UL 1917

STANDARD FOR SAFETY

Solid-State Fan Speed Controls

UL Standard for Safety for Solid-State Fan Speed Controls, UL 1917

Fifth Edition, Dated June 17, 2022

Summary of Topics

This new edition of UL 1917 dated June 17, 2022 is being issued to add requirements covering separable terminals; 2.7, 2.10, Sections 9.2.2, 14.6, 14.7, and 38, 42.16, 42.17, 43.5 and 43.7.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated April 22, 2022.

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UL 1917

Standard for Solid-State Fan Speed Controls

Prior to the first edition, the requirements for the products covered by this standard were included in the Standard for Electric Industrial Control Equipment, UL 508.

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Second Edition – February, 1994
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Fifth Edition

June 17, 2022

This ANSI/UL Standard for Safety consists of the Fifth Edition.

The most recent designation of ANSI/UL 1917 as an American National Standard (ANSI) occurred on June 17, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or Preface.

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 solid state speed controls rated 300 volts or less, single phase, intended to be connected to 15 – 20 ampere branch circuits and intended to be installed in accordance with the National Electrical Code, ANSI/NFPA 70 and used with:

a) Fans and blowers that circulate air, such as desk, bracket, ceiling, hassock, pedestal, and utility fans;

b) Fans and blowers that ventilate air, such as attic, wall-insert, ceiling-insert, household hood- and canopy-types, and window fans;

c) Evaporative coolers;

d) Air-filtering appliances;

e) Fan-type deodorizers; and

f) Fan-type air fresheners.

1.2 Inductive-type and capacitive-type fan speed controls are also covered by these requirements.

1.3 These requirements also cover the solid state fan speed control portion of controls which include dimmers for use with lighting fixtures.

1.4 Solid state fan speed controls provided with a power supply cord, those intended for permanent connection, and direct plug-in devices are also covered by this Standard.

1.5 These requirements do not cover solid state speed controls used with air heaters incorporating fans, heating-ventilating units, or blowers comprising components of such equipment as furnaces, mechanical-refrigeration equipment, air conditioners, or direct current output applications.

1.6 These requirements do not cover solid state speed controls used with fans intended to be:

a) Used in hazardous locations as defined in the National Electrical Code, ANSI/NFPA 70;

b) Installed over solvents or chemically flammable liquids or vapors; or

c) Located in chemically corrosive environments.

2 Glossary

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

2.2 CORD CONNECTED DEVICE – A device intended for connection to the power source by means of a supply cord. Such a device is intended to be moved for reasons of interchange or realignment of the units of the system.

2.3 FAN, CEILING SUSPENDED – A fan intended to be mounted to a ceiling outlet box or ceiling building structure, and whose blades rotate below the ceiling. Popularly called a paddle fan.

2.4 FAN, GENERAL PURPOSE – Any fan not considered to be a ceiling-suspended fan or any fan which has a Locked Rotor Current/Full Load Current ratio greater than 1.5.

2.5 FAN SPEED CONTROL, CAPACITIVE-TYPE – A fan speed control that uses switchable capacitors to regulate the speed of the motor.

2.6 FAN SPEED CONTROL, INDUCTIVE-TYPE – A fan speed control that uses inductors to regulate the speed of the motor.

2.7 FAN SPEED CONTROL, MODULAR ASSEMBLY – A device consisting of a separable terminal assembly and fan speed control.

2.8 FAN SPEED CONTROL, SEMICONDUCTOR-TYPE – A fan speed control that utilizes semiconductors to regulate the speed of the motor. See 42.12.

2.9 LEAD CONNECTED DEVICE – A device which is intended to be permanently connected to the power source. Such a device is not intended to be moved or realigned once it is installed.

2.10 SEPARABLE TERMINAL ASSEMBLY – A two-piece terminal provided with an integral mechanical latching mechanism(s). May be either installed (i.e., special purpose connector) into a device box or secured (i.e., back plate) to the device box. Provided with either insulated conductors or wiring terminals for connection to the branch circuit conductors.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component. See Annex A for a list of standards covering components generally used in the products covered by this standard.

3.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

3.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

4 Units of Measurement

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

5 Undated References

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

6 General

6.1 The term "speed control" as used in this standard refers to a solid-state speed control used with electric fans for non-industrial applications.

CONSTRUCTION

7 Enclosure

7.1 General

7.1.1 A speed control shall be provided with a complete enclosure for all live parts and all operating parts other than necessarily exposed operating parts, such as an actuating member.

Exception: An open speed control (see 20.4) intended for installation in a wall box is not required to be provided with a complete enclosure of the field wiring terminals.

7.1.2 An enclosure of a speed control shall be constructed and assembled so that it has the strength and rigidity necessary to resist the abuses to which it is likely to be subjected, without total or partial collapse resulting in a risk of fire, electric shock, or injury to persons due to reduction of spacings, loosening or displacement of parts, or other serious defects.

7.1.3 An enclosure shall be constructed so as to reduce the risk of unintentional contact with enclosed electrical devices, and to provide internal devices with protection from specified external conditions.

7.1.4 The enclosure shall be constructed such that the switchplate cover mounting means, such as mounting screws, shall not enter the interior of the speed control.

Exception: The mounting means may penetrate the interior of the speed control if the applicable evaluations defined in Sections 7 – 36 are performed with a screw having a length of 3/8 inch (9.5 mm) in place.

7.1.5 Mechanical protection shall be provided to protect components during and after installation. See Crush Test, Section 28.

7.2 Cast metal

7.2.1 A cast-metal enclosure shall be at least 1/8 inch (3.2 mm) thick at every point, more than 1/8 inch thick at reinforcing ribs and door edges, and at least 1/4 inch (6.4 mm) thick at tapped holes for conduit.

Exception: Other than at plain or threaded conduit holes, malleable iron and die-cast or permanent mold cast aluminum, brass, bronze, or zinc shall be:

a) At least 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (155 cm^2) or having any dimension more than 6 inches (152 mm); and

b) At least 1/16 inch (1.6 mm) thick for an area of 24 square inches or less having no dimension more than 6 inches. The area considered may be bounded by reinforcing ribs subdividing a larger area.

7.3 Sheet metal

7.3.1 The thickness of a sheet-metal enclosure shall not be less than that specified in Table 7.1 and Table 7.2, except that at points to which a wiring system is to be connected, uncoated steel shall be at least 0.032 inch (0.81 mm) thick, zinc-coated steel at least 0.034 inch (0.86 mm) thick, and nonferrous metal at least 0.045 inch (1.14 mm) thick.

Exception: Enclosure thickness at points other than where a wiring system is to be connected need not comply with these thickness requirements if the enclosure complies with the requirements in Sections 29 and 30.

7.3.2 Table 7.1 and Table 7.2 are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

Table 7.1
Thickness of Sheet Metal for Enclosures Carbon Steel or Stainless Steel

Maximum width[a]		Maximum length[b]		Minimum thickness			
				Uncoated		Metal coated	
inches	(cm)	inches	(cm)	inches	(mm)	inches	(mm)
4.0	(10.2)	Not limited					
4.75	(12.1)	5.75	(14.6)	0.020	(0.51)	0.023	(0.58)
6.0	(15.2)	Not limited					
7.0	(17.8)	8.75	(22.2)	0.026	(0.66)	0.029	(0.74)
8.0	(20.3)	Not limited					
9.0	(22.9)	11.5	(29.2)	0.032	(0.81)	0.034	(0.86)
12.5	(31.8)	Not limited					
14.0	(35.6)	18.0	(45.7)	0.042	(1.07)	0.045	(1.14)

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

[b] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

Table 7.2
Thickness of Sheet Metal for Enclosures Aluminum, Copper, or Brass

Maximum width[a]		Maximum length[b]		Minimum thickness	
inches	(cm)	inches	(cm)	inches	(mm)
3.0	(7.6)	Not limited			
3.5	(8.9)	4.0	(10.2)	0.023	(0.58)
4.0	(10.2)	Not limited			
5.0	(12.7)	6.0	(15.2)	0.029	(0.74)
6.0	(15.2)	Not limited			
6.5	(16.5)	8.0	(20.3)	0.036	(0.91)
8.0	(20.3)	Not limited			
9.5	(24.1)	11.5	(29.2)	0.045	(1.14)
12.0	(30.5)	Not limited			

Table 7.2 Continued on Next Page

Table 7.2 Continued

Maximum width[a]		Maximum length[b]		Minimum thickness	
inches	(cm)	inches	(cm)	inches	(mm)
14.0	(35.6)	16.0	(40.6)	0.058	(1.47)

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

[b] Not limited applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

7.4 Polymeric

7.4.1 A polymeric electrical enclosure or a polymeric part of an electrical enclosure shall comply with the applicable requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and also with the additional requirements specified in this standard.

Exception: A polymeric plug or other closure made of a material rated 5V in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, need not comply with UL 746C.

7.5 Doors and covers

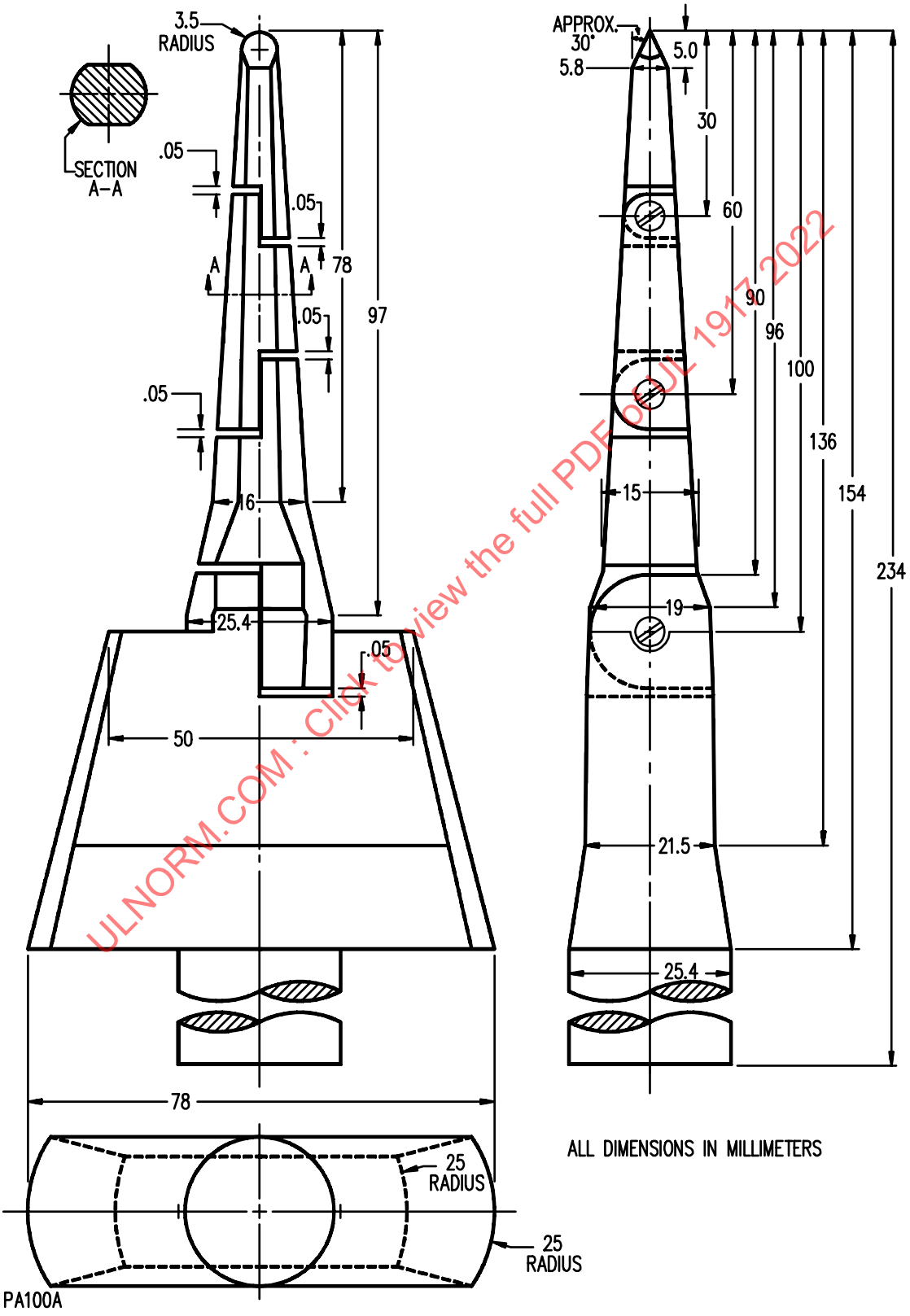
7.5.1 A part of an enclosure, such as a door or a cover, shall be provided with a means – such as latches, locks, interlocks, or screws – for firmly securing it in place.

Exception: A snap-on cover that complies with the requirements in the Securement of Snap-On Cover Test, Section 31, is not required to have additional securing means.

7.5.2 The articulate probe illustrated in Figure 7.1 shall be used as a measuring instrument to judge the accessibility to uninsulated live parts and film-coated wire provided by openings of the cover plate and not as an instrument to judge the strength of a material; the probes shall be applied with only the minimum force necessary to determine the accessibility.

Figure 7.1

Articulate probe with web stop



7.6 Application of probes

7.6.1 The probe illustrated in Figure 7.1 shall be applied to any depth that the opening will permit and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to try to contact an uninsulated live part or film-coated wire. The probe shall be applied in the above-described manner and in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening. Configuration refers to positioning of the jointed portions of the probe.

7.6.2 Any part that can be contacted by the probe is judged to be accessible.

7.7 Conduit connection

7.7.1 A polymeric enclosure intended for connection to a rigid conduit system shall comply with the test requirements described in Section 32, Polymeric Enclosure Conduit Connection Tests.

7.8 Bonding

7.8.1 An enclosure made of insulating material, either wholly or in part, shall have an acceptable bonding means to provide continuity of grounding between all conduit openings. The bonding means may be either completely assembled on the product or provided as separate parts for field installation.

Exception: A bonding means is not required for the enclosure of a fan speed control that is intended to be connected to a single conduit.

7.8.2 The continuity of a conduit system shall be provided by metal-to-metal contact not relying on a polymeric material.

Exception: The continuity of the grounding system may rely on the integrity of the polymeric enclosure if samples have been subjected to the creep test requirements in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. Overcurrent tests shall be conducted at 200 percent of the rated current of the branch circuit-protective device.

7.8.3 A separate bonding conductor, whether in a plastic or metal enclosure, shall be copper, a copper alloy, or other material acceptable for use as an electrical conductor. Ferrous metal parts in the grounding path shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means. A separate bonding conductor shall:

a) Be protected from mechanical damage or be located within the confines of the outer enclosure or frame; and

b) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is unlikely to be omitted after removal and replacement of the fastener.

7.8.4 The size of a separate component bonding conductor shall not be less than 12 AWG (2.32 mm^2) for copper and 10 AWG (2.95 mm^2) for aluminum, or the size of the conductor supplying the component, whichever is smaller.

Exception: A bonding conductor may be smaller than that specified if it complies with the bonding conductor requirements in the Standard for Industrial Control Equipment, UL 508.

7.9 Adjustment opening

7.9.1 An adjustment opening shall not permit the entrance of a 1/8 inch (3.2 mm) diameter rod. If the distance between the opening and the nearest live part is more than 4 inches (102 mm), the opening shall not permit the entrance of a 1/2 inch (12.7 mm) diameter rod.

8 Corrosion Protection

8.1 General

8.1.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other finish that has been found by investigation to be acceptable for the purpose. This requirement applies to all enclosing cases whether of sheet steel or cast iron, and to all springs and other parts upon which proper mechanical operation may depend.

Exception: This requirement does not apply to:

a) Small parts of iron or steel, such as washers, screws, bolts, and the like, that are not current carrying, if the corrosion of such parts would not result in a risk of fire, electric shock, or injury to persons; and

b) Parts made of stainless steel that are polished or treated, if necessary.

8.1.2 If the yoke, strap, or mounting ears are made of steel, as described in 9.2.1.1, the corrosion protection for a fan speed control for use in a flush-device box or on an outlet-box cover shall be a zinc or cadmium coating not less than 0.00015 inch (0.0038 mm) thick in accordance with the method for determining protection against corrosion in the Standard for Metallic Outlet Boxes, UL 514A, or other coatings determined to be acceptable for the particular application.

8.2 Outdoor enclosures

8.2.1 Enclosures intended for other than indoor Type 1 use shall comply with the applicable enclosure requirements in the Standard for Enclosures for Electrical Equipment, UL 50.

9 Mounting

9.1 Surface mounted

9.1.1 Provisions shall be made for securely mounting an enclosed speed control to a supporting surface. A bolt, screw, or other part used to mount a component of the equipment shall not be used for securing the equipment to the supporting surface.

9.2 Wall box mounted

9.2.1 General

9.2.1.1 If the fan speed control does not completely enclose the wall box, a metal yoke, strap, or mounting ear shall not be less than 0.04 inch (1.02 mm) or more than 0.09 inch (2.3 mm) thick. If a nonferrous metal is used, it shall be of sufficient thickness to provide mechanical strength and rigidity not less than that of 0.04 inch (1.02 mm) thick steel.

9.2.1.2 A nonmetallic yoke, strap, or mounting ear shall be of a material and design acceptable for the intended use. The nonmetallic mounting means shall not be more than 0.09 inch (2.3 mm) thick.

9.2.1.3 The yoke, strap, or mounting ear may be provided with extension plaster ears, which may be scored so that they can be broken off.

9.2.1.4 Plaster ears, whether separate pieces or integral with the mounting means, shall not carry the identifying marking or the electrical ratings of the fan speed control, unless the marking and rating also appear elsewhere on the device.

9.2.1.5 A screw provided for use in mounting the speed control to an outlet box or other enclosure shall project not more than 7/8 inch (22 mm) beyond the strap or cover and shall have a flat or blunt end. The end of the screw shall have no burrs, fins, or sharp edges that can damage wiring. This does not preclude thread-cleaning slots or grooves in the end of a screw.

9.2.2 Separable terminal assembly

9.2.2.1 A separable terminal assembly shall consist of permanently attached pins, contacts or tabs capable of receiving the intended fan speed control (module) and is provided with either conductor leads or terminals for connection to the branch circuit conductors.

9.2.2.2 A separable terminal assembly shall:

a) Be provided with a mechanical means such as a lock, latch or similar means, which prohibits unintentional separation when in the mated condition;

b) Be reliably keyed by a physical or mechanical means to maintain correct polarity and voltage consistent with the intended use. The terminals shall be marked identifying the terminal positions and identifying the unidentified (hot), grounded (neutral) and grounding terminal. Color-coding of integral wire leads is an acceptable means of terminal identification;

c) Be reliably keyed to limit interconnection to only like voltage;

d) Be either placed in a device box or secured to the device box as identified by the manufacturer. When secured to a device box, two machine screw having 32 threads per inch shall be provided;

e) When secured to a device box shall also comply with all applicable requirements of UL 514D, the Standard for Cover Plates for Flush-Mounted Wiring Devices and Cover plates for flush-mounted wiring devices, CSA C22.2 No. 42.1;

f) Be rated either 15 or 20 amperes only; and

g) Additionally, comply with testing as described in Section 38.

9.2.2.3 The grounding-conductor terminal shall connect before mating supply conductor terminals connect when two or more connectors are mated as intended. During disconnection of mating connectors, the supply-conductor terminals shall disconnect before the grounding-conductor terminal disconnects,

9.2.2.4 Live parts of a separable terminal assembly when not mated to the intended fan speed control (actuator) module shall not be accessible to contact by the probe in Figure 7.1.

10 Direct Plug-In Devices

10.1 A direct plug-in speed control shall have a receptacle that accepts either a polarized or grounding-type attachment plug. The blade configuration of the device shall be the same as the blade configuration that is accepted by the receptacle.

10.2 A direct plug-in speed control shall also comply with the requirements in the Abuse Test, Section 33.

10.3 The maximum acceptable moment, center of gravity, dimensions, and weight of a device shall comply with the requirements specified in (a), (b), (c), and (d). See 10.4:

a) The quotient of WY/Z shall not exceed 48 ounces (1361 g).

b) The quotient of WY/S shall not exceed 48 ounces.

c) The product of WX shall not exceed 80 ounce-inches (0.56 N·m).

d) The weight of a device shall not exceed 28 ounces (794 g).

Where:

W is the weight of the device in ounces (g).

Y is the distance illustrated in Figure 10.1 in inches (mm).

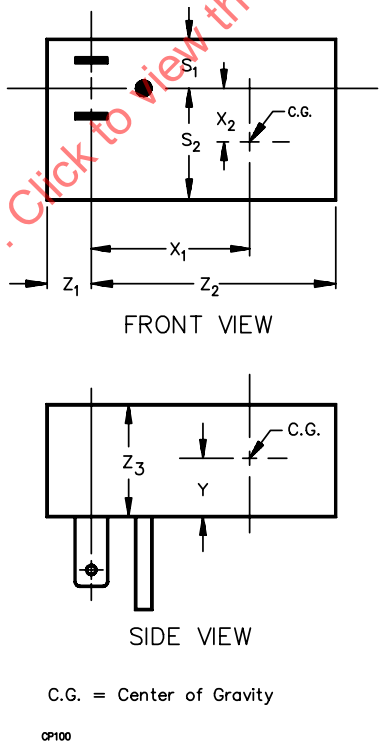
Z is the lesser of the two distances, Z_1 or Z_2, as illustrated in Figure 10.1 in inches (mm).

S is the lesser of the two distances, S_1 or S_2, as illustrated in Figure 10.1 in inches (mm).

X is the greater of the two distances, X_1 or X_2, as illustrated in Figure 10.1 in inches (mm).

Figure 10.1

Dimensions of a Direct Plug-In Device



10.4 The moment and weight specified in 10.3 are to be determined as follows:

a) For devices with an output cord, the cord is to be cut off at the enclosure, or at the strain-relief means if the strain-relief means is outside the enclosure.

b) For devices with directly mounted accessories, the values are to be measured with the accessories in place.

c) A mounting tab is not to be included in measurements of the linear dimensions for the purpose of determining moments unless:

1) The tab and enclosure withstand the impacts described in 33.2 with one impact on the tab itself, without deformation, and

2) For a polymeric-enclosed device having an integral tab, the tab and enclosure do not distort at temperatures to which the material may be subjected under conditions of normal and abnormal use as determined by the mold stress-relief distortion test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

11 Switches

11.1 General

11.1.1 A fan speed control shall include a positive "off" position provided by an air-gap-type switch that complies with the applicable requirements in the Standard for General-Use Snap Switches, UL 20, or in the Standard for Special-Use Switches, UL 1054, or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1, or the equivalent.

Exception No. 1: Controls may be provided without air gap switches by complying with UL 991, Tests for Safety-Related Controls Employing Solid-State Devices.

Exception No. 2: A remote auxiliary control is not required to be provided with an air-gap-type switch.

11.1.2 A supplementary switch provided for the control of a light kit shall be provided with a tungsten rating.

Exception: A switch intended for a resistive or general purpose load may be used if the switch is rated at least 600 percent of the tungsten load.

11.2 Dimmers

11.2.1 Supplementary circuits provided in a wall box fan speed control intended to dim incandescent lighting shall be evaluated in accordance with the requirements for wall-box dimming products.

11.2.2 Supplementary circuits provided in fan speed controls for use with specific fans shall be tested in accordance with Section 23, Overload Test, and Section 24, Endurance Test.

12 Live Parts

12.1 A current-carrying part shall have mechanical strength and ampacity for the intended use and shall be a copper alloy.

12.2 An uninsulated live part, including a terminal, shall be secured to its supporting surface by a method other than friction between surfaces so that it will be prevented from turning or shifting in position if such motion results in reduction of spacings to less than those required elsewhere in this standard. The security of a contact assembly shall maintain continued alignment of contacts.

Exception: A pressure terminal connector is not required to be prevented from turning if no spacings less than those required result when the terminals are turned toward each other, or toward other uninsulated parts of opposite polarity, or toward grounded metal parts.

12.3 A live screwhead or nut on the underside of an insulating base shall be prevented from loosening and shall be acceptably insulated or spaced from the mounting surface. This may be accomplished by:

a) Countersinking such parts at least 1/8 inch (3.2 mm) and then covering them with a waterproof, insulating sealing compound that does not melt at a temperature of 15 °C (27 °F) higher than its normal operating temperature in the equipment, but at least 65 °C (149 °F); or

b) Securing such parts and insulating them from the mounting surface by a barrier, or the equivalent, or by through air or over surface spacings specified elsewhere in this standard.

13 Internal Wiring

13.1 General

13.1.1 The wiring and connections between parts of the equipment shall be protected from mechanical damage during installation.

13.1.2 The insulation on all internal wires of the equipment shall be rated for the voltage and the temperature conditions of use. It shall also be considered with respect to other conditions of service to which it is likely to be subjected. Insulation shall be at least 1/32 inch (0.8 mm) thick if the internal wiring is subjected to movement, flexing, handling, or manipulation during its intended use, or during mechanical maintenance.

13.2 Routing of internal wiring

13.2.1 A hole through which insulated wires pass in a sheet metal wall within the enclosure of the equipment shall be provided with a smooth, well-rounded bushing or shall have smooth, well-rounded surfaces upon which the wires may bear to reduce the risk of abrasion of the insulation.

13.2.2 Wires shall be routed away from sharp edges, screw threads, burrs, fins, moving parts, drawers, and the like, that can abrade the wire insulation.

13.3 Clamps and guides

13.3.1 Clamps and guides, either metallic or nonmetallic, used for routing stationary internal wiring shall be provided with smooth, well-rounded edges. The clamping action and bearing surface shall be such that abrasion or cold flow of the insulation cannot occur. Auxiliary nonconducting mechanical protection shall be provided under a metallic clamp that exerts pressure on a conductor having thermoplastic insulation less than 1/32 inch (0.8 mm) thick and having no overall braid.

13.4 Insulating bonding and grounding conductors

13.4.1 Insulated grounding and bonding conductors shall be identified by the color green with or without one or more yellow stripes. No other leads shall be so identified in the field wiring area.

13.5 Splices and connections

13.5.1 All splices and connections shall be mechanically secure and shall provide electrical continuity.

13.5.2 Electrical connections shall be soldered, welded, crimped, or otherwise securely connected. A soldered joint shall be mechanically secure before soldering.

Exception: Leads inserted through printed wiring board traces are not required to be mechanically secured before soldering.

13.5.3 A lead is considered to be mechanically secure if it is:

a) Wrapped at least halfway (180 degrees) around a terminal;

b) Provided with at least one right angle bend when passed through an eyelet, opening, or intended for quick-connect detent; or

c) Twisted with other conductors.

Exception: A right angle bend described in (b) is not required for a dedicated thru-soldering lug.

13.5.4 If stranded internal wiring is connected to a wire-binding screw, the construction shall be such that loose strands of wire cannot contact:

a) Other uninsulated live parts not always of the same polarity as the wire; and

b) De-energized metal parts.

This can be accomplished by any acceptable means including use of machine- or tool-applied pressure terminal connectors, soldering lugs, or crimped eyelets, or soldering all strands of the wire together.

13.5.5 Solderless wrapped connections shall not be used on wires that are subject to movement or flexure during conditions of normal operation or user servicing.

13.6 Splice insulation

13.6.1 A splice shall be provided with insulation equivalent to that of the wires involved.

13.6.2 In determining if splice insulation consisting of coated-fabric, thermoplastic, or other types of tubing is acceptable, consideration is to be given to electrical and mechanical properties including dielectric voltage-withstand ability, heat resistance, and moisture resistance. Thermoplastic tape shall not be wrapped over a sharp edge or connection.

14 Supply Connections – Permanently Connected Speed Controls

14.1 General

14.1.1 Supply connections are considered to be those electrical connections that are made in the field when the equipment is installed.

14.1.2 A speed control intended for permanent connection to the power supply shall have provision for connection of one of the applicable wiring systems in accordance with the National Electrical Code, ANSI/NFPA 70.

14.2 Tapped holes for conduit

14.2.1 A tapped hole for the attachment of threaded rigid conduit shall be provided with:

a) An end stop, or shall be located so that a standard bushing may be attached to the end of the conduit;

b) A tapered thread in equipment for outdoor use, if not provided with an end stop; and

c) At least three full threads when tapped all the way through the wall of an enclosure, or with at least 3-1/2 full threads and a smooth, rounded inlet hole having a diameter approximately the same as the internal diameter of a standard bushing to provide protection for the conductors equivalent to that provided by such a bushing.

14.3 Knockouts

14.3.1 A knockout in a sheet-metal enclosure shall be reliably secured but capable of being removed without undue deformation of the enclosure.

14.3.2 A knockout shall be provided with a flat surrounding surface for proper seating of a conduit bushing, and shall be located so that installation of a bushing at any knockout likely to be used during installation will not result in spacings between uninsulated live parts and the bushing that are less than the minimum values specified in this standard.

14.4 Terminals

14.4.1 Speed controls shall be provided with wiring terminals or leads for connection of conductors having an ampacity of 125 percent of the full-load motor current specified in Table 23.2 for the horsepower rating.

14.4.2 It is assumed that speed controls having a current rating or a horsepower rating with a full-load motor current as specified in Table 23.2 will be connected with wire of a size determined in accordance with Table 310-16 of the National Electrical Code, ANSI/NFPA 70. The size is to be based upon wire rated in accordance with Table 21.2. The type of insulation is not specified.

14.4.3 If a wiring terminal will accommodate the next larger size conductor than that required in 14.4.1, the terminal shall comply with the secureness and pullout requirements with that size conductor, unless the equipment is marked to restrict its use to only the smaller size conductor.

14.4.4 A lead that is intended to be spliced in the field to a circuit conductor shall not be smaller than 18 AWG (0.82 mm^2). The insulation, if of rubber or thermoplastic, shall not be less than 1/32 inch (0.8 mm) thick. The effective lead length outside of the speed control shall not be less than 4 inches (102 mm).

14.4.5 The length of a grounding lead, if provided, shall not be less than 6 inches (152 mm) and shall be finished to show a green color with or without one or more yellow stripes.

14.4.6 A terminal to which field wiring is to be connected shall be a soldering lug or pressure wire connector.

Exception: A terminal to which 10 AWG (5.3 mm^2) or smaller wiring connections are to be made may consist of a clamp or binding screw with a terminal plate having upturned lugs or the equivalent to hold the wire in position.

14.4.7 A field-wiring pressure wire connector provided with or specified for use with a speed control shall comply with one or more of the following, as applicable:

a) The performance requirements in the Standard for Wire Connectors, UL 486A-486B; or

c) The performance requirements in the Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E.

14.4.8 The tightening torque for a field-wiring terminal shall be as specified by the fan speed control manufacturer and shall be marked as specified in 42.11. The specified tightening torque shall not be less than 90 percent of the value employed in the static heating test as specified in the requirements in the Standard for Wire Connectors, UL 486A-486B, or the Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E, for that wire size corresponding to the ampere rating of the fan speed control. See 37.1.

Exception No. 1: The value of tightening torque may be less than 90 percent of the value specified if the connector is investigated in accordance with UL 486A-486B or UL 486E, with the lesser assigned torque value.

Exception No. 2: A field-wiring terminal intended only for the connection of a control circuit conductor need not be marked with a value of tightening torque if tested in accordance with the applicable requirements in UL 486A-486B or UL 486E, with a value of tightening torque of 7 pound-inches (0.8 N·m).

14.4.9 A wire-binding screw to which field-wiring connections are made shall be 8 (4.2 mm) or larger.

Exception: A No. 6 screw (3.5 mm) may be used at a terminal intended only for connection of a 14 AWG (2.1 mm^2) conductor.

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

Exception: Two full threads are not required if fewer threads result in a secure connection in which the threads will not strip upon application of a 20 pound-inch (2.3 N·m) tightening torque.

14.4.11 A terminal plate formed from stock having the required thickness specified in 14.4.10 may have the metal extruded at the tapped hole for the binding screw to provide two full threads.

14.4.12 A wire-binding screw shall thread into metal.

14.5 Field wiring space

14.5.1 The space within the enclosure of a permanently connected speed control shall be sufficient to provide room for the distribution of wires and cables required for the proper wiring of the control.

14.6 Separable terminal assembly interchangeability

14.6.1 A fan speed control with a separable terminal assembly employing wiring terminals shall be uniquely keyed to prevent interchangeability of fan speed control where the wiring terminal conductor size ampacity is less than the fan speed control ampere rating.

14.7 Separable terminal supply wiring leads

14.7.1 A fan speed control with a separable terminal assembly employing wire leads shall be either solid or stranded copper conductors according to 14.4.1. When the lead size is other than 12 AWG (3.3 mm^2), the separable terminal assembly shall be uniquely keyed to prevent interchangeably of fan speed control where the conductor size ampacity is less than the fan speed control ampere rating.

15 Supply Connections – Cord Connected Speed Controls

15.1 Cords and plugs

15.1.1 A cord-connected speed control shall be provided with a length of flexible cord and an attachment plug for connection to the branch-circuit supply.

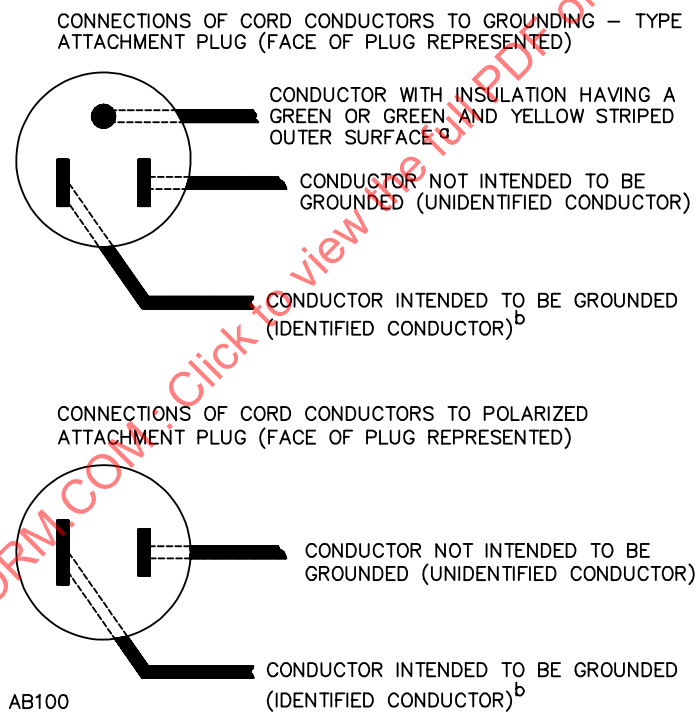
15.1.2 The power supply cord shall be of the grounding type or be provided with a polarized plug and shall employ one of the following flexible cord types: SP-2, SJ, SJE, SJO, SJT, SJTO, or SVT.

15.1.3 Flexible cord type SP-2 shall be used in lengths not to exceed 8 feet (2.4 m).

15.1.4 For nominal 120 V fan speed controls, both the attachment plug and receptacle connections shall comply with Figure 15.1, and the polarity identification of the flexible cord shall comply with Table 15.1.

Figure 15.1

Connection to Attachment Plug



[a] In the above illustration, the blade to which the green conductor is connected may have a U-shaped or circular cross section.

[b] Signifies a conductor identified in accordance with Table 15.1.

Table 15.1
Polarity Identification of Flexible Cords

Method of polarity identification	Acceptable combinations	
	Wire intended to be grounded[c]	All other wires
Colored braid	Solid white or gray	Solid color other than white or gray
Tracer in braid	Colored tracer in braid of a color other than white or gray	No tracer in braid of solid color other than white or gray
Color insulation[b]	Solid white or gray[a]	Solid color other than white or gray
	Light blue[c]	Solid color other than light blue, white, or gray[c]
Color separator[d]	White or gray	Color other than white or gray
Surface marking[d]	One or more stripes, ridges, or grooves, or a combination of these on the exterior surface of the cord	–

[a] A conductor having insulation finished to show a green color with or without one or more straight or helical unbroken yellow stripes or having a green braid with or without one or more yellow tracers is to be used only as an equipment grounding conductor. See Figure 15.1 for the connection of conductors to attachment plugs.

[b] Only for a cord having no braid on any individual conductor.

[c] Only for a cord having a jacket that is not integral with the circuit conductor insulation.

[d] Only for Types SP-2, SPE-1, and SPE-2 cords.

15.1.5 The conductor of the power supply cord that is intended to be grounded shall have the terminal or lead of a receptacle intended to be grounded connected to it. Table 15.1 identifies the supply cord conductor intended to be grounded.

15.1.6 The length of a power supply cord – as measured from the outside surface of the enclosure of the speed control to the plane of the face attachment plug – shall not exceed 16 feet (4.9 m) nor be less than 6 feet (1.8 m).

15.1.7 A power supply cord shall have a voltage rating not less than the rated voltage of the speed control and have an ampacity not less than the current rating of the speed control.

15.1.8 The attachment plug shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. It shall be of a type suitable for use:

a) With a current not less than the rated current of the speed control; and

b) At a voltage equal to the rated voltage of the speed control.

15.2 Strain relief

15.2.1 Strain relief shall be provided so that a mechanical stress on the supply cord is not transmitted to a terminal, splice, or internal wiring. The cord shall be prevented from being displaced within the enclosure resulting in reduced spacings to values less the minimum acceptable values.

Exception: Strain relief is not required if the conductors of the supply cord are assembled to a wiring device, such as a switch, a lampholder, or the like, by the manufacturer of the wiring device in such a manner that replacement of the cord requires the disassembly of the wiring device by removal of a rivet, a drive screw, a drive pin, or the equivalent.

15.2.2 A bushing employed for strain relief shall be separately investigated and suitable for the type and size of conductor intended to be used.

15.2.3 If a knot in a flexible cord serves as strain relief, a surface that the knot may contact shall be free from projections, sharp edges, burrs, fins, and the like, that may cause abrasion of the insulation on the conductors.

15.2.4 Means shall be provided to prevent the supply cord or lead from being pushed into the enclosure of a product through the cord-entry hole when such displacement results in:

a) Subjecting the supply cord or lead to mechanical damage;

b) Exposing the supply cord or lead to a temperature higher than that for which it is rated;

c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or

d) Damaging internal connections or components.

15.3 Bushings

15.3.1 At the point where a flexible cord passes or is intended to pass through an opening in a wall, barrier, or the overall enclosure, there shall be a bushing or the equivalent that is substantial, reliably secured in place, and has a smooth, well rounded surface against which the cord can bear.

15.3.2 If the cord hole is in porcelain, phenolic composition or other nonconducting material having a smooth rounded surface is considered to be equivalent to a bushing.

15.3.3 Ceramic materials and some molded compositions are acceptable generally for insulating bushings, but a bushing of wood composition is not acceptable.

15.3.4 Vulcanized fiber employed as a bushing shall not be less than 3/64 inch (1.2 mm) thick and formed and secured in place so that it will be adversely affected by conditions of ordinary moisture; and shall not be employed where it will be subjected to a temperature higher than 90 °C (194 °F) under normal operating conditions.

15.3.5 A bushing of any of the materials mentioned in 15.3.3 is acceptable on a supply cord anywhere in a speed control if it is used in conjunction with a type of cord for which an insulating bushing is not required. The edges of the hole in which such a bushing is so used shall be free from burrs, fins, and other conditions capable of damaging the bushing.

15.3.6 A bushing of the same material as and molded integrally with the supply cord is acceptable if the built-up section is no less than 1/16 inch (1.6 mm) thick at the point at which the cord passes through the enclosure.

15.3.7 An insulated metal grommet may be used in place of an insulating bushing if the insulating material is no thinner than 1/32 inch (0.8 mm), and completely fills the space between the grommet and the metal in which the grommet is mounted.

15.4 Receptacles

15.4.1 The receptacle outlets of a speed control shall have a voltage and current configuration the same as that of the attachment plug on the power supply cord. They may be of the same or different slot configurations (locking and non-locking).

16 Supply Connections – Direct Plug-In Devices

16.1 Direct plug-in attachment plug blades, grounding pin, and receptacles shall be evaluated in accordance with the Standard for Electrical Attachment Plugs and Receptacles, UL 498 except where superseded by this Standard.

17 Spacings

17.1 General

17.1.1 The electrical spacings in primary circuits shall be at least those specified in Table 17.1, and shall be reliably maintained.

Table 17.1
Minimum Acceptable Spacings (Other Than Field Wiring Terminals)

Parts involved		Minimum spacing inch (mm)		
		Potential involved in volts		
		0 – 50	51 – 125	126 – 300
Between any uninsulated live part of opposite polarity, uninsulated grounded part other than the enclosure, or exposed metal part	Through air or oil	1/16 (1.56)	1/16 (1.56)	1/6 (1.56)
	Over surface	1/16	3/32[a] (2.38)	1/8 (3.18)
Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable	Shortest distance	1/2 (12.7)	1/2	1/2

[a] For units rated less than 7.2 amperes, the spacing shall not be less than 1/16 inch.

17.1.2 Spacings at or within a component or device are judged based on the requirements for the component or device and are not specified.

17.1.3 The spacing between field wiring terminals of opposite polarity and the spacing between a field wiring terminal and a grounded dead metal part shall be at least 1/4 inch (6.4 mm) if short-circuiting or grounding of such terminals may result from projecting strands of wire.

17.1.4 A ceramic, vitreous-enamel, or similar coating is not acceptable as insulation in place of spacings unless, upon investigation, the coating is found to be acceptable for the purpose.

17.2 Primary circuit spacings

17.2.1 The spacings between lines of a 2-wire speed control are not specified because of single polarity. All other spacings shall be evaluated in accordance with 17.1.1.

17.2.2 Spacings within a circuit derived from a limiting impedance in a primary circuit need not be further investigated provided that the impedance limits the product of the current through and the voltage across the impedance to a value not exceeding the wattage rating of the impedance and to a level not exceeding 15 watts when a direct short is applied across the remainder of the circuit.

17.2.3 Film-coated wire is considered to be an uninsulated live part in determining compliance with the spacing requirements in this standard.

17.2.4 Spacings between leads or from any portion of any circuit at a voltage in excess of 30 volts rms (42.4 volts peak) to accessible dead metal shall comply with the spacings outlined in Table 17.1.

17.3 Secondary circuit spacings

17.3.1 Electrical spacings in secondary circuits shall be at least those specified in Table 17.1 unless indicated otherwise in 17.3.2 – 17.3.6.

17.3.2 Secondary circuits shall be provided with isolation from the primary circuits.

17.3.3 Relays, transformers, and similar components complying with the requirements in this standard are considered as providing the isolation required by 15.3.2.

17.3.4 A pulse transformer provided with isolation other than required by this standard shall be acceptable for the application and shall have a dielectric voltage-withstand capability of not less than 2500 volts ac rms or 3540 volts dc for 1 minute if it is relied upon to provide the isolation between primary and secondary circuits required by 17.3.2.

17.3.5 An optic isolator shall have an isolation voltage of 2500 volts ac rms.

17.3.6 Solid-state switching components in contact with accessible dead metal shall have an isolation voltage of 2500 volts ac rms.

17.4 Limited energy

17.4.1 Circuits supplied by an isolated transformer secondary winding having a maximum available capacity (as defined in 17.4.2) of 200 volt-amperes or less at a maximum potential of 100 volts are not required to be further investigated. For a multiple winding transformer, a secondary winding used for limited energy circuits is not required to be further tested if the connected circuit complies with the requirements for Separation of Circuits, Section 18.

17.4.2 Maximum available capacity is the maximum product of simultaneously measured values of secondary voltage and secondary current. The values shall be determined by placing a resistive load on the secondary winding and measuring available current and voltage while varying the resistive load from open circuit to short circuit in 1-1/2 to 2-1/2 minutes.

17.5 Battery power

17.5.1 A circuit involving a potential of not more than 42.4 volts peak supplied by a primary (nonrechargeable) battery that complies with all the performance requirements for a Class 2 transformer and complies with the requirements for Separation of Circuits, Section 18, is not required to be further tested.

17.5.2 A circuit involving a potential of not more than 42.4 volts peak supplied by a secondary (rechargeable) battery that complies with all the performance requirements for a Class 2 transformer is not required to be further tested if the battery is charged by the secondary circuit of an isolation transformer complying with Class 2, isolated power, limited energy or controlled environment requirements, and the circuit complies with the requirements for Separation of Circuits, Section 18.

17.6 Insulating barriers

17.6.1 An insulating barrier or liner used as the sole separation between uninsulated live parts and grounded dead metal parts, including the enclosure, or between uninsulated live parts of opposite polarity shall be of a material that is acceptable for the mounting of uninsulated live parts and shall not be less than 0.028 inch (0.71 mm) thick.

Exception: Fiber less than 0.028 inch thick may be used as the sole separation between the enclosure and an uninsulated metal part electrically connected to a ground circuit conductor.

17.6.2 An insulating barrier or liner that is used in addition to an air space in place of the required spacing through air shall be at least 0.028 inch (0.71 mm) thick. If the barrier or liner is of fiber, the air space shall not be less than 1/32 inch (0.8 mm), and if the barrier or liner is of other material that is not acceptable for the support of uninsulated live parts, the air space provided shall be acceptable for the application.

Exception: A barrier or liner that is used in addition to not less than one-half the required spacing through air may be less than 0.028 inch but not less than 0.013 inch (0.33 mm) thick if the barrier or liner:

a) Is of a material that is acceptable for the mounting of uninsulated live parts;

b) Has the necessary mechanical strength if exposed or otherwise likely to be subjected to mechanical damage;

c) Is held in place; and

d) Is located so that it will not be adversely affected by operation of the equipment in service.

17.6.3 Insulating material having a thickness less than that specified in 17.6.1 and 17.6.2 may be used if investigated and found to be acceptable for the application.

18 Separation of Circuits

18.1 Insulated conductors shall be separated by barriers or segregated from:

a) Each other if used in different internal wiring circuits; and

b) Uninsulated live parts connected to different circuits.

Exception: This requirement does not apply to conductors that are provided with insulation rated for the highest voltage involved.

18.2 Segregation of insulated conductors shall be accomplished by clamping, routing, or equivalent means that provides permanent separation from insulated or uninsulated live parts of a different circuit.

18.3 Means shall be provided for separation of field-installed conductors from:

a) Field- and factory-installed conductors connected to any other circuit.

Exception: Complete instructions in conjunction with a wiring diagram may be acceptable in lieu of a barrier if, upon investigation, the combination is found to be acceptable and the instructions specify that the conductors of both circuits are to be insulated for the maximum voltage of either circuit.

b) Uninsulated live parts of any other circuit of the device.

Exception: Field-installed conductors may make contact with other circuit wiring terminals provided marked instructions indicate that wiring in accordance with the National Electrical Code, ANSI/NFPA 70, is to be used.

18.4 To determine if a speed control complies with the requirement of 18.3, it is to be wired as intended for service with a reasonable amount of slack left in each conductor within the enclosure and normal care exercised in stowing the slack into the wiring compartment.

19 Grounding

19.1 A fan speed control shall have provision for grounding all noncurrent carrying metal parts that are exposed or that are likely to be contacted by persons during normal operation or adjustment of the equipment and that are likely to become energized. An acceptable means for grounding permanently-connected equipment consists of a knockout or other opening in the enclosure for the connection of a wiring system, in accordance with the National Electrical Code, ANSI/NFPA 70.

Exception: A cord-connected unit provided with a 2-conductor polarized plug is not required to ground accessible dead metal.

19.2 A wire binding screw intended for the connection of a field-installed equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both.

19.3 A pressure wire connector intended for connection of a field-installed equipment grounding conductor shall be identified by:

a) Use of a wire-binding screw with a green-colored head that is slotted or hexagonal, or both; or

b) Use of a threaded stud with a green-colored hexagonal nut; or

c) Use of a green-colored pressure-terminal connector; or

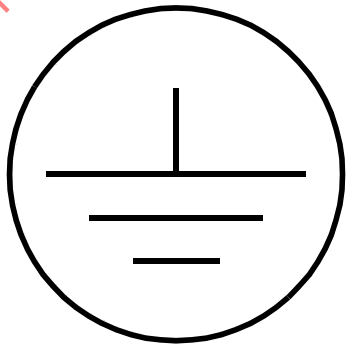
d) Being marked "G," "GR," "GRD," "Ground," "Grounding," or the like; or

e) A marking on a wiring diagram provided on the product; or

f) The grounding symbol illustrated in Figure 19.1 on or adjacent to the terminal or on a wiring diagram provided on the product.

Figure 19.1

Grounding Symbol



IEC417, Symbol 5019

19.4 A flush-type fan speed control intended for mounting in a flush-device box shall be so constructed that a metallic flush faceplate is bonded to ground when installed in the intended manner.

PERFORMANCE

20 General

20.1 The performance of a speed control shall be investigated by subjecting a representative sample or samples in commercial form to the tests indicated in Table 20.1. The table indicates a sequence for some tests. Consideration shall be given to heat sink, solid state device ratings, and other criteria in determining whether a sample is representative.

Table 20.1
Test Summary

Section	Test	Sample number[a] 1 Sequence	2 Sequence	3 Sequence	4 Sequence	5 Sequence
21	Temperature	1				
22	DC Offset Voltage					1,4[b]
23	Overload		1			2
24	Endurance		2			3
25	Dielectric Voltage-Withstand	2	3			
26	Short Circuit			1		
27	Breakdown of Components				1	
28	Crush Test[c]					

NOTE – Other tests not specified in the table apply to specific constructions.

[a] All or any combination of sequences may be conducted on a single sample, if agreeable to those concerned; but one sample is to be subjected to the overload test, followed by the endurance test, followed by the dielectric voltage withstand test. For other tests, one sequence need not be completed as a prerequisite to the starting of another. More than one sample may be used if more than one rating is being tested.

[b] The DC Offset Voltage Test is to be conducted only on fan speed controls utilizing semiconductors. The test is to be conducted before the Overload Test and after the Endurance Test.

[c] The Crush Test may follow any test sequence, or it may be performed on a new sample.

20.2 Tests are to be conducted at rated frequency and at a test potential as indicated in Table 20.2. The samples are to be operated at a rated current while connected in series with the ungrounded side of a test load that has been adjusted to a power factor as indicated in Table 23.1 unless it can be shown that power factor does not affect the results. Additionally, temperature or current sensitive devices or systems that cause termination of a test shall be investigated to determine their acceptability.

Table 20.2
Values of Voltage for Tests

Test	Voltage rating of equipment[a] 110 – 120	220 – 240	254 – 277	277 – 300
Temperature	120	240	277	300
Overload	120	240	277	300
Endurance	120	240	277	300
DC Offset	120	240	277	300

[a] If the rating of the equipment does not fall within any of the indicated voltage ranges, the test program shall be based on the rated voltage.

20.3 Unless indicated otherwise, the tests are to be conducted at any ambient temperature within the range of 10 – 40 °C (50 – 104 °F). The ambient temperature is to be determined using either thermometers or thermocouples placed at different points around the equipment being tested at a distance of 3 to 6 feet (0.9 to 1.8 m).

20.4 A speed control with an incomplete or partial enclosure is considered to be an open device with respect to the performance requirements in this standard.

21 Temperature Test

21.1 When operating in the normal mode resulting in maximum heating and as described in 21.6, a speed control shall not attain a temperature at any point high enough to constitute a risk of fire, adversely affect any materials or components employed in the speed control, or exceed, at stabilized temperatures, the temperature rises specified in Table 21.1 and 21.4 – 21.6.

Table 21.1
Maximum Acceptable Temperature Rises

	Materials and components	°C	(°F)
1.	Fuse Clip or Receptacle Contacts	30	(54)
2.	Rubber- or thermoplastic-insulated conductors:	35	(63)
	internal to device[a,b]		
	intended for field connections[g,j]		
3.	Surfaces that can be contacted by field wiring conductors or conductors in wall box[j]	35	(63)
4.	Field-wiring terminals[c]	50	(90)
5.	Contacts		
	Solid and built-up silver, silver alloy, and silver faced	d	d
	All other metals	65	(117)
6.	External surfaces subject to contact (metallic and nonmetallic)[g]	65	(117)
7.	Insulation systems		
	Class 105 insulation systems[f]		
	Thermocouple method	65	(117)
	Resistance method	85	(153)
	Class 105 insulation systems on single-layer series coil with exposed surfaces either uninsulated or enameled, thermocouple method	90	(162)
	Class 130 insulation systems[f]		
	Thermocouple method	85	(153)
	Resistance method	105	(189)
8.	Phenolic composition[a]	125	(225)
9.	On the embedding material of a resistor	300	(540)
10.	On bare resistor material		
	Thermocouple method	375	(675)
11.	Capacitor	e	e
12.	Power switching semiconductors	h	h
13.	Printed-wiring boards	i	i

Table 21.1 Continued on Next Page

Table 21.1 Continued

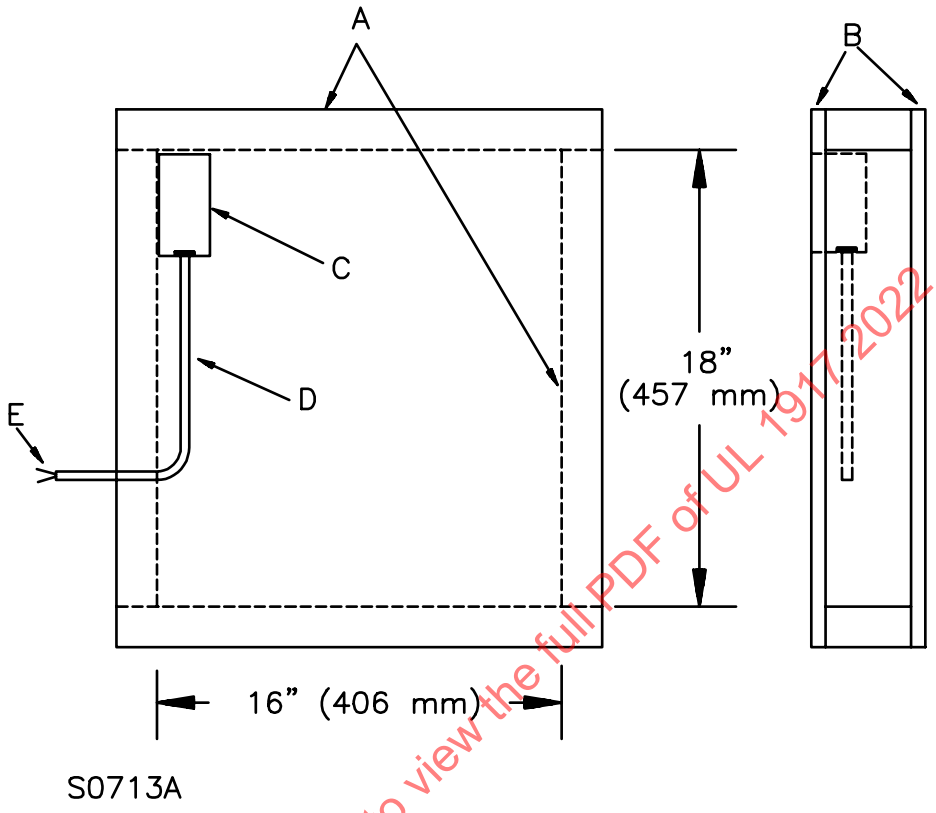
Materials and components	°C	(°F)
[a] The limitation on phenolic composition and on rubber and thermoplastic insulation does not apply to compounds that have been investigated and found acceptable for a higher temperature. [b] For standard insulated conductors other than those mentioned in item 2, reference should be made to the National Electrical Code, ANSI/NFPA 70, and the maximum temperature rise shall not exceed the maximum operating temperature specified in the Code for the wire in question minus an assumed ambient (room) temperature of 25 °C (77 °F). However, a temperature rise on any conductor shall not exceed 35 °C (63 °F) where the conductor may come in contact with other conductors. [c] The temperature on a wiring terminal or lug is measured at the point most likely to be contacted by the insulation of a conductor installed as in actual service. [d] Temperature is limited by the temperature limitations on the material for adjacent parts. There shall be no structural deterioration of the contact assembly, loosening of parts, cracking or flaking of materials, loss of temper of springs, annealing of parts, or other visible damage. [e] For a capacitor, the maximum acceptable temperature rise is the marked temperature limit of the capacitor minus an assumed ambient temperature of 25 °C (77 °F). [f] In equipment marked for 60 °C (140 °F) supply wire, the terminal temperature rise shall not exceed 50 °C (90 °F). [g] Any part of the speed control more than 1/4 inch (6.4 mm) behind the mounting yoke is to be considered a part which can contact field wiring. [h] The maximum acceptable temperature rise on the semiconductor is the maximum temperature for the applied power dissipation recommended by the semiconductor manufacturer minus an assumed ambient of 40 °C (104 °F) for an enclosed device and 50 °C (122 °F) for an open device, at the location specified by the semiconductor manufacturer. [i] The maximum acceptable operating temperature of the printed-wiring board shall not be exceeded based on an assumed ambient temperature of 25 °C (77 °F). [j] Higher values permitted in accordance with the Exception to 21.4 and marked in accordance with 42.15 and Table 42.1.		

21.2 The maximum temperature rise of any part that is exposed to contact on the outside of the speed control, when mounted and installed in accordance with the manufacturer's instructions, other than those indicated in 21.3, shall not be more than 65 °C (117 °F).

21.3 The temperature rise of any wood part of the frame (see Figure 21.1) adjacent to the speed control, when mounted and installed in accordance with the manufacturer's instructions, shall not be more than 65 °C (117 °F).

Figure 21.1

Test Enclosure



A – Trade size 2 x 4 frame of wood having 3-1/2 by 1-1/2 inches (89 by 38 mm) cross section. Frame well-fitted.

B – 3/8 inch (9.5 mm) thick gypsum wallboard carefully fitted and assembled to frame, but not sealed to it.

C – Outlet box to house control. See 21.2. All unused knockouts in place. Front face is flush with wallboard face. Gap between front surface of wallboard and front edges of installed box is to be no more than 1/8 inch (3.2 mm).

D – 1/2 inch trade size metal conduit and fitting.

E – 14 AWG (2.1 mm^2) copper conductors for control electrical supply.

21.4 For a fan speed control intended for installation in an outlet box, the temperature rise of any part of the speed control, any part of the test enclosure that can contact the field wiring, and the field wiring terminals or leads shall not exceed 35 °C (63 °F). Any part of the speed control or box more than 1/4 inch (6.4 mm) behind the mounting yoke is to be considered a part that can contact field wiring.

Exception: The temperature rise may exceed 35 °C but not more than 50 °C or 65 °C provided the control is appropriately marked in accordance with 42.15, and the conductors for field connection integral to the device are rated at least equal to the temperature specified in the marking.

21.5 A surface mounted speed control is to be mounted in accordance with the manufacturer's instructions.

21.6 A device intended for installation in a wall is to be mounted as follows. The control is to be secured inside its own enclosure, if provided; otherwise, it is to be installed inside the smallest standard flush-type outlet box that will accommodate it, and the box or enclosure is to be mounted in a simulated wall section as illustrated in Figure 21.1. The outlet box is to conform with the specifications in the installation instructions. If the type of box is not specified, the test is to be conducted using a metal outlet box, and is to be repeated with a polymeric (plastic) outlet box. The wall section is to be filled with insulation rated R-11 unless the control is marked in accordance with 43.5. Unless the control is provided with a cover plate that cannot be removed or one which can only be used with that control, it is to be covered with an ivory colored nonmetallic cover.

21.7 The test is to be conducted with the speed control setting which results in maximum heat and with the control mounted in the intended operating position.

21.8 If an internal factory adjustment is provided, the setting is to be adjusted to provide maximum heating.

21.9 Temperatures are to be measured with all parts operating simultaneously, as the heating of one part may affect the heating of another part.

21.10 The rated current for horsepower-rated equipment is to be as specified in Table 23.2.

21.11 A speed control is to be tested with 4 feet (1.2 m) of wire attached to each field-wiring terminal. The wire is to be of the smallest size having an ampacity of at least 125 percent of the test current for motor loads and at least 100 percent for other loads. The wire size is to be in accordance with Table 21.2 based on the wire temperature rating marked on the equipment. The type of insulation is not specified. The temperature test may be conducted with conductors having other than black insulation, but referee temperature measurements are to be conducted with black-insulated conductors.

Table 21.2
Ampacities of Insulated Conductors

Wire size		Ampacity (amperes)			
		60 °C (140 °F)		75 °C (167 °F)	
AWG	(mm^2)	Copper	Aluminum	Copper	Aluminum
18	(0.82)	10		10	
16	(1.3)	13		13	
14	(2.1)	15		15	
12	(3.3)	20	15	20	15
10	(5.3)	30	25	30	25

21.12 If referee measurements of ambient temperatures are necessary, several thermometers are to be placed at different points around the equipment at a distance of 3 to 6 feet (0.9 to 1.8 m). The thermometers are to be located in the path of the cooling medium, but are to be protected from drafts and abnormal heat radiation. The ambient temperature is to be the mean of the readings of the temperatures taken at equal intervals of time during the final quarter of the duration of the test.

21.13 The thermocouple method for temperature measurement as specified in Table 21.1 consists of the determination of temperature by use of a temperature indicating instrument and thermocouples that are applied to the hottest accessible parts. The thermocouples are to be made of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). The thermocouples and related instruments are to be accurate and calibrated in accordance with good laboratory practice. The thermocouple wire is to conform with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

21.14 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material of which the temperature is being measured. In most cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place; but if a metal surface is involved, brazing or soldering the thermocouple to the metal may be necessary.

21.15 The resistance method for temperature measurement as specified in Table 21.1 consists of the calculation of the temperature rise of a winding using the equation:

$$\Delta T = \frac{r_2}{r_1}(k + t_1) - (k + t_2)$$

in which:

ΔT is the temperature rise of the winding in degrees C.

r_2 is the resistance of the coil at the end of the test in ohms.

r_1 is the resistance of the coil at the beginning of the test in ohms.

t_1 is the room temperature in degrees C at the beginning of the test.

t_2 is the room temperature in degrees C at the end of the test.

k is 234.5 for copper, 225 for electrical conductor grade (EC) aluminum; values of the constant for other conductors are to be determined.

21.16 Because it is generally necessary to de-energize the winding before measuring r_2, the needed value of r_2 at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time may be plotted and extrapolated to give the value of r_2 at shutdown.

21.17 The preferred method of measuring the temperature of a coil is the resistance method; but temperature measurements by either the thermocouple or resistance method are acceptable; except that the thermocouple method is not to be employed at any point where supplementary insulation is employed.

21.18 A temperature rise is considered to be constant when three successive readings that are taken at intervals of 10 percent of the previously elapsed duration of the test but not less than 10 minute intervals indicate no change in the temperature rise.

22 DC Offset Voltage Test

22.1 Before the overload test (in the as-received condition) and after the endurance test (still in a well-heated condition), the output voltage from a semiconductor-type fan speed control (see 2.8) shall not have a dc component greater than 2 volts when tested as described in 22.2 and 22.3.

22.2 This test is to be conducted with the control installed, connected, loaded, and operated as described in Section 21, Temperature Test. A voltmeter with a damped frequency response in the 0 to 120 hertz range is to be used to measure the dc voltage across the test load.

22.3 The test is to include varying the fan speed control over its full range and varying any trim components (such as but not limited to trim potentiometers, capacitors, inductors, and the like.) to obtain all possible conditions of operation. Several tests may be necessary to determine the setting of the trim components.

23 Overload Test

23.1 During the overload test described in this section, there shall be no electrical or mechanical malfunction of the equipment, no undue burning or pitting of the contacts, and no welding of the contacts. The fuse specified in 23.12 shall not open.

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

23.3 Tests on a speed control having an alternating-current rating are to be conducted using a circuit having a frequency of 60 hertz.

Exception: A test circuit frequency in the range of 25 – 60 hertz may be considered to be representative.

23.4 A speed control intended for general purpose is to close and open a test circuit with 6 times the device's full load current at a power factor of 0.4 – 0.5 as described in Table 23.1. If a control is rated in horsepower instead of current, the horsepower rating is to be converted to a full load current value using the information in Table 23.2 in order to apply Table 23.1.

Table 23.1
Overload Test Circuit

Intended device application	Current, amperes	Power factor
General purpose fan (HP)	6 times full load current	0.40 – 0.50
Ceiling-suspended fan (paddle fan)	1.5 times full load current	0.75 – 0.80
AC incandescent lamps	1.5 times full load current	0.75 – 0.80

Table 23.2
Full-Load Motor-Running Currents in Amperes Corresponding to Various a-c Horsepower Ratings

Horsepower	Current (amperes)	
	110 – 120 volts (single phase)	220 – 240 volts[a] (single phase)
1/10	3.0	1.5
1/8	3.8	1.9
1/6	4.4	2.2
1/4	5.8	2.9
1/3	7.2	3.6
1/2	9.8	4.9
3/4	13.8	6.9
1	16.0	8.0
1-1/2	20.0	10.0

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

[b] The FLA at 277 volts is obtained by decreasing the FLA at 240 volts by 17 percent.

23.5 A speed control intended for use with a ceiling fan is to close and open a test circuit with 1.5 times the control's full load current (FLA) at a power factor of 0.75 – 0.80 as described in Table 23.1. If a control is rated in horsepower instead of current, the horsepower rating is to be converted to a full load current value using the information in Table 23.2 in order to apply Table 23.1.

23.6 As an alternate, controls intended for use in a specific end product may close and open a test circuit consisting of the controlled motor under locked rotor conditions or a synthetic load which represents a motor at 100 percent of the control's rated locked rotor current (LRA).

23.7 A speed control intended to control incandescent lights is to close and open a test circuit with 1.5 times the control's full load current at a power factor of 0.75 – 0.80 as described in Table 23.1.

23.8 Air core type reactors are to be used to obtain the reactive power factor specified in Table 23.1. Reactors may be connected in parallel. No reactor is to be connected in parallel with a resistor.

Exception: An air-core reactor in any phase may be connected in parallel with a resistor if the resistor power consumption (R_{SH}) is approximately 1 percent of the total power consumption in that phase calculated in accordance with the following formula:

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

in which

PF is the power factor,

E is the closed-circuit phase voltage, and

I is the phase current.

23.9 The closed test circuit voltage is to be 100 to 110 percent of the overload test voltage specified in Table 20.2.

23.10 The speed control is to open and close the test circuit 50 times.

23.11 For all speed controls except a reversing control, the test cycle is to be as follows:

a) If provided with an on/off switch which is operated independently of the speed setting, the on/off switch is actuated.

b) If provided with an on/off switch which is integral with the speed adjustment, the speed adjustment is smoothly moved through a complete cycle (1 second on and 9 seconds off).

Exception: If the control operation will not permit these cycle times, times as close as possible to these are to be used.

23.12 During the test, the enclosure is to be connected through a 30-ampere cartridge fuse that does not have a time delay to the electrical test circuit pole considered least likely to strike to ground.

24 Endurance Test

24.1 During the endurance test, there shall be no electrical or mechanical breakdown of the control, or welding, undue burning, or pitting of the contacts. The fuse specified in 23.12 shall not open. After the test, the control shall comply with the requirements of the Dielectric Voltage-Withstand Test as described in Section 25.

24.2 The conditions for the endurance test shall be the same as the conditions for the Overload Test as specified in Section 23, except as described in this section.

24.3 The control is to close and open a test circuit having the applicable current and power factor specified in Table 24.1. The number of test cycles and the test cycle times are to be as specified in Table 24.1. The closed circuit test voltage is to be 100 to 110 percent of the endurance test voltage specified in Table 20.2. A control intended to control incandescent lamps shall use incandescent lamps as the load.

Table 24.1
Endurance Test

Intended control application	Test current amperes	Power factor	No. of cycles	Test cycle times, seconds	
				On	Off
General purpose fan (HP)	Twice full-load current	0.4 – 0.5	6000	1	9
Ceiling-suspended (paddle fan)	Rated current	0.75 – 0.8	6000	1	9
AC incandescent lamps	24.4 – 24.7	1.0	6000	1	59[a]

[a] A control may be operated faster than 1 cycle per minute if synthetic loads are used or if a sufficient number of banks of lamps controlled by a commutator are employed so that each bank will cool for at least 59 seconds between successive applications.

24.4 When incandescent lamps are used as the load, the load is to be made up of the smallest possible number of 100-watt lamps, or of larger lamps if agreeable to those concerned; except that one or two lamps smaller than the 100-watt size may be used if necessary to make up the required load.

24.5 As an alternate to 24.3, a component speed control intended for use in a specific end product is to close and open a test circuit consisting of the controlled motor under full load conditions for 6000 cycles (1 second on and 9 seconds off) or a synthetic load which represents a motor at 100 percent of rated full load current.

24.6 With regard to 24.4, the circuit is to be such that the peak value of the inrush current will be reached in 1/240 of a second after the circuit is closed.

24.7 A synthetic load may be used in place of tungsten-filament lamps if it is equivalent to a tungsten-filament lamp load on the test circuit in question, and the inrush current is at least ten times the normal current.

24.8 A synthetic load used in place of tungsten-filament lamps may consist of noninductive resistors if they are connected and controlled so that a portion of the resistance is shunted during the closing of the switch under test. A synthetic load may also consist of a noninductive resistor or resistors that are connected in parallel with a capacitor.

25 Dielectric Voltage-Withstand Test

25.1 While in a well heated condition, a speed control shall withstand for 1 minute without breakdown the application of a 60 hertz essentially sinusoidal potential:

a) Between uninsulated live parts and the enclosure with the contacts open and closed;

b) Between terminals of opposite polarity with the contacts closed; and

c) Between uninsulated live parts of different circuits.

25.2 With respect to 25.1, the test potential shall be 1000 volts plus twice the rated voltage of the equipment.

25.3 A transformer, a coil, an electronic part, or a similar device normally connected between lines of opposite polarity is to be disconnected from one side of the line during the test described in 25.1(b).

25.4 To determine whether a speed control complies with the requirements in 25.1, it is to be tested by means of a 500 volt-ampere or larger capacity transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero to the required value at a substantially uniform rate and as rapidly as is consistent with its value being correctly indicated by a voltmeter.

Exception: A 500 volt-ampere or larger capacity transformer is not required if the transformer is provided with a voltmeter that directly measures the applied output potential.

26 Short Circuit Test

26.1 A speed control shall comply with the following acceptance criteria when tested in accordance with 26.3:

a) The cotton shall not ignite;

b) Molten metal shall not exit the enclosure nor shall any other risk of a fire occur;

c) The ground fuse shall not open; and

d) The cover plate shall not blow off; deformation is acceptable, but not to the extent that deformation results in the accessibility of live parts as described in 7.5.2.

26.2 The test current shall be determined by the rating of the speed control in accordance with Table 26.1. For a speed control rated in amperes, multiply rated input voltage by rated input current to obtain rated VA. For a speed control rated in horsepower, convert horsepower to amperes from Table 23.2 and calculate VA as above. For a speed control rated in amperes and horsepower, calculate VA using amperes and horsepower values, choosing the larger of the two.

Table 26.1
Short Circuit Test

VA	Test current, amperes[a]	Power factor
0 – 1920	1,000	0.70 – 0.80
1921 – 6000	5,000	0.70 – 0.80
[a] Symmetrical rms amperes		

26.3 If the speed control is provided with an on/off switch that is integral with the speed adjustment, three samples are to be tested. The test circuit is to be closed once on each control while the control is set as follows. The first control is to be set at maximum output with the solid-state devices in the circuit. The second control is to be set at minimum output with the solid-state devices in the circuit. The third control is to be set at midpoint output.

26.4 If the control is provided with an on/off switch which operates independently of the speed adjustment, 6 samples are to be tested. The test described in 26.3 is to be done with the switch closed and then repeated on three additional samples, with the on/off switch being closed on the test circuit.

26.5 If the control employs an independent set of switch contacts for full power operation, the test in 26.3 is to be repeated with the solid-state devices out of the circuit and the independent switch contacts in the circuit.

26.6 Any trim components inside the speed control are to be set to the most adverse positions. Additional samples may need to be tested if the most adverse trim component positions cannot be determined except by test.

26.7 A 20-ampere branch circuit-type fuse is to be connected in series with the pole judged most likely to strike ground. If the control is marked for use only in a 15-ampere branch circuit, a 15-ampere branch circuit type fuse may be used.

26.8 The test is to be conducted with the speed control mounted as intended using sheet steel or a metallic outlet box and cover connected through a nontime-delay, 3-ampere, cartridge fuse to the electrical supply live pole judged least likely to strike to ground. The connection is to be made to the load side of the limiting impedance by a 12 AWG (3.3 mm^2) copper wire that is 4 – 6 feet (1.22– 1.83 m) long.

26.9 The enclosure is to be draped with surgical cotton. The cotton shall not ignite during this test.

27 Breakdown of Components Test

27.1 General breakdown of components test

27.1.1 There shall be no emission of flame or molten metal nor ignition of cotton loosely placed over all openings of ventilated controls or totally around open controls when a single capacitor, diode, or other solid state component is individually short- or open-circuited. The 3-ampere fuse connected between the enclosure and ground shall not open.

Exception: The test is not required:

a) For components in circuits that comply with 17.4 and 17.5 (Class 2 circuits);

b) For components in circuits that comply with 17.2.2;

c) On power semiconductor devices if equivalent testing is accomplished during short circuit tests; and

d) For components complying with requirements applicable to the component.

27.1.2 The speed control is to be installed in accordance with the Temperature Test, Section 21; a 3-ampere nontime-delay fuse is to be connected between the enclosure and ground; the fault condition is to be implemented; the control is to be energized; and all control adjustments are to be adjusted through their ranges.

27.2 Abnormal switching test

27.2.1 Controls incorporating electronic circuitry to trigger the switching device during a more advantageous electrical condition, such as at zero crossing, shall be subjected to this abnormal switching test. This test is applicable when:

a) Loads and circuits are non-safety.

b) Switching components are used beyond their evaluated ratings. These evaluated ratings of switching devices are typically determined without electronic triggering techniques, such as zero cross switching.

27.2.2 Two test samples are to be prepared and connected as follows:

a) The trigger circuit of the switching device is to be removed or modified to allow random switching.

b) A ground arc indicating fuse is connected to accessible dead metal of the control. The ground arc detection fuse shall be rated not greater than 3A and not less than the working voltage.

c) The control shall be covered in a single layer of cheesecloth, except for the mounting surface, and then placed on a softwood surface that has been covered with white tissue paper. The cheesecloth shall be, bleached untreated cotton cloth running 14 – 15 square yards per pound (26 – 28 m^2/kg) and for any square inch a count of 32 threads in one direction and 28 in the other direction (for any square centimeter, 13 threads in one direction and 11 in the other direction).

d) The rated supply shall be connected through a branch circuit protection device sized according to installation requirements.

e) The control is connected to its rated electrical load.

27.2.3 The prepared test samples shall be operated in accordance with the endurance test requirements specifying the number of operating cycles and on/off periods using random switching. The test samples shall be operated until either the required number of endurance test cycles are achieved or until ultimate results are demonstrated for 1 h stabilized duration.

27.2.4 Immediately after each abnormal switching test, each control shall be subjected to the Dielectric Voltage-Withstand Test, Section 25.

27.2.5 The control shall either operate as intended in accordance with the endurance test requirements, or demonstrate an end-of-life fail safe condition with no evidence of an imminent electrical shock, fire or injury to persons. There shall be no:

a) Opening of the ground arc detection fuse.

b) Burning of the cheesecloth.

c) Opening of the branch circuit protection device.

d) Breakdown during the post-dielectric withstand testing.

28 Crush Test

28.1 When tested as described in 28.2, the mechanical protection specified in 7.1.4 shall withstand without splitting or cracking and without damage to internal components – including movement of the internal component or a reduction of spacings below those specified in Section 17, Spacings, – a crushing force of 10 pounds (44.5 N).

28.2 A sample is to be placed between two maple blocks each not less than 1/2 inch (12.7 mm) thick. A crushing force of 10 pounds (44.5 N) is to be applied gradually in a direction normal to the mounting surface for a period of one minute.

29 Compression Test

29.1 An enclosure that is thinner than that specified in Table 7.1 and Table 7.2, in accordance with the Exception to 7.3.1, shall be reinforced so that its deflection is not more than that of a reference sheet-metal enclosure of the maximum length and width constructed of the minimum required sheet metal thickness.

29.2 The enclosure is to rest on a flat, unyielding horizontal surface. A vertical force is to be applied at any point on the surface of the enclosure except for the door or cover using a flat face of a steel bar having a 1/2 inch (13 mm) square cross-section. Force is to be applied to the end, side, and rear walls of each enclosure. The value of force and limit of deflection are not specified, but the force on each wall of both the test and reference enclosures is to be sufficient to result in a measurable deflection on the test enclosure.

30 Deflection Test

30.1 A drawn, embossed, flanged, or similarly strengthened door, front, or cover made of metal having a thickness less than specified in Table 7.1 and Table 7.2 shall not deflect inward more than 1/4 inch (6.4 mm) when a vertical force of 100 pounds (445 N) is applied at any point on the door, front, or cover.

30.2 The force is to be applied through a bar having a flat, square face 1/2 inch (13 mm) on an edge. The equipment is to rest on its back on a flat, unyielding horizontal surface with the door closed and the front or cover secured as intended.

30.3 If a flange on the edges of a telescoping door or cover is reduced in width or is omitted, the door or cover shall not deflect more than 3/8 inch (9.5 mm) when subjected to a force of 100 pounds (445 N) applied at any point 1 inch (25.4 mm) from the edges.

30.4 The test is to be conducted with the door or cover mounted on the box in the intended manner, and the enclosure placed with its back on a flat, unyielding horizontal surface. The force is to be applied through the bar described in 30.2.

31 Securement of Snap-On Cover Test

31.1 A snap-on cover providing part of the overall enclosure that gives access to uninsulated live parts and that does not have a separate tool-operated fastener shall have no apparent means for removal, such as an extending tab, and is to comply with all of the following:

a) A cover that could be disengaged from the enclosure by a squeezing force applied with one hand shall not be released when a squeezing force of 14 pounds (62 N) or less is applied at any two locations not more than 5 inches (127 mm) apart. The distance is to be measured by a tape stretched tightly over that portion of the surface of the cover that would be encompassed by the palm of the hand.

b) A cover shall not disengage from the enclosure when a direct pull force of 14 pounds is applied by gripping the cover at any two convenient locations.

c) A cover shall not be disengaged from the enclosure by an impact force of 1 foot pound (1.4 J) applied to the accessible faces of the cover. The impact is to be applied by a steel ball having a diameter of not less than 2 inches (51 mm). Each accessible face is to receive one impact.

31.2 The tests described in 31.1 (a) and (b) are to be conducted in the as-received condition and after the cover has been removed and replaced ten times.

32 Polymeric Enclosure Conduit Connection Tests

32.1 General

32.1.1 A polymeric enclosure intended for connection to a rigid conduit system shall not pull apart or sustain damage such as cracking and breaking as a result of the procedures described in Pullout, 32.2, Torque, 32.3, and Bending, 32.4. If knockouts are incorporated in the enclosure, they shall remain in place as a result of the procedure described in 32.5.1.

Exception: A polymeric enclosure shall be provided with instructions indicating that the hub is to be connected to the conduit before the hub is connected to the enclosure if it:

a) Is intended for connection to a rigid conduit system;

b) Has not been subjected to the torque test described in 32.3.1; and

c) Is not provided with a preassembled hub.

32.2 Pullout

32.2.1 The enclosure is to be suspended by a length of rigid conduit installed in one wall of the enclosure or mounted as intended in service and a pulling force of 200 pounds (890 N) is to be applied for 5 minutes to a length of conduit installed in the opposite wall.

32.3 Torque

32.3.1 The enclosure is to be securely mounted as intended in service. A torque [800 pound-inches (90.4 N·m) for 3/4 inch (19 mm) and smaller conduit] is to be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm is to be measured from the center of the conduit.

Exception: An end-of-line enclosure – an enclosure that is intended to be connected at the end of a run of conduit and has only one 3/4-inch maximum trade size opening for the connection of conduit – need only be subjected to a tightening torque of 200 pound-inches (22.6 N·m).

32.4 Bending

32.4.1 A length of conduit at least 1 foot (305 mm) long of the intended size is to be installed:

a) In the center of the largest unreinforced surface; or

b) In a hub or an opening if provided as part of the enclosure. The enclosure is to be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. A weight is to be suspended from the end of the conduit to produce the bending moment specified in Table 32.1. The magnitude of the weight is to be determined from the equation:

$$W = \frac{M - 0.5CL}{L}$$

in which:

W is the weight, in pounds, to be hung at the end of the conduit;

L is the length of the conduit, in inches, from the wall of the enclosure to the point at which the weight is suspended;

C is the weight of the conduit, in pounds; and

M is the bending moment required, in pound-inches.

For the SI system of units, the equation is

$$W = \frac{0.1M - 4.9CL}{L}$$

in which:

W and *C* are measured in kilograms;

M is in newton-meters; and

L is in meters.

Table 32.1
Bending Moment

Normal mounting plane of enclosure surface[a]	Conduit size	Bending moment			
		Metallic conduit		Nonmetallic conduit	
		Pounds-inches[b,c] (N·m)		Pounds-inches[b,c] (N·m)	
Horizontal	All	300	(33.9)	300	(33.9)
Vertical	1/2 – 3/4	300	(33.9)	300	(33.9)
	1 – up	600	(67.8)	300	(33.9)

[a] If the enclosure surface may be installed in either a horizontal or a vertical plane, the vertical bending moment value is to be used.

[b] The test procedure may be terminated prior to attaining the values specified if the deflection of the conduit exceeds 10 inches (255 mm) for a 10 foot (3.05 m) length of conduit.

[c] For an end-of-line enclosure as defined in the Exception to 32.3.1, the bending moment is to be 150 pound inches (17.0 N·m).

32.5 Knockouts

32.5.1 A knockout is to be subjected to a force of 20 pounds (89 N) applied at right angles by means of a mandrel with a 1/4-inch (6.4 mm) diameter flat end. The mandrel is to be applied at the point most likely to cause movement of the knockout.

33 Abuse Test

33.1 The enclosure of a direct plug-in device shall withstand the mechanical abuse test described in 33.2 without making live parts accessible or producing any other condition that results in a risk of electric shock.