UL 150

STANDARD FOR SAFETY

Antenna Rotators

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UL Standard for Safety for Antenna Rotators, UL 150

Fourth Edition, Dated November 9, 2004

Summary of Topics

This revision to ANSI/UL 150 dated September 1, 2020 is being issued to update the title page to reflect the most recent designation as a Reaffirmed American National Standard (ANS). No technical changes have been made.

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

The requirements are substantially in accordance with Proposal(s) on this subject dated June 26, 2020.

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UL 150

Standard for Antenna Rotators

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Fourth Edition

November 9, 2004

This ANSI/UL Standard for Safety consists of the Fourth Edition including revisions through September 1, 2020.

The most recent designation of ANSI/UL 150 as a Reaffirmed American National Standard (ANS) occurred on August 31, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover antenna rotators intended for household and commercial use on supply circuits in accordance with the National Electrical Code, NFPA 70.

1.2 An antenna rotator generally consists of:

a) A mast-mounted (generally outdoors), motorized drive unit that rotates the antenna to the desired receiving azimuth,

b) An indoor-located (usually near television- or radio-receiving equipment) user-operated control unit that delivers operating power and direction signals to the drive unit, and,

c) A length of multiple-conductor Class-2 circuit cable to electrically interconnect the drive unit and the control unit.

Some antenna rotating units may control antenna elevation separately or in addition to azimuth. In some cases, the drive unit may be located indoors.

1.3 The power used to drive the motor of an antenna rotator is derived from a circuit complying with Class 2 limitations in accordance with Article 725 of the National Electrical Code, ANSI/NFPA 70.

1.4 These requirements do not cover systems that use a stationary antenna and change or rotate the receiving pattern by electronic or switching means. Such systems are covered by the Standard for Audio-Video Products and Accessories, UL 1492.

2 General

2.1 Components

2.1.1 A component shall be used in accordance with its rating established for the intended conditions of use. See Appendix A for a list of standards covering components generally 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 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.2 Units of measurement

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

2.2.2 Alternating-current electrical measurements are in rms units unless otherwise stated.

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2.3 Undated references

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

3 Glossary

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

3.2 ACCESSIBLE PART – A part located so that it can be contacted by means of a probe. See Accessibility of Parts, Section 10.

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

3.4 CONTROL UNIT – A user-operated, indoor-mounted unit with total output limited to Class 2 levels (see 1.3), the primary function of which is to deliver power to and control a drive unit.

3.5 DRIVE UNIT – A mast-mounted (generally outdoors), motorized unit that may be user-installed and is intended to position an antenna and that requires an energy source limited to Class 2 levels. See 1.3.

3.6 FIBER – Vulcanized fiber.

3.7 INSULATION, BASIC – The insulation necessary for the intended functioning of the product and for basic protection to reduce the risk of electric shock.

3.8 INSULATION, REINFORCED – An improved basic insulation with mechanical and electrical qualities such that it, in itself, provides the same degree of protection to reduce the risk of electric shock as an insulation system comprised of both basic insulation and supplementary insulation.

3.9 INSULATION, SUPPLEMENTARY – An independent insulation provided in addition to the basic insulation to provide protection to reduce the risk of electric shock in case of electrical breakdown of the basic insulation.

3.10 MAJOR ENCLOSURE PART – A part of the enclosure that:

a) Forms more than 50% of any one surface, and

b) Is needed to comply with the requirements to

1) Reduce the risk of fire, electric shock, or injury to persons, or

2) Reduce the risk of mechanical damage to internal parts.

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

3.12 OPERATING CONTROL – A control, usually a knob, pushbutton, or 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.

3.13 ORDINARY TOOLS – Flat-bladed and cross-head screwdrivers, nut-drivers, pliers, and the like.

3.14 POWER-SUPPLY CORD – The cord provided to connect the control unit to the supply circuit.

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

3.16 UNINSULATED PART – A part that is bare (without insulation) or has insulation that is not suitable for the operating conditions (such as potential and temperature) involved.

3.17 USER SERVICING – User servicing includes:

a) Fuse – Replacement of a fuse other than:

1) A fuse intended to be soldered in place.

2) A fuse not readily perceptible to the user. A fuse is not readily perceptible if it is located within a chassis, compartment, or enclosure within the overall product that makes the fuse invisible to the user. If the enclosure has a cover, it is to be one that:

i) Does not need to be opened or removed in normal operation or user servicing,

ii) Can be opened or removed only with a tool, and

iii) Is prevented from being discarded.

A fuse is readily perceptible if it is recognizable during normal operation or user servicing, either visually or by touch; or if the fuse is indicated, either on the product or on literature packed with it.

3) A clipped-in-type fuse that is within a compartment provided with the marking described in 53.4.1.

b) User Adjustment – Adjustment of a marked adjustable control or an adjustable component if the adjustment can be accomplished:

1) By using an ordinary tool,

2) With the product in operation, and

3) Without defeating an interlock.

c) Unmarked Adjustment – Adjustment of an unmarked adjustable control if the adjustment can be accomplished:

1) Without a tool,

2) With the product in operation, and

3) Without defeating an interlock.

d) Lamp – Replacement of lamp, whether a single lamp or one of a series or parallel string, intended for connection directly across the supply circuit of a nominal 120 or 220 V.

Exception: This requirement does not apply to a lamp that is intended to be soldered in place and is soldered in place in the product, or a neon lamp, such as an electric-discharge lamp with neon as the filling gas.

3.18 WET LOCATION – In direct contact with earth and locations subject to saturation with water, or unprotected and exposed to weather.

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CONSTRUCTION

4 General

4.1 The construction of a product shall be such that:

a) Intended use and user servicing 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.

4.2 The materials and components referred to in 4.1 and elsewhere in these requirements are those involving a risk of fire, electric shock, or injury to persons and are so considered unless specifically indicated otherwise.

4.3 A product shall be formed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it might be subjected, without causing a risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacing, loosening, or displacement of parts, or other serious defects.

5 Enclosure

5.1 Control unit

5.1.1 A control unit shall be provided with an enclosure that houses all live parts, other than cords and cables, that involves a risk of fire, electric shock, or injury to persons. The enclosure shall be constructed to reduce the risk of mechanical damage to the various parts of the product.

5.1.2 Major enclosure parts (see 3.10) that are molded of polymeric material shall be identified in accordance with the Standard for Polymeric Materials – Fabricated Parts, UL 746D.

5.2 Drive unit

5.2.1 A drive unit shall be provided with a metallic enclosure that renders all live parts that involve a risk of electric shock or injury to persons inaccessible as specified in Accessibility of Parts, Section 10.

Exception: A polymeric enclosure may be employed if found to comply when investigated in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6 Mechanical Assembly

6.1 A switch, lampholder, attachment plug, or similar component shall be mounted securely and prevented from turning.

Exception No. 1: A switch need not be prevented from turning if any one of the following conditions 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 the normal operation of the switch,

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b) The means of mounting the switch make it unlikely that operation of the switch will loosen it,

c) The spacings are not reduced below the minimum acceptable values, as determined using Section 23, if the switch rotates, and

d) The normal 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 where the lamp is sealed in by a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum acceptable values, as determined using Section 23.

Exception No. 3: A user-accessible lampholder intended to be readily removable without the use of a tool need not be prevented from turning.

6.2 An uninsulated live part shall be secured to the base or mounting surface so that it will be prevented from turning or shifting in position if such displacement can result in a reduction of spacings below the minimum acceptable values, as determined using Section 23.

6.3 The means for preventing the turning or shifting mentioned in 6.1 and 6.2 is to consist of more than friction between surfaces; for example, a lock washer is suitable for use as the means for preventing a small stem-mounted switch or other device that has a single-hole mounting means from turning.

7 Materials

7.1 General

7.1.1 Cellulose nitrate or any comparably flammable material shall not be used.

7.1.2 A material shall comply with the applicable requirements in Table 7.1.

Exception: This requirement does not apply to a drive unit.

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Table 7.1
Material flammability requirements

	Material and application	Minimum flammability classification[a]
1.	Fiber and similar material regardless of use or location	V-1
2.	Polymeric material in contact with an uninsulated part that involves a power greater than 15 W[b, c]	V-2 or HF-2
3.	Polymeric material used as a required part of the enclosure	V-2
4.	Material in contact with an uninsulated part that involves a power equal to or less than 15 W[b, c]	HB or HBF
5.	Material used in applications other than those specified in (1 – 4)	HB or HBF

NOTE – The requirements in Table 7.1 do not apply to a small part. For the purpose of Table 7.1, a small part is defined as one that complies with all of the following items:

1) Its volume does not exceed 0.122 in^3 (2 cm^3).

2) Its maximum dimension does not exceed 1.18 in (3 cm).

3) 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.

[a] The flammability classifications (V-0, V-1, V-2, and HB if the specific gravity is equal to or greater than 0.6; or, HF-1, HF-2, and HBF if the specific gravity is less than 0.6) are to be determined by the tests described in the Standard for Tests for Flammability of Plastic Materials in Devices and Appliances, UL 94. Test samples are to be flat stock approximately 5-in (127-mm) long, 1/2-in (12.7-mm) wide, and of the smallest thickness used; or, for an assembly, the samples may consist of the assembly. 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, larger samples of the same material can be tested, provided they represent thicknesses that are the same or less than the part in question. None of the larger samples is to be entirely consumed by flame. Samples that consist of an assembly or a section thereof, and that are not flat stock samples are to be positioned in what is considered to be the position most conducive to burning. A material for a part, other than the enclosure, rated using 1/16-in (1.6-mm) thick bar specimens may be accepted in lesser thicknesses in the end product. For polymeric enclosures, a material rated using 1/8-in (3.2-mm) thick bar specimens may be accepted in lesser thicknesses in the end product.

[b] Does not apply to the internal insulation system of a component or where component requirements exist (see 2.1.1).

[c] Power measured in accordance with 43.1.1.

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7.1.3 A material in contact with an uninsulated live part shall comply with the requirements in 7.1.4 and 7.1.5.

7.1.4 A material in contact with an uninsulated live part shall have a dielectric strength of at least 175 V per mil (7000 V/mm) after conditioning for 96 h at 35.0 ±1.0°C (95.0 ±1.8°F) and 90 ±5% relative humidity, conducted in accordance with the Standard Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies, ASTM D149.

7.1.5 A material in contact with an uninsulated live part shall have a volume resistivity of:

a) At least 50 MΩ-cm as measured after conditioning for 40 h at 23.0 ±1.0°C (73.4 ±1.8°F) and 50 ±5% relative humidity as indicated in Procedure A of the Standard Practice for Conditioning Plastics for Testing, ASTM D618, and

b) 10 MΩ-cm after being conditioned for 96 h at 35.0 ±1.0°C (96.8 ±1.8°F) and 95 ±5% relative humidity as indicated in Procedure C conducted in accordance with the Standard Test Methods for D-C Resistance or Conductance of Insulating Materials, ASTM D257.

7.2 Guard and barrier insulating material for rendering live parts inaccessible

7.2.1 A guard or barrier of insulating material employed to parts involving a risk of electric shock or injury to persons in order to render the part inaccessible shall:

a) Not be less than 0.028-in (0.71-mm) thick.

Exception No. 1: Fiber or the equivalent that is not less than 0.013-in (0.33-mm) thick may be used to cover a splice within the overall enclosure.

Exception No. 2: A covering of paper that is not less than 0.028-in thick may be used on an electrolytic capacitor or similar part.

Exception No. 3: A fiber shell of a metal-jacketed pilot lampholder covering all live parts may not be less than 0.020-in (0.51-mm) thick.

b) Comply with the requirement specified in 7.1.2.

8 Protection Against Corrosion

8.1 A metal part, unless inherently corrosion resistant, shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means, if corrosion of the unprotected part would result in a risk of fire, electric shock, or injury to persons.

9 Current-Carrying Parts

9.1 A current-carrying part shall be of silver, copper, a copper-base alloy, stainless steel, aluminum, or other material acceptable for the intended use.

Exception No. 1: Plated steel may be used for secondary-circuit parts and for some primary-circuit parts, such as for capacitor terminals where a glass-to-metal seal is necessary and for leads or threaded studs of semiconductor devices.

Exception No. 2: Blued steel or steel that is equivalently resistant to corrosion is acceptable for the current-carrying arms of a mechanically or magnetically operated leaf switch, but not elsewhere.

9.2 A contact of a socket, separable connector, and similar parts, connected in a circuit involving a risk of fire shall be made of nonferrous spring metal acceptable for the intended use.

10 Accessibility of Parts

10.1 General

10.1.1 A part that involves a risk of electric shock or injury to persons shall not be accessible to the extent that it can be touched during normal operation or user servicing. See Electric Shock, Section 11.

10.1.2 An opening in an enclosure is acceptable if the opening will not permit the entrance of a 1-in (25.4-mm) diameter sphere and the probe illustrated in Figure 10.1 cannot be made to touch any uninsulated live part, film-coated wire, or moving part when inserted into the opening. The probe may be articulated into any configuration and may be rotated or angled to any position before, during, or after insertion into the opening, and the penetration may be to any depth allowed by the opening size, including minimal depth combined with maximum articulation. No force is to be applied to the probe.

10.2 Control unit

10.2.1 When determining the accessibility of parts of a control unit, any of the following operations may be performed.

a) Removal or opening of friction-fit knobs, snap covers, and similar loose parts;

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b) Removal, opening, or loosening of parts as described in the installation and operating instructions; and

c) Removal of knobs not captive in accordance with Captive Parts, Section 21.

10.3 Drive unit

10.3.1 The accessibility of parts of a drive unit is to be determined only after the installation of the unit has been completed in accordance with the manufacturer's installation instructions.

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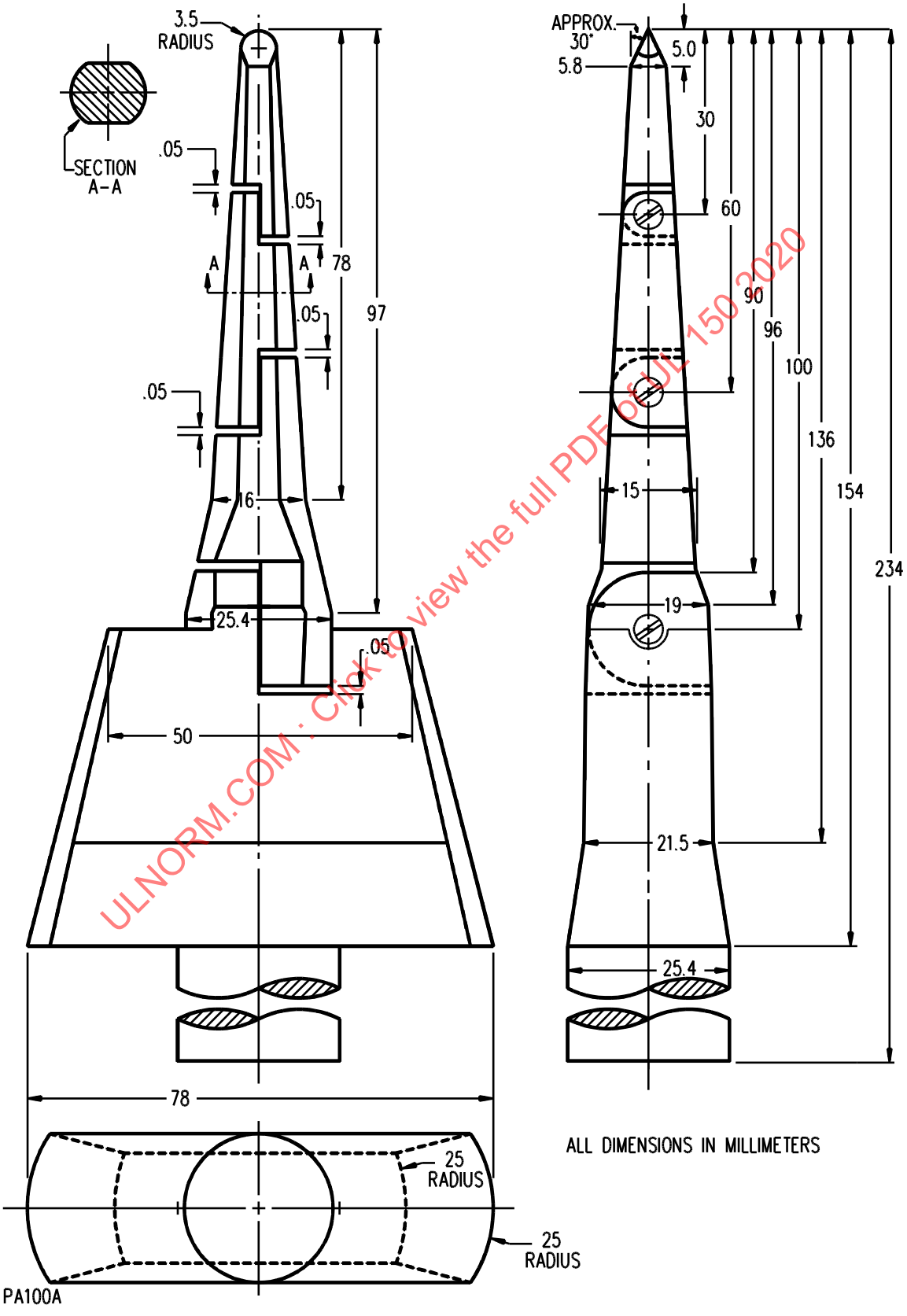
Figure 10.1

Probe for determining accessibility of live parts



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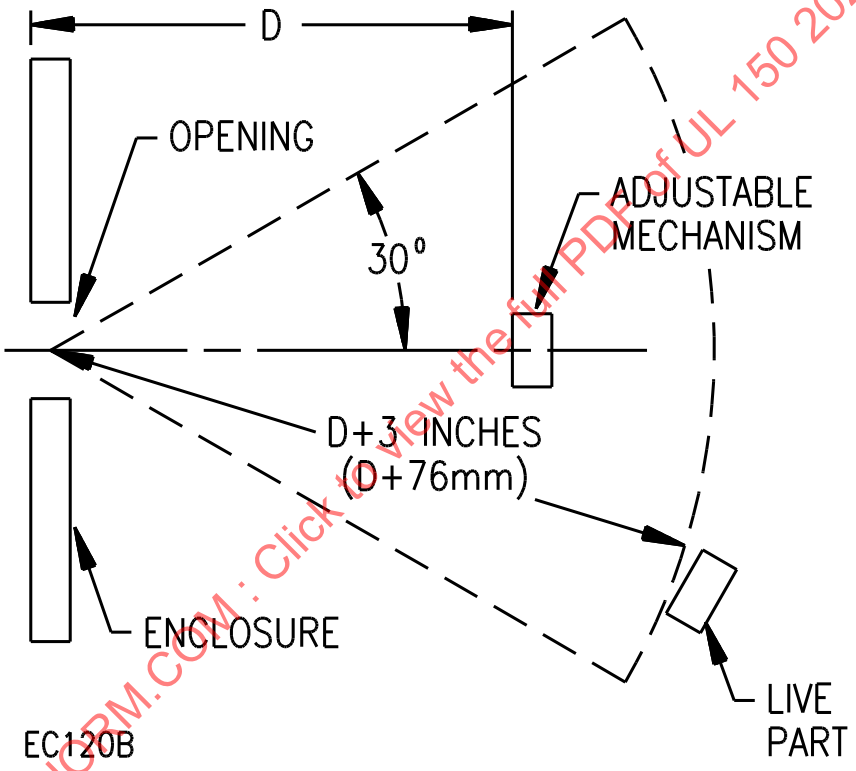
10.4 Adjustment openings and control shafts – control unit

10.4.1 A part beyond an opening in a control unit that may be used in making an adjustment considered to be a function of user servicing, is considered not to be accessible if a 1/8-in (3.2-mm) diameter straight rod is unable to touch the part when the rod is inserted through the opening and moved to all positions possible without producing an angle of more than 30° 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 inside the opening is not to exceed the distance between the opening and the face of the adjusting mechanism by more than 3 in (76.2 mm). See Figure 10.2

Figure 10.2

Accessibility of live part through adjustment opening



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10.4.2 A control shaft formed of polymeric material is not considered to be part of the enclosure, but may be considered to be a barrier.

10.5 Top opening – control unit

10.5.1 An opening in the top of the overall enclosure of a control unit shall not permit passage of a sphere having a diameter of 3/32 in (2.4 mm), if passage of a conductive object through the opening results in a risk of electric shock.

Exception No. 1: An opening such as D in Figure 10.3, in a top surface that makes an angle of 30° or more with the horizontal is acceptable if the opening projection onto a horizontal plane does not exceed 3/32 in 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° to the horizontal.

Exception No. 2: An opening in the top of an overall enclosure having a dimension larger than 3/32 in and protected by a knob, handle, louver, or similar part is acceptable if:

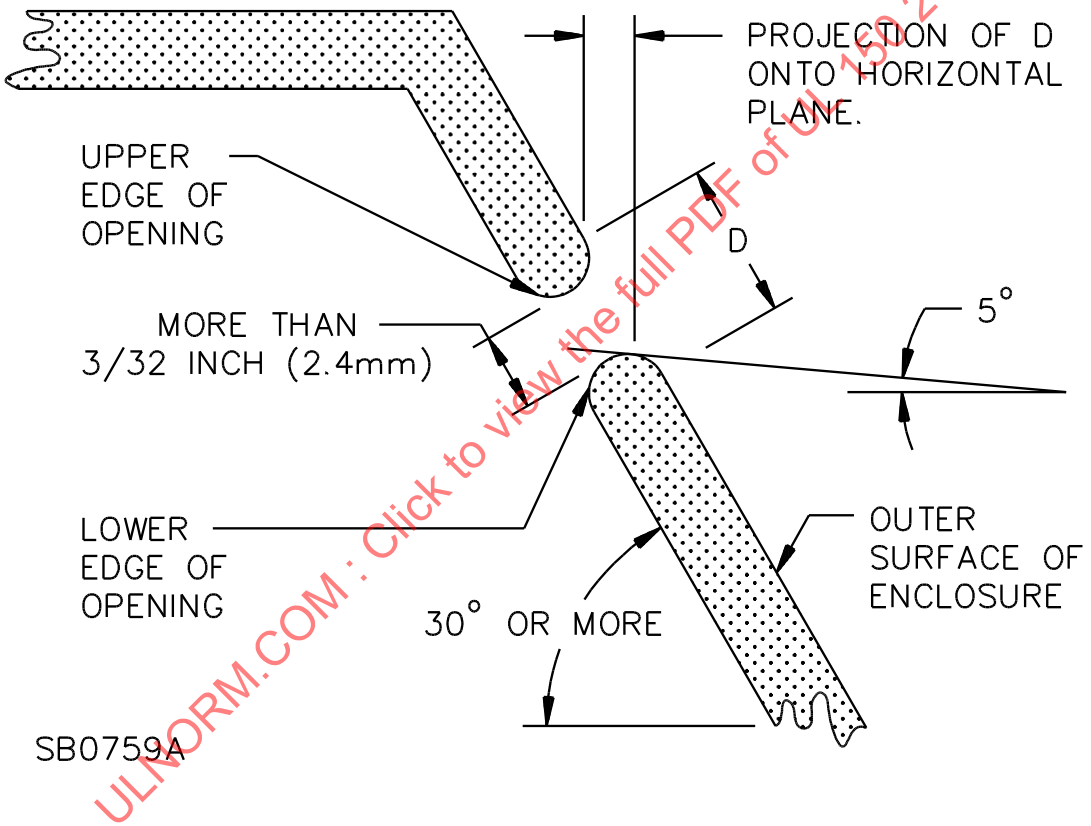
a) A falling object cannot pass directly through the opening in a vertical direction; and

b) The construction is such that an object placed at any point on the enclosure top does not slide or roll into a top opening. See 10.5.3.

This generally requires a 1/16-in (1.6-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 actually contacting the enclosure.

Figure 10.3

Cross section of enclosure showing opening



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10.5.2 During evaluation of a product according to the requirement in 10.5.1, all of the following apply:

a) The top of the overall enclosure is considered to be that portion of the enclosure that is visible in a plan view when the product is resting on a horizontal surface.

b) Only those covers needed for operation are to be opened.

c) Pushbuttons are to be in the maximum displaced position that the construction permits.

10.5.3 During applications of the requirement in Exception No. 2(b) to 10.5.1, openings other than top openings into which an object might slide or roll shall be evaluated according to the intent of the requirement.

11 Electric Shock

11.1 A risk of electric shock exists at any part if:

a) The open-circuit potential between an accessible part and earth ground or any other simultaneously accessible parts (see 34.1.4) is:

1) More than 30 V rms (42.4 V peak) if wet contact is not likely to occur; or

2) More than 15 V rms (21.2 V peak) if wet contact is likely to occur; and

b) Any of the following conditions exist:

1) The leakage current (measured according to the Leakage-Current and Shock-Current Tests, Section 34) at any accessible part exceeds 0.5 mA.

2) A continuous current flow through a 500-Ω resistor (measured according to Leakage Current and Shock Current Test, Section 34), at a part exposed only during user-servicing, exceeds the limits specified in Table 34.1

12 Supply Connections

12.1 General

12.1.1 A control unit shall be provided with a length of flexible cord and an attachment plug for connection to a supply circuit.

12.2 Power-supply cord

12.2.1 The ampacity of the cord shall not be less than the sum of the marked current rating of the product and the marked current rating of all conventional parallel-slot receptacles used to supply power to another product or accessory.

12.2.2 A power-supply cord shall be one of the types specified in Table 12.1, or of a type rated for equivalent or heavier duty.

Table 12.1
Cords for products

Type of cord	Maximum length, ft (m)
SPT-2	10 (3.05)
SJ, SJT	25 (7.62)

12.2.3 The length of the cord shall not be more than specified in Table 12.1 and not less than 5-1/2 ft (1.68 m).

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

12.2.5 A power-supply cord shall have a flame-retardant rating of VW-1.

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12.3 Cord strain relief

12.3.1 The power-supply cord shall be attached to the product so that a mechanical stress on the cord leaving the overall enclosure cannot:

a) Be transmitted to terminals, splices, or interior wiring;

b) Separate an interlock connector from the part of the product to which it is attached; or

c) Damage an interlock so that it does not perform its intended function.

12.3.2 To determine compliance with 12.3.1, the product is to be subjected to the Strain Relief Test, Section 45.

12.3.3 If a knot in a power-supply cord serves as strain relief, any surface which the knot may contact shall be free from projections, sharp edges, burrs, fins, and the like, that can cause abrasion of the insulation on the cord.

12.4 Cord push-back relief

12.4.1 The power-supply cord shall be provided with a means that prevents the cord from being deliberately pushed inside the enclosure if any of the following can occur when pushed inside:

a) The insulation on the cord is subjected to temperatures or voltages that exceed those for which it is rated,

b) The cord can come in contact with a sharp edge or moving part that could damage insulation,

c) The cord displaces a part resulting in a reduction of spacings below acceptable values, as determined using Section 23, or

d) The cord places stress on internal connections.

12.5 Bushings

12.5.1 An opening in a wall, barrier, or overall enclosure through which a supply cord passes shall be provided with a bushing or the equivalent that is substantial, secured in place, and that has a smooth, rounded surface against which the cord may bear. A smooth metal bushing is acceptable if a Type SJ or heavier cord is used.

Exception: If the exit for the cord is in wood, wood composition, or an insulating material, a surface free of fins, burrs, and the like, is considered equivalent to a bushing.

12.5.2 Ceramic, porcelain, phenolic, and some molded compositions are acceptable for insulating bushings. A separate bushing shall not be made of wood or rubber.

12.5.3 Fiber may be employed if the finished bushing is not less than 3/64-in (1.2-mm) thick and is formed and secured in place so that it will not be adversely affected by ordinary moisture.

12.5.4 A bushing of the same material as, and molded integrally with, the supply cord is acceptable if the built-up section is not less than 1/16-in (1.6-mm) thick at the point at which the cord passes through the enclosure.

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

12.6 Cord Routing

12.6.1 A separate flexible cord or wire that is not connected in the supply circuit or that does not involve a risk of fire or electric shock shall not be routed through a bushing or opening with the power-supply cord at a point of flexure.

12.7 Attachment plug

12.7.1 An attachment plug shall have a configuration complying with the Wiring Devices – Dimensional Specifications, ANSI/NEMA WD6. It shall be of a type acceptable for use with a current not less than the rated current of the product and at a voltage equal to the rated voltage of the product. If the product can be adapted for use on two or more different supply voltages by means of an input voltage selector, the attachment plug provided with the product shall be configured and rated for one of the voltages for which the product is intended to be connected.

12.8 Polarization

12.8.1 A product shall be provided with a polarized attachment plug of the 2-wire, parallel-blade configuration or the 3-wire grounding configuration that complies with all of the following:

a) There shall be no risk of electric shock with the attachment plug inserted in the supply-circuit receptacle and then with the supply-circuit connections reversed.

b) A switch; the center contact of a lampholder; or a circuit breaker, fuse, or other protective device shall not be connected in a circuit that is connected to the grounded supply-circuit conductor of the attachment plug.

Exception: A switch or protective device which simultaneously interrupts all conductors of the supply circuit may be connected to the ground supply conductor.

c) 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.

d) A parallel-slot receptacle provided on the product shall be of a polarized type and shall be polarized. The identified (grounded) terminal of the receptacle shall be connected to the supply circuit conductor of the attachment plug that is intended to be grounded.

12.8.2 For evaluation of the risk of electric shock, the conductor of the supply circuit that is connected to the grounded supply-circuit conductor of the attachment plug (wide blade on a polarized 2-wire plug, and the right-hand blade of a 3-wire plug when looking at the face of the plug with the grounding pin down) is considered to be at grounded potential.

Exception: If there is no risk of electric shock when the supply circuit connections are reversed as in 12.8.1(a), the conductor need not comply.

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13 Grounding

13.1 General

13.1.1 If a product is provided with a grounding type (3-wire) supply cord, it shall comply with the requirements in 13.1.2 – 13.3.1.

13.1.2 An equipment-grounding conductor of a flexible cord shall be:

a) Finished to show a green color or green with one or more yellow stripes;

b) Connected to the grounding member of an attachment plug having a fixed grounding contact;

c) Connected to the frame or enclosure of the product by a screw or other means not likely to be removed during servicing that does not involve the power-supply cord. Solder alone shall not be used for securing a grounding conductor; and

d) Of at least the same size as the other conductors of the cord.

13.1.3 The screw mentioned in of 13.1.2(c) shall be of corrosion-resistant metal, or shall be protected against corrosion in a manner that will not inhibit electrical conductively between the screw and any other conductor. A lock washer shall be employed to prevent the screw from becoming loosened by vibration.

13.1.4 If a grounding means is provided on a product, all exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during any servicing operation and are able to become energized shall be connected to the grounding means.

13.1.5 With reference to the requirement in 13.1.4, the following dead metal parts do not involve a risk of becoming energized:

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

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

2) Electrically isolated from all electrical components.

b) A panel or cover that does not enclose insulated live parts and is electrically isolated from other electrical components.

c) Cores and assembly screws or a relay, a solenoid, and similar parts.

13.1.6 It may not be practical to connect certain conductive parts – control shafts, mounting screws, and similar parts – to the grounding means. Such parts do not involve a risk of becoming energized if supplementary insulation is employed in addition to the basic insulation provided. Where it is impractical to provide separate basic insulation and supplementary insulation, reinforced insulation may be used.

13.1.7 Basic insulation shall have a dielectric voltage-withstand capability of 1000 V for 1 min and a minimum through-air over over-surface spacing of 1/16 in (1.6 mm).

13.1.8 The insulation qualities and the resistance to deterioration with aging of a material employed as supplementary insulation shall not be less than that which would be required for the same material employed as basic insulation. The minimum spacing through supplementary insulation used in circuits involving 125 V or less shall be 1/32 in (0.8 mm) and this insulation shall have a dielectric voltage-withstand capability of at least 2500 V for 1 min. The minimum through-air or over surface spacing between conductive parts separated by supplementary insulation shall be 1/16 in (1.6 mm).

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13.1.9 The insulation qualities and resistance to deterioration with aging of a material employed as reinforced insulation shall not be less than the total of that which would be required for the combination of basic and supplementary insulation. The minimum spacing through reinforced insulation used in a circuit involving 125 V or less shall be 5/64 in (2.0 mm) and this insulation shall have a dielectric voltage-withstand capability of at least 3500 V for 1 min. The minimum through-air or over surface spacing between a live part and an accessible conductive part shall be 1/8 in (3.2 mm).

13.2 Grounding-type cord-connector body

13.2.1 If a product is provided with a power-supply cord or extension cord incorporating a separable cord-connector body and has conductive parts that are connected to the grounding conductor that may be contacted during the connection or disconnection of the cord-connector body at the product end of the cord, the construction shall be such that the grounding connection is made first and broken last with respect to the power-supply conductor.

13.3 Grounding adapters

13.3.1 A grounding adapter packaged with a product equipped with a grounding-type supply cord shall not be attached to the attachment plug before reaching the user. Also, see 53.6.1.

13.3.2 A convenience receptacle provided on a product that is intended to be grounded shall be of a grounding type. The grounding contact of the receptacle shall be electrically connected to the grounding means of the product.

14 Transformers

14.1 A transformer or motor transformer that is normally connected across the supply circuit shall comply with the construction requirements in the Standard for Transformers and Motor Transformer for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411.

15 Capacitors

15.1 The voltage rating of a capacitor shall equal or exceed the maximum steady-state potential to which the capacitor is subjected during normal operation of the product.

15.2 A capacitor shall employ materials and be constructed so that it will not constitute a risk of fire or injury to persons. A paper capacitor shall be impregnated or otherwise enclosed to exclude moisture. A paper cover for a capacitor shall not be less than 0.028-in (0.71-mm) thick if a risk of electric shock is involved.

15.3 A capacitor employing a liquid dielectric medium more combustible than askarel shall not expel the dielectric medium when tested in accordance with the applicable performance requirements in this standard, including faulted overcurrent conditions based on the branch circuit in which it is used.

15.4 A capacitor shall comply with the applicable requirements in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414 when the capacitor is:

a) Connected across the supply circuit, or

b) Used in primary supply circuits for line bypass or metal-enclosure isolation, or

c) Connected between live parts and exposed metal parts, or

d) Used for antenna blocking.

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15.5 A capacitor is considered to be connected across the supply circuit when used in any of the following applications:

a) With the capacitor in a shorted condition and with the product in a heated condition, a primary-circuit current of more than 1 A passes through the capacitor. The current through the capacitor can be limited to 1 A or less by a fixed impedance or a protective device rated 1 ampere or less; or

b) A capacitor used for line bypass in a product provided with a terminal or connector intended to be grounded.

15.6 If the current through a capacitor is not limited to 1 A or less in accordance with 15.5 (a), the combination of the capacitor and the limiting means shall comply with the applicable requirements in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

16 Lampholders

16.1 The terminals of a lampholder shall be securely riveted or otherwise secured in place. The center contact and its mounting shall be secured so that it will be held within the shell when the lamp is removed. The lampholder terminals and other live parts, including the lamp base, shall be protected so that grounding or a risk of electric shock during use or user servicing is unlikely.

17 Receptacles

17.1 An unused receptacle that involves a risk of electric shock, such as one provided for the attachment of an accessory, shall not be of the type employed as a receptacle for a single-prong, shielded-type phonograph plug, and if of the conventional parallel-slot type shall involve line power only. See 12.8.1(d) and 13.3.2.

17.2 If the face of a receptacle is less than 5/8-in (15.9-mm) wide or less than 7/8-in (22.2-mm) long, the face of the receptacle shall project not more than 3/26 in (4.8 mm) from the part of the mounting surface that is within a rectangle 5/8-in wide and 7/8-in long symmetrically located about the receptacle contacts; and if the mounting surface is conductive, the face of the receptacle shall project not less than 3/32 in (2.4 mm) from that part of the mounting surface.

17.3 The area surrounding an unused attachment-plug receptacle shall be free of any projections that would prevent full insertion of the blades of a circular attachment plug having a face diameter of 1-3/16 in (30.2 mm).

Exception: Projections that prevent the blades of the attachment plug from being inserted to make electrical contact with the contacts of the receptacle are considered to comply.

18 Overload Protection

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

19 Wiring

19.1 Sleeving, tape, tubing, and wire insulation– control unit

19.1.1 Sleeving, tape, tubing, and wire insulation employed on wiring or parts of a control unit 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 of VW-1.

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Exception: Sleeving, tape, tubing, and wire insulation employed on wiring or parts not involving a risk of electric shock or on wiring or parts having available power of 15 W or less as determined by the procedure described in the Available-Power Test, Section 43, need not be flame retardant, provided they are segregated (such as by routing) from parts involving a risk of electric shock or power of more than 15 W.

19.2 Mechanical protection

19.2.1 Wire smaller than 24 AWG (0.21 mm^2) shall be protected against mechanical damage, taking into consideration the effects of vibration, impact, and handling during user servicing.

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

19.2.3 Wiring not involving a risk of electric shock that is not housed entirely within the enclosure and that may contact a part involving a risk of fire or electric shock shall be insulated within the enclosure. Such wiring shall be provided with strain and push-back relief that complies with the requirements specified in 12.3.1(a) and in 12.4.1.

19.3 Cable and wiring subject to motion

19.3.1 If damage to the insulation of wire, cable, or cord that is subject to stress or motion either inside or outside the control unit enclosure can result in a risk of fire or electric shock, the wire, cable, or cord shall:

a) Comply with the requirements in the Flexing Test, Section 47, to determine that continued operation under the stress or motion to which it is subjected will not cause such damage; and

b) Be provided with the following, as applicable:

1) If located within the enclosure, insulation between conductors, and between conductors and adjacent conductive parts, at all points of stress or motion.

2) If located outside the enclosure, strain relief in accordance with 12.3.1(a) and a bushing in accordance with 12.5.1 – 12.5.5.

19.4 Opening in metal

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

20 Connectors, Components, and Leads

20.1 Quick-connect terminals

20.1.1 A nominal 0.110-, 0.125-, 0.187-, 0.205-, or 0.250-in wide quick-connect terminal shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310. Other sizes of quick-connect terminals shall be investigated with respect to crimp pull-out, engagement-disengagement forces of the connector and tab, and temperature rises; all tests are to be conducted in accordance with UL 310.

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20.2 Aluminum terminations

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

20.2.2 With reference to 20.2.1, a wire-binding screw or a pressure wire connector used as a terminating device shall be a type intended for use with aluminum under the conditions involved; for example, temperature, heating cycling, and vibration.

21 Captive Parts

21.1 General

21.1.1 A part of the product that is essential for compliance with the requirements in this standard shall be made captive or otherwise arranged so that it will not 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 normal use (see 3.17(a)(2) for the definition of readily perceptible).

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

21.2 Captive knobs

21.2.1 A captive knob and shaft assembly shall withstand the tests specified in 48.3.1 (pressure), 48.4.1 (impact), and 48.6.1 (pull), without exposing parts involving a risk of electric shock or injury to persons, or adversely affecting the means provided to make the part captive.

22 Switches

22.1 General

22.1.1 A switch connected to wiring involving a risk of fire or electric shock and not employed to control the drive unit shall be acceptable for the intended use and have an electrical rating not less than the maximum steady-state current it controls.

22.2 Drive-unit-control switches

22.2.1 A switch in the control unit that is employed to energize the drive unit shall be of the momentary contact type, or of a type that will automatically open the circuit supplying the drive unit within one revolution of antenna rotation. The switch may be located in the primary or secondary circuit.

22.2.2 A switch that controls a drive unit shall comply with Drive-Unit-Control Switch Tests, Section 44.

Exception: The switch need not be subjected to the tests in Section 44 if it is connected in a circuit complying with Control-Unit-Output Limitations, Section 24.

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23 Spacings

23.1 Primary circuits

23.1.1 In primary circuits, there shall be a spacing through air or over surface between uninsulated live parts of opposite polarity, and between an uninsulated live part and dead metal parts of not less than 1/8 in (3.2 mm).

Exception: This requirement does not apply if the location and relative arrangement of parts are such that acceptable permanent separation is provided. Such spacings are to be judged on the basis of the Dielectric Voltage-Withstand Test, Section 40.

23.1.2 When measuring spacings between parts where hand soldering is involved, the spacing may be measured assuming production accumulations of solder on parts and lead connections.

23.2 Barriers and liners

23.2.1 A barrier or liner of fiber or similar material, employed where spacings would otherwise be unacceptable between uninsulated live parts of opposite polarity involving a risk of fire or electric shock or between such parts and exposed dead metal parts, shall:

a) Not be less than 0.028-in (0.71-mm) thick.

Exception: If the barrier or liner is used in conjunction with an air spacing not less than one-half the required spacing through air, the thickness may be not less than 0.013 in (0.33 mm).

b) Comply with the requirements specified in 7.1.2 and 7.1.3.

c) Comply with the applicable Strength of Enclosure Tests, Section 48, if it is likely to be handled during intended use or user servicing.

d) Be held in place by means other than friction.

e) Be located so that it is not likely to be damaged by operation of the product.

23.3 Fuse and fuse clip

23.3.1 There shall be a minimum spacing of 1/8 in (3.2 mm) between parts of a fuse clip that involve a risk of electric shock and uninsulated live parts and dead metal parts when measured with the fuse in place.

Exception: This requirement does not apply if a barrier complying with the requirements in 23.2.1 is provided.

24 Control-Unit-Output Limitations

24.1 The output of a control unit supplying a drive unit shall be limited to an open-circuit voltage of 30 V rms (42.4 V peak) or less and:

a) A short-circuit current of 8 A or less after 1 min, or

b) A volt-ampere capacity of 250 VA or less.

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If the output is limited in accordance with (b), the output circuit shall be provided with an overcurrent-protective device rated at not more than 3.2 A. A fixed-series impedance or regulator circuit may be used to limit the output if investigated and found to comply. See Control-Unit-Output Tests, Section 39.

24.2 The overcurrent-protective device mentioned in 24.1 shall:

a) Not be of an automatic-reset type,

b) Be trip-free from the reclosing mechanism if of the manually reset type, and

c) Not be interchangeable with one of a higher current rating if it is a renewable, user-serviceable device.

25 Drive-Unit-Discharge Path

25.1 Each terminal or lead provided for the connection of a drive unit shall be conductively connected to the supply circuit. The conductive connection shall:

a) Have a maximum resistance of 12 MΩ,

b) Have a minimum power rating of 1/2 W, and

c) Be effective with the power switch on or off.

Exception No. 1: The conductive connection need not be provided if the product employs two isolating means and electrical breakdown of one of the isolating means establishes such a connection without resulting in a risk of electric shock.

Exception No. 2: A capacitor with a built-in shunt resistor that complies with the applicable requirements in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414, may be rated 1/4 W minimum.

25.2 The maximum resistance specified in 25.1 shall not exceed 12 MΩ assuming the maximum tolerance of the resistor used. For example, a resistor rated 10 MΩ with 20% tolerance or a resistor rated 10.9 MΩ with 10% tolerance is acceptable.

PROTECTION AGAINST INJURY TO PERSONS

26 General

26.1 If operation, maintenance, or reasonably foreseeable misuse of a product by the user involves a risk of injury to persons, protection shall be provided for the reduction of such risk. See the Strength of Enclosure Test, Section 48.

26.2 Among the factors to be considered in judging the acceptability of an exposed moving part are:

a) The degree of exposure necessary to perform its intended function,

b) The sharpness of the moving part,

c) The risk of unintentional contact therewith,

d) The speed of the moving part, and

e) The risk of injury to a part of the body or of clothing being entangled by the moving part.

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These factors are to be determined with respect to both intended operation of the product and its reasonably foreseeable misuse.

26.3 The acceptability of a guard, a safety release, an interlock or similar part, and whether or not such a device is required, are to be determined from a study of the complete product, its operating characteristics, and the risk of injury to persons resulting from a cause other than gross negligence. The investigation is to include consideration of the results of breakdown or malfunction of any one component, but not more than one component at a time, unless one event contributes to another. If the study shows that malfunction of a particular component can result in a risk of injury to persons, that component is to be investigated for reliability.

27 Power-Operated Moving Parts

27.1 The accessibility of a power-operated moving part, such as a gear or linkage, is to be judged by the applicable requirements in Accessibility of Parts, Section 10.

28 Enclosures and Guards

28.1 A guard or portion of an enclosure acting as a guard for parts capable of causing a risk of injury shall be

a) Mounted to the assembly so that such parts cannot be operated with a guard removed,

b) Secured to the assembly using fasteners requiring a tool for removal, or

c) Provided with an interlock to reduce the risk of access to the parts capable of causing injury.

29 Sharp Edges

29.1 An enclosure, a frame, a guard, a handle, or similar part, shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use.

30 Installation and Assembly

30.1 The means for user-mechanical installation and assembly, such as the mounting of a drive unit, shall be such that:

a) The assembly and installation can be accomplished by the use of ordinary tools (see 3.13) and

b) All hardware parts, such as screws, bolts, and similar parts, that are required for completion of installation or assembly are provided. See also Installation and Operating Instructions, Section 55.

PERFORMANCE

31 General

31.1 Voltmeters

31.1.1 Unless otherwise indicated, voltage measurements are to be made with a voltmeter having a resistance of 2000 Ω per volt minimum for potentials of 1000 V or less.

31.1.2 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

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significantly affect the circuit being measured. In general, a measuring instrument with a minimum input impedance of 1 MΩ is to be used.

31.2 Cheesecloth indicators

31.2.1 The cloth used for tests is to be bleached cheesecloth running 14 – 15 yd^2/lb (26 – 28 m^2/kg) and having what is known in the trade as a count of 32 by 28; that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any cm^2, 13 threads in one direction and 11 threads in the other direction).

31.2.2 Tests involving cheesecloth are to be conducted in a room free of drafts.

31.3 Supply circuit

31.3.1 All operational tests are to be conducted with the product connected to a supply circuit of rated frequency. A product with a dual-frequency rating is to be tested at 60 Hz if 60 Hz is included in the rating and may also be tested at the second frequency if such testing is warranted.

31.3.2 A product having both alternating- and direct-current ratings is to be tested with the product connected to both an alternating-current supply and a direct-current supply.

Exception: If it can be established that one test results in the more severe operating conditions, then only that test need be conducted.

32 Operation Test

32.1 General

32.1.1 Operation of a product as described in 32.1.2 shall not result in a risk of fire, electric shock, or injury to persons.

32.1.2 With reference to 32.1.1, an as-received sample of the product is to be set up or installed in accordance with the manufacturer's instructions. The sample is to be operated in accordance with the manufacturer's instructions with respect to the intended uses of the product, including maintenance and cleaning recommended by the manufacturer and lack of such maintenance and cleaning. All accessories recommended by the manufacturer for use with the product are to be tested. The product is to be manipulated as it would be in actual use, including manipulation of all controls and operation under the various loading conditions that can be expected. The product is to be operated for a sufficient length of time or through a sufficient number of cycles to determine that all reasonably foreseeable complications are revealed.

33 Connector and Component Displacement Test

33.1 The disconnection and displacement of a part resulting from shipping or moving of the product shall not result in a risk of fire, electric shock, or injury to persons.

33.2 Any handling, disconnection, or displacement, intentional or unintentional, of a component, connector, lead, cover, or other similar part that may occur during normal operation or user servicing shall not result in a risk of fire, electric shock, or injury to persons.

33.3 A barrier, mechanical restraint, and the effect of gravity are to be given consideration as means of fastening a connector, but a fastening means that relies solely on friction between parts is to be investigated with respect to its effectiveness. A fastening means is not to be removed if it cannot be

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removed unintentionally and need not be removed during user servicing. A flexible fastening means is to be constructed so that it returns to its original position and shape after flexing.

33.4 A disconnecting part, such as an electrical connector, secured by friction fit only is to be investigated with respect to the risk of fire or electric shock while in its most extreme disconnected position.

Exception: A part need not be tested in the extreme disconnected position if the part complies with any of the following:

a) The part withstands a separation force of 1.1 lbf (4.9 N) after five insertions and withdrawals.

b) The part is soldered together and need not be removed for user servicing.

c) The part is of such dimensions or is permanently routed or secured so that no risk of fire, electric shock, or injury to persons can result if the part becomes disconnected.

d) A 1/32-in (0.8-mm) thick minimum insulating sleeve having at least a 1/16-in (1.6-mm) overlap is provided over the connector part.

34 Leakage-Current and Shock-Current Tests

34.1 Leakage current test

34.1.1 The leakage current at any accessible part shall not be more than 0.5 mA, when tested in accordance with 34.1.3 – 34.1.9.

34.1.2 Exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively when simultaneously accessible, and from one surface to another where simultaneously accessible. A part is considered to be an exposed surface unless guarded by an enclosure considered to reduce the risk of electric shock.

34.1.3 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of the equipment and ground, or other exposed conductive surfaces of the equipment.

34.1.4 Parts are simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of this measurement, one hand is able to simultaneously contact parts that are within a 4 by 8 in (10 by 20 cm) rectangle; and two hands of a person are considered to be able to simultaneously contact parts that are not more than 6 ft (1.8 m) apart.

34.1.5 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil with an area of 4 by 8 in (10 by 20 cm) in contact with the surface. If the surface is less than 4 by 8 in (10 by 20 cm), the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the equipment.

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

a) The meter is to have an input impedance of 1500 Ω resistive shunted by a capacitance of 0.15 μF.

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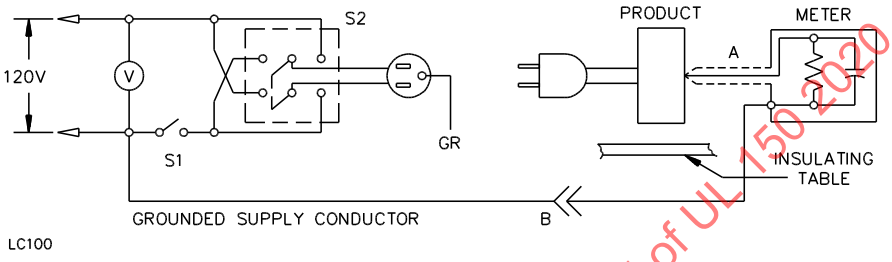
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-Ω resistor shunted by a 0.15-μF capacitor to 1500 Ω. At an indication of 0.5 mA, the measurement is to have an error of not more than 5% at 60 Hz.

Figure 34.1

Leakage-current measurement circuits



Product intended for connection to a 120 V power supply.

A – Probe with shielded lead.

B – Separated and used as clip when measuring currents from one part of equipment to another.

34.1.7 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.

34.1.8 A sample of the product is to be tested for leakage current starting with the as-received condition with all switches closed, but with its grounding conductor, if any, open at the attachment plug. A product that has not been energized for more than 48 h prior to the test and that is at room temperature is considered to be in the as-received condition. The supply voltage is to be the maximum voltage marked on the equipment, but not less than 120 V. The test sequence, with reference to the measuring circuit – Figure 34.1 – is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the product switching devices in their normal-operating positions.

b) Switch S1 is then to be closed, energizing the product, and within 5 s the leakage current is to be measured using both positions of switch S2, and with the product switching devices in their normal-operating positions.

c) Leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation of the product as in the Temperature Test, Section 38.

34.1.9 Normally, the complete leakage-current test described in 34.1.8 is to be conducted without interruption for other tests. With the concurrence of those concerned, the leakage current test may be interrupted for the purpose of conducting other nondestructive tests.

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34.2 Shock current test

34.2.1 If the open-circuit potential between any part exposed only during user servicing and earth ground or any other simultaneously accessible part exceeds the values specified in 11.1 (a), the continuous current flow through a 500-Ω resistor shall not exceed the limits specified in Table 34.1

Table 34.1
Current during user servicing

Frequency, Hz[a]	Maximum acceptable current through a 500 Ω resistor, mA peak
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000	27.5
or more	

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

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34.2.2 Unreliable insulation, such as that usually used between the terminals of an electrolytic capacitor or the elements of a solid-state component (diode, transistor, integrated circuit, or similar part), may be short-circuited during this test.

34.2.3 Current measurements are:

a) Made with any operating control, or adjustable control that is subject to user operation, in all operating positions; and

b) Made with or without a fuse, separable connector, or similar device in place.

35 Leakage-Current Test After Humidity Conditioning

35.1 After being conditioned as specified in 35.2, a product shall comply with the requirements for leakage current in 34.1.1.

35.2 A sample of the product is to be heated to a temperature just above 34°C (93°F) to reduce the risk of moisture condensation during conditioning. The heated sample is then to be placed in a humidity chamber and conditioned for 48 h at a temperature of 32 ±2°C (90 ±4°F) and a relative humidity of 88 ±2%. After the conditioning, the sample is to be tested unenergized as specified in 34.1.8(a). The sample is then to be energized and tested as specified in 34.1.8(b) and 34.1.8(c). The test is to be discontinued when the leakage current stabilizes or decreases.

36 Resistance of Grounding Circuit Test

36.1 The resistance between the point of connection of the equipment-grounding means, at or within the product, and any other point in the grounding circuit shall not be more than 0.1 Ω.

36.2 Any appropriate instrument may be used to determine whether a product complies with the requirement in 36.1. If results of greater than 0.1 Ω are recorded, an alternating current of at least 20 A from a power supply of not more than 12 V is to be passed from the point of connection of the equipment-grounding means to any point in the grounding circuit. The current and the resulting drop in potential are to be measured between the two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points. The grounding conductor of a power-supply cord is not to be tested by the latter method.

37 Power-Input Test

37.1 The current or wattage consumption of a product shall not exceed the marked input rating by more than 5% when the product is tested as specified in 37.2.

37.2 A drive unit that rotates a vertically mounted mast is to be loaded with a 15-lb (6.8-kg) weight, the center of gravity of which is along the central axis of the mast mounting means. For other mast mounting orientations, consideration is to be given to the weight and moment of the intended mast and antenna combination. The control unit is to be connected to the drive unit by an interconnecting cable of the maximum size (AWG) recommended by the manufacturer and not more than 15-ft (4.5-m) long. The product is then to be operated as intended, while connected to a supply circuit of rated frequency and maximum voltage (but not less than 120 V) and with controls adjusted to give maximum input.

38 Temperature Test

38.1 General

38.1.1 When a product is tested as specified in this section:

a) The temperature at any part shall not be sufficiently high to constitute a risk of fire or to adversely affect any materials employed,

b) The maximum temperatures attained shall not exceed those specified in Table 38.1 and Table 38.2, and

c) A thermal- or overcurrent-protective device shall not function.

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Table 38.1
Maximum acceptable temperatures

Materials and components	°C	°F
A. COMPONENTS		
1. Capacitor[a]		
a. Electrolytic	65	149
b. Other type	85	185
2. Conductor, rubber- or thermoplastic-insulated[b]	60	140
3. Fuses		
Class G, J, L, T, or CC		
Tube	125	257
Terminals	90	194
Other	90	194
4. Silicon rectifier[b, c]	100	212

Table 38.1 Continued on Next Page

Table 38.1 Continued

Materials and components	°C	°F
5. Windings of a motor, relay, solenoid, magnet, transformer, and the like, with Class 105 insulation systems[d]		
Thermocouple method	90	194
Resistance method	100	212
6. Wood and other combustible material	90	194
B. ELECTRICAL INSULATION – GENERAL		
1. Fiber employed as electrical insulation	90	194
2. Phenolic composition employed as electrical insulation or as a part the deterioration of which could result in a risk of fire or electrical shock[b]		
a. Laminated	125	257
b. Molded	150	302
3. Varnished-cloth insulation	85	185
C. SURFACES		
1. Interior surface of an overall enclosure of polymeric material (control and drive units)	50[b]	122[b]
2. Exterior surface of an overall enclosure other than polymeric (control and drive units)	90	194
3. Handle or knob	See Table 38.2	
4. Polymeric materials (other than phenolic)	50[b]	122[b]

[a] A capacitor operating at a temperature higher than that specified in the table may be judged on the basis of its marked temperature rating. If not marked with a temperature rating, it may be investigated to determine its acceptability at the higher temperature.

[b] This limitation does not apply to an insulated conducted, a rectifier, a material, or component that has been investigated and found to comply at a higher temperature.

[c] A rectifier operating at a temperature higher than 100°C (212°F) may be judged on the basis of its case temperature at the actual current compared with the case temperature at rated current – derating curves.

[d] At a point on the surface of a coil where the temperature is affected by an external source of heat, a hot-spot temperature not higher than 105°C (221°F) on the surface of a coil winding complies if the temperature, as measured by the resistance method, is not more than that specified in the table.

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Table 38.2
Maximum surface temperature

Location	Composition of surface[a]	
	Metal	Nonmetallic
Handle or knob that is grasped for lifting, carrying or holding	50°C (122°F)	60°C (140°F)
Handle or knob that is contacted but does not involve lifting, carrying or holding, and other surfaces subject to contact and user maintenance	60°C (140°F)	85°C (185°F)

[a] A handle, knob or similar part made of a material other than metal, that is plated or clad with metal having a thickness of 0.005 in (0.13 mm) or less is considered to be, and judged as, a nonmetallic part.

38.1.2 The temperatures specified in Table 38.1 and Table 38.2 are based on an assumed ambient temperature of 25°C (77°F). A test may be performed at an ambient temperature within the range of 10 – 40°C (50 – 104°F).

38.1.3 During a test performed at an ambient temperature of 25°C (77°F), an observed temperature shall not be greater than the required value specified in Table 38.1 and Table 38.2.

38.1.4 If a test is performed at an ambient temperature other than 25°C (77°F), an observed temperature other than as mentioned in 38.1.5 shall be corrected as described in 38.1.6. Neither a corrected

temperature nor an observed temperature as mentioned in 38.1.5 shall exceed the required value specified in Table 38.1 and Table 38.2.

38.1.5 An observed temperature limited by an automatic temperature control or by a process such as the boiling of water or the introduction of a liquid at a fixed temperature is not to be corrected.

38.1.6 An observed temperature is to be corrected by addition (if the ambient temperature is lower than 25° C (77° F)) or subtraction (if the ambient temperature is higher than 25° C) of the difference between 25°C and the ambient temperature.

38.1.7 If a corrected temperature exceeds the required value specified in Table 38.1 and Table 38.2, at the request of the manufacturer, the test may be repeated at an ambient temperature closer to 25° C (77°F).

38.2 Thermal equilibrium

38.2.1 Thermal equilibrium is considered attained when three successive readings taken at 15-min intervals indicate that there is no temperature change of the part.

38.3 Test conditions

38.3.1 The product is to be tested with the maximum projection on the back of the control unit in contact with a flat vertical wall of wood or comparable heat-insulating material except that the spacing between the wall and the main surface of the back of the control unit is not to be less than 1 in (25.4 mm).

38.3.2 Doors and covers that may be closed during operation of the product are to be closed during the test.

38.3.3 Rubber-like and felt materials are to be removed from supporting feet to the extent that they are likely to be worn off in normal service.

38.3.4 A horizontal ventilating screen that is subject to the accumulation of dust and that has holes less than 3/64 in (1.2 mm) in diameter are to be covered with loose cotton.

38.4 Operating conditions

38.4.1 The product is to be operated until constant temperatures are reached:

a) Under the conditions specified in 37.2;

b) With all unused receptacles loaded to their maximum rating; and

c) With the product mounted, positioned, closed, or enclosed to represent intended use.

38.4.2 The operation of the product is to be such that an antenna attached to the drive unit would undergo two complete cycles of rotation (one cycle consisting of one full clockwise and one full counterclockwise rotation) every 15 min.

38.5 Thermocouples

38.5.1 When thermocouples are used in the determination of temperatures, it is common practice to employ thermocouples consisting of 30 AWG 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 Tolerances on Initial Values of EMF versus Temperature tables in the Standard

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Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M, may be used.

38.6 Winding-temperature measurement

38.6.1 Ordinarily, 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. If the winding is inaccessible for mounting a thermocouple, the resistance method is to be used.

38.6.2 When determining the temperature by the change-in-resistance method, the windings are to be at room temperature at the start of the test. The temperature of a winding is to be calculated by using the following equation:

$$T = \frac{R}{r}(k + t_1) - k$$

In which:

T is the temperature in °C;

R is the resistance of the coil at the end of the test in ohms;

r is the resistance of the coil at the beginning of the test in ohms;

t_1 is the room temperature at the beginning of the test in °C; and

k is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum. Values of the constant (k) for other grades must be determined.

39 Control-Unit-Output Tests

39.1 Current-capacity test

39.1.1 To comply with 24.1(a), under any noncapacitive condition of loading (including short circuit), the output current of a control unit shall comply with the requirements in 39.1.2 or 39.1.3, as applicable.

39.1.2 The output current of a control unit not provided with a thermostat shall not be more than 8 A 1 min after the primary is energized to the maximum rated voltage but not less than 120 V. The unit is to be tested with all combinations of interconnection of output terminals.

39.1.3 The output current of a control unit provided with a thermostat shall comply with one of the following:

a) If the thermostat remains closed for 1 min after the primary is energized at maximum rated voltage, the current shall not be more than 8 A at the end of that period. The unit is to be tested with all combinations of interconnection of output terminals.

b) If the thermostat opens in less than 1 min after the primary is energized at maximum rated voltage, the current shall not be more than 8 A when the thermostat opens. The unit is to be tested with all combinations of interconnection of output terminals.

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Exception: The current may be more than 8 A but not more than 10 A when the thermostat opens if, when the unit is retested with the thermostat shunted out, the current is not more than 8 A 1 min after the primary is energized.

39.2 Volt-ampere-capacity test

39.2.1 To comply with 24.1 (b), the maximum volt-ampere output capacity of a control unit shall not exceed 250 VA. The unit is to be tested with all combinations of interconnection of output terminals.

39.3 Measurement

39.3.1 The short-circuit current or maximum volt-ampere output capacity of the control unit is to be determined as follows. The control unit, at room temperature, is to be connected as intended, overcurrent-protective devices are to be short-circuited, and the output in question is to be connected to a variable resistance load. If a fixed-series impedance or relied upon to limit the output, that impedance or regulator circuit is regulator circuit to be included in the circuit during the test. A multiple-output unit is to have one output tested with all the other outputs open-circuited, and is to be allowed to cool to room temperature again before another output is tested. The control unit is to be connected to a source of maximum rated voltage but not less than 120 V.

39.3.2 The load on the output is to be varied in approximately ten increments from open-circuit to short-circuit conditions in 2-1/2 min. For each step or increment in the resistance, the product of the output voltage and current are to be recorded, plotted, and drawn as a smooth curve. The peak value obtained from this graph shall not exceed that specified in 39.2.1.

39.4 Continuous operation test

39.4.1 The output of the control unit is to be subjected to continuous operation under short-circuit conditions and at maximum power to the externally connected resistor as described in 42.1.8. The current or volt-ampere capacity measurements in 39.3.1 or 39.3.2 are to be repeated and the results shall not exceed the limits specified in Control-Unit-Output Limitations, Section 24.

Exception: If the short-circuit test runs continuously for 7 h, the maximum-power test need not be conducted.

39.5 Open-circuit-voltage test

39.5.1 The open-circuit voltage between any two output terminals shall not be more than 30 V rms (42.4 V peak) when the unit is connected to a source of maximum rated voltage but not less than 120 V. The measurement is to be made between any combination of interconnected output terminals.

39.6 Unreliable-component-failure test

39.6.1 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 limits in 24.1 to be exceeded.

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40 Dielectric Voltage-Withstand Test

40.1 General

40.1.1 The insulation and spacings of a product shall withstand without breakdown for 1 min the application of the test potentials specified in Table 40.1.

Exception: This requirement does not apply if an investigation shows that such breakdown will not result in a risk of fire or electric shock.

40.1.2 A d-c test voltage is not to have more than 3% ripple.

40.1.3 The test voltage is to be measured directly across the points of application of the test potential with a high-resistance voltmeter.

40.1.4 The test voltage is to be raised gradually and smoothly to the specified value measured as described in 40.1.3 so that there are no transients that may cause the instantaneous test potential applied to exceed the peak value specified.

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Table 40.1
Dielectric voltage-withstand test potentials and applications

Circuit or component being tested	Areas of application[a]	Test potential, V[b]
Primary circuit		
Printed-wiring	c, d	1000 ±2V, dc
All parts	c, d	1000, 60 Hz
Power transformer	e	1,000, 60 Hz
Other circuit		
Power-transformer-supplied secondary	f	1000 +2V, dc
Load side of rectifier of direct-connected supply	d, f	1000 +2V, dc
Functional insulation	g	1000, 60 Hz
Supplementary insulation	g	2500, 60 Hz
Reinforced insulation	g	3500, 60 Hz

[a] Power-dissipating component parts, electronic devices, 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] V 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 products operating under the conditions specified in 40.2.1 – 40.2.3.

[c] Across the insulation and spacing 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.

3) Accessible conductive parts.

[d] Across the insulation and spacing between parts of opposite polarity.

[e] Across the insulation and spacing between windings and parts of a transformer conductively connected to the supply circuit. The windings and parts to be tested are to include each of the following:

1) Primary to shield or guard (if employed).

2) Primary to core.

Table 40.1 Continued on Next Page

Table 40.1 Continued

Circuit or component being tested	Areas of application[a]	Test potential, V[b]
3) Primary to each secondary (or all secondaries connected together).		
[f] Across the insulation and spacing between parts of circuits involving a risk of electric shock or fire and each of the following:		
1) The grounding terminal (if provided).		
2) The enclosure, with a conductive foil wrapped around insulating portions of the enclosure.		
3) Accessible conductive parts.		
4) All other circuits.		
[g] Across the insulation. See 13.1.7 – 13.1.9.		

40.2 Maximum voltage

40.2.1 The maximum voltage used as a basis for the calculation of the dielectric voltage-withstand potentials specified in Table 40.1 is to be determined in accordance with 40.2.2 and 40.2.3.

40.2.2 To obtain the maximum voltage, any combination of fuses and other protective devices may be opened.

40.2.3 A connector or comparable part that is likely to be disconnected during normal operation or user servicing is to be both connected and disconnected during the test so that the maximum voltage may be obtained.

41 Capacitor Test

41.1 If the maximum voltage across an electrolytic capacitor is more than its marked operating-voltage rating when measured under the conditions specified in 40.2.2 and 40.2.3, the capacitor shall not short-circuit when subjected to the test specified in 41.2.

41.2 The product is to be operated until the capacitor reaches normal operating temperature after which the maximum voltage conditions specified in 40.2.2 and 40.2.3 are to be introduced. The voltage is to be measured across the capacitor for 15 min. If there is any increase in the leakage current or a corresponding decrease in voltage, two additional samples are to be tested under the same conditions. The capacitor complies if the three samples operate for 15 min without short circuiting.

42 Abnormal-Operation Tests

42.1 General

42.1.1 During the abnormal operation test specified in 42.1.2 – 42.2.3, there shall be:

a) No glowing or flaming of the single layer of cheesecloth.

b) No glowing or flaming of the tissue paper.

c) No flaming resulting from the test that continues for more than 30 s.

d) No opening of the 1-A fuse connected to earth ground.

e) No development of an opening in the overall enclosure larger than that acceptable as determined by Accessibility of Parts, Section 10.

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42.1.2 The product is to be connected to a supply circuit fused at 30 A. The control unit is to be placed on a white tissue-paper-covered softwood surface. Exposed dead metal parts are to be connected to earth ground through a 1-A nontime-delay fuse. 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.

42.1.3 The supply-circuit voltage is to be 130 V, except that a lower test voltage may be used, but not less than 105 V, if the lower value will represent a more severe test condition or if a protective device would open at a higher test voltage.

42.1.4 A single layer of cheesecloth is to be draped loosely over the control unit.

42.1.5 A part of the product subject to removal during user servicing may be omitted if it is:

a) Not necessary for the functioning of the product,

b) Not exposed to view during normal operation, and

c) Not held captive.

42.1.6 Inherent-overheating protection, if provided, is to be investigated to determine its acceptability.

42.1.7 An abnormal-operation test involving stalling a motor or short-circuiting or overloading a component or circuit to maximum power is to be conducted until a risk of fire develops, the circuit under test burns open, or no further change is likely to take place, but not for longer than 7 h.

42.1.8 The term maximum power referred to in 42.1.7 is defined as the maximum power that the source of power is capable of delivering into an external variable resistor connected between the points being investigated and any return to the source of power.

42.1.9 If the circuit is interrupted by the opening of a component or protective device, the test is to be repeated twice, using new components if necessary.

42.2 Component abnormal operation test

42.2.1 A risk of fire or electric shock shall not result when a product is operated under abnormal conditions that are likely to occur during intended use.

42.2.2 The test conditions are to be as specified in 42.1.2 – 42.1.9.

42.2.3 Malfunction of a component and likely misuse of the product that may result in a risk of fire or electric shock are to be simulated during the abnormal tests. Only one fault is to be assumed at a time. Examples are:

a) Stalling the rotors of a motor, including that of a drive unit, due to bearing wear, loss of lubrication, ice buildup, or the like.

b) Blocking the plunger of a solenoid in the de-energized position.

c) Short-circuiting any two terminals of an unreliable component (electrolytic capacitor, diode, transistor, vacuum tube, and the like).

Exception: It is not necessary to short-circuit a component connected in a circuit that has an available power of less than 15 W, determined in accordance with the Available-Power Test, Section 43.

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d) Continuous operation of a user-actuated drive-unit control switch of the type mentioned in 22.2.2.

e) Continuous operation with any combination of control-unit-output terminals short-circuited.

43 Available-Power Test

43.1 General

43.1.1 To determine the power available to a part as mentioned in the Exception to 19.1.1, note c to Table 7.1, and 42.2.3(c), the source of power for the part in question shall be investigated according to 43.2.1 – 43.3.4, as applicable.

43.1.2 The supply-circuit voltage is to be as described in 42.1.3.

43.2 15-W point determination

43.2.1 A source of power for a component part or assembly is to be investigated to determine the points nearest the power supply not capable of delivering a power of more than 15 W into an external resistor connected singly between each of these points and any return to the power supply.

43.2.2 The measurements specified in 43.2.1 are to be made with the product operating as intended and with all components and circuits in place.

43.2.3 To locate the points not capable of delivering more than 15 W of power that are mentioned in 43.2.1, an adjustable resistor is to be set for maximum resistance and then connected to a wattmeter and the circuit under investigation as illustrated in Figure 43.1. The external resistor is to be adjusted until it consumes the maximum power as indicated by a peak reading of the wattmeter. If the reading is more than 15 W, the desired point has not been located and it is then necessary to move the input to the wattmeter resistor to other points away from the supply side of the circuit. If a protective device is used in the product, a shorting switch is to be connected across the protective device in the closed position. The external resistor is to be adjusted for maximum resistance before being connected in the circuit. The resistor is then to be adjusted so the power it dissipates is exactly 15 W as indicated by the wattmeter reading. The switch across the protective device is then to be opened and the time required for the protective device to open is to be recorded. If the protective device opens the circuit in 5 s or less, the desired point not capable of delivering more than 15 W has been located.

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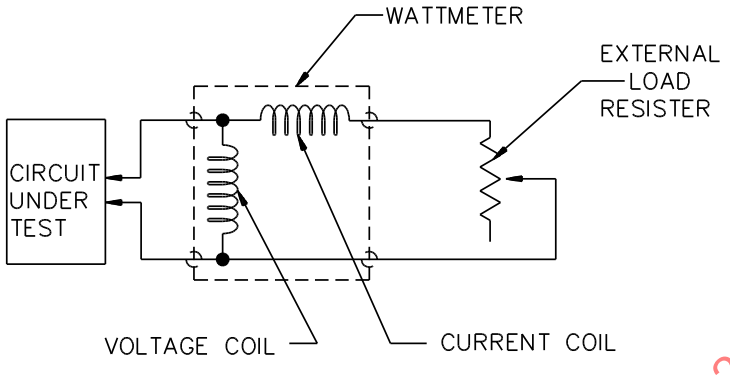
Figure 43.1

Connection of wattmeter



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43.2.4 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 in that circuit shall not cause the limit specified in 43.2.1 to be exceeded.

43.3 Circuit abnormal-operation test

43.3.1 The points determined by the measurements specified in 43.2.1 – 43.2.4 shall not result in a risk of fire or electric shock under the conditions of separately short-circuiting them or loading them to maximum power.

43.3.2 As a result of the test specified in 43.3.1, no components located between the points being tested and the power supply shall be affected to such a degree – for example, by a change in value or characteristics – as to cause the limit in 43.2.1 to be exceeded.

43.3.3 The test conditions are to be as specified in 42.1.1 – 42.1.9.

43.3.4 If the short-circuit tests specified in 43.3.1 continue for 7 h, it is not necessary to conduct the maximum-power test.

44 Drive-Unit-Control Switch Tests

44.1 General

44.1.1 A drive-unit control switch (see 22.2.1 and 22.2.2) that is not connected in a circuit complying with the requirements in Control-Unit-Output Limitations, Section 24, shall be tested as described in 44.1.2 – 44.2.1. There shall be:

a) No electrical or mechanical malfunction of the switch,

b) No welding or undue-burning or pitting of the contacts, and

c) No opening of a 1-A nontime-delay fuse connected between accessible conductive parts and earth ground.

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44.1.2 Three samples are to be tested. Each sample is to be operated at a rate of not more than 10 cycles per minute for the tests described in 44.1.3 and 44.2.1, except that a faster rate may be employed if agreeable to those concerned.

44.1.3 Each sample is to be subjected to 50 cycles of operation with the rotor of the drive unit stalled and the control unit connected to a supply circuit of maximum rated voltage, but not less than 120 V.

44.2 Endurance test

44.2.1 Following the overload test, each sample is to be subjected to 100,000 cycles of operation as in intended use with the control unit connected to a supply circuit of maximum rated voltage, but not less than 120 V.

45 Strain-Relief Test

45.1 The attachment of the power-supply cord to the product shall be subjected to the test described in 45.2. As a result of the test, there shall be:

a) No cutting or tearing of the insulation or covering on the flexible cord.

b) No sliding of the bushing through the hole in the chassis or enclosure.

c) No sliding of cemented-on bushings on the cord.

d) No separation of an interlock connector from the product, or damage to the connector so that it does not perform its intended function.

e) No transmission of stress to terminals, splices, or internal conductors.

45.2 Three samples are to be tested. The force is to be applied by a weight that exerts a force of 35 lbf (156 N) or by a steady pull of 35 lbf. With the chassis in the cabinet in the intended manner. The force is to be applied to the cord from any angle possible. The average time of holding is not to be less than 15 s. One sample may hold for less than 15 s, but not less than 5 s.

45.3 As an alternative to the test method described in 45.2, only one sample need be tested if the cord withstands a 35-lbf (156-N) force for 1 min.

45.4 The test described in 45.2 or 45.3 is to be conducted both before and after the temperature stability test specified in 48.4.2 when the integrity of the strain-relief means is dependent upon a polymeric material.

46 Separable-Connector-Cycling Test

46.1 A separable-type connector (that is, one not held to its mating part by a screw, clamp, or similar part, and that does not require the use of a tool to accomplish the separation) shall withstand without damage the cycling test described in 46.2.

46.2 The test is to be conducted with the product operating as intended. The connector is to be made to make and break the circuit at 6-s intervals for:

a) 10 cycles if it is in a circuit on the load side of a rectifier, or

b) 50 cycles if it is in the supply (primary) input circuit.

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47 Flexing Test

47.1 The insulation of wiring that is subjected to flexing during intended use and that involves a risk of fire or electric shock shall not be cut, abraded, or otherwise damaged when subjected to the flexing test specified in 47.2.

47.2 The wiring is to be subjected to 100,000 cycles of operation simulating intended use.

48 Strength of Enclosure Tests

48.1 General

48.1.1 When control unit enclosure is subjected to the tests specified in 48.1.3 – 48.5.2, there shall be:

a) No development of an opening larger than acceptable as determined by Accessibility of Live Parts, Section 10.

b) No effect on the performance of the product that results in a risk of fire, electric shock, or injury to persons.

48.1.2 In addition, when a control-unit enclosure is subjected to the test specified in 48.5.1 and 48.5.2, there shall be no shrinkage, warping, or other distortion that could result in interference with normal operation or user servicing of the unit.

48.1.3 A captive knob used to reduce the risk of accessibility of parts involving a risk of electric shock shall withstand the pull test specified in 48.6.1 and 48.6.2 without damage to the means that holds the knob captive or parts involving a risk of electric shock becoming accessible.

48.2 Loading test

48.2.1 The overall enclosure of a control unit weighing more than 10 lbs (4.5 kg) is to be subjected for 1 min to the loading test specified in 48.2.2.

48.2.2 The complete control unit is to be set on a 2-in (50.8-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 times the weight of the product in pounds (kg) plus 4 lbs (1.8 kg) is to be placed on top of the product, directly over the steel ball. Rubber-like and felt materials are to be removed from supporting feet to the extent that they are likely to be worn off in intended service. Supporting feet that are not permanently secured to the enclosure are to be removed.

48.3 Pressure test

48.3.1 A force of 20 lbf (89 N) is to be applied for 1 min to any point on the overall enclosure except the bottom. The force is to be applied by a 1/2-in (12.7-mm) diameter rod, the end of which is rounded to a 1/2-in diameter hemisphere. The force is to be applied normal to the plane of the enclosure surface.

48.3.2 Any point on the bottom of the overall enclosure of a control unit weighing 10 lbs (4.5 kg) or less is to be subjected to a 1-min application of a force of 15 lbf (67 N) applied as described in 48.3.1.

48.4 Impact test

48.4.1 The top, sides, and front of the overall enclosure of a control unit are to be subjected to a single impact of 5 ft-lbs (0.69 kg-m) as specified in 48.4.2.

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48.4.2 The impact is to be produced by allowing a steel sphere, 2 in (50.8 mm) in diameter and weighing 1.18 lbs (535 g), to fall vertically from rest through the necessary distance to produce the desired impact. For surfaces other than the top of an enclosure, the steel sphere is to be suspended by a cord and allowed to swing as a pendulum, dropping through the necessary distance to produce the desired impact. The test is to be conducted with the enclosure placed against a vertical wall. Parts of the enclosure that may interfere with the cord of the pendulum are to be removed.

48.5 Temperature-stability test

48.5.1 The overall enclosure of a control unit constructed of a polymeric material is to be subjected to one of the following tests at the manufacturer's option:

a) A sample of the complete unit is to be placed in a cubical, unvented test cell having a volume not less than 40 times that of the control unit and arranged so that the circulation of air within the cell simulates normal room conditions. The air temperature within the cell, as measured at the base of the unit, is to be maintained at 60°C (140°F). The unit is to be connected to a 130-V supply circuit and operated continuously for 7 h while resting on a supporting surface having an area approximately equal to that of the unit base and centrally located in the test cell.

b) The complete unit is to be placed in a air-circulating oven for 7 h. The oven is to be maintained at a temperature of 10°C (18°F) higher than the maximum operating temperature of the enclosure, measured at the hottest spot on the inside of the enclosure, under normal operating conditions, but not less than 70°C (158°F). The unit is not to be operated during the test.

48.5.2 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 normal operation or user servicing of the control unit provided that removal of the parts does not result in inability of the unit to comply with the requirements in 48.1.1.

48.6 Captive knob pull test

48.6.1 A captive knob used to prevent accessibility of parts involving a risk of electric shock is to be subjected for 1 min to a pull of 15 lbf (67 N) in any direction made possible by the construction of the product.

48.6.2 If polymeric materials are involved in the construction, the test described in 48.6.1 shall be conducted both before and after one of the temperature stability tests specified in 48.5.1.

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MANUFACTURING AND PRODUCTION TESTS

49 Dielectric Voltage-Withstand Test

49.1 Each product shall withstand without electrical breakdown, as a routine production-line test, the application of a 40 – 70 Hz potential between the primary wiring, including connected components and accessible metal parts.

49.2 The test potential is to be 1000 V applied for 1 min or 1200 V applied for 1 s.

49.3 The test is to be conducted when the product is complete and ready for packing, or when it is complete except for the installation of a part, such as a snap cover or friction-fit knob, that interferes with the performance of the test. For the test, the product may be in the heated or unheated condition.

49.4 The test equipment is to include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visible indicator of electrical breakdown, and either a manually