit figure, whichever is lower.

68.6 Thermocouples

68.6.1 When thermocouples are used in the determination of temperatures, it is common practice to use thermocouples consisting of 30 AWG (0.051 mm^2) iron and constantan wires and a potentiometer-type instrument. When it is not practical to use iron and constantan thermocouples, some other type as described in the Initial Calibration Tolerances for Thermocouples table in Temperature Measurement Thermocouples, ANSI/ISA MC96.1, in a size of 28 – 32 AWG (0.081 – 0.032 mm^2), can be used.

68.7 Winding temperature measurement

68.7.1 The temperature on a winding is to be measured by using one of the methods specified in (a) and (b).

a) The temperature on a winding is to be measured by applying a thermocouple to the hottest part of the surface of the coil winding. If the winding is enclosed, a hole is to be made in the case; and, if the winding is potted, a heated wire may be used to provide a hole in the compound before the thermocouple is placed in contact with the coil surface.

b) The temperature of a copper or aluminum winding is to be calculated by Equation 68.2 (windings are to be at room temperature at the start of the test).

Equation 68.2
Calculation of temperatures of windings

$$t_2 = \frac{R}{r}(K + t_1) - K$$

in which:

t_2 is the temperature of the coil in degrees Celsius at the end of the test;

R is the resistance of the coil at the end of the test;

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

K is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum (values of the constant for other grades must be determined); and

t_1 is the room ambient temperature in degrees Celsius at the beginning of the test.

69 Maximum Voltage Measurement

69.1 General

69.1.1 The maximum voltage used as a basis for the calculation of the dielectric voltage-withstand test potentials specified in Table 71.1 is to be determined under all of the following conditions of operation:

a) Any combination of tubes and fuses can be removed.

b) An automatic voltage-regulating device, assembly, or circuit is to be rendered inoperative.

Exception: This requirement does not apply when the device, assembly, or circuit, upon investigation, is found to guard against any unacceptable increases in voltage. The investigation is to take into consideration any likely malfunction or breakdown in either the regulating device or the product, and the possibility of the device being disconnected if it is not permanently connected in the circuit.

c) A connector or comparable part that is likely to be disconnected during the operation or user-servicing of the product is to be both connected and disconnected.

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d) The product is to be connected to a supply circuit of maximum rated voltage.

e) If a complex voltage is present, the peak value of the voltage is to be measured.

69.2 Maximum voltage – V_1

69.2.1 The value of V_1 to be used in calculating the dielectric voltage-withstand test potential specified in 71.7.1 is to be determined in accordance with 69.2.2 or 69.2.3, whichever results in a higher value. See also 69.3.3.

69.2.2 All controls are to be adjusted to give the maximum voltage possible with a usable picture.

69.2.3 Voltages are to be measured with and without any accessories, with and without any one tube or fuse (exclusive of copper or copper alloy links in any low-voltage heater circuit) disabled in any manner that might occur in service, and with any combination of these conditions. In each case, all operating controls and all user-servicing controls are to be adjusted to produce the maximum voltage, V_1, regardless of the effect on the picture.

69.3 Maximum voltage – V_2

69.3.1 The value of V_2 to be used in calculating the dielectric voltage-withstand test potential specified in 71.7.1 is to be determined in accordance with 69.3.2. See also 69.3.3.

69.3.2 Voltages are to be measured with and without any accessories, with and without any combination of fuses (exclusive of copper or copper alloy links in any low-voltage heater circuit) and tubes removed, with connectors that are likely to be disconnected during normal operation or user-servicing both connected and disconnected, and with any combination of these conditions. In each case, all controls are to be adjusted to produce the maximum voltage, V_2, regardless of the effect on the picture.

69.3.3 In determining the values of V_1 and V_2 in accordance with 69.2.1 and 69.3.1, an automatic voltage-regulating device that has been found to be reliable when investigated as described in 69.1.1 is not to be rendered inoperative.

70 Audio Output Power Limitation Measurement Test

70.1 The audio output power of an amplifier circuit having provision for connection of an external speaker or speakers shall be 240 W or less per audio output channel when tested as described in 70.2.

Exception: This requirement does not apply to a product that complies with the requirements in 35.11.2 – 35.11.6.

70.2 A 1000-Hz, sinewave signal generator is to be connected to the input connections, separate matched load impedances as specified in 64.3(f)(2), 64.3(f)(3), or 64.3(f)(4) are to be connected across the audio amplifier output circuit terminations, and speakers, if provided, are to be disconnected. The input signal voltage is to be adjusted to such a value that maximum available undistorted sinewave power [see 64.3(h)(4)] is delivered to the loads. The maximum, available, undistorted, sinewave power is then to be measured after 1 minute of operation. If, because of limiters or protection circuitry, the maximum power cannot be maintained for the 1 minute, the value to be measured is that which was obtained just before operation was affected by such limiters or protection circuitry.

71 Dielectric Voltage-Withstand Tests

71.1 General

71.1.1 The insulation and spacings between conductors and parts shall withstand without breakdown the application of the test potentials shown in Table 71.1 for 1 minute.

Exception: This requirement does not apply where an investigation shows that such a breakdown does not result in a risk of fire or electric shock.

71.1.2 A DC test voltage is not to have more than 3 percent ripple.

71.1.3 The indicated test voltage is to be measured directly across the points of application of the test potential with a high-resistance voltmeter.

71.1.4 The test voltage is to be raised gradually and smoothly to the specified value measured as indicated in 71.1.3 so that there are no transients that may cause the instantaneous test potential applied to exceed the peak value specified.

71.2 Primary circuit when factory dielectric voltage-withstand test potential exceeds 1300 V, 50 or 60 Hz, or is applied for more than 2 seconds

71.2.1 If the production-line, dielectric voltage-withstand test potential (see Tests by the Manufacturer, Section 125) exceeds 1300 V, 50 or 60 Hz, or 1840 V DC, or a time duration of more than 2 seconds, the insulation and spacings of a product shall withstand, without breakdown for 1 minute, a 2875-V, 60-Hz potential applied between parts involving a risk of electric shock and accessible, conductive parts.

71.3 Primary circuit when factory dielectric voltage-withstand test potential exceeds 2000 V, 50 or 60 Hz, or 2828 V DC, or is applied for more than 4 seconds

71.3.1 If the production-line, dielectric voltage-withstand test potential (see Tests by the Manufacturer, Section 125) exceeds 2000 V, 50 or 60 Hz, or 2828 V DC, or a time duration of more than 4 seconds, three samples of the product are to be subjected to the continuous application of the voltage potential that the manufacturer intends to use on the production line for a duration that is 100 times the factory-test time. There shall not be breakdown of insulation or spacings in the product that would result in a risk of fire or electric shock.

71.4 Requirements for AC test equipment

71.4.1 The test equipment for conducting AC dielectric voltage-withstand tests is to have an output voltage that has a sinusoidal waveform, has a frequency that is within the range of 40 – 70 Hz, and has a peak value of the waveform that is not less than 1.3 and not more than 1.5 times the root-mean-square value.

71.4.2 The sensitivity of the test equipment is to be such that when a 120,000-ohm resistor is connected across the output, the test equipment does not indicate unacceptable performance for any output voltage less than the specified test voltage, and does indicate unacceptable performance for any output voltage equal to or greater than the specified test voltage. The calibrating resistor is to be adjusted as close to 120,000 ohms as instrumentation accuracy can provide, but not more than 120,000 ohms.

Exception No. 1: The sensitivity of the test equipment may be reduced (a lower value of calibrating resistance used) if testing circuits or components that do not involve accessible conductive parts.

Exception No. 2: The sensitivity of the test equipment may be increased (a higher value of calibrating resistance used) if agreeable to those concerned.

Table 71.1
Dielectric voltage-withstand test potentials and applications

Circuit or component	Points of application[a]	Test potentials[b]
Primary circuits		
Printed-wiring portions	c, d	(2E + 1000) V DC
All parts	c, d	1000 V 60 Hz
Power transformers	e	1000 V; 60 Hz
Other circuits – power-transformer-supplied secondary	f	(2E + 1000) V DC
Load side of rectifier of direct-connected supply	d, f	(3E) V DC[g]
Audio output	h	(4E) V DC[g]

[a] Power-dissipating component parts, unreliable components, and electrolytic capacitors located between the circuits under test are to be removed or disconnected so that the spacings and insulations, rather than such component parts, are subjected to the full dielectric voltage-withstand test potential. Switches and other controls, whether accessible or not, are to be set or adjusted so that all conductors and parts intended to be tested are connected to the circuit under test.

[b] E equals the maximum peak potential in volts between the conductor or part to be tested and earth, an accessible conductive part, or other conductive part; measured with the product operating under the conditions described in Maximum Voltage Measurement, Section 69.

[c] The insulations and spacings are to be tested between primary circuit parts and the following parts all connected together:

1) The grounding terminal (if any),
2) The enclosure, with a conductive foil wrapped around insulating portions of the enclosure, and
3) Accessible conductive parts.

Care should be taken to make sure that each capacitor, winding separation, or other separation (such as a spacing between conductors) that isolates accessible conductive parts from the primary circuit is tested.

[d] The insulations and spacings between parts of opposite polarity are to be tested.

[e] The insulations and spacings between windings and parts of a transformer conductively connected to the supply circuit are to be tested. The windings and parts to be tested shall include each of the following:

1) Primary to shield or guard (if provided),
2) Primary to core, and
3) Primary to each secondary (or all secondaries connected together).

Table 71.1 Continued on Next Page

Table 71.1 Continued

Circuit or component	Points of application[a]	Test potentials[b]
[f] The insulations and spacings between parts of circuits involving the risk of fire or electric shock and each of the following are to be tested: 1) The protective grounding terminal (if provided); 2) The enclosure, with a conductive foil wrapped around insulating portions of the enclosure; 3) Accessible conductive parts; and 4) All other circuits. [g] Not less than 1270 V DC. [h] Each capacitor, winding separation, or other separation (such as a spacing between conductors) that isolates accessible parts of an audio circuit involving the risk of fire or electric shock.		

71.5 Requirements for dc test equipment

71.5.1 The test equipment for conducting the dc dielectric voltage-withstand test is to provide a means for indicating unacceptable performance. For the purpose of these requirements, unacceptable performance is defined as:

a) An abrupt decrease or nonlinear advance of voltage as the test voltage is increased, or similarly

b) An abrupt increase in current.

71.6 Accessible part

71.6.1 The direct-current potential specified in Table 71.2 is to be applied between a part involving a risk of electric shock and:

a) An accessible metal part or

b) An accessible part that is not considered to be reliable insulation

if contact between such parts can result in a risk of electric shock.

Exception No. 1: A potential need not be applied if a conductive shield or coating is provided between the parts and connected back to opposite polarity parts.

Exception No. 2: A potential need not be applied if through-air spacings between the parts are permanent and comply with curve 1 in Figure 117.1 for a voltage value of 2V + 1000.

71.6.2 A material that is not considered to be reliable insulation is to be covered with a conductive coating such as metal foil.

71.6.3 A spark gap or a gaseous-discharge tube may be used as a means of preventing electrical breakdown in other parts of the circuit if, upon investigation, it is determined to be acceptable.

Table 71.2
Direct-current test voltages

Maximum peak potential of live parts in volts (V)[a]	Test potential in volts (DC)
0 – 1000	3V (1270 minimum)
Over 1000	2V + 1000
a Maximum peak voltage between the live part and earth, or an accessible metal part, measured with the product operated under the conditions described in 69.1.1 or 69.2.2 and 69.2.3, whichever is applicable.	

71.7 Elevated-voltage system

71.7.1 A voltage source over 1000 volts peak and associated circuits, such as deflection coils, and the like, operating in the B-plus circuit, shall operate without breakdown for 1 minute when the voltage source output is $1.25V_1$+ 1750 volts, or $1.1V_2$, whichever is greater.

71.7.2 V_1 is to be the maximum voltage measured between any point of the voltage source and the chassis under the conditions described in 69.2.2 and 69.2.3. V_2 is to be the maximum voltage measured between the same points under the conditions described in 69.3.2 and 69.3.3.

71.7.3 The voltage applied to the voltage source is to be gradually increased until the required test value is obtained in the output or until breakdown occurs. The operating frequency and voltage wave form of the circuit being tested are to be maintained as nearly normal as possible.

71.8 High-voltage isolating component

71.8.1 A component, such as a high-voltage transformer (flyback), deflection yoke, and the like:

a) Operating at peak voltage of more than 2500 volts,

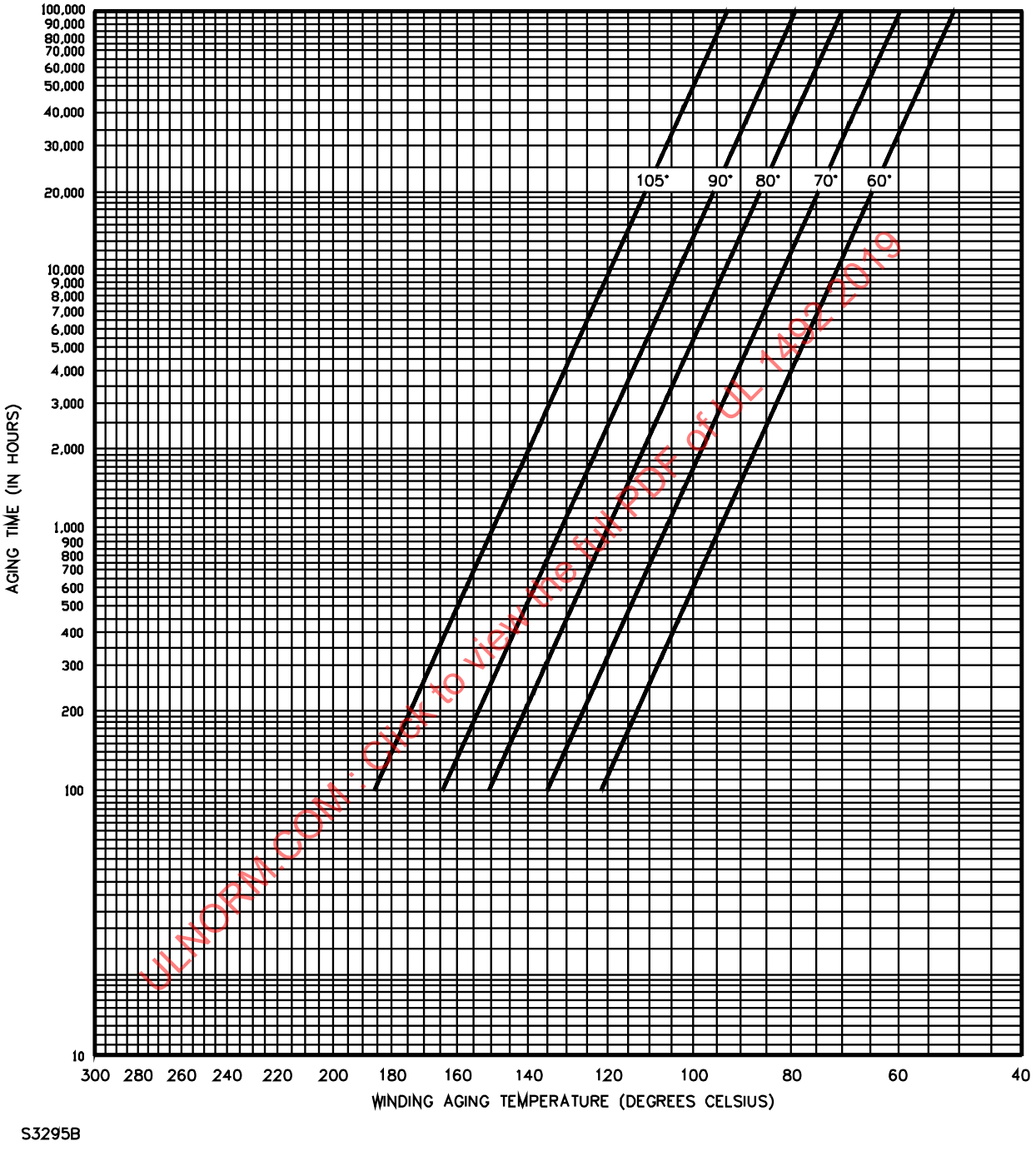
b) Having one winding connected to the primary AC source of supply, and

c) Having another winding, located within the same component housing that is connected to an accessible part

shall withstand the conditioning and dielectric voltage-withstand tests described in 71.8.2 and 71.8.3. There shall not be breakdown of the insulating materials if such breakdown would result in a risk of electric shock.

71.8.2 Three samples of the high-voltage component, connected as in normal operation, are to be conditioned in a circulating-air oven. The operating temperature of the oven is that necessary for the component winding to reach the winding aging temperature. The winding aging temperature is obtained from the horizontal axis of Figure 71.1. This temperature is determined by the intersection of the aging time and historical class 105 (A) system response curve. The historical class 105 (A) system response curves are the slanted lines illustrated in Figure 71.1. The aging time and historical class 105 (A) system response curves are determined by the manufacturer. The curve chosen may not be less than the normal operating temperature of the winding of the component.

Figure 71.1
Historical class 105 (A) system response



71.8.3 After completion of the conditioning test described in 71.8.2, the samples are to be allowed to cool to room temperature and subjected to the 1.25 x V_1 plus 1750-volt DC dielectric voltage-withstand test described in71.7.1.

Exception: The test potential is to be 2 x V_1 plus 1000 volts DC for a component intended to provide double protection against the risk of electric shock in accordance with 52.6(b).

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72 Primary Insulation Voltage Test

72.1 A high-voltage part that is accessible while energized, or that is likely to be left in contact with accessible metal, with parts of the power supply circuit, with a wooden cabinet, or with a similar part having a relatively low level of insulation, shall not cause a breakdown of the primary insulation or develop a voltage of more than 1270 volts peak across primary insulation when connected to the chassis or earth.

73 Special Option Tests

73.1 Limited-power determination

73.1.1 To determine compliance with 17.4.1 – 17.4.4 (Special construction option), the sources of power for a component part or assembly shall not be capable of delivering a power of more than 15 W into an external resistor. The measurement is to be made between any two points on the assembly with all components (load circuit) beyond the two points disconnected and on individual windings or circuits and then added together.

73.1.2 If a regulating or other type of circuit is located between the points being measured and the power supply, the opening or short-circuiting (singly) of any unreliable component (electrolytic capacitor, transistor junction, diode, vacuum tube, and the like) in that circuit shall not cause the limit in 73.1.1 to be exceeded.

73.1.3 As a result of the tests described in 73.1.4, components located between the points being tested and the power supply shall not be affected to such an extent, such as by a change in value or characteristics, as to cause the limit in 73.1.1 to be exceeded.

73.1.4 Except as noted otherwise in 73.1.1 – 73.4.1, the methods for measuring power capability are to be as described in the Power Supply Tests, Section 77.

73.2 Limited-power fire tests

73.2.1 The points determined by the measurements described in 73.1.1 – 73.1.4 shall be investigated to determine all of the following:

a) That a risk of fire or electric shock is not produced under the conditions of separately short-circuiting them, or loading them to maximum or limited power;

b) That a risk of fire or electric shock is not produced under the conditions of short-circuiting, singly, any unreliable component between the points and the power supply; and

c) Following the tests described in 73.2.1(a) and 73.2.1(b), the circuit tested shall be capable of withstanding without breakdown for a period of 1 minute, a 1000-V alternating potential having a frequency of 60 Hz, between any live part conductively connected to the supply circuit and any accessible conductive parts, and between any live or current-carrying part of the primary or power-supply circuit, and any live or current-carrying part of the secondary circuit.

73.2.2 To determine if the product complies with 73.2.1, it is to be tested as described in 73.2.3, 73.3.1, 74.1.1 – 74.3.1, and 74.4.2 – 74.11.1, and the applicable provisions of 77.5.2.

73.2.3 If the short-circuit tests required by 73.2.1(a) continue for 4 hours or until 74.9.1(f) is satisfied, it is not necessary that the maximum-power or limited-power tests be conducted. Likewise, if the maximum-power test continues for 4 hours or until 74.9.1(f) is satisfied, it is not necessary that the limited-power test be conducted.

73.3 Limited power

73.3.1 The term ″limited power″ referred to in 73.2.1 is defined as the overload condition that does not cause a component or protective device to open. To create this condition, sufficient impedance is to be introduced into the circuit so that the component or protective device does not open for 4 hours or until 74.9.1(f) is satisfied. After the time period has ended, the impedance is to be reduced to cause the component or protective device to open.

73.4 Maximum power

73.4.1 The term ″maximum power″ referred to in 73.2.1 is defined as the maximum power that the source of power is capable of delivering into an external variable resistor connected in parallel to the points being investigated.

74 Abnormal Operation Test Method

74.1 General

74.1.1 For abnormal-operation tests, the product is to be operated according to applicable requirements contained in this Section.

74.2 Supply-circuit fuse rating

74.2.1 The product is to be connected to a supply circuit fused at 30 A.

74.3 Product supporting surface

74.3.1 The product is to be placed on a white tissue-paper-covered, softwood surface.

74.4 Cheesecloth indicator

74.4.1 A single layer of cheesecloth is to be draped loosely over the component being tested.

74.4.2 A single layer of cheesecloth is to be draped loosely over the whole product.

74.5 User-removable parts

74.5.1 Parts of the product that are subject to removal during user servicing are to be omitted if all of the following conditions apply:

a) The parts are not necessary for the functioning of the product,

b) The parts are not exposed to view during the operation of the product, and

c) The parts are not captivated.

74.6 Fuse indicator

74.6.1 Accessible conductive parts are to be connected to earth ground through a 1-A, non-time-delay type fuse.

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74.7 Polarization

74.7.1 The supply-circuit connection is to be such that the maximum potential exists between the protective device of the product, if any, and the chassis.

74.8 Inherent overheating protection

74.8.1 Inherent overheating protection that functions during the abnormal operation test is to be investigated to determine its acceptability.

74.9 Test duration

74.9.1 Except as noted otherwise for the limited-power test condition described in 73.3.1, an abnormal-operation test is to be conducted for 4 hours or until one or more of the following results are observed:

a) A risk of fire develops. See 74.10.1.

b) A risk of electric shock develops. See 74.10.1.

c) The branch-circuit fuse opens.

d) The circuit being tested opens or reacts in some manner to terminate the abnormal condition.

e) A predictable shut-down circuit terminates the abnormal condition before overheating of parts occurs.

f) A minimum of 1 hour has elapsed, circuit conditions have stabilized, and there is no further evidence of any overheating of parts.

g) A printed-wiring-board conductor or individual wire opens.

74.9.2 The overheating of parts referred to in 74.9.1 and 74.11.1 may be detected by such indicators as: odor, smoke, discoloration, cracking of material, charring, flaming, glowing, arcing, changes in circuit current through the applied fault, or similar phenomenon.

74.10 Unacceptable conditions

74.10.1 An unacceptable condition is considered to exist if the test results in one or more of the following conditions:

a) The single layer of cheesecloth glows or flames;

b) The tissue paper glows or flames;

c) The 1-A fuse connected to earth ground opens;

d) An opening develops in the overall enclosure (cabinet) that does not comply with the requirements in Enclosures, Section 17;

e) Flame resulting from the test continues for more than 30 seconds. This does not apply to the arcing covered by 74.10.1(g);

f) A printed-wiring-board conductor or individual wire opens; and

g) Flame resulting from the arcing continues for more than 30 seconds after arcing is discontinued. This applies only to the arcing tests described in 117.1.

74.11 Circuit interruption

74.11.1 An abnormal-operation test is to be conducted once. If there is evidence of overheating of parts, the test is to be repeated using new components, when necessary, and the product repaired to its intended operating condition.

74.11.2 If an arcing test is interrupted by the opening of a component or protective device, sufficient impedance is to be introduced into the circuit in series with the probe so that the component or protective device does not open and the test can be continued for a total of 15 minutes at each point.

74.11.3 A manually-reset, overload-protective device shall perform acceptably for 50 cycles of operation under the most unfavorable of the overload conditions.

75 Component Abnormal-Operation Test

75.1 A product shall not result in a risk of fire or electric shock when operated under abnormal conditions that are likely to occur during operation of the product.

75.2 The test conditions are to be as described in 74.1.1 – 74.4.1 and 74.5.1 – 74.10.1.

75.3 Malfunction of components and likely misuse of the product that might occur are to be simulated during the abnormal tests mentioned in 75.1. Products that have features not contemplated in the test procedures according to this Section are to be tested as necessary to comply with the intent of this Section. Only one fault is to be assumed at a time. Examples are:

a) Jamming of tape that is likely to stall or overload a drive or similar type motor.

b) Malfunction of fans or blowers that provide ventilation. During this test the fan or blower is to be disconnected rather than stalled.

c) Stalling of rotors of all motors due to bearing wear or loss of lubrication, or the like.

d) Solenoid with plunger blocked in the de-energized (at rest) position.

76 Receptacle Overload Test

76.1 Each convenience receptacle provided on a product shall withstand an overload of 16.5 A as drawn by a resistive load without resulting in unacceptable conditions as described in 74.10.1.

76.2 The test conditions are to be as described in 74.1.1 – 74.3.1, 74.4.2, 74.6.1 – 74.9.2, and 74.11.3.

77 Power Supply Tests

77.1 General

77.1.1 The acceptability of the power-supply circuitry of the product and associated component parts shall be evaluated by one of the test options shown in Table 77.1. See also Table 77.2 for DC-operated circuits.

Table 77.1
Power-supply test options

Type of power supply	Supply output watts[a]	Transformers comply with UL 1411[b] requirements		Resistors used in more than 15-W[a] circuits comply with UL 1412[b] require-ments	UL 1411 abnormal tests required[b]		Power-supply test required			
							At more than 15-W[a] circuit points		At more than 50-W[a] circuit points	
		Abnormal tests	Con-struction		7-hour abnormal test sequence	15-day abnormal test sequence	Determine points[c]	Electronic device and elec-trolytic capacitor shorts	Determine points[c]	Electronic device and elec-trolytic capacitor shorts
1 Trans-former	15 or less	Yes	Yes	NA	–	–	–	–	–	–
2 Trans-former	> 15	Yes	Yes	NA	–	–	X	–	X	X
3 Trans-former	> 15	No	Yes	NA	X or X		X	–	X	X
4 Trans-former	> 15	No	Yes	NA	–		X	X	–	–
5 Direct-connected	Any	NA	NA	No	NA	NA	X	X	–	–
6 Direct-connected	Any	NA	NA	Yes	NA	NA	X	–	X	X

[a] The power capable of being delivered across the circuit, as measured by the procedure described in 77.2.1– 77.2.4.

[b] UL 1411 is the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances and UL 1412 is the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances.

[c] If the applicable test option only requires unreliable-component short-circuit tests on components located in circuitry having a power capability of more than 50 W, the determination of these points is still necessary to determine the acceptability of materials with regard to Table 20.1.

Table 77.2
Abnormal-operation test options for DC input circuits rated 42.4 volts peak or less

Option	Resistors comply with UL 1412[c] and used in more than 15-W circuits	Overcurrent protective device[d,e]	Abnormal operation tests			
			At more than 15-W[a] circuit points		At more than 50-W[b] circuit points	
			Determine points	Electronic device and electrolytic capacitor shorts	Determine points	Electronic device and electrolytic capacitor shorts
A	No	No	X	X		
B	No	Yes	X		X	X
C	Yes	No	X		X	X
D	Yes	Yes	X		X	X

Table 77.2 Continued on Next Page

Table 77.2 Continued

Option	Resistors comply with UL 1412[c] and used in more than 15-W circuits	Overcurrent protective device[d,e]	Abnormal operation tests			
			At more than 15-W[a] circuit points		At more than 50-W[b] circuit points	
			Determine points	Electronic device and electrolytic capacitor shorts	Determine points	Electronic device and electrolytic capacitor shorts

[a] Refer to 77.1.2(a) and 77.2.1 – 77.2.4 for description of tests.

[b] Refer to 77.1.2(b) and 77.2.1 – 77.2.4 for description of tests.

[c] UL 1412 is the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances.

[d] Complies with the applicable component requirements and is intended for the purpose of overcurrent protection.

[e] Circuits are considered to be limited to 15 or 50 W when protected by an overcurrent protective device rated as follows:

$$I_{protector} \leq 0.8P_{max} / V_{max}$$

in which:

P_{max} *is 15 or 50 W and*

V_{max} *is determined according to the maximum-voltage measurement.*

See Maximum Voltage Measurement, Section 69. Table 77.3 illustrates some examples of this calculation.

Table 77.3
Examples of V_{max} calculation

V^{max}	Maximum overcurrent protector rating (amperes)	Power limited to	
		15 W	50 W
64.5	2.6	X	
	8.9		X
6.0	2.0	X	
	6.7		X
7.5	1.6	X	
	5.3		X
9.0	1.3	X	
	4.4		X
12.0	1.0	X	
	3.3		X

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77.1.2 The power-supply tests required on the complete product are to consist of the applicable tests described in (a) – (d), as required by the Table 77.1 or 77.2 option selected. The power supply shall be subjected to the following:

a) 15-W Power Measurement – The points nearest the supply circuit capable of delivering a power of more than 15 W for more than 5 seconds into an external resistor connected singly between each of these points and its power-supply return (circuit common) are to be located. See 77.2.1 – 77.2.4.

b) 50-W Power Measurement – The points nearest the supply circuit capable of delivering a power of more than 50 W for more than 1 minute into an external resistor connected singly between each of these points and its power-supply return (circuit common) are to be located. See 77.2.1 – 77.2.4.

c) Unreliable Components and Electrolytic Capacitors – It is to be determined that a risk of fire or electric shock is not produced under the conditions of separately short-circuiting any unreliable component – one terminal to another (one pair at a time) – or any electrolytic capacitor located in circuitry having a power capability of more than the 15- or 50-W, as required by the applicable test options from Table 77.1 or 77.2.

d) Dielectric Voltage-Withstand – It is to be determined that, while in a heated condition from the tests described in (c), the product is capable of withstanding the 1000-V, 60-Hz, 1-minute dielectric voltage-withstand test described in the Dielectric Voltage-Withstand Tests, Section 71, with the potential applied between each of the following points:

1) Supply-circuit connected parts and accessible parts and

2) Supply-circuit connected parts and accessible parts and

Also see 77.6.1 and Figure 77.1.

Refer to 77.5.1 – 77.5.4 for test considerations. The test conditions are to be as described in 74.2.1, 74.3.1, and 74.4.2 – 74.11.1.

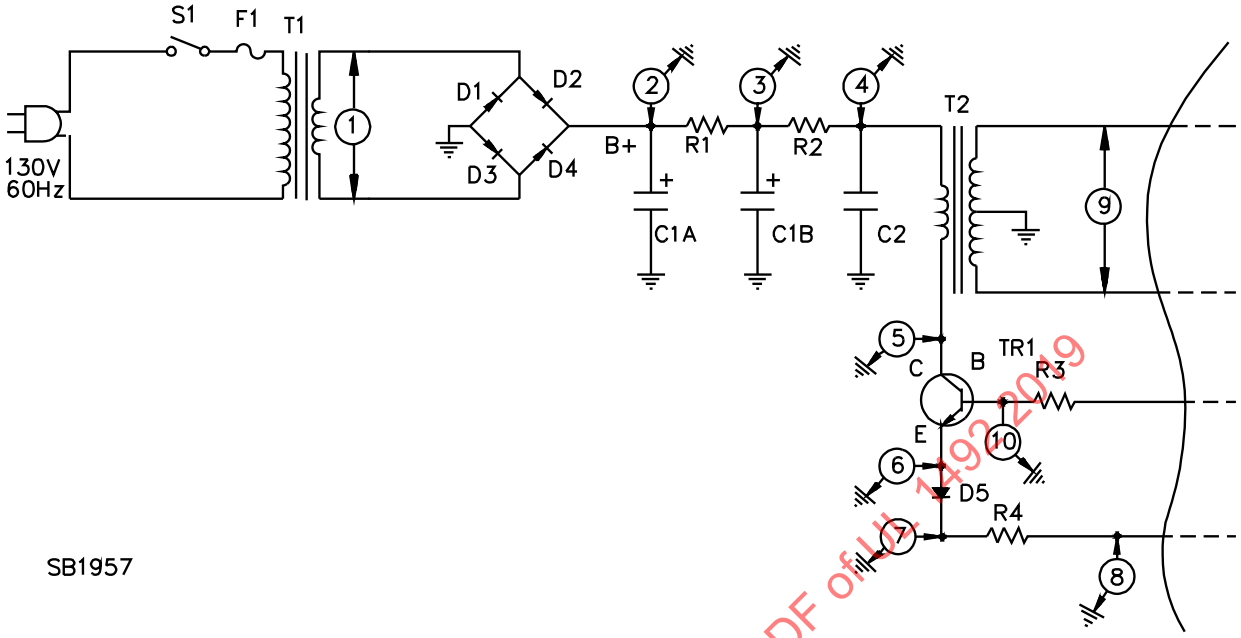
Exception: Alternatively, it is acceptable for integrated circuits (ICs) to comply with the requirements of 77.7.1.

77.2 Measurement procedure

77.2.1 An external variable resistor/wattmeter circuit, connected in accordance with Figure 77.2, is to be applied between the points to be evaluated. The resistor is to be initially set for maximum resistance. Power dissipation in the resistor is to be determined from the wattmeter reading.

77.2.2 The resistor is to be quickly adjusted to dissipate more than 15 or 50 W, to whichever power capability the points are being evaluated. As soon as more than 15 or 50 W dissipation is attained, the resistor is to be continuously adjusted (if necessary) to maintain that dissipation. If more than 15 or 50 W dissipation can be maintained for more than 5 seconds or 1 minute, respectively, points complying with the criteria in 77.1.2 (a) or (b) have been located. If such dissipation cannot be maintained for the prescribed time interval, the points do not comply with this criteria, and testing between the points is to be terminated.

Figure 77.1
Example illustrating the test requirements for the points referred to in 77.2.1



Point	1	2	3	4	5	6	7	8	9	10
Power capability by procedure described in the Power Supply Tests, Section 77 (watts)	>50	>50	>50	>50	>50	>50 >15	>50 >15	>15	>15	>15

NOTE – Assume the product is being tested to the 50-W test option from Table 77.1. Points 1, 2, 3, and 5 have unreliable components and electrolytic capacitors connected to them, and are capable of delivering a power of more than 50 W.

Therefore, unreliable components and electrolytic capacitors D1 (or D2 or D3 or D4)[a], C1A, C1B, and TR1 must be subjected singly to the unreliable component and electrolytic capacitor short-circuit test. TR1 requires two separate tests: C-B and C-E. If the more than 15-W point test option had been selected from Table 77.1, the only additional tests required are the short-circuiting of unreliable components and electrolytic capacitors TR1 (E-B) and D5.

[a] If there is symmetry within a circuit, it is generally only necessary to test one representative leg of the circuitry or device within that circuitry. For example, only one diode in a bridge rectifier circuit, or only the B-plus circuitry in a plus-minus supply.

77.2.3 The adjustment of the resistor to dissipate more than 15 or 50 W is to take place as quickly as possible, and within 15 seconds of the connection of the resistor/wattmeter circuit. If more than 15 or 50 W dissipation cannot be attained by any adjustment of the resistor, the resistor is instead to be continuously adjusted to maintain maximum possible resistor power dissipation until 15 seconds has elapsed since the resistor/wattmeter circuit was initially connected to the points.

77.2.4 If the circuit loading effects caused by the maintenance of maximum dissipation for the 15-second adjustment interval noted in 77.2.3 result in the ability to dissipate more than 15 or 50 W during the 15-second interval, then the measurement is to immediately continue in accordance with 77.2.2. If more than 15 or 50 W dissipation cannot be attained within 15 seconds of the initial connection of the resistor/wattmeter circuit the points do not comply with the criteria in 77.1.2 (a) or (b), and testing between the points is to be terminated.

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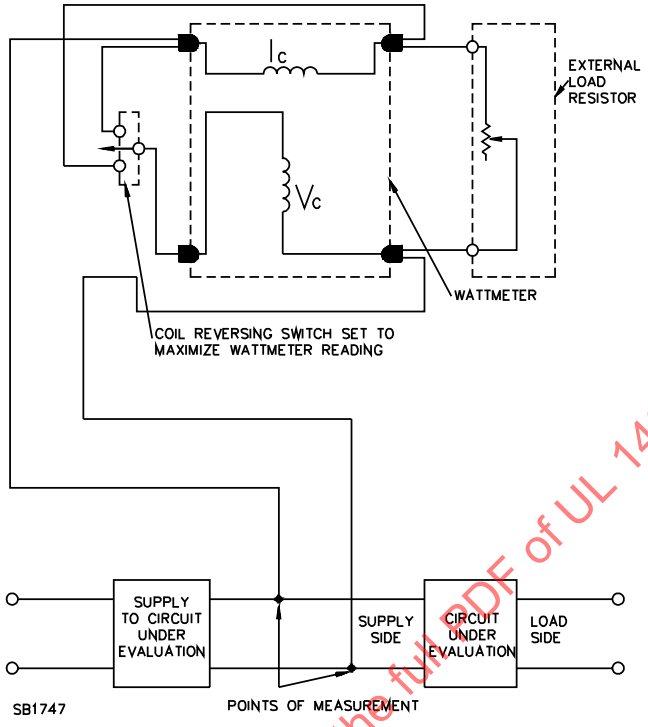
Figure 77.2
Connection of wattmeter



77.3 Power measurement tolerance

77.3.1 The more than 15 W and more than 50 W capability criteria referred to in this Section are defined as any discernible wattmeter indication of power in excess of 15 or 50 W, respectively. This indication is not to exceed 15 W by more than 1/2 W and 50 W by more than 1 W.

77.4 Referee procedures

77.4.1 If a protective device is used in a product in which the points capable of delivering a power of more than 15 or 50 W are being determined, and that protective device operates during the course of the measurements described in 77.2.2 – 77.2.4, the referee procedure described in 77.4.2 is to be used to determine whether the points being evaluated are capable of delivering power at that level for the required time period.

77.4.2 A shorting switch is to be connected across the protective device in the closed position. The variable resistor/wattmeter circuit is to be set for maximum resistance before being connected between the points being evaluated. The resistor is then to be quickly adjusted until slightly more than 15 or

50 W is dissipated. The switch across the protective device is then to be opened and the time required for the protective device to open recorded. If the protective device does not operate within 5 seconds or 1 minute, whichever applies, after the shorting switch is opened, the points being evaluated comply with the criteria for that power level.

77.4.3 If a circuit component is overloaded so that it changes value or opens during the power measurements described in 77.2.1 – 77.2.4, and there is any question whether or not a faster adjustment of the variable resistor could have satisfied the capability criteria, the referee procedure described in 77.4.4 is to be performed.

77.4.4 The procedure is to be as described in 77.2.1 – 77.2.4, except that the variable resistor shall be pre-adjusted to that resistance producing more than 15 or 50 W dissipation, whichever is applicable, before the resistor/wattmeter is connected to the points being evaluated.

77.5 Additional test details

77.5.1 The measurements and tests required by 77.1.2 (a) – (c) are to be conducted with all load circuits connected and operating normally, but with all input signals and external loads disconnected.

77.5.2 Any controls that are accessible to the user (can be adjusted by the user without violating a no user-serviceable parts compartment warning as described in 129.1.1 – 129.1.3), that might affect the level of power measurements, are to be adjusted to maximize the power reading during the particular measurement. All internal, factory-only adjustable controls are to be left in their factory preset position.

77.5.3 Before any power measurements are conducted, the product is to be operated for at least 15 minutes (warm-up period) in accordance with 77.5.1.

77.5.4 If components of a product show evidence of overheating during the power measurements, the product and components are to be allowed to cool to approximately the level present at the conclusion of the warm-up period described in 77.5.3 before testing is resumed. Overheating may be detected by the indicators described in 74.10.1. Any components suspected of having been damaged during the measurements described in this Section are to be replaced before testing is continued.

77.6 Conduction of dielectric voltage-withstand test

77.6.1 Unless it is necessary to replace components after conducting the tests in 77.1.2(c), the dielectric voltage-withstand test described in 77.1.2(d) need be conducted only after the last test on the power supply is completed.

77.7 Multiple-pin integrated circuits (ICs)

77.7.1 As an alternative to being subjected to the tests described in 77.1.2 (a) and (c), multiple-pin ICs located in circuits investigated to test option 4 of Table 77.1 shall comply with all of the following:

a) The circuits shall be supplied from a limited power source (as determined by the Special Option Tests, Section 73) that is capable of delivering a power of greater than 15 W but not more than 50 W into an external resistor.

b) All electrolytic capacitors directly connected to the IC shall be provided with a means of relieving excessive internal pressure.

Exception: Electrolytic capacitors not more than 10 mm in diameter and rated not less than the DC value of the supply circuit need not comply with this requirement.

c) The circuits shall be encapsulated in a material having a flammability classification of not less than V-2 or be provided with a separate enclosure. If provided with a separate enclosure, the enclosure shall be constructed of metal or a material having a flammability classification of not less than V-2. The enclosure shall not be provided with holes or louvers that allow the circulation of air. Holes for the entrance of wires may be provided if the unused portion of any hole is not larger than 130 mm^2 in area. Any hole provided for lead wire but not so used, shall be closed by metal or by a material having a flammability classification of not less than V-2.

78 Picture-Tube Filament Short-Circuit Test

78.1 Any likely conditions of an internal short-circuit of a picture tube as described in 78.2 shall not result in the risk of fire or electric shock.

78.2 Short-circuits that are considered likely to occur are to be simulated by a connection between a heater terminal and a terminal of any other element of the tube such that at least one heater or a portion thereof remains in the test circuit. The heater of any picture tube, except a power-rectifier tube with a directly-heated cathode, that obtains its heater power from a low-voltage winding of a power transformer, is to be short-circuited.

78.3 The test conditions are to be as described in 74.2.1, 74.3.1, 74.4.2 – 74.9.1, 74.10.1, and 74.11.1.

79 Unenclosed Transformer Short-Circuit Test

79.1 A transformer as described in the Exception to 38.2.1(b) shall not result in a risk of fire or electric shock when all secondary windings are short-circuited. Three samples are to be tested until the windings open or until seven hours have elapsed.

79.2 The test conditions are to be as described in 74.1.1 – 74.4.1, 74.6.1, 74.8.1, and 74.10.1.

79.3 The test is to be followed by a dielectric voltage-withstand test. It is to be determined that, following the short-circuit test, and while in a heated condition, the transformer is capable of withstanding the 1000 V, 60 Hz, 1-minute dielectric voltage-withstand test described in the Dielectric Voltage-Withstand Tests, Section 71, with the potential applied between each of the following points:

a) Primary windings and secondary windings and

b) Primary windings and transformer core.

80 Multiple-Voltage Product Test

80.1 A product having a supply-circuit voltage selector is to have its voltage selector set in any marked supply-circuit voltage position with the product connected to any one of the rated supply circuits. The combinations of selector settings and supply circuit to which the product is connected is to be that which develops the most severe operating conditions. The test conditions are to be as described in 74.2.1, 74.3.1, and 74.4.2 – 74.11.1.

80.2 An externally operable voltage-selector switch is to be operated for 50 cycles – 25 cycles while the product is connected to the minimum rated supply voltage, and 25 cycles while the product is connected to the maximum rated supply voltage. The test conditions are to be as described in 83.4.

81 Part Disconnection and Component Handling Arcing

81.1 With the product operating as described in 69.2.1 – 69.2.3, a conductor, component, or lead that may become disconnected or displaced during shipping or moving of the product or that may be disconnected or displaced during normal operation or user-servicing in accordance with 31.2.1 (Component handling) shall withstand the arcing test in 81.2 and 81.3 without producing a risk of fire or electric shock.

81.2 The component, lead, or connector is to be brought into contact with any part of different potential with which contact is likely to be established. If the contact results in arcing, the arc is to be maintained for 15 minutes. A material that has not been investigated and determined to be acceptable as an insulation can be considered conductive. A material located between the lead or connector and the part of different potential in the path of possible electrical breakdown is to be subjected to the arcing to determine if any ignition can be produced. There shall not be opening of the ground fuse or flaming or glowing of any material for more than 30 seconds following the discontinuance of the arcing.

Exception: A condition established only as a result of user-servicing of the product and that results in the disabling of all the intended functions of the product is acceptable.

81.3 The test conditions are to be as described in 74.2.1, 74.3.1, and 74.5.1 – 74.7.1, and 74.11.1.

82 Cable Arcing Test

82.1 A single- or multiple-conductor remote cable as described in 35.10.2(d)(2) shall withstand the arcing test described in 82.2 and 82.3 between conductors and between any conductor and ground without producing any conditions that involve risk of fire.

82.2 The cable is to be connected to the product and to the remote unit in the intended manner. The insulation of one of the conductors is to be removed to expose the bare conductor for a length of approximately 1.5 mm. A piece of surgical cotton is to be placed in intimate contact with the bared portion of the conductor. An ordinary straight brass pin connected to a conductor of opposite polarity or to ground return, is to be touched repeatedly, during a 15-minute period, to the bared conductor in an attempt to cause arcing.

82.3 The test conditions are to be as described in 74.2.1, 74.7.1, and 74.11.2, and the surgical cotton is not to be ignited.

83 Relay Endurance Test

83.1 A relay as specified in 36.11.1 shall perform acceptably when subjected to 25,000 cycles of operation making and breaking the normal current of the product.

Exception: The test need not be conducted on a relay that has previously been tested for 25,000 cycles of operation using a tungsten load.

83.2 A relay as specified in the Exception to 36.12.1 shall perform acceptably when subjected to 25,000 cycles of operation making and breaking the maximum, steady-state (rms) current that the receptacle controls, based on the marked receptacle rating. A tungsten load is to be connected to the receptacle for the test.

Exception No. 1: The test need not be conducted on a relay that has been tested for 25,000 cycles of operation using a tungsten load equal to or greater than the marked receptacle rating.

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Exception No. 2: The test need not be conducted when the receptacle is marked for a specific product and it can be determined that the peak inrush current controlled by the relay does not exceed the relay current rating in amperes (rms) times 1.414.

83.3 If a relay controls both the product supply circuit and a supply-circuit-connected receptacle, then the loading conditions prescribed in 83.1 and 83.2 are to be simultaneously applied during the testing.

83.4 To determine if the control device performs acceptably in the tests mentioned in 80.2, 83.1, and 83.2, the product is to be connected to a grounded supply circuit. During the test, exposed dead-metal parts of the product are to be connected to ground through a 1-ampere plug fuse, and the connection is to be such that any single-pole, current-interrupting device is located in the ungrounded conductor of the supply circuit. If the product is intended for use on direct current, or on direct current as well as alternating current, the exposed dead-metal parts of the product are to be connected so as to be positive with regard to a single-pole, current-interrupting control device. The device is to be operated at a rate of not more than 10 cycles per minute. A faster rate of operation may be used if agreeable to all concerned. Electrical or mechanical breakdown of the control device, undue burning or pitting of the contacts, or opening of the fuse in the grounding connection is not acceptable.

84 Test on Solid-State Switches

84.1 Abnormal operation

84.1.1 A product containing any solid-state component or device that functions as a power on/off switch is to be subjected to the following tests in the order given. Results of the normal operation, overvoltage, and undervoltage tests are acceptable in each case if the product operates as intended throughout.

a) Normal Operation – Fifty cycles of operation consisting of making and breaking the actual or rated output load.

b) Overvoltage – Fifty cycles of overvoltage while connected to an input of 110 percent of rated input voltage and to actual or rated output load.

Exception: A solid-state component or device that functions as a switch that is not connected in the supply circuit, controls a power of 50 watts or less, and is constructed and connected so that no risk of electric shock will result if the switch malfunctions need not be subjected to the overvoltage test.

c) Undervoltage – Fifty cycles of undervoltage while connected to an input of 85 percent of rated input voltage and to actual or rated output load.

d) Voltage Surge – Fifty random applications of a 3.5-kilovolt surge impulse at 60-second intervals as described in 84.2.1. Results are acceptable if there is no tripping of circuit protection, if there has been no fire or development of a source of electric shock, as described in 74.1.1 – 74.3.1, 74.4.2 – 74.7.1, and 74.10.1, and if the switch operates as intended for 50 cycles of operation with the product connected to a supply of rated voltage.

84.2 Voltage surge

84.2.1 The sample is to be connected to a supply of rated voltage. The grounding lead or terminal, if provided, of the sample is to be connected to the supply conductor serving as the neutral. The sample is to be in the on condition and is to be subjected to 15 surges from a 0.005-microfarad capacitor, 15 surges from a 0.05-microfarad capacitor, and 20 surges from a 0.5-microfarad capacitor.

84.2.2 The circuit for performing the surge test is to be as illustrated in Figure 87.1 except:

a) C_d – Three dump capacitors are to be used having capacitance values of 0.005 microfarad, 0.05 microfarad, and 0.5 microfarad, respectively, and

b) V_{dc} – 3.5-kilovolt, direct-current source of supply.

85 Loudspeakers and Loudspeaker-Crossover Combinations

85.1 If more than 15 watts of DC supply power are supplied to the last audio amplifying device (transistor, integrated circuit, or the like) and the maximum undistorted audio output power (64.3) to the loudspeaker (or loudspeaker-crossover combination, if supplied) is greater than 2 watts, the following tests are to be conducted:

a) Unreliable-component, short-circuit tests on the following:

1) The last unreliable-component located before the loudspeaker (or loudspeaker-crossover combination, if supplied) and

2) Each unreliable-component located in the crossover network (if supplied).

b) Loudspeaker voice coil short-circuit test – The voice coil of a loudspeaker is to be short-circuited (or the voice coil of each loudspeaker in a multi-loudspeaker system is to be singly short-circuited).

c) Dielectric voltage-withstand tests – The product is to be tested as described in 77.1.2(d).

85.2 To determine compliance with the applicable tests required in 85.1, the product is to be tested as described in 74.2.1, 74.3.1, 74.4.2 – 74.11.1, and 77.5.1 – 77.5.4.

86 Leakage Current Test After Humidity Conditioning

86.1 A product shall comply with the requirements for leakage current in 67.2.1 – 67.2.3 following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C.

86.2 To determine whether a product complies with the requirement in 86.1, a sample of the product is to be heated to a temperature just above 34°C to reduce the likelihood of condensation of moisture during conditioning. The heated sample is to be placed in the humidity chamber and is to remain for 48 hours under the conditions specified in 86.1. Following the conditioning, the sample is to be tested unenergized as described in 67.2.3(a). The sample is then to be energized and tested as described in 67.2.3 (b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

87 Voltage Surge Test

87.1 The complete product is to be tested in accordance with 87.2 – 87.7.

87.2 The circuit for performing the voltage-surge test is illustrated in Figure 87.1.

87.3 The product circuit is to be subjected to the voltage-surge test between the following parts:

a) The two blades of the attachment plug. The on-off switch, if provided, is to be in the off position.

b) Both blades of the attachment plug connected together and any other connectors or terminals (with the connectors or terminals connected together) that are intended to accommodate a signal from a cable or an antenna (such as a VHF, UHF, FM, or cable-TV terminal). The on-off switch, if provided, is to be in the on position.

87.4 For the voltage-surge test, the complete product is to be placed on a tissue-paper-covered softwood surface and is to be covered with a single layer of cheesecloth.

87.5 The circuit specified in 87.3(a) is to be subjected to four discharges from a 0.1-microfarad dump capacitor, charged to a direct-current voltage of 6 kilovolts with an interval of 5 seconds between successive discharges.

87.6 The circuits specified in 87.3(b) are to be subjected to four discharges from a 0.01-microfarad dump capacitor, charged to a direct-current voltage of 10 kilovolts with an interval of 5 seconds between successive discharges.

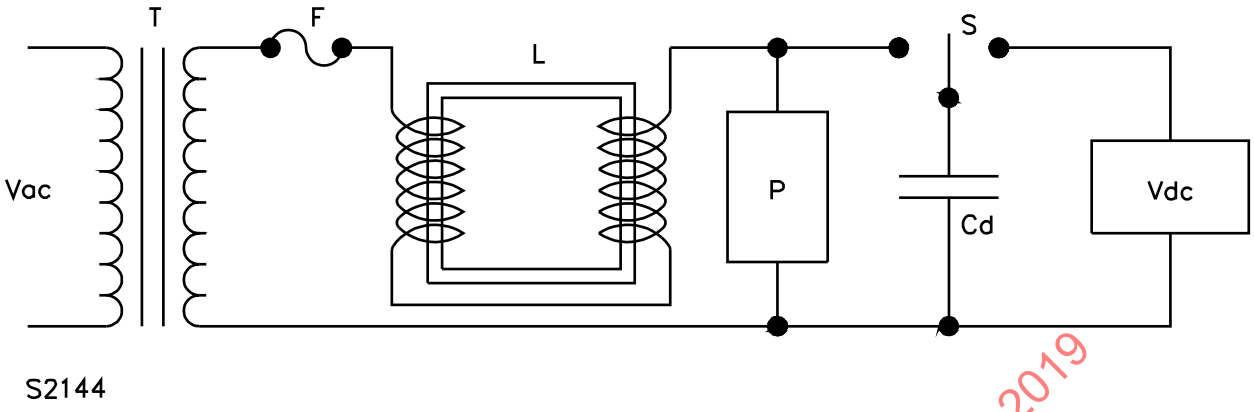
87.7 As a result of the surges, there shall not be:

a) Glowing or flaming of the cheesecloth or tissue paper,

b) Leakage current in excess of 0.5 milliampere from accessible conductive parts when the product is tested in accordance with the leakage-current test described in 67.2.1 – 67.2.3, or

c) Noncompliance with the dielectric voltage-withstand test (for primary to accessible conductive parts) when the product is tested in accordance with the Dielectric Voltage-Withstand Tests, Section 71.

Figure 87.1
Circuit for voltage surge test



V_{ac}	–	120-V, 60-Hz, 30-A voltage source.
T	–	Optional isolation transformer for pulse blocking, 120 V, 3 kVA, minimum. Adequate isolation must be provided to prevent the pulse from entering the supply source and breaking down wiring, switches, receptacles, and the like.
F	–	Plug fuse rated 30 A, 125 V.
L	–	Choke consisting of two coils of 16 AWG (1.31 mm^2) solid film coated copper wire wound on insulating tubes placed on an approximately 80 by 90 by 15 mm ferrite core from a color television receiver horizontal output transformer (spacers between core pieces removed). Each coil is to consist of approximately 2.3 m of wire wound into 30 turns. The two coils are to be connected in circuitry such that the magnetic flux is adding, thereby producing an effective inductance and resistance of each coil of approximately 3 millihenries and 0.03 ohms, respectively.
P	–	Product – see 87.3 for connection to test circuit.
S	–	High-voltage switch.
C_d	–	Dump capacitor having a capacitance value of 0.1 or 0.01 µF as specified in 87.5 or 87.6.
V_{dc}	–	6-kV or 10-kV, direct-current source of supply as specified in 87.5 or 87.6.

88 Battery and Battery-Circuit Tests – Electrical

88.1 Battery overcharge

88.1.1 A fully-charged, rechargeable battery provided with or recommended for use with a product is to be overcharged for a period of 7 hours:

a) With the product charging circuit adjusted for the maximum charging rate, and again

b) With any single junction or part of an unreliable component or electrolytic capacitor in the charging circuit either short-circuited or open-circuited.

88.1.2 The test conditions are to be as described in 74.2.1, 74.3.1, 74.4.2 – 74.7.1, 74.10.1, and 74.11.1, and, in addition, shall not result in any of the unacceptable conditions described in 89.3.1.

88.2 Battery discharge test

88.2.1 Short-circuiting of the terminals of a fully charged rechargeable battery provided with or recommended for use with a product shall not result in any of the unacceptable conditions described in 89.3.1.

89 Battery Tests – Mechanical

89.1 Battery drop

89.1.1 Each of three samples of a fully-charged, rechargeable battery is to be dropped three times from a height of 0.9 m onto a hardwood floor in the position most likely to produce adverse results without producing any of the unacceptable conditions described in 89.3.1(a) – (c).

89.2 Battery oven

89.2.1 A fully-charged, rechargeable battery that uses a polymeric case shall withstand either of the temperature-stability tests described in 98.2.1 without producing any of the unacceptable conditions described in 89.3.1(a) – (c).

89.3 Battery test results

89.3.1 The results of the tests are considered unacceptable if one or more of the following results occur:

a) The battery case cracks,

b) Battery electrolyte leaks from the case,

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c) The battery explodes, and

d) A printed-wiring board conductor or individual wire opens to terminate the test.

90 Battery Supply Short-Circuit Test

90.1 To determine the acceptability of the rating of the fuse or protective device described in 42.5.1 (Battery-circuit fuse), the product is to be connected to the storage battery (if provided with the product) or a test supply of rated voltage that has a 30-A minimum capability. Using the intended connecting means, the product is to be evaluated according to 90.2 and 90.3.

90.2 A battery-supply cord is to be short-circuited at any point on the cord, but not within 13 cm of the battery-connecting means, without resulting in the risk of fire.

90.3 The product is to be evaluated for the risk of fire in accordance with the Power Supply Tests, Section 77.

90A Ground Printed-Wiring Board (PWB) Trace Test

90A.1 One sample of the product shall be subjected to the following short circuit test. The power source for the test circuit shall be calibrated to supply 200 A under short circuit conditions for a product with an input rating up to 9.8 A at 120 V, or 4.9 A at 240 V, or 1000 A under short circuit conditions for a product with an input rating more than 9.8 A at 120 V or 4.9 A at 240 V. The voltage of the test circuit shall be either 130 or 260 V depending on the nominal voltage marked on the equipment. A nonrenewable cartridge fuse with a rating of 20 A shall be connected in series with the grounding circuit being tested. For equipment with a detachable power supply cord, the test circuit is to be connected between the ground pin of the motor attachment cap and the PWB trace being tested. For equipment with a non-detachable power supply cord, the test circuit is to be connected in series between the ground pin of the power supply cord attachment plug cap and the PWB trace being tested. Surgical cotton is to be placed outside the openings in the enclosure of the equipment. The test is concluded when the short circuit test current is interrupted.

90A.2 The test results are considered unacceptable if:

a) The ground PWB trace becomes damaged,

b) There is damage to the product which would result in contact between the grounding circuit and a bare live part, or

c) The surgical cotton ignites.

91 Strain Relief Test

91.1 Power-supply cord

91.1.1 The attachment of the power-supply cord to the product shall be capable of withstanding a force of 150 N applied to the cord as described in 91.1.2.

91.1.2 The force is to be applied by a steady pull of 150 N. With the chassis in the cabinet in the intended manner, the force is to be applied from any angle possible. Three samples are to be tested. The minimum average time of holding is not to be less than 15 seconds, however, one sample may hold for less than 15 seconds, but not less than 5 seconds.

91.1.3 The results of the test are not acceptable if one or more of the following conditions occur:

a) The insulation or covering on the flexible cord is cut or torn,

b) The bushing slides through the hole in the chassis or enclosure,

c) Cemented-on bushings slide on the cord,

d) An interlock connector is separated from the product or is damaged so that it does not perform its intended function, and

e) Strain is placed on internal connections during the holding time.

91.1.4 As an alternative to the test method of 91.1.2, one sample can be tested if the force of 150 N is applied for 1 minute.

91.1.5 If the integrity of the strain-relief means is dependent upon a polymeric material, the test in 91.1.2 or 91.1.4 is to be conducted before and after either of the temperature-stability tests described in 98.3.1.

91.1.6 If an audio-input connection cord is permanently attached to a separately enclosed loudspeaker, the cord shall withstand a force of 40 N, or a force of 150 N for separately enclosed loudspeakers intended for connection to an audio amplifier not limited in accordance with 70.1. The test method and evaluation are as described in 91.1.2 – 91.1.5.

92 Power-Supply Cord Push-Back Relief Test

92.1 To determine compliance with 24.9.1, a product is to be tested in accordance with 92.2 without occurrence of any of the conditions specified in 24.9.1 (a) – (e).

92.2 The power-supply cord is to be held by the fingers 25 mm distant from the point where the cord emerges from the product. It is then to be pushed back with casual force (see Figure 92.1). The force is to be applied until the cord is buckled; however, in no case is the force to exceed 25 N.

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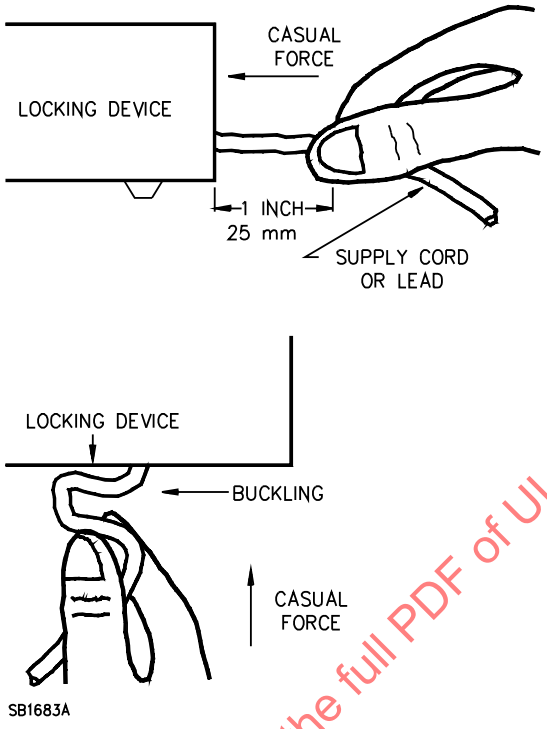
Figure 92.1
Power-supply cord push-back/strain-relief evaluation



93 Interlock Strain Relief Test

93.1 Before and after the temperature-stability test (98.2.1 – 98.3.1), an appliance coupler and motor-attachment plug cap of an interlock assembly shall be tested in accordance with 93.2 and 93.3.

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93.2 A force is to be applied to the cord by a steady pull of 150 N. With the enclosure placed in the normal manner, the force is to be gradually applied and held at 150 N for 1 minute in the direction that is most likely to cause unacceptable results. The two pins of the connector base are to be electrically connected together. The resistance of the interlock connection, as measured between the blades of the attachment plug is to be measured both before and after the 150 N pull has been applied to the power-supply cord.

93.3 After application of the 150 N force described in 93.2, the increase in resistance of the connection between the blades of the interlock shall not exceed 0.2 ohm.

94 Separable-Connector Cycling Test

94.1 A separable-type connector (one not held to its mating part by a screw, clamp, or the like, and that does not require the use of a tool to accomplish the separation) shall perform without damage when subjected to the cycling test described in 94.2.

94.2 The test is to be conducted with the product operating in the intended manner. The connector is to be made to make and break the circuit at 6-second intervals for:

a) Ten cycles, if it is in a circuit not conductively connected to the supply circuit, but involving a risk of fire or electric shock or

b) Fifty cycles, if it is conductively connected to the supply (primary) input circuit.

95 Solderless Wire Wrap Connections Test

95.1 General – contact points

95.1.1 Contact points on solderless wire wrap connections are to produce compression or flow of the conductor rather than a nick that weakens the mechanical strength of the conductor such that fracture might occur as determined by the tests in 95.2.1 and 95.3.1.

95.2 Unwrapping test

95.2.1 The conductor shall be capable of being sufficiently unwrapped (all turns do not have to be unwrapped) to free the wire from the terminal, without breaking. The unwrapping process shall not additionally twist or stress the conductor. Five samples are to be tested with no conductor fracture. If one but not more than one unacceptable result occurs, the test is to be repeated on ten additional samples with no conductor fracture. A tool as illustrated in Figure 95.1 may be used in the conduct of the unwrapping test.

95.3 Strip force

95.3.1 Using a tool as illustrated in Figure 95.2, the strip force required to displace the complete wrap a distance equal to the diameter of the wire, is not to be less than 30 N. The stripping force is to be applied evenly and gradually such that any inertial force is negligible. The clearance between the tool and terminal is to be such that no binding occurs between the tool slot and terminal. Five samples are to be tested. If one but not more than one unacceptable result occurs, the test is to be repeated on ten additional samples with no unacceptable result. Referring to Figure 95.2, the metal ring at the top of the device is intended to engage the force-producing instrument.

Figure 95.1
Unwrapping tool

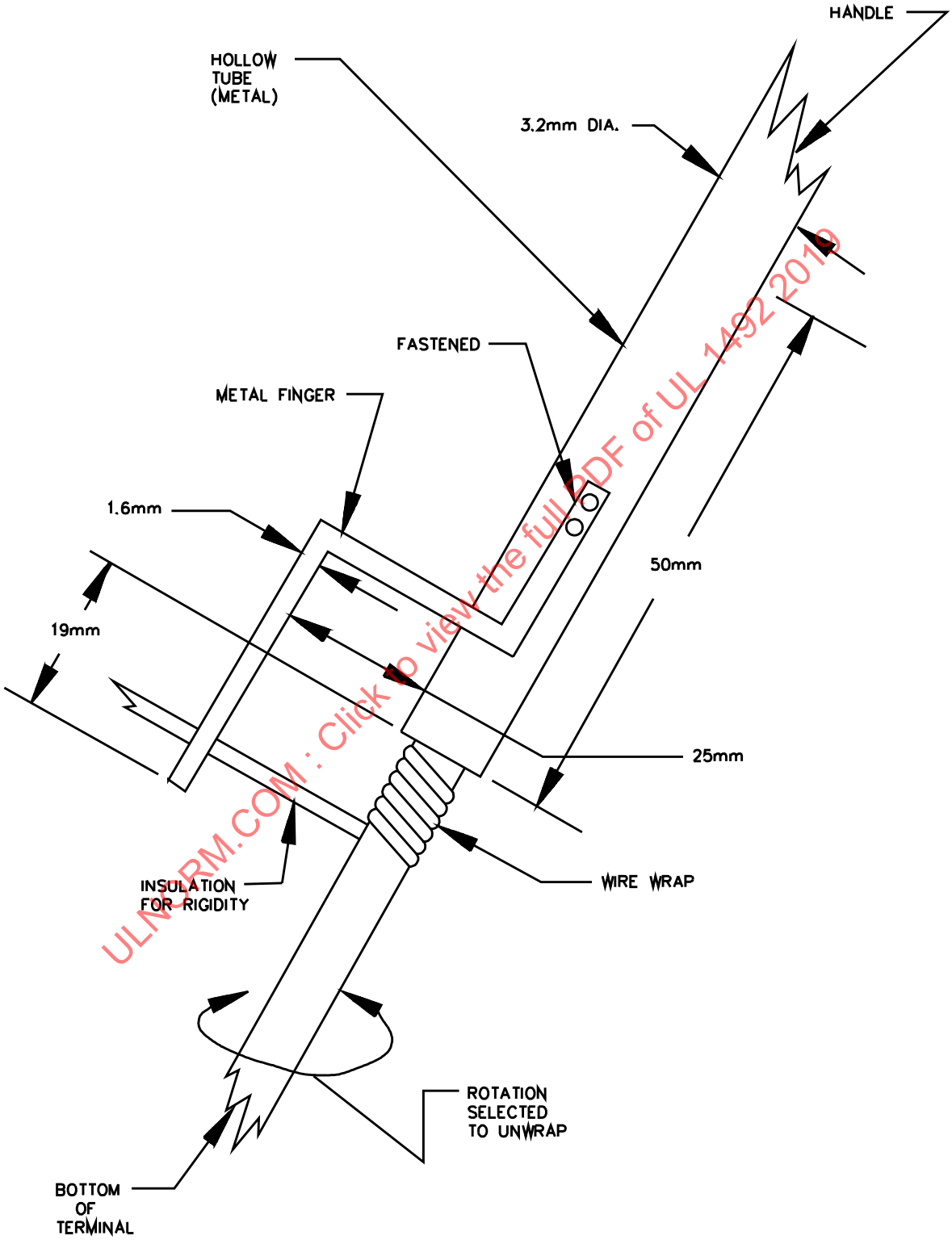
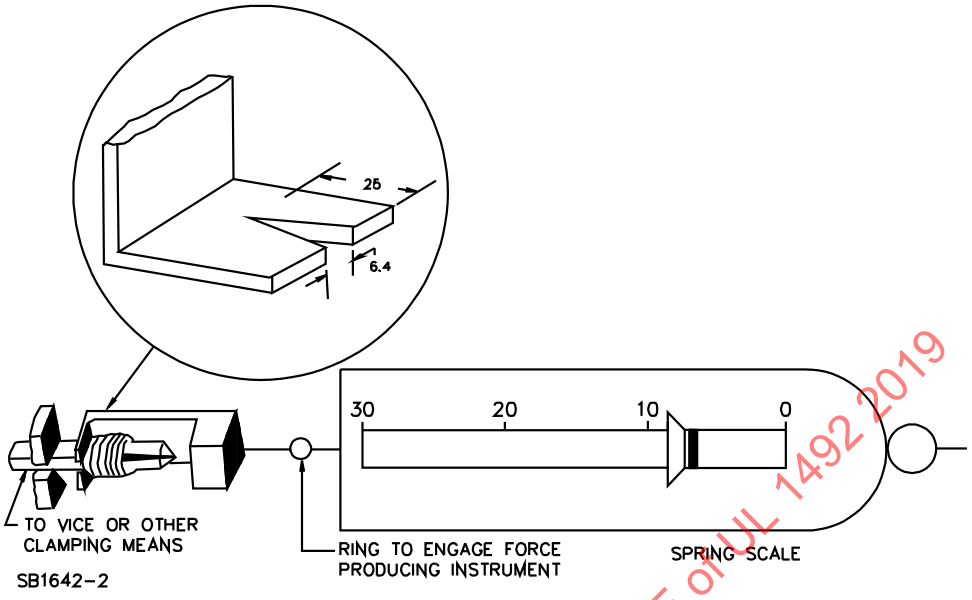


Figure 95.2
Typical pull test



NOTE – All dimensions in millimeters

96 Injury to Persons Test

96.1 General

96.1.1 All products shall be subjected to the applicable tests described in this Section. A product shall be subjected to the applicable tests alone and again while placed on any cart or stand that is provided or recommended by the product manufacturer.

96.2 Use of polymeric materials

96.2.1 If polymeric materials are involved in the construction, the applicable tests described in 96.4.1 – 96.11.8 shall be conducted both before and after the temperature-stability test described in 96.3.1.

96.3 Product, cart, or stand temperature stability

96.3.1 A product, cart, or stand using polymeric materials in its construction shall withstand either of the temperature-stability conditions described in 98.3.1 without any shrinkage, warpage, or other distortion of the polymeric materials that causes the product, cart, or stand not to comply with 96.3.2 – 96.11.8.

96.3.2 During the temperature-stability test mentioned in 96.3.1, a product intended for use with a companion cart or stand shall be tested with the product placed on the cart or stand in accordance with the instructions provided by the manufacturer.

96.4 Wheel or caster securement

96.4.1 A wheel or caster shall be capable of withstanding a pull of 22 N as described in 96.4.2 without being damaged or pulled free from its securing means.

96.4.2 The pull force is to be applied by a weight, or a steady pull, for a period of 1 minute in any direction made possible by the construction.

96.5 Mechanical stability

96.5.1 Apparatus having a mass exceeding 7 kg shall have adequate stability. In addition, the stability shall be ensured when legs or stands supplied by the manufacturer are fitted.

96.5.1.1 Compliance is checked by the tests of 96.5.2, 96.5.2.1, 96.5.3, 96.5.3.1, 96.5.4, 96.5.4.1, and 96.5.5.

96.5.1.1.1 Apparatus whose functionality requires it to be fastened in place is not required to be subjected to these tests, and the tests in 96.5.4, 96.5.4.1 and 96.5.5 apply only to:

a) Apparatus with a direct view CRT having a diagonal dimension of 48 cm or greater, or

b) Apparatus, other than a speaker, with a mass greater than 47 kg, or

c) Apparatus other than a speaker with a mass of 25 kg or more, having a height of 1 m or more, or

d) Apparatus with a mass of 25 kg or more in combination with a supplied or recommended cart or stand with a total height of 1 m or more.

96.5.1.2 During the tests in 96.5.2, 96.5.2.1, 96.5.3, 96.5.3.1, 96.5.4, and 96.5.4.1 the apparatus shall not overbalance and during the test in 96.5.5 the apparatus shall not slide.

96.5.2 The apparatus is placed in its intended position of use on a plane, inclined at an angle at 10° to the horizontal. All doors, drawers, casters, wheels, adjustable feet (levelers) and other appurtenances of the apparatus are positioned in any combination that results in the least stability. Legs and other means are blocked to keep the apparatus from sliding. The apparatus is then rotated slowly through an angle of 360° about its normal vertical axis.

96.5.2.1 If, however, the apparatus is such that, were it to be tilted through an angle of 10° when standing on a horizontal plane, a part of it not normally in contact with the supporting surface would touch the horizontal plane, the apparatus is to be placed on a horizontal support and tilted in the most unfavorable direction through an angle of 10°. The test on the horizontal support may be necessary, for example, for apparatus provided with small feet, casters or the like.

96.5.3 The apparatus is placed in its intended position of use on a non-skid surface that is at an angle not exceeding 1° to the horizontal with lids, flaps, drawers, doors, casters, wheels, adjustable feet (levelers) and other appurtenances in the most unfavorable position.

96.5.3.1 A force of 100 N directed vertically downwards is to be applied in such a way as to produce the maximum overturning moment, to any point of any horizontal surface, protrusion or recess, provided that the distance of that point to the non-skid surface does not exceed 75 cm.

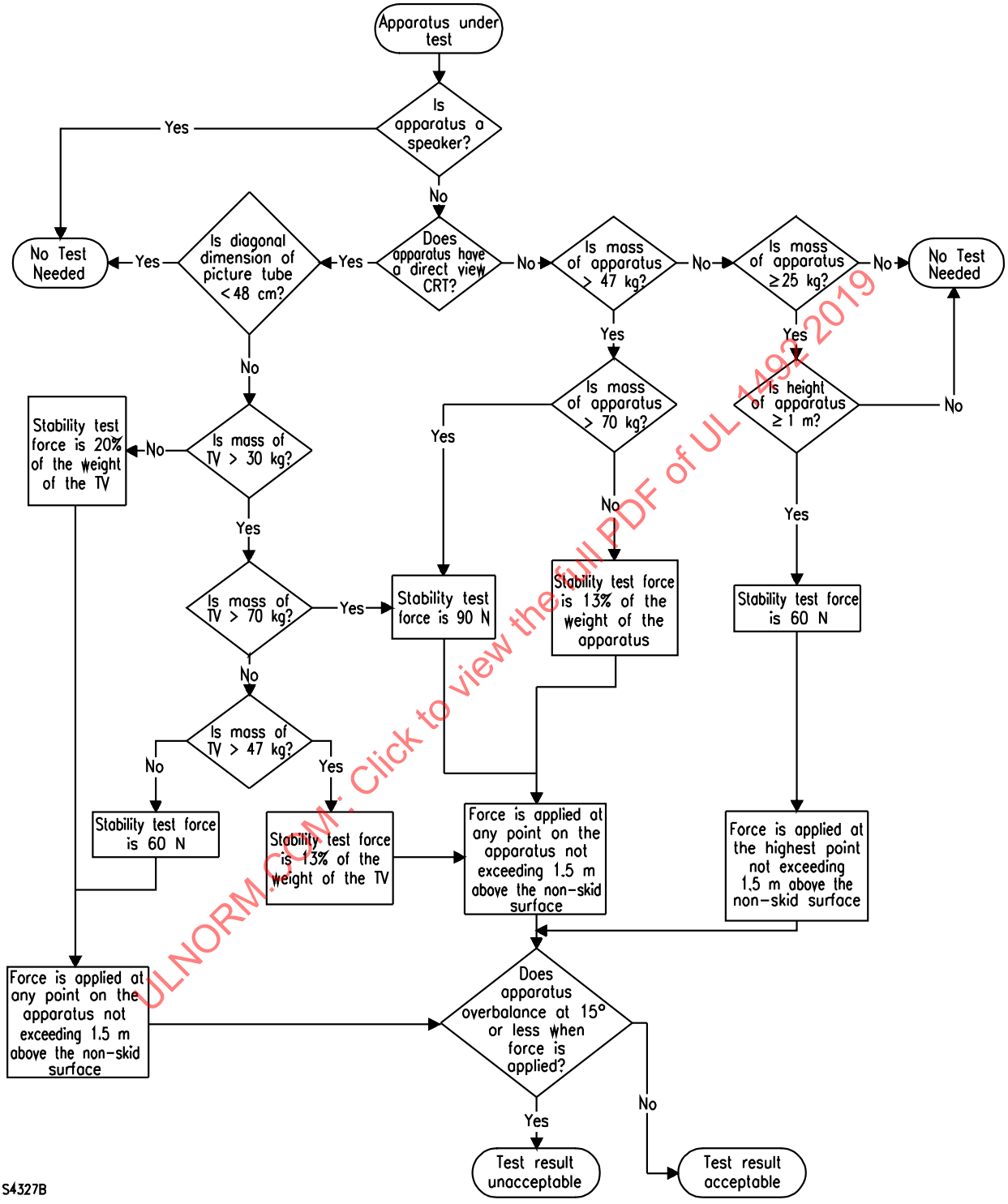
96.5.4 The apparatus is placed on a non-skid surface with lids, flaps, drawers, doors, casters, wheels, adjustable feet (levelers) and other appurtenances in the most unfavorable position.

96.5.4.1 A force as described in Table 96.1 is to be directed horizontally in such a way as to produce the maximum overturning moment to a point on the apparatus as identified in Table 96.1. The flowchart in Figure 96.1 provides information identical to that in Table 96.1.

Table 96.1
Values for horizontal force test

Apparatus description	Value of force	Application of force
An apparatus with a direct view CRT having a diagonal dimension of 48 cm or greater with a mass not greater than 30 kg	A force of 20% of the weight of the apparatus	Applied at any point on the apparatus not exceeding 1.5 m above the non-skid surface until the apparatus is tipped 15 degrees off vertical
An apparatus with a direct view CRT having a diagonal dimension of 48 cm or greater with a mass greater than 30 kg and not greater than 47 kg	60 N	Applied at any point on the apparatus not exceeding 1.5 m above the non-skid surface until the apparatus is tipped 15 degrees off vertical
An apparatus, other than a speaker, having a height of 1 m or greater and a mass of 25 kg or greater and not greater than 47 kg	60 N	Applied at the highest point not exceeding 1.5 m above the non-skid surface until the apparatus is tipped 15 degrees off vertical
An apparatus, other than a speaker, having a mass greater than 47 kg and not greater than 70 kg	A force of 13% of the weight of the apparatus.	Applied at any point on the apparatus not exceeding 1.5 m above the non-skid surface until the apparatus is tipped 15 degrees off vertical
An apparatus, other than a speaker, having a mass greater than 70 kg	90 N	Applied at any point on the apparatus not exceeding 1.5 m above the non-skid surface until the apparatus is tipped 15 degrees off vertical

Figure 96.1
Horizontal force test flowchart



96.5.4.2 Deleted

96.5.5 A table-top apparatus with a CRT or other type of viewing screen having a diagonal dimension of 48 cm or greater is placed on a clean, dry, glass covered horizontal surface such that only the supporting feet are in contact with the glass. The glass covered surface is then tilted in the most unfavorable direction through an angle of 10°.

96.5.6 Deleted

96.6 Cart or stand loading

96.6.1 A cart or stand shall be constructed so that permanent deformation or damage that is capable of resulting in injury to persons does not occur when it is subjected to a weight that exerts a force of 220 N applied for 1 minute to any appurtenance accessible to a child.

96.6.2 To determine compliance, the force is to be applied through the end of a 5-cm diameter right circular cylinder. The force is to be applied to a shelf, drawer, dowel rung support, or equivalent part that is within 75 cm of the floor and will support some or all of a child's weight. The force is to be applied for 1 minute with the cart or stand at room temperature. The part is not to collapse or break so as to expose sharp edges or produce pinch points that are capable of resulting in injury.

96.6.3 In addition, a cart or stand shall be constructed so that permanent deformation or damage that is capable of resulting in injury to persons does not occur when each supporting surface is loaded, one at a time, with:

a) Two times the specific weight of the apparatus plus 440 N for the surface intended to support a television.

b) Four times the manufacturer's specified load or 108 N, whichever is greater, for all other supporting surfaces.

c) The maximum intended load specified by the manufacturer for a dedicated storage area intended to accommodate specific accessories such as media tapes, discs, etc.

96.6.4 The weight is to be applied for 1 minute on each supporting surface with the other supporting surfaces unloaded.

96.6.5 The test is repeated with all supporting surfaces simultaneously loaded for one minute with:

a) The specific weight of the apparatus for a surface intended to support a television, and

b) The manufacturer's specified load or 108 N, whichever is greater, for all other supporting surfaces, and

c) The maximum intended load specified by the manufacturer for a dedicated storage area intended to accommodate specific accessories such as media tapes, discs, etc.

96.7 Cart or stand impact

96.7.1 When tested as described in 96.7.2, a cart or stand shall not produce a risk of injury to persons.

96.7.2 A single 7.0 Joule impact is to be applied to any part of the cart or stand and the test method is to be as described in 98.11.1.

96.8 Handle strength

96.8.1 When tested as described in 96.8.2 – 96.8.5, a handle or support system shall not break nor shall there be any breakage of the securing means, including that portion of the enclosure to which the handle or support system is attached.

96.8.2 A product handle or support system shall withstand a force of four times the weight of the product.

96.8.3 A cart or stand handle or support system shall withstand a force of twice the combined weight of the cart or stand and the product.

96.8.4 The weight of the product plus a weight that exerts a force of three times the weight of the product is to be used. The load is to be uniformly applied without clamping over a 7.5-cm width at the center of testing the handle. The additional load is to be started at zero and gradually increased so that the total value is attained within 5 – 10 seconds and then maintained for a period of 1 minute. If more than one handle is furnished on the product, the force is to be distributed between the handles. The distribution of forces is to be determined by measuring the percentage of the product weight sustained by each handle, with the product in the intended carrying position. If a product is furnished with more than one handle and can be carried by only one handle, each handle shall be capable of sustaining the total test load.

96.8.5 A handle on a cart or stand is to be tested in a manner similar to that described in 96.8.4 with the test load specified in 96.8.3.

96.9 Wall-, ceiling-, or rack-mounting securement

96.9.1 When tested as described in 96.9.2 and 96.9.3, a wall-, ceiling-, or rack-mounting means shall remain in place and not break, nor shall there be any breakage or damage to the mounting bracket or its securing means, including that portion of the audio or video product to which the mounting system is attached.

96.9.2 A wall- or ceiling-mounting system is to be mounted in accordance with the manufacturer's installation instructions, using the hardware and construction described. If wall constructions are not specified, a wall construction of 9.5-mm thick plasterboard (dry wall) on 38 by 89 mm (nominal 2 by 4 inch) wood studs spaced on 406-mm centers is to be used as the support surface. The hardware is to be applied as specified in the instructions, and, if not otherwise indicated, the securing screws are to be positioned between the studs and secured into the plasterboard. An adjustable mounting system is to be adjusted to the position that gives the maximum projection from the wall. The force is to be applied to the audio or video product and is to be increased within a 5 – 10 second interval until a load equal to the weight of the product plus a weight that exerts a force of three times the weight of the product, but not less than 50 N, is applied to the mounting system. The load is to be sustained for 1 minute.

96.9.3 A rack-mounted product is to be mounted as intended with the hardware supplied or referenced in the literature shipped with the product. A force of three times the weight of the product, but not less than 150 N, is to be applied to the top of the product (resulting in a total load equal to the weight of the product plus a weight that exerts a force of three times the weight of the product), the center of force acting through the plane located one half the distance between the front and rear of the product. The force is to be increased within a 5 – 10 second interval until the total load is applied. The load is to be sustained for 1 minute.

96.10 Antenna end-piece securement

96.10.1 An antenna end-piece used to blunt the exposed end of a telescoping or rod antenna (see 31.5.1) shall be capable of withstanding the test described in 96.10.2 and, if screwed on, shall be capable of withstanding the test described in 96.10.3. Each test is to be conducted on a different sample while at room temperature. If polymeric materials are involved in the end-piece construction or securing means, the tests are to be conducted both before and after the temperature stability test described in 96.3.1.

96.10.2 The antenna end-piece shall not become detached from the antenna, and there shall be no separation of the telescoping antenna sections, when a force of 22 N is applied to the end-piece for 1 minute. The force is to be applied with regard to the attachment point of the antenna to the product by a weight or a steady pull, along with the major axis of the antenna.

96.10.3 A loosening torque as specified in Table 96.2 is to be applied to the end piece in the plane perpendicular to the axis of the antenna. The torque is to be applied gradually to the end piece with the rod fixed, and when the specified torque value is reached it is to be maintained for not less than 5 seconds and not more than 15 seconds. Five samples are to be tested. The average holding time of the five samples shall not be less than 8 seconds, and the holding time for any sample shall not be less than 5 seconds.

Table 96.2
Torque values for test

Original Table 96.1 relocated as Table 96.2

End-piece, diameter	Torque, newton · meters
6.0 but less than 8.0	0.3
8.0 to 13	0.6

96.11 Implosion

96.11.1 A product provided with a picture tube shall withstand the implosion tests described in 96.11.2 – 96.11.8 without expelling pieces of glass exceeding the limits specified in 96.11.5 or 96.11.8.

Exception No. 1: A product provided with a picture tube having a diameter of less than 7.5 cm or equivalent area need not be subjected to these tests.

Exception No. 2: A product provided with a picture tube having integral implosion protection which, when mounted in a reliable and conventional manner, is represented by the investigation of the integrally protected picture tube need not be subjected to these tests.

Exception No. 3: A product provided with a picture tube that is not directly viewed and is totally enclosed, including the face, as described in 50.3.1 need not be subjected to these tests.

96.11.2 Two implosion methods are described in 96.11.3 and 96.11.6. The thermal-shock method is preferred; however, if an implosion cannot be induced by the thermal-shock method, the high-energy impact method is to be used. If neither method induces the implosion, another method is to be used.

96.11.3 The thermal-shock method of inducing the implosion is to be as follows: the rim of the picture tube adjacent to the seal is to be scratched with a glass cutter, diamond scriber, or hard tool. Six 20-mm long scratches are to be made parallel to the central horizontal axis of the tube and spaced to occupy an area approximately 20 mm wide. The end of an ordinary glass rod approximately 10 mm in diameter is to be heated until nearly fluid. The heated end of the rod is to be passed through a prepared access hole in the cabinet and pressed firmly on the scratched surface of the tube. If implosion does not occur within 10 seconds, the rod is to be withdrawn and cold water is to be poured slowly onto the scratched area. If implosion is not induced, the process is to be repeated.

96.11.4 To test the enclosure for the picture-tube implosion by means of the thermal-shock method, the product is to be complete with all hardware and covers in place except for access holes required for test purposes. A table-model product is to be placed on a 76-cm high, rigid, table-like test stand. A floor-model product is to be tested standing on the floor. A barrier 13 mm thick, 24 cm high, and 2 m long is to be placed on the floor. The barrier is to be located at a distance of 15 cm from the plane of the front edge of the enclosure. A non-skid surface such as a blanket or rug is to be placed on the floor between the product and the barrier.

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96.11.5 A product complies with the picture-tube implosion requirement if after the induced implosion by means of the thermal shock method there is no glass beyond the barrier.

Exception: Shale, slivers, and other pieces of glass that are deflected or fall by gravity and are not projected or thrown as a result of the devacuation of the tube shall not be considered when determining compliance with 96.11.5.

96.11.6 The high-energy impact method of inducing implosion is to be as follows: a 25-mm diameter steel pin is to be inserted through a prepared hole in the cabinet and caused to rest on the rim of the tube near the face seal line. A weight that exerts a force of 45 N, or heavier if necessary to induce an implosion, is to fall from a height of approximately 1.4 m and impact the pin at the end of its free fall. An equivalent impact can be used. The implosion pin is to be restricted so that its travel on impact is only enough to induce the implosion.

96.11.7 To test the enclosure for the picture-tube implosion by means of the high-energy impact method, the product is to be complete with all hardware and covers in place except for access holes required for test purposes. A table-model product is to be placed on a 76-cm high, rigid, table-like test stand. A floor model product is to be tested standing on the floor. Two barriers each 13 mm thick, 24 cm high, and 2 m long are to be placed on the floor. The barriers are to be located at distances 0.9 and 1.5 m from the plane of the front edge of the enclosure, respectively. A nonskid surface such as a blanket or rug is to be placed on the floor beyond the second barrier.

96.11.8 A product complies with the picture-tube implosion requirement by means of the high-energy impact method if after the induced implosion of the picture tube all of the following conditions exist:

a) There is no single piece of glass having a mass more than 14 grams between the two barriers,

b) The total mass of all the pieces of glass between the two barriers is not more than 43 grams, and

c) There is no glass, except slivers, beyond the barrier that is 1.5 m from the front edge of the enclosure.

97 Sharp Edge Test

97.1 To determine compliance with 13.1.1 relating to the sharpness of an edge, the sharp-edge tester is to be applied to the edge in accordance with the requirements in the Standard for Test for Sharpness of Edges on Equipment, UL 1439. The edge shall be considered unacceptable if the sensing tapes – the two outer layers – are cut through as a result of the application of the tester.

97.2 The edges to be subjected to the test specified in 97.1 are those contacted during normal use or user assembly of a product or cart or stand.

98 Strength of Enclosure Tests

98.1 Mechanical tests – general

98.1.1 The overall enclosure and back cover of a product shall withstand the mechanical-abuse tests described in 98.2.1 – 98.11.4 without resulting in any of the following:

a) Damage that results in the risk of fire as determined by visual examination or, if some question remains, by operating the product as described in 74.2.1 – 74.4.1 and 74.5.1 – 74.7.1, and evaluating the results according to 74.10.1;

b) Damage that results in the risk of electric shock as determined by Electric Shock, Section 12, and the Dielectric Voltage-Withstand Tests, Section 71; or

c) Openings larger than those that are acceptable according to Table 18.1.

Exception: The strength of enclosure tests described in 98.2.1 – 98.16.1 do not apply to separately enclosed loudspeakers intended for connection to an audio amplifying source limited in accordance with 70.1.

98.2 Enclosure temperature stability

98.2.1 The overall enclosure, installed so that parts involving the risk of electric shock are not accessible, shall withstand either of the temperature-stability conditions described in 98.3.1 without any shrinkage, warpage, or any other distortion that results in one or both of the following conditions:

a) Interference with the operation or user-servicing of the product and

b) Noncompliance with the criteria specified in 98.1.1.

98.2.2 Component parts such as knobs, windows, and inserts that are distorted as a result of the temperature-stability test may be removed in order to eliminate interference with the operation or user-servicing of the product provided that removal of the parts does not result in inability of the product to comply with Electric Shock, Section 12; Enclosures, Section 17; and Double Protection for High-Voltage Products, Section 52.

98.3 Enclosure temperature-stability test method

98.3.1 The enclosure temperature-stability test mentioned in 98.2.1 can, at the manufacturer's option, be conducted as described in either (a) or (b). For an undercabinet product, the product is to be mounted as specified in 104.2 and 104.3 and the entire alcove is to be placed in the oven.

a) A sample of the complete product is to be placed in a cubical unvented test cell and arranged so that the circulation of air within the cell simulates normal room conditions. The air temperature within the cell, measured at the base of the product, is to be maintained at 60°C. The product is to be connected to a 130 V supply circuit (260 V for a product rated at nominal 230 V) and operated continuously for 7 hours while resting on a supporting surface having an area approximately equal to that of the product base and centrally located in the test cell.

b) The complete product is to be placed in a circulating-air oven for 7 hours. The oven is to be maintained at a temperature of 10°C higher than the maximum operating temperature of the enclosure, measured at the hottest spot on the inside of the enclosure, under operating conditions, but not less than 70°C. The product is not to be operated during the test.

98.4 Control-button, -knob, and -shaft pull

98.4.1 A control-button, -knob, or -shaft that:

a) Provides the second level of insulation for double protection as described in 52.6(a),

b) Protrudes 6.4 mm or less from the outside surface of the enclosure and provides both levels of insulation for double protection as described in 52.6(b), or

c) Protrudes 6.4 mm or less from the outside surface of the enclosure and serves as a barrier to parts involving a risk of electric shock

shall withstand for 1 minute, a force of 14 N in any direction, without exposing parts involving a risk of electric shock or resulting in breakdown of the captivating means.

98.4.2 A control-button, -knob, or -shaft that:

a) Protrudes more than 6.4 mm from the outside surface of the enclosure and provides both levels of insulation for double protection as described in 52.6(b) or

b) Protrudes more than 6.4 mm from the outside surface of the enclosure and serves as a barrier to parts involving a risk of electric shock

shall withstand for 1 minute, a force of 67 N in any direction, without exposing parts involving a risk of electric shock or resulting in breakdown of the captivating means.

98.4.3 If polymeric materials are involved in the construction, the test described in 98.4.1 or 98.4.2 is to be conducted both before and after either of the temperature-stability tests described in this Section.

98.5 Overall enclosure pressure

98.5.1 Any point on the overall enclosure of a product, except the bottom, shall withstand, for 1 minute, the application of a 90 N force as described in 98.7.1.

98.6 Enclosure bottom pressure

98.6.1 Any point on the bottom of the overall enclosure of a product shall withstand, for 1 minute, the application of a 67 N force as described in 98.7.1.

98.7 Pressure test method

98.7.1 The 67 or 90 N force is to be applied to the complete product by a 12.5 ±0.5 mm diameter rod, the end of which is rounded to a 12.5 ±0.5 mm diameter hemisphere.

98.8 Pressure test evaluation for grilles and other nonrigid surfaces

98.8.1 The results are to comply with 98.1.1 and the rod described in 98.7.1 is not to pass through grille openings or other nonrigid surfaces of the enclosure unless the parts inside the enclosure that involve a risk of electric shock are insulated according to the requirements in this standard.

98.9 Enclosure top loading for high-voltage products

98.9.1 The application of a weight of 23 kilograms for 1 minute to any point on the top of the overall enclosure of a high-voltage product shall not result in a risk of electric shock or damage to any part of the product that results in a risk of fire.

98.9.2 The 23-kilogram weight is to be applied by placing the weight on a 50.5 ±0.5 mm diameter steel sphere, so that only the steel sphere is in contact with the enclosure, while the complete product is resting on a horizontal surface.

98.10 Enclosure bottom loading

98.10.1 The loading described in 98.10.2 is to be applied to the bottom of the overall enclosure of:

a) A table-top product that weighs more than 4.5 kilograms but not more than 35 kilograms or

b) Any product that has one or more handles.

98.10.2 The complete product is to be set on a 50.5 ±0.5 mm diameter steel ball resting on a horizontal surface having dimensions not less than those of the base of the product. A weight that exerts a force of 0.25 W plus 2 kilograms – W being the weight of the product in kilograms – is to be placed on top of the product directly over the steel ball for a period of 1 minute. Rubber-like and felt materials are to be removed from supporting feet to the extent that they are likely to be worn off in service and supporting feet that are not permanently secured to the enclosure are to be removed.

98.11 Impact

98.11.1 The impact force applied to a part of an enclosure is to be obtained using a solid, smooth, steel sphere 50.5±0.5 mm in diameter and weighing approximately 0.5 kilogram. The sphere is to fall freely from rest through the distance required to cause it to strike the top of the enclosure with the specified impact. For surfaces other than the top of the enclosure, the sphere is to be suspended by a cord and is to fall as a pendulum through the distance required to strike the surface with the specified impact. The enclosure is to be placed so that the surface tested is vertical and in the same vertical plane as the point of support of the pendulum. Parts of the enclosure that may interfere with the cord of the pendulum are to be removed. During the test, the enclosure is to be placed against a vertical wall. The height needed for the steel sphere to strike the enclosure with the specified impact force can be computed by using the formula:

$$h = \frac{I}{mg}$$

in which:

h is the height computed in meters,

I is the impact force in Joules,

m is the mass of the steel sphere in kilograms, and

g is the gravitational constant 9.8 meters/second^2.

98.11.2 For the impact test, a component, such as a knob, a window, a cover, a control shaft, and the like, that is intended to be in place during normal use is to be mounted in the intended manner.

98.11.3 The external surfaces of a product enclosure used to reduce the likelihood of contact with live parts, to complete the enclosure of parts involving a risk of fire, or to enclose a picture tube shall withstand a single impact of the value specified in Table 98.1. The enclosure parts to be subjected to the impact test include the top, sides, front, back, windows, covers, knobs, buttons, control shafts, antenna terminals, jacks, and the like. The enclosure bottom need not be subjected to the impact test.

98.11.4 When considering the results of the impact test, a mechanically weak material or construction, such as a speaker cone, is not considered to be an acceptable barrier.

Table 98.1
Product enclosure impact test

Enclosure part	Impact, joules	Results
Top, sides, back, and front of portable, table-top, or undercabinet products (includes all parts not mentioned below, for example, glass[a,b], decorative glass or mirror[c], LCD, antenna terminals, jacks, and the like)	2	Shall not develop any opening larger than those specified in the requirements to reduce the risk of fire and electric shock; shall not create a risk of electric shock. Decorative glass or mirror shall not be shattered (either totally or in part), broken, or displaced from its mounting in a manner that could result in a skin-lacerating injury.
Top, sides, back, and front of floor-mounted (console) products (includes all parts not mentioned below, for example, glass[a,b], decorative glass or mirror[c], LCD, antenna terminals, jacks, and the like)	3.5	
Picture-tube enclosure:		
CRT > 15 cm	7	Shall not develop any opening larger than those specified in 50.3.1 (picture-tube enclosure opening).
7.5 cm ≤ CRT ≤ 15 cm	2	
Face of picture-tube having integral implosion protection:		
CRT > 15 cm	7	Shall not expel glass particles more than 0.9 m from the front edge of the picture-tube enclosure.[d]
7.5 cm ≤ CRT ≤ 15 cm	1	
Transparent window covering tube face:		
CRT > 15 cm	7	Shall not result in damage that renders the window or its mounting means unacceptable for reuse; shall not crack a tempered-glass window.
7.5 cm ≤ CRT ≤ 15 cm	1	
Unprotected buttons, controls, knobs, and shafts[e]	2	Shall not damage the button, control, knob, or shaft so that any opening develops larger than those specified in the requirements to reduce the risk of fire or electric shock; shall not break off any conductive part that may fall into the overall enclosure of the product, unless the presence of the conductive part cannot result in a risk of fire or electric shock.
Protected buttons, controls, knobs, and shafts[f]	1	
Buttons, controls, knobs, and shafts located within a compartment having a nondetachable door or cover	0.7	

[a] A tempered-glass window having a minimum thickness of 4.8 mm need not be subjected to the impact test.

[b] If a permanent part of the product limits the impact of the sphere to a lesser value, the lesser value shall be used.

[c] To be applied to a part that has an area greater than 0.1 m^2 or a major dimension greater than 46 cm.

[d] The impact test is to be conducted as described in the Standard for Mechanical Safety for Cathode Ray Tubes, UL 61965.

[e] An unprotected control– for example, a button, knob, or shaft – is one that will contact or pass through an infinite plane placed as close as possible to all top, side, front, or back surfaces with all parts in place.

[f] A protected control is one that will not contact or pass through the infinite plane discussed in note f.

98.12 Drop test – portable product

98.12.1 A portable product (see 3.38 and 3.39) shall be subjected to the drop test specified in 98.14.1.

Exception: Video cameras/camcorders need not be subjected to this test.

98.13 Drop test – portable product power supply and battery charger

98.13.1 A power supply unit intended to be connected to a portable product or any cord-connected or direct, plug-in battery charger shall be subjected to the drop test specified in 98.14.1.

98.14 Drop test method

98.14.1 Each of three samples is to be subjected three separate times to the impact that results from its being dropped through a distance of 0.9 m to strike a hardwood surface (see 98.15.1) in the positions most likely to produce adverse results.

Exception: For products employing a CRT – if the CRT cracks, breaks, and/or evacuates in a manner noticeable on the CRT face, testing is to be terminated on that sample and the acceptability of the results on that sample are to be judged in accordance with 98.16.1. The test shall continue on any remaining samples.

98.14.2 With regard to 98.14.1, the test is to be conducted so that the sample strikes the hardwood surface in a different position for each of the three drops on each sample. If applicable, the samples are to be dropped with batteries recommended by the manufacturer in place.

98.15 Drop test – impact surface

98.15.1 The hardwood surface specified in 98.14.1 is to consist of a layer of tongue-and-groove oak flooring mounted on two layers of nominally, 19-mm thick plywood. The oak flooring is to be nominally 19 mm by 57 mm. The assembly is to rest on a concrete floor or an equivalent, nonresilient surface.

98.16 Drop test – results

98.16.1 The samples shall withstand the test described in98.14.1 without producing openings that allow accessibility as described in 18.1.2 – 18.1.4. If live parts become accessible when a previously untested sample is subjected to its first, second, or third drop, the results of the test are unacceptable.

Exception: For products employing a CRT – if the CRT cracks, breaks, and/or evacuates in a manner noticeable on the CRT face, accessibility shall not be judged through openings in the face of the CRT. This exception does not include damage to the mounting means of a CRT.

98.17 Drop test – number of samples to be tested

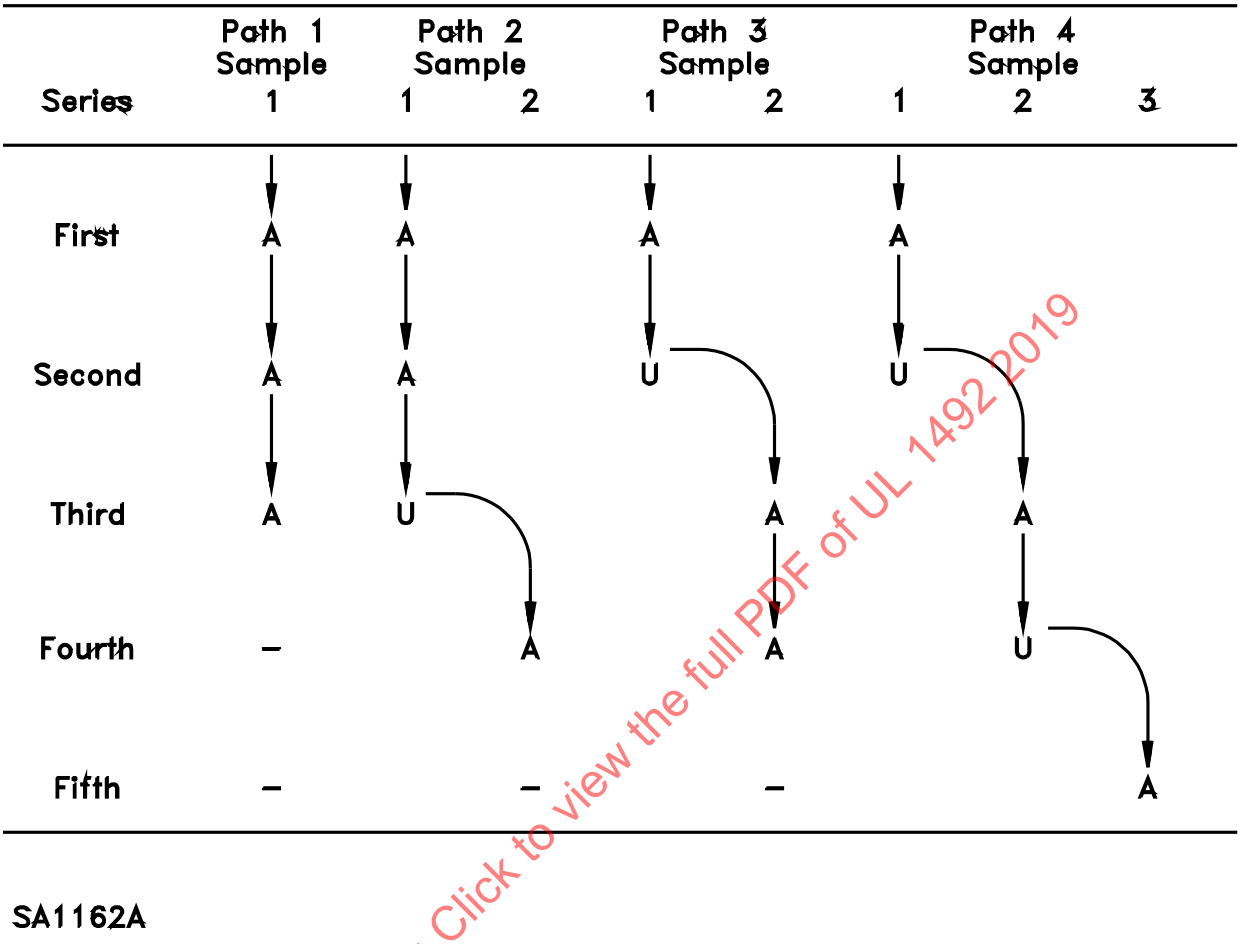
98.17.1 If the manufacturer so elects, fewer than three samples may be used. The overall performance is acceptable upon completion of any one of the procedure paths represented in Figure 98.1. These paths all result in three acceptable series of drops with no unacceptable results on the first series of drops on any sample.

Table 98.2
Procedure for enclosure drop test

Table 98.2 relocated as Figure 98.1

Figure 98.1
Procedure for enclosure drop test

Table 98.2 relocated as Figure 98.1



Arrows indicate sequence of test procedure.

a) A indicates acceptable results for a series (three drops) on a single sample (see the Exception to 98.14.1).

b) U indicates unacceptable results on a series (three drops) for a previously tested sample. Since this is the second or third series of drops conducted on a specific sample, the results of this series of drops are considered inconclusive and additional samples must be tested to determine the final results of the drop test.

99 Alternate Enclosure Material Evaluation

99.1 The acceptability of an alternate polymeric enclosure material of the same generic type can be judged by the performance criteria indicated in 99.2 and 99.3 and Table 99.1 without conducting a complete series of product enclosure tests if the same part dimensions apply and if equivalent or better material properties are demonstrated by standardized small-scale tests on the alternate material when compared to the same properties of the original enclosure material having acceptable application performance.

Table 99.1
Waiving of enclosure tests for alternate materials based on material small-scale test performance

Product strength of enclosure test consideration	Relevant material property[a]
Loading test (98.9.1 – 98.10.2)	Tensile or flexural strength
Pressure tests (98.5.1 – 98.8.1)	Tensile or flexural strength
Impact tests (98.11.1 – 98.11.4)	Tensile or izod impact
Drop test for portable – product, power supply, battery charger (98.12.1– 98.17.1)	Tensile or izod impact
Temperature stability test (98.2.1– 98.3.1)	Heat deflection[b], vicat softening point, or ball pressure temperature

[a] These relevant material property tests are described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

[b] The heat deflection temperature test is to be conducted using a fiber stress of 455 kN/m^2.

99.2 All alternate enclosure materials shall have:

a) The minimum flammability classification required by Table 20.1, as determined by tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and

b) The same or higher temperature index as the original material, as determined by tests or assigned generic thermal index as described in the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B.

99.3 If the originally tested material was considered acceptable on the basis of special tests (for example, determining the resistance of the material to ultraviolet light for an outdoor application or wetting tests and salt spray), these tests are to be conducted on the alternate material to determine acceptability.

100 Adhesive Securement Test

100.1 A product enclosure as described in 17.1.2 or a component as described in 31.4.1 shall withstand the conditioning described in 100.2 without deterioration of the adhesive that results in a risk of electric shock or non-compliance with the requirement in 17.1.1.

100.2 Two samples of the product enclosure or component are to be conditioned as follows:

a) One sample in an air-circulating oven for 7 days at 100.0 ±1.0°C, 14 days at 90 ±1.0°C, 21 days at 87.0 ±1.0°C, or 60 days at 82.0 ±1.0°C and

b) One sample for 7 days in an environment of 85 ±5 percent relative humidity at 32.0 ±2.0°C.

101 Adhesive-Backed Parts Peel Test

101.1 A part or label of conductive material that is secured in place by an adhesive, and located as described in 31.4.2, is acceptable if it withstands a minimum peel force of 4.9 N/30 mm width, both before and after conditioning as described in 101.2.

Exception: The test described in 101.2 does not apply to separately enclosed loudspeakers intended for connection to an audio amplifying source limited in accordance with 70.1.

101.2 Nine samples of the adhesive-backed part or label, each secured to its mounting surface, are to be tested. Each part, or label, is to be conditioned as follows:

a) Three of the samples are to be tested in an as-received condition;

b) Three of the samples are to be tested after conditioning for 7 days in a circulating-air oven operating at 100.0 ±1.0°C; 14 days at 90.0 ±1.0°C; 21 days at 87.0 ±1.0°C; or 60 days at 82.0 ±1.0°C; and

c) The remaining three samples are to be tested after conditioning for 7 days in an environment of 85 ±5 percent relative humidity at 32.0 ±2.0°C.

102 Tablet Flammability Test

102.1 When a material is tested as described in 102.2, the sample shall not burn further than 5 cm from the center of the tablet.

102.2 To determine whether a material complies with the requirement in 102.1 it is to be supported so that its thinnest outside solid surface of the part to be tested is in a horizontal position. A tablet[b] comprised of hexamethylene-tetramine ($C_6H_{12}N_4$) having a weight of 0.15 ±0.02 gram, and having a controlled burning time of 105 ±5 seconds, is to be placed on the thinnest section of the part. The tablet is then to be ignited with a match. This test is to be conducted on the thinnest portion of each material used. The tablet is to be permitted to burn until it is completely consumed and the material ceases to flame or glow. If, when testing thin material such as grille cloth, the tablet burns through the cloth and falls to the surface below, the test is concluded when the grille cloth ceases to flame or glow.

[b]Lilly tablets No. 1588 are acceptable for this purpose.

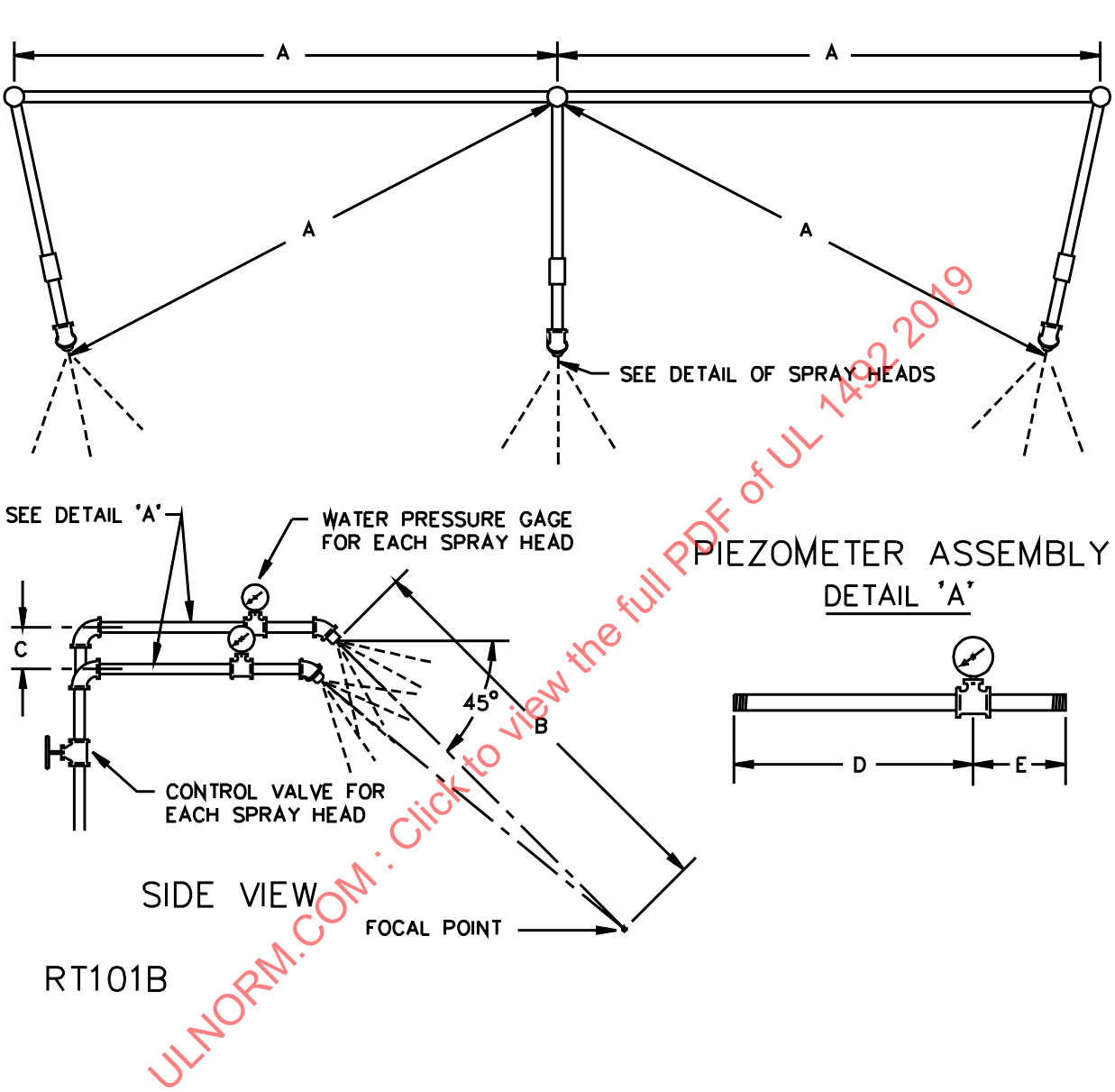
103 Outdoor-Use Wetting Test

103.1 After being subjected to the conditions described in 103.2, the leakage current of a product that is intended for outdoor use shall not be more than 0.5 milliampere when tested in accordance with the Product-Leakage and Shock-Current Test, Section 67, if the open-circuit potential between the accessible part and earth ground or any other accessible part is more than 21.2 V peak.

Exception: The tests described in 103.1 and 103.2 do not apply to separately enclosed loudspeakers intended for connection to an audio amplifying source limited in accordance with 70.1.

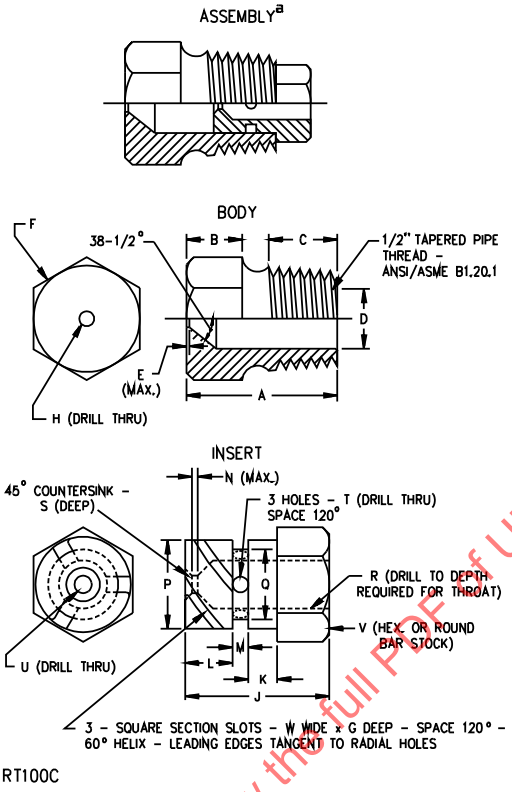
103.2 The product is to be positioned as in actual service and subjected for 1 hour (not operating) to a water spray. The water-spray test equipment is to consist of three spray heads mounted in a water-supply pipe rack as shown in Figure 103.1. The spray heads are to be constructed in accordance with the details shown in Figure 103.2. The product being tested is to be brought into the area where the water sprays from the three heads converge (see Figure 103.3) in a position that causes the greatest quantity of water to enter the product. The water pressure is to be maintained at 34.5 kPa at each spray head. The spray is to be directed at an angle of 45 degrees to the vertical toward the product. The leakage-current test is to be conducted immediately upon conclusion of the wetting period and is to be discontinued when the leakage current stabilizes.

Figure 103.1
Water-spray-test spray-head piping



Item	mm
A	710
B	1400
C	55
D	230
E	75

Figure 103.2
Water-spray-test spray head



Item	mm	Item	mm
A	31.0	M	2.38
B	11.0	N	0.80
C	14.0	P	14.61
D	14.68		14.63
	14.73	Q	11.51
E	0.40		11.53
F	c	R	6.35
G	1.52	S	0.80
H	5.0[b]	T	2.79[d]
J	18.3	U	2.49[e]
K	3.97	V	16.0
L	6.35	W	1.52

[a] Molded nylon Rain-Test Spray Heads are available from Underwriters Laboratories Inc.

[b] ANSI B94.11 Drill Size, No. 9.

[c] Optional– To serve as wrench grip.

[d] ANSI B94.11 Drill Size, No. 35.

[e] ANSI B94.11 Drill Size, No. 40.

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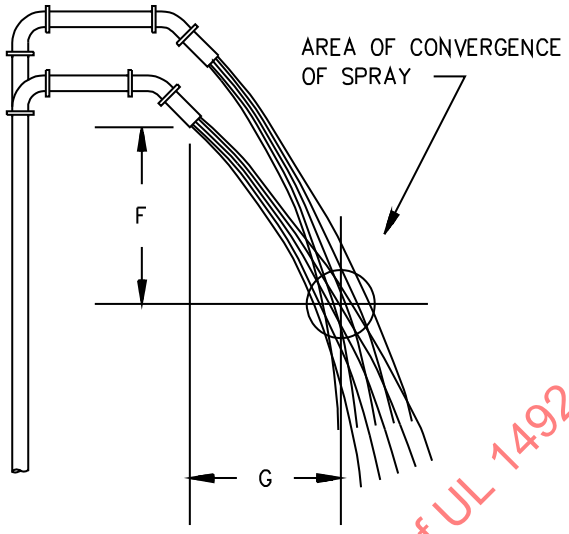
Figure 103.3
Convergence of water spray



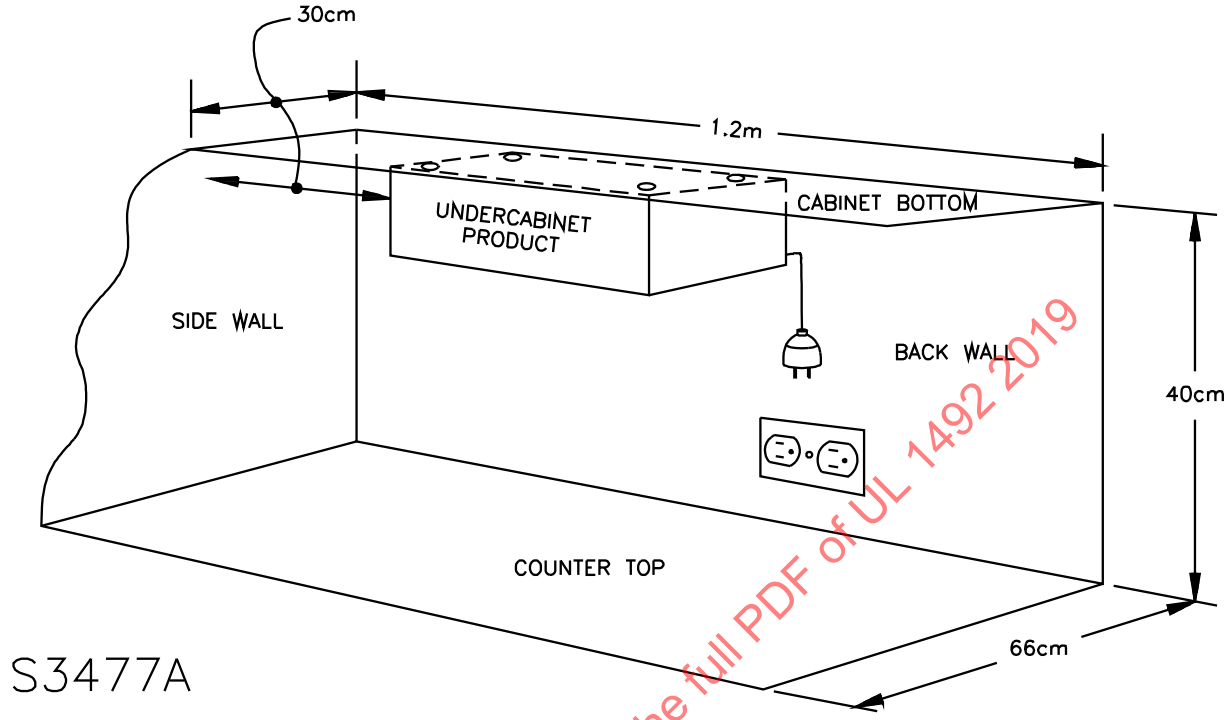
104 Undercabinet Product Temperature Test

104.1 An undercabinet product shall not attain a temperature at any part sufficiently high to constitute a risk of fire or to adversely affect any materials used, and shall not attain temperatures at specific points greater than those indicated in Table 68.1 when tested under the conditions described in 68.2.1 – 68.7.1, as applicable, and when mounted in accordance with 104.2 and 104.3.

104.2 An alcove to simulate a typical undercabinet mounting arrangement, as shown in Figure 104.1, is to be constructed using nominal, 19-mm, outdoor-grade plywood. The underside of the cabinet surface is to be 40 cm above the countertop surface.

104.3 The undercabinet product is to be secured to the cabinet surface in accordance with the manufacturer's installation instructions. However, the product is to be located so that it is 30 cm from the side wall (measured from the closest edge of the product). The product is to be located so as to produce the most severe operating condition that the supplied hardware allows.

Figure 104.1
Undercabinet product test set-up



105 Undercabinet Elevated Ambient Test

105.1 Following the conditioning specified in 105.3, an undercabinet product shall comply with the applicable requirements specified for accessible parts in 18.1.1 – 18.6.2, 19.1, 19.2, and the Dielectric Voltage-Withstand Tests, Section 71.

105.2 An undercabinet product is to be mounted as specified in 104.2 and 104.3. If the distance between the bottom surface of the product and the countertop surface is less than 250 ±6 mm, the countertop surface is to be adjusted downward so that the distance is 250 ±6 mm. If this distance is greater, no adjustment is necessary.

105.3 The product is to be connected to a supply circuit in accordance with 63.5.1 and energized. An electric fry pan is to be used as the source of heat for this test. The fry pan is to be rated 1200 watts, have a cooking surface area of 800 – 1000 cm^2, and have the cooking surface area located 5.0 – 7.0 cm above the countertop surface. The thermostatic control of the fry pan is to be bypassed and a thermocouple is to be placed in the center of the cooking area of the fry pan with the fry pan located away from the alcove. The fry pan is to be connected to a variable 60 Hz supply circuit adjusted to produce a temperature of 200 ±5°C at the center of the fry pan as measured by the thermocouple. When the temperature has stabilized, the fry pan is to be positioned directly below the undercabinet product with the back edge of the fry pan spaced 25 mm from the back wall of the alcove. The fry pan power supply is then to be readjusted to maintain the 200 ±5°C temperature. The test is to be continued for 1-1/2 hours at which time the dielectric voltage-withstand test is to be conducted while the product is still in the heated condition.

106 Undercabinet Increased Moisture Test

106.1 Following the conditioning specified in 106.3, an undercabinet product shall comply with the requirements specified for product leakage current in Electric Shock, Section 12, and the Dielectric Voltage-Withstand Tests, Section 71.

106.2 The undercabinet product is to be mounted as specified in 105.2.

106.3 The undercabinet product is to be connected to a supply circuit in accordance with 63.5.1; but the product is not to be energized during the test. Leakage current measuring equipment is to be connected between accessible metal and earth ground, and adjusted to produce the maximum leakage current value. Leakage current is to be monitored throughout the duration of the test. An electric kettle is to be used for this test. The kettle is to have a minimum capacity of 1.5 L and a spout opening of 12 – 17 cm^2, and the spout opening is to be located 12 – 14 cm above the countertop surface. The electric kettle is to be connected to a 60 Hz variable supply circuit adjusted to produce 1500 watts of input power and the kettle is to be filled with 1.5 L of tap water. The spout is to be positioned to direct steam towards the bottom center portion of the product, allowing the kettle to boil dry. A final leakage current measurement is to be made with the product both energized and unenergized, and recorded when the kettle has boiled off the water. The Dielectric Voltage-Withstand Tests, Section 71, are to be conducted immediately after the final leakage current measurement.

107 Undercabinet Mounting Security Test

107.1 An undercabinet product shall withstand a downward vertical force of 90 N for 1 minute, following the enclosure temperature stability test described in 98.3.1, when mounted in accordance with 104.2 and 104.3. Adhesive alone shall not be used to secure the product.

LIQUID CRYSTAL DISPLAY (LCD) VIDEO PRODUCTS

108 Normal Temperature Test

108.1 An LCD video product, when tested as described in the Temperature Test, Section 68, shall not display temperatures on surfaces that are exposed to the user, either during normal operation or lamp servicing, greater than those indicated in Table 68.1.

Exception: The temperature limits of Table 68.1 may be exceeded on surfaces within the product that are exposed only during user-servicing of a projection lamp if the product is provided with a warning marking, such as that indicated in 133.2.1.

109 Electric Shock Test

109.1 General

109.1.1 During relamping, a user-serviceable fluorescent lamp shall comply with the requirements in 109.2.1 – 109.3.2.

109.2 Lamp pin measurements

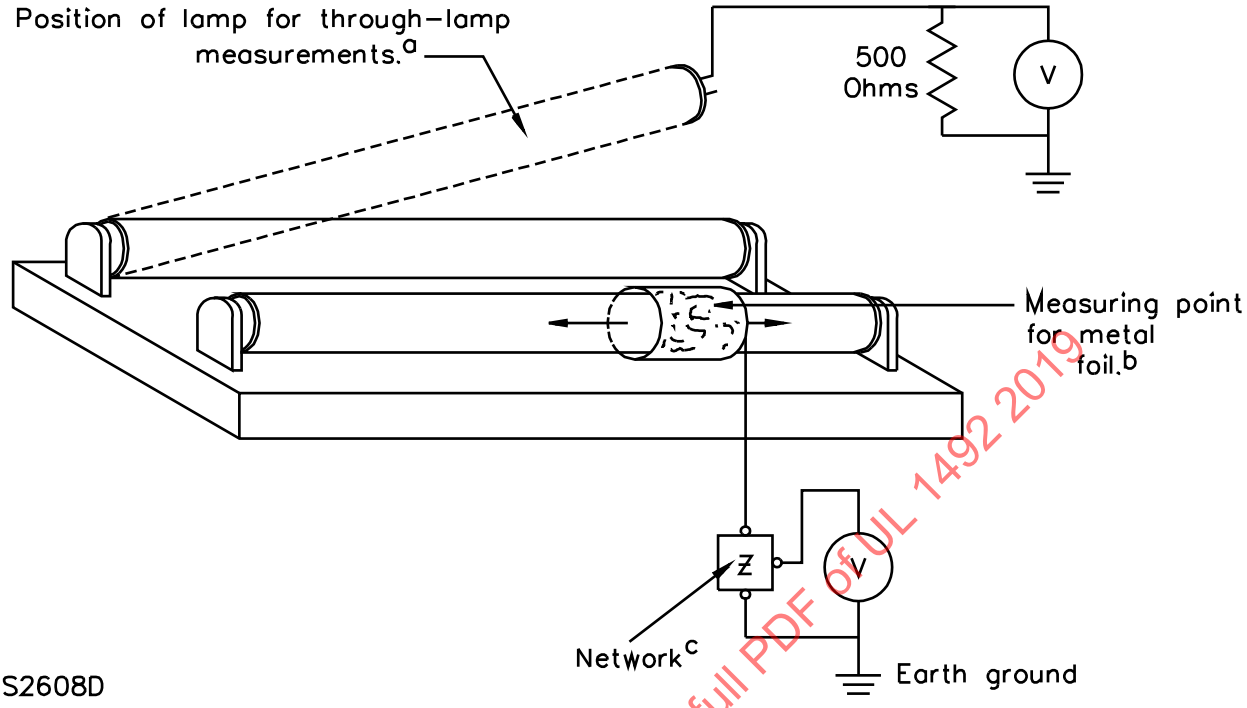
109.2.1 Each end of a fluorescent lamp, in turn, is to be removed from its lampholder, and a noninductive, 500-ohm resistor is to be connected between one of the accessible lamp pins and ground (see Figure 109.1). The current through the resistor shall not exceed the values specified in the second column of Table 109.1. Measurements are to be made under the following conditions:

a) With a new lamp or lamps and with a conditioned lamp or lamps;

b) With a lamp or lamps that are at room temperature and with a lamp or lamps heated from normal operation. The measurement in the heated condition is to be made as quickly as possible; and

c) With a lamp or lamps that are deactivated.

Figure 109.1
Test setup for shock-current measurements



[a] See 109.2.1 for lamp position.

[b] See 109.3.2 for foil measurement conditions.

[c] See Figure 109.2 for the reaction current network.

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Table 109.1
Shock-current measurements

Frequency (Hz)	Maximum current[a,b] (milliamperes peak)
	Pin
60 or less	7.07
180	8.17
500	8.64
1000	10.76
2500	15.71
5000	23.02
10,000 or more	43.45[c,d]

[a] Straight-line interpolation between adjacent values in the table may be used to determine the maximum current values corresponding to frequencies not shown.

[b] To be calculated by determining the peak voltage across a noninductive, 500-ohm resistor when using an oscilloscope.

[c] Impulses greater than 43.45 milliamperes peak at the lamp pin may be acceptable after further investigation as indicated in note d. However, for a rapid approximate determination, a wide-band, true rms indicating meter may be used to determine if a complex waveshape is below 30.7 milliamperes (rms) at the lamp pin. If a spectrum analyzer and a 1000X attenuator probe are used, the analyzer will display the rms voltage of the various component frequencies. For frequencies of 10 kHz and above, the maximum value of voltage across the 500-ohm resistor is 15.3 millivolts (minus 36.3 dBV) at the lamp pin.

[d] Impulse peaks greater than 43.45 milliamperes peak at the lamp pin, including dynamic modes of operation such as starting, may be acceptable if, after further oscilloscope evaluation, the waveform has been determined to comply with the intent of the requirement. Consideration is to include pulse width, height, repetition and rms equivalent, minimum off time such as in a starting sequence and likely method of body contact for the particular shock-current measurement.

109.3 Foil measurement (electronic ballasts)

109.3.1 For an electronic, ballast-operated lamp, a piece of metal foil 51 mm wide is to be wrapped around the entire circumference of the lamp. The foil is to be moved along the longitudinal axis of the lamp as illustrated in Figure 109.1. A lead from the foil is to be attached to the reaction current network shown in Figure 109.2. The measured current shall not exceed 0.2 milliampere through the 200-ohm resistor, if the frequency is 60 Hz. When using an rms-indicating voltmeter, the voltage at the network output shall not exceed 40 millivolts (minus 28 dBV), regardless of the frequency.

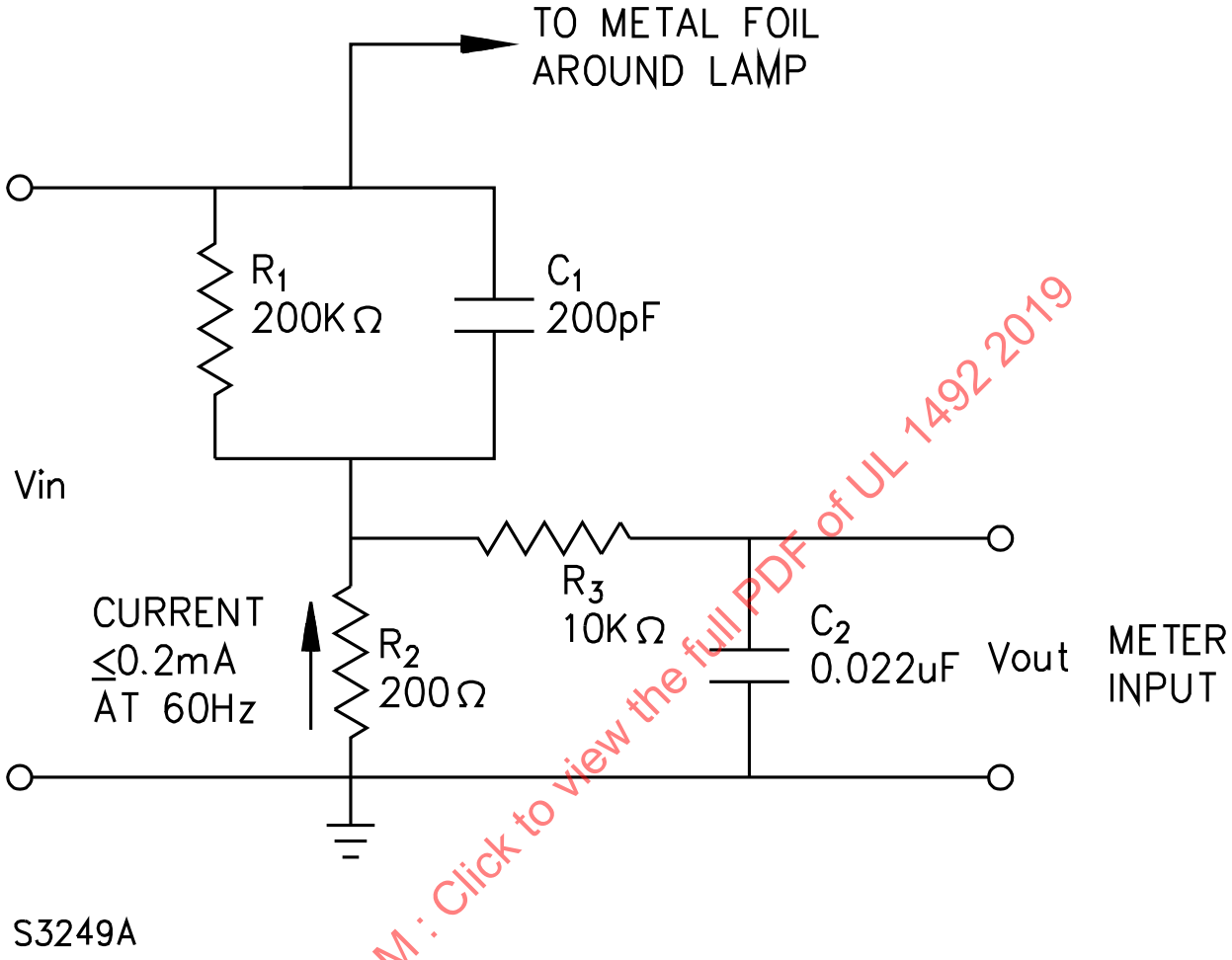
109.3.2 The measurements using metal foil as described in 109.3.1 are to be made under the following conditions:

a) Normal operation;

b) With a standard lamp or lamps and an energy-saving lamp or lamps; and

c) For multiple lamps, the other lamp or lamps are to be removed from the circuit, in turn, deactivated.

Figure 109.2
Reaction current network



NOTES

1) The current network consists of two portions, R_1–C_1–R_2 represents a body impedance compensation for a single hand grasping a lamp and contacting a grounded surface with a knuckle, and R_3-C_2 represents a frequency sensitive compensation (or weighting) where reaction to current and frequency are related.

2) To determine response of an actual network, a signal generator and a voltmeter can be used. The response at selected frequencies is shown in Table 109.2.

Table 109.2
Reaction current network attenuation

Frequency (Hz)	Attenuation[a]	
	Ratio (V_{in}/V_{out})	(dBV)
60	1000	-60.0
100	1010	-60.1
500	1207	-61.6
700	1365	-62.4
1000	1656	-64.4
2000	2629	-68.4
5000	4353	-72.8
10,000	5129	-74.2
20,000	5403	-74.7
50,000	5489	-74.8
100,000	5503	-74.8

[a] V_{in} = 1 volt and dBV = 20 $\log_{10}$ (V_{out}/V_{in}). See Figure 109.2.

110 Lamp Rupture Test

110.1 An LCD video product using a medium- or high-pressure lamp shall withstand a test (for example, by water or impact) that results in lamp rupture without emission of glass particles other than dust.

110.2 When conducting the lamp rupture test, the product is to be mounted in its intended operating position.

111 Lamp Particle Ignition Test

111.1 General

111.1.1 In accordance with Exception No. 1 to 48.2, a polymeric material shall be subjected to the test described in 111.2.1 – 111.2.4.

111.2 Test method

111.2.1 Three sections of the polymeric material, each a minimum of 51 mm square and of the thickness used in the lamp compartment, are to be supported by their outer edges and oriented as they would be during normal operation. A surface located 305 mm below the test samples is to be covered by a layer of dry, absorbent cotton that is nominal 6.4 mm.

111.2.2 During the test, each sample of the material is to be heated to and maintained at the maximum operating temperature recorded during the Temperature Test, Section 68.

111.2.3 Three quartz test segments, as specified in Table 112.1, are to be preheated to 1100°C for a minimum of 15 minutes.

111.2.4 Each quartz test segment is then to be placed on the material such that the longitudinal axis of the cylinder is perpendicular to the plane of the barrier. The transfer of each test segment from the oven to the surface of the material shall not exceed 2 seconds.

111.2.5 The results are considered acceptable if, during the testing of the samples, the dry absorbent cotton located below the test sample is not ignited by flaming drips of the polymeric material or any quartz test segment that penetrates the material and falls on the cotton.

112 Glass Thermal Shock/Containment Test

112.1 General

112.1.1 In accordance with Exception No. 2 to 48.2, a glass material shall be subjected to the glass thermal shock/containment test described in 112.2.1 – 112.2.3.

112.2 Test method

112.2.1 Each of three samples of the glass to be tested is to be supported by its outer edges and oriented as it would be during normal operation. The glass is to be maintained at a temperature of 25 ±5°C.

112.2.2 Three quartz test segments, as specified in Table 112.1, are to be preheated to 1100°C for a minimum of 15 minutes.

Table 112.1
Quartz test segments

Lamp wattage	Outer diameter, mm	Wall thickness, mm	Length, mm
400 or less	21.6	1.24	6.4
greater than 400	25.8	1.9	12.7

112.2.3 Each quartz segment is then to be removed from the oven and, within 2 seconds, placed on the thinnest part of each glass. Each quartz segment is to be placed on the glass such that the longitudinal axis of the segment is perpendicular to the plane of the glass.

112.2.4 The results are acceptable if none of the samples of the glass material shatter or crack.

113 Ozone Test

113.1 An LCD product that produces ozone during normal operation shall not produce an average, time-weighted concentration above background in excess of 0.1 parts per million, nor a transitory concentration of more than 0.3 parts per million, when tested in accordance with 113.2 and 113.3. The average, time-weighted concentration shall be considered as the average concentration over an 8-hour operation period.

113.2 Ozone concentration measurements are to be made at all probable operating positions with the product installed in the center of a closed room of approximately 28.3 m^3 – 2.44 by 3.70 by 3.05 m high. The product is to be operated with controls adjusted within the range of intended operation so as to produce maximum ozone. The test room is to be at normal temperature and relative humidity, and there is not to be circulation of air other than that resulting from product operation.

113.3 If operation of the product is possible with any of its fans not functioning, the test described in 113.1 is to be repeated with the various components not operating, to determine whether these conditions result in ozone concentrations above that specified in 113.2.

114 Ultraviolet Radiation Test

114.1 Products that produce ultraviolet radiation shall comply with the recommended guidelines for ultraviolet radiation as specified in the current edition of the Threshold Limit Values and Biological Exposure Indices issued by the American Conference of Governmental Industrial Hygienists.

114.2 When determining compliance with 114.1, all removable parts, such as lenses and filters, that are user-serviceable are to be removed from the product if their removal results in an increase in the amount of ultraviolet radiation exposure to the user.

115 Abnormal Operation Tests

115.1 An electric-discharge, lamp-supply circuit shall be subjected to the following tests:

a) For a rapid- or instant-start circuit, the test is to be conducted with a deactivated lamp.

b) For a preheat circuit, the test is to be conducted with either the starter short-circuited, or a lamp deactivated, so that maximum heating will result.

115.2 If a semiconductor component can be short-circuited but the lamp supply would appear to operate normally, the component shall be separately shorted.

115.3 There shall be no evidence of a risk of fire, electric shock, or injury to persons as a result of separately:

a) Simulating belt or blade breakage of a fan or blower assembly that ventilates the lamp.

b) Stalling the rotor of a drive motor, fan motor, or the like.

c) Blocking the ventilation path. Ventilating openings that are subject to the accumulation of dust, being placed on a rug, being positioned against drapes, or other similar circumstances are to be covered, one surface at a time, with three layers of cheesecloth loosely draped over the openings, such that the cheesecloth covers 100 percent of the opening areas.

115.4 When conducting the tests described in 115.3, products that include a projection lamp that may be independently switched on and off shall be tested with the lamp both energized and de-energized. If the lamp burns out during the test, the test is to be continued without replacement of the lamp. A new lamp is to be used for each test.

115.5 To determine whether a product complies with 115.1 – 115.4, it is to be tested as described in 74.1.1 – 74.3.1, 74.4.2 – 74.9.1, 74.10.1, and 74.11.1.

HIGH-VOLTAGE PRODUCTS

116 X-Radiation Test

116.1 The x-radiation of a product when measured as described in 116.2, shall not exceed a dose rate, averaged over an area of 10 square centimeters, of 0.5 milliroentgen per hour at any external location 5 cm from the outer surface of the overall enclosure of the product.

116.2 X-radiation measurements are to be made under the following conditions:

a) The product is to be complete, except that mechanical parts that need to be removed during user-servicing can be omitted if they are not necessary for the functioning of the product, not exposed to view during normal operation, and not held captive by a chain, hinge, loose rivet, or the like.

b) The voltage of the supply circuit is to be 130 volts if the rating of the product is within the range 105 – 130 volts, and 260 volts if the rating of the product is within the range 210 – 260 volts.

c) After measurements have been made with the supply voltage specified in (b), the supply voltage is to be adjusted to any other voltage within the mentioned ranges that results in greater x-radiation.

d) All user adjustments [see 15.1(d)] are to be positioned to cause maximum x-radiation during product operation with sound volume at any level, including no sound, and a usable picture. A usable picture consists of a display that is in synchronization and in which the picture size, color, shape (distortion), contrast, brightness content, and the like may be at any level of viewable intelligence.

e) In addition to the adjustments described in (d), all controls, regardless of location, are to be adjusted for maximum x-radiation during product operation with sound volume at any level, including no sound, and a usable picture. Service adjustments (adjustments provided to change the product performance) that are marked on the product or in the product service manual including those that involve the removal of components, the cutting of circuit conductors, the use of jumpers, and the like are to be considered as service controls and adjusted for maximum radiation.

f) In addition to the adjustments described in (d) and (e), all of the components the faulting (open-circuiting, change in value beyond tolerance limits, or short-circuiting) of which increases the x-radiation emission of the product are to be faulted one component and one fault at a time unless the faulting results in an unusable picture. The adjustments described in (d) and (e) are to be made before and after the component faulting is introduced.

g) For a multiple-function product, measurements are to be made with the product in any mode of normal operation, such as one with a video-tape playback unit operating at any one of its speeds that produces a usable picture.

h) When measuring x-radiation, picture information is to be injected into the product through the antenna terminals by means of a signal generator. The picture display is to be an Indian head, National Television Standards Committee color bar, or equivalent test pattern.

117 Arcing Test

117.1 With the product adjusted as described in 69.2.2 and 69.2.3, a part operating at more than 2500 volts peak and a part of different potential shall withstand the arcing test described in this Section without producing a risk of fire or electric shock.

117.2 In applying 117.1, a part that is not reliable insulation with regard to the temperature, voltage, arc tracking, and the like involved need not be subjected to the arcing test if the spacings specified in 117.7 are provided.

117.3 If an isolating power transformer is used in the product and arcing involves a part connected to the supply circuit, the test is to be conducted both with and without one side of the line connected to the chassis.

117.4 The test conditions are to be as described in 74.2.1, 74.3.1, 74.4.2 – 74.7.1, and 74.10.1 – 74.11.2.

117.5 All combustible parts operating at more than 2500 volts peak, and all combustible parts that form all or part of an enclosure of a part operating at more than 2500 volts peak, are to be conditioned for 168 hours in a full-draft, circulating-air oven at a temperature 20°C higher than the normal operating temperature, but not less than 70°C. The oven is to maintain a tolerance of ±2.0°C. The enclosure mentioned above refers to the individual enclosure of the high-voltage part and not to the overall enclosure (cabinet) of the product. If, during the conditioning mentioned above, wax or other materials melt out of the parts, the arcing test is to be conducted on samples in the as-received condition and also on samples that have been conditioned for 168 hours.

117.6 The arc, using the energy available from the parts involved, is to be established between the high-voltage part and any adjacent part of different potential where breakdown is likely to occur. See 117.7. The arc is to be used to attempt to ignite materials forming parts of the high-voltage enclosure or to ignite materials located between the parts of different potential. The arc is to be established by means of a conductive probe. The conductive probe is to be used to break through insulation (except previously investigated wire insulation) or to create arc tracking across the surface of insulating materials (for example, tube sockets, terminal boards, or the like). The arc length developed with the probe is not to exceed the spacing specified in Figure 117.1. The arcing is to be continued for 15 minutes at each location. During the 15-minute period, the arcing may be stopped at any time by disconnecting power to the product and the time of flaming measured. If the flame self-extinguishes in less than 30 seconds, the arcing is to be re-established and continued for a total arcing time of 15 minutes.

117.7 Breakdown shall be considered likely to occur between a high-voltage part and an adjacent part of different potential, if the over-surface or through-air spacings between the parts are less than those shown in Figure117.1. The arc-tracking characteristics of insulating materials are to be determined by the tests described in the Standard Test for High-Voltage, Low-Current, Arc Resistance of Solid Electrical Insulating Material, ASTM D495.

117.8 A spark gap or a gaseous discharge tube can be used as a means of preventing electrical breakdown in other parts of the circuit if, upon investigation, it is determined to be acceptable.