UL 705

STANDARD FOR SAFETY

Power Ventilators

UL Standard for Safety for Power Ventilators, UL 705

Seventh Edition, Dated July 19, 2017

Summary of Topics

This revision of ANSI/UL 705 dated August 19, 2022 includes the following:

– Addition to Scope to add requirements to cover power ventilators for smoke control systems; 1.2.3

– Update internal wiring for hazardous voltage; 2.7, 11.1, 11.3

– Addition of solid state speed controller test requirements; Section 31A

– Correct SC10.2.1 for maximum temperature rise.

– Add new requirement for NEC Class 2 Marking; 36.22

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated April 1, 2022, July 8, 2022 and July 15, 2022

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UL 705

Standard for Safety for Power Ventilators

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Seventh Edition

July 19, 2017

This ANSI/UL Standard for Safety consists of the Seventh Edition including revisions through August 19, 2022.

The most recent designation of ANSI/UL 705 as an American National Standard (ANSI) occurred on August 19, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 705 on February 5, 1993. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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 power ventilators of the roof-and wall-mounted types and duct fans of the straight-through type intended for commercial or industrial use, residential fans intended for heated and conditioned air and for connection to permanently installed wiring systems in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements also cover dryer exhaust duct power ventilators (DEDPV) for single residential dryers.

1.2.1 These requirements cover roof or wall-mounted ventilators and duct fans of the straight-through type for restaurant exhaust appliances.

1.2.2 These requirements cover power ventilators for restaurant exhaust appliances.

1.2.3 These requirements cover power ventilators for smoke control systems.

1.3 These requirements do not cover the following:

a) Ventilating equipment such as attic, wall-insert, ceiling-insert, household hood, window fans, or canopy fans or blowers;

b) Air-moving equipment with integral air-tempering means;

c) Dryer type fans used for drying carpets or floors;

d) Household and commercial blower inflator type fans;

e) Evaporative coolers; Evaporative cooler pumps, including retrofit pumps;

f) Air filtering appliances;

g) Deodorizers and air fresheners;

h) Component fans;

i) Low voltage component fans;

j) Fans and blowers that circulate air, such as desk, ceiling-suspended, and hassock fans;

k) Ventilators rated more than 600 volts;

l) Ventilators employing universal motors rated more than 250 volts;

m) Air heaters equipped with fans;

n) Draft fans for furnaces;

o) Heating-ventilating units;

p) Blowers employed as components in equipment such as furnaces, mechanical-refrigeration equipment, or air conditioners;

q) Fusible links and similar equipment that may be provided to disconnect a fan or close shutters in the event of fire;

r) Ventilators specifically intended for use in exhausting any of the following: gases other than air, atmospheres causing corrosion to the ventilator, air with water spray, or flammable vapors; or

s) Ventilators for the removal or conveyance of dust, stock, or refuse.

t) Microwaves, ventilating and otherwise; and

u) Ducted and non-ducted heat recovery units.

2 Glossary

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

2.2 CAPACITOR, CLASS X – Capacitor or RC unit of a type suitable for use in situations where failure of the capacitor or RC unit would not lead to danger of electrical shock but could result in a risk of fire. Examples would be units connected phase to phase or phase to neutral.

Note 1 X1 capacitors are generally used in circuits of permanently connected appliances. However, if the appliance is provided with a separate surge protective device that limits the impulse voltage to ≤ 2.5KV, an X2 capacitor is permitted.

Note 2 X2 capacitors are generally used in circuits of cord-connected appliances.

2.3 CAPACITOR, CLASS Y – Capacitor or RC unit of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock. Examples would be capacitors connected across the primary and secondary circuits where electrical isolation is required to prevent an electric shock or between hazardous live parts and accessible parts.

Note 1 Y1 capacitors are used in circuits where the prevention of electric shock is afforded solely by the isolation provided by the capacitor. Two Y2 capacitors connected in series is considered to provide the same level of protection as one Y1 capacitor.

Note 2 Y2 capacitors are used where the prevention of electric shock is provided by the combination of the capacitor and earth ground for circuits operating at voltages ≥ 150V and ≤ 300V.

Note 3 Y4 capacitors are used where the prevention of electric shock is provided by the combination of the capacitor and earth ground for circuits operating at voltages ≤ 150V.

2.4 CIRCUIT, CLASS 2 – An low voltage circuit with a power of 100 VA or less; or has 30 V dc supplied by a primary battery; or is supplied by a Class 2 transformer; or is supplied by a combination of a transformer and fixed impedance that, as a unit, complies with all the performance requirements for a Class 2 transformer; or is supplied by a power supply (such as a switching power supply) whose output meets the requirements of a Class 2 circuit. A circuit that is derived from a circuit that exceeds 30 V by connecting resistance or impedance, or both, in series with the supply circuit to limit the voltage and current, is not considered to be a class 2 circuit.

2.5 CIRCUIT, LOW-VOLTAGE – A circuit that has an ac potential of not more than 30 V rms (42.4 V peak or 30 V dc).

2.6 CIRCUIT, HAZARDOUS VOLTAGE – A circuit of any voltage exceeding those of an low-voltage circuit.

2.7 DUCT FAN – A ventilator installed within a duct or provided with flanges for connection to a duct and which may be used with heated air within the duct.

2.8 FIELD WIRING TERMINAL – A terminal to which a wire may be connected in the field, unless the wire and a means of making the connection – such as a pressure terminal connector, soldering lug,

soldered loop, or crimped eyelet – that is factory assembled to the wire or provided as part of the ventilator.

2.9 MOTORS –

a) Open Motor – A motor having ventilating openings that permit passage of external cooling air over and around the windings of the motor.

b) Totally Enclosed Motor – A motor that is enclosed so as to prevent the free exchange of air between the inside and outside of the case but not sufficiently enclosed to be termed airtight.

c) Totally Enclosed Fan-Cooled Motor – A totally enclosed motor with external cooling by a fan or fans integral with the motor but external to the enclosing parts.

d) Electronically Commutated Motor (ECM) – A motor assembly consisting of the motor and a control. The control provides an AC electric signal (typically non-sinusoidal) to the motor by an inverter/switching power supply. The sensors and other electronics on the control adjust waveform and output levels of the signal. The control is often used to provide protective functions to prevent overheating or mitigate other hazardous conditions.

2.10 POWER VENTILATOR – An air-moving appliance consisting of an impeller – which may be of the centrifugal, axial, or propeller type – and an integral driver. A power ventilator is:

a) Installed in a weather-resisting base intended to fit, usually by a curb, over a wall or roof opening; or

b) Provided with flanges for connection to a duct.

2.11 SAFETY CRITICAL FUNCTION – Control, protection and monitoring functions which are being relied upon to reduce the risk of fire, electric shock or casualty hazards.

2.12 VENTILATOR – A power ventilator or a duct fan.

3 Units of Measurement

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

4 Undated References

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

CONSTRUCTION

5 Components

5.1 General

5.1.1 A component of a product covered by this standard shall:

a) Comply with the requirements for that component as indicated in 5.2 – 5.6 or the individual component section;

b) Be used in accordance with its rating(s) established for the intended conditions of use;

c) Be used within its established use limitations or conditions of acceptability; and

d) Additionally comply with the applicable requirements of this end product standard.

Note – 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.

Exception No. 1: A component of a product covered by this standard is not required to comply with a specific component requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product, or

b) Is superseded by a requirement in this standard, or

c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

Exception No. 2: A component complying with a UL component standard other than those cited in 5.2 – 5.6 or the individual component section is acceptable if:

a) The component also complies with the applicable component standard of 5.2 – 5.6 or the individual component section; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements of the National Electrical Code, ANSI/NFPA 70, where appropriate;

2) Considers long-term thermal properties of polymeric insulating materials in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, and

3) Any use limitations of the other component standard is identified and appropriately accommodated in the end use application. For example, a component used in a household application, but intended for industrial use and complying with the relevant component standard may assume user expertise not common in household applications.

5.1.2 A component that is also intended to perform other functions, such as over current protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable UL standard(s) that cover devices that provide those functions.

Exception: Where these other functions are not required for the application and not identified as part of markings, instructions, or packaging for the appliance, the additional component standard(s) need not be applied.

5.1.3 A component not anticipated by the requirements of this standard, not specifically covered by the component standards of 5.2 – 5.6 or individual component sections and that involves a potential risk of electric shock, fire, or personal injury, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 5.1.1 (b) – (d).

5.1.4 With regards to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of this standard.

5.2 Connectors and terminals

5.2.1 Quick-connect terminals, both connectors and tabs, for use with one or two 22 – 10 AWG copper conductors, having nominal widths of 3.5, 3.2, 4.8, 5.2, and 6.3 mm (0.110, 0.125, 0.187, 0.205, and 0.250 in), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception: Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with UL 310.

5.2.2 Single and multi-pole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory connection and for factory assembly to copper or copper alloy conductors, or for factory assembly to printed wiring boards, shall comply with the Standard for Component Connectors for Data, Signal, Control and Power Applications, UL 1977.

5.2.3 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B.

5.2.4 Splicing wire connectors shall comply with the Standard for Splicing Wire Connectors, UL 486C.

5.2.5 Multi-pole splicing wire connectors that are intended to facilitate the connection of hard-wired utilization equipment to the branch-circuit conductors of buildings or that are intended for consumer connection within and between parts of electrical equipment, shall comply with the Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459.

5.2.6 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

5.2.7 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059, and, if applicable, be suitably rated for field wiring.

5.3 Electrical enclosures and raceways

5.3.1 Electrical enclosures and the associated bushings and fittings, and raceways, of the types specified in Chapter 3 of the National Electrical Code, ANSI/NFPA 70, and that comply with the relevant UL standard (such as UL 514A, UL 514C, UL 514D) and 5.1 are considered to fulfill the requirements of this Standard.

5.4 Overcurrent protection

5.4.1 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another appropriate UL standard for the fuse are considered to fulfill this requirement.

5.4.2 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.

Exception: Circuit breakers used in telecommunications circuitry that comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A, need not comply with UL 489.

5.4.3 Circuit breakers having integral ground fault circuit interrupter capability for protection against electrical shock shall additionally comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943.

5.4.4 Supplementary protectors shall comply with the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077.

5.5 Power supplies

5.5.1 Class 2 power supply shall comply with one of the following:

a) Standard for Class 2 Power Units, UL 1310; or

b) Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS".

Exception: This requirement does not apply to circuits that comply with Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

5.5.2 A non-Class 2 power supply shall comply with one of the following:

a) Standard for Power Units Other Than Class 2, UL 1012; or

b) Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

5.6 Supplemental insulation, insulated bushings, and assembly aids

5.6.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill a requirement of this standard. In such cases:

a) Insulating tape shall comply with the Standard for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape, UL 510;

b) Sleeving shall comply with the Standard for Coated Electrical Sleeving, UL 1441;

c) Tubing shall comply with the Standard for Extruded Insulating Tubing, UL 224.

5.6.2 Insulating bushings that comply with Components, General, 5.1 of this end product standard, and the Standard for Insulating Bushings, UL 635, are considered to comply with the requirements of this Standard.

6 Frame and Enclosure

6.1 General

6.1.1 A ventilator shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it may be subjected without increasing the risk of fire, electric shock, or injury to persons due to a total or partial collapse with a resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

6.1.2 Among the factors taken into consideration when the acceptability of an enclosure is being judged are its:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Combustibility;

e) Resistance to corrosion; and

f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

6.1.3 A cast- or sheet-metal section of an enclosure shall have a thickness not less than that specified in Table 6.1.

Table 6.1
Minimum acceptable thickness of enclosure metal

Metal	Minimum thickness, inch (mm)		
	At small, flat, unreinforced surfaces and at surface of a shape or size to ensure adequate mechanical strength	At surfaces to which a wiring system is to be connected in the field	At relatively large unreinforced flat surfaces
Die-cast metal	3/64 (1.2)	– –	5/64 (2.0)
Cast malleable iron	1/16 (1.6)	– –	3/32 (2.4)
Other cast metal	3/32 (2.4)	– –	1/8 (3.2)
Uncoated sheet steel	0.026 (0.66)	0.032[a] (0.81)	0.026 (0.66)
Galvanized sheet steel	0.029 (0.74)	0.034[a] (0.86)	0.029 (0.74)
Nonferrous sheet metal	0.036 (0.91)	0.045 (1.14)	0.036 (0.91)

[a] A sheet-steel wall of thickness less than that specified is acceptable if the area surrounding the knockout has a thickness not less than 0.053 inch (1.35 mm).

6.1.4 The enclosure of an appliance shall prevent molten metal, burning insulation, flaming particles, and other ignited material from falling onto flammable materials, including the surface upon which the appliance is supported when the appliance is:

a) Installed in a remote location or unattended area.

b) Thermostatically controlled.

6.1.5 The requirements in 6.1.4 necessitate the use of a metal barrier or a non-metallic barrier of a material having a zero flame spread rating when tested as described in the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723:

a) Under a motor unless:

1) The structural parts of the motor or of the appliance provide the equivalent of such a barrier (such as the use of metal louvers as bottom barriers);

2) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the appliance or into the wiring compartment when the motor is energized under each of the following fault conditions:

i) Open main winding;

ii) Open auxiliary winding;

iii) Starting switch short-circuited; and

iv) Capacitor of a permanent-split capacitor motor short-circuited and the rotor locked - the short circuit is to be applied before the motor is energized;

3) The motor complies with the requirements for impedance-protected motors in the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, and the Standard for Thermally Protected Motors, UL 1004-3, and the temperature of the motor winding does not exceed 150°C (302°F) during the first 72 hours of operation with the rotor of the motor locked; or

4) The motor is provided with a thermal motor protector that prevents the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor runs without causing the protector to cycle and from exceeding 150°C (302°F) with the rotor of the motor locked.

Exception: A direct drive fan motor is required to only be subjected to the locked rotor test.

b) Under wire, unless the wire:

1) Is thermoplastic wire which complies with the requirements of the Vertical Wires test in the Reference Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581 and is marked VW-1; or

2) Has at least equivalent characteristics as determined in the flame tests specified in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

c) Under a switch, relay, solenoid, or similar component unless:

1) A short circuit or overload in the component does not result in a risk of fire; or

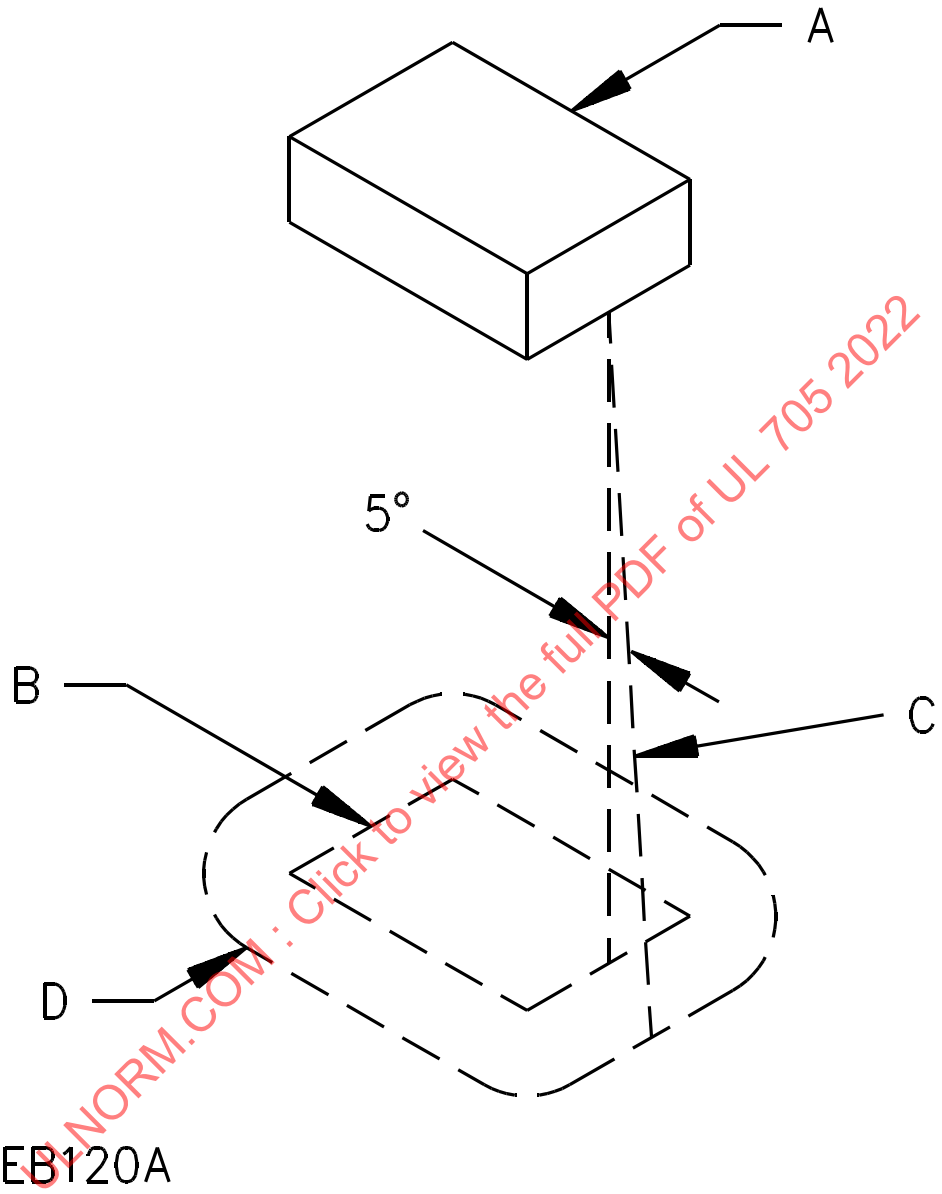
2) There are no openings in the enclosure through which molten metal, burning insulation, flaming particles, or other ignited material can fall.

Exception: A terminal is not required to have a barrier.

6.1.6 The barrier mentioned in 6.1.5 shall be horizontal, shall be located as illustrated in Figure 6.1, and shall have an area in accordance with the illustration. Openings for drainage, ventilation, and the like, shall not be employed in the barrier unless such openings do not permit molten metal, burning insulation, or similar material, to fall onto flammable material.

Figure 6.1

Barrier



A – Region to be shielded by barrier. This will consist of the entire component if it is not otherwise shielded and will consist of the unshielded portions of a component that is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. The line is always:

1) Tangent to the component,

2) 5 degrees from the vertical, and

3) So oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

6.1.7 A ventilating opening provided in the enclosure of an appliance or an externally mounted component of an appliance where the appliance is intended to be recessed into a wall or false ceiling shall not vent into a concealed space where the spread of a fire occurs undetected.

6.2 Non-metallic enclosures

6.2.1 A non-metallic enclosure shall comply with the applicable mechanical and electrical property considerations, flammability, and thermal requirements as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. A 6.8 J (5 ft·lbf) impact value shall apply to all appliances when determining the impact resistance of polymeric enclosures. This impact value shall also be used for cold impact testing of appliances intended to be used or stored in cold environments, such as fans mounted in the crawl space or attic and outdoor use products.

Exception: A polymeric grille used in a fan intended to be mounted at least 2.4 m (8 feet) above the floor is not required to comply with the Resistance to Impact Test of UL 746C.

6.3 Non-metallic parts other than enclosures

6.3.1 Polymeric material used to enclose a metal housing that encloses insulated or uninsulated live parts, or used as a decorative part, shall be classed either 5VA, 5VB, V-0, V-1, V-2, or HB by the burning tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception No. 1: Decorative parts are not required to be made of a material classed 5VA, 5VB, V-0, V-1, V-2, or HB when the part does not occupy a volume greater than 2 cubic centimeters (0.122 cubic inch), does not have any dimension greater than 3 cm (1.18 inch), and is located so it does not propagate flame from one area to another or bridge between a possible source of ignition and other ignitable parts.

Exception No. 2: A material is determined to be equivalent when it complies with the 12-mm (0.47 inch) flame test, the 19-mm (0.75-inch) flame test, or 127-mm (5-inch) flame test of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, when flame tested as used in the equipment. The use of a flame-retardant coating applied to the inside of a polymeric enclosure is not considered to comply with this requirement unless the coating/material interface is found to be compliant by separate investigation.

6.3.2 An impeller of polymeric material outside a motor shall not be located within 25.4 mm (1 inch) of an opening in the motor housing.

Exception:

a) The material is classed as V-2, V-1, V-0, or 5V in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. The coil wrap that complies with the 127 mm (5 inches) end product flame test as described in the Standard for Polymeric Materials – Use in Electric Equipment Evaluations, UL 746C does not need to possess a 5VA flame rating;

b) The material complies with the requirements for enclosure flammability using a 19-mm (3/4-inch) flame, in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C;

c) No motor opening within 25.4 mm of the blade has a dimension more than 6.75 mm (17/64 inch) or an area more than 35.48 mm^2 (0.055 square inch), and no more than six such openings are provided; or

d) The material has a hot wire ignition rating of at least 7 seconds as described in the Standard Test Method for Ignition of Materials by Hot Wire Sources, ASTM D3874-1990a.

6.3.3 Foamed thermoplastic shall be classed HF-2 or HF-1.

6.3.4 A thermoplastic damper shall be classed HB, V-2, V-1, V-0, or 5V.

6.3.5 A thermoplastic part that is not decorative and that does not serve as an enclosure shall be classed HB, V-2, V-1, V-0, or 5V.

6.4 Flame spread and smoke developed requirements for non-metallic enclosures and other parts of permanently connected equipment

6.4.1 Materials in a compartment handling conditioned air for circulation through a duct system shall have a flame spread rating of not more than 25, and a smoke developed rating of not more than 50, when tested as specified in the requirements for the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. This requirement does not apply to the following:

a) Air filters, drive belts, wire insulation, paint applied for corrosion protection, or tubing of material equivalent to one of the types of wire insulation permitted by this Standard;

b) Gaskets forming air or water seals between metal parts;

c) Miscellaneous small parts such as refrigerant line bushings or insulating bushings, resilient or vibration mounts, wire ties, clamps, labels, or drain line fittings having a total exposed surface area not exceeding 161.29 cm^2 (25 in^2);

d) An adhesive that, when tested in combination with the specific insulating material, complies with the requirement;

e) Moulded or formed components (not liners) of polymeric materials in such quantities that their total exposed surface area within the compartment does not exceed 0.93 m^2 (10 ft^2); or

f) Materials in a compartment handling air for circulation through a duct supplying only one room.

6.4.2 Polymeric materials exempted by 6.4.1(e) shall have a flame spread rating of not more than 25, or shall comply with the requirements of the vertical burning test for classifying materials 5VA in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

6.5 Accessibility of moving parts

6.5.1 Electrical parts of a ventilator shall be located or enclosed so that protection against unintentional contact with uninsulated live parts will be provided.

6.5.2 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part or film-coated wire, or injury to persons from a moving part, the enclosure shall comply with the following:

a) A probe as illustrated in Figure 6.2 shall not touch film-coated wire when inserted through an opening;

b) A probe as illustrated in Figure 6.3 shall not touch any uninsulated live part when inserted through an opening; and

c) A probe as illustrated in Figure 6.4 shall not contact a moving part when inserted through an opening.

Figure 6.2

Probe for film-coated wire

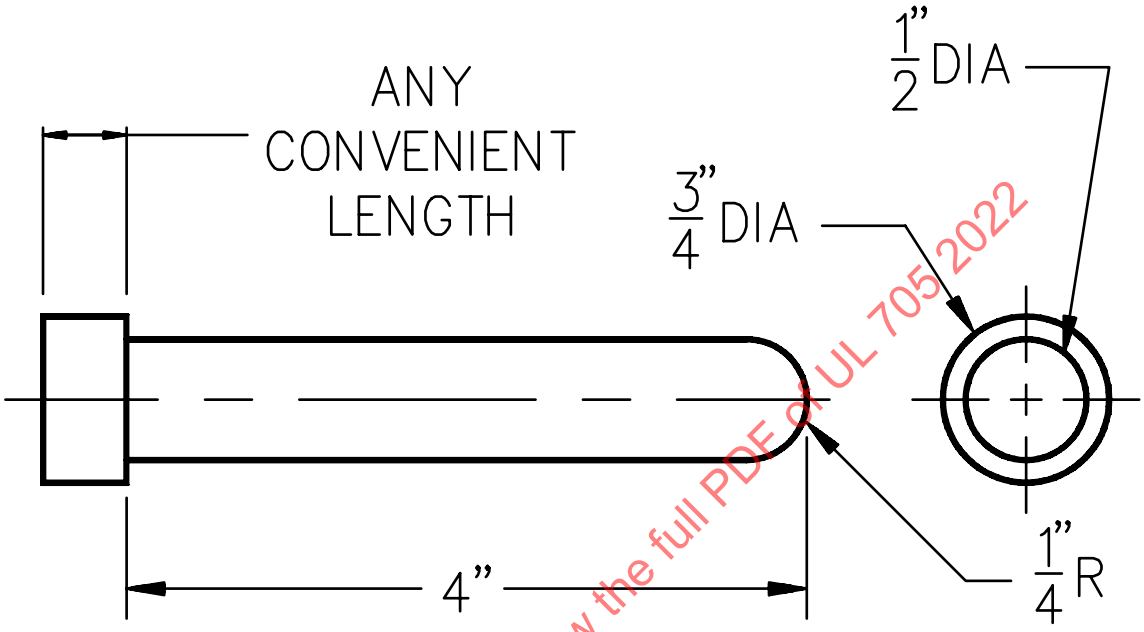


Figure 6.3

Probe

(Other than moving parts)

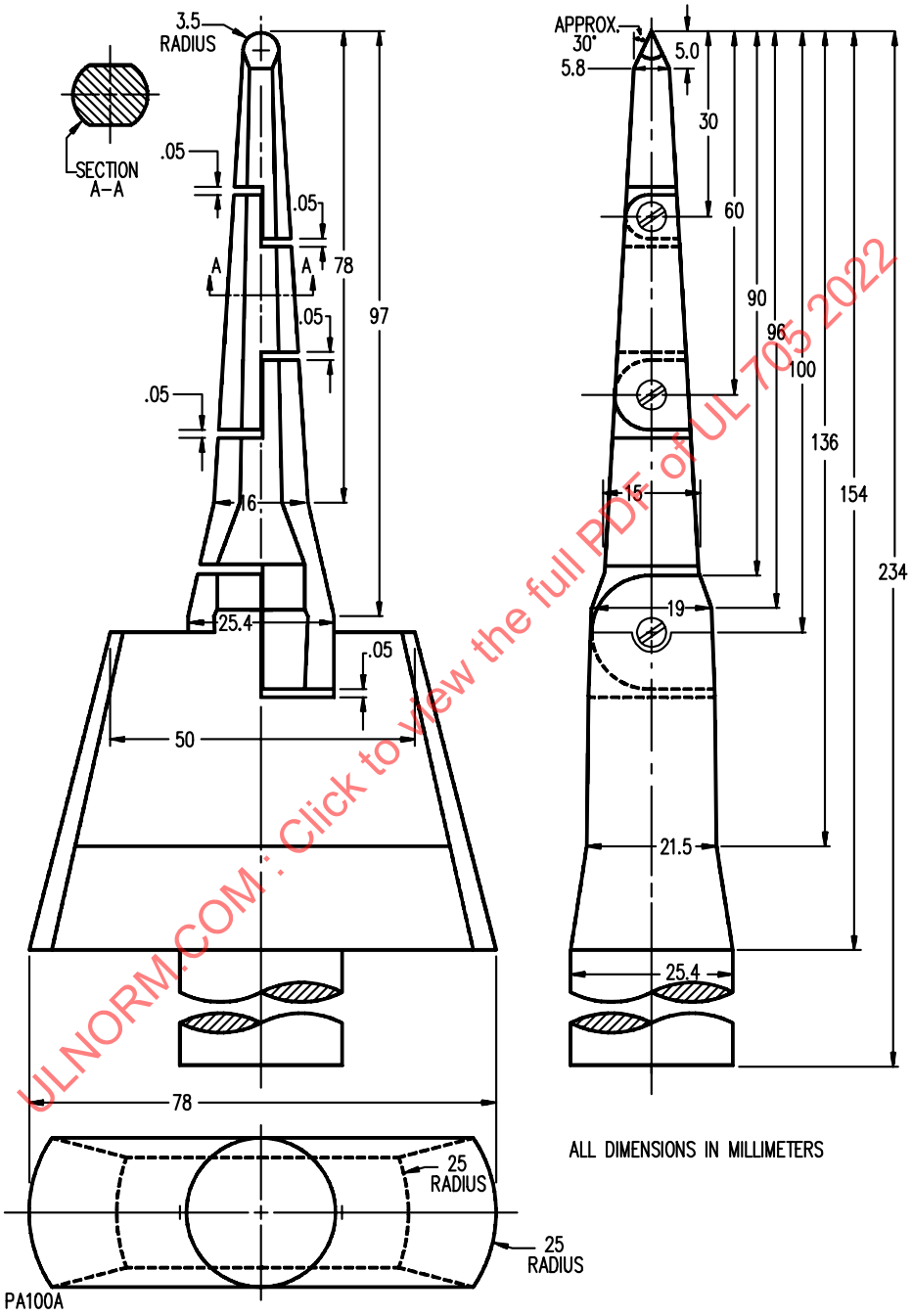
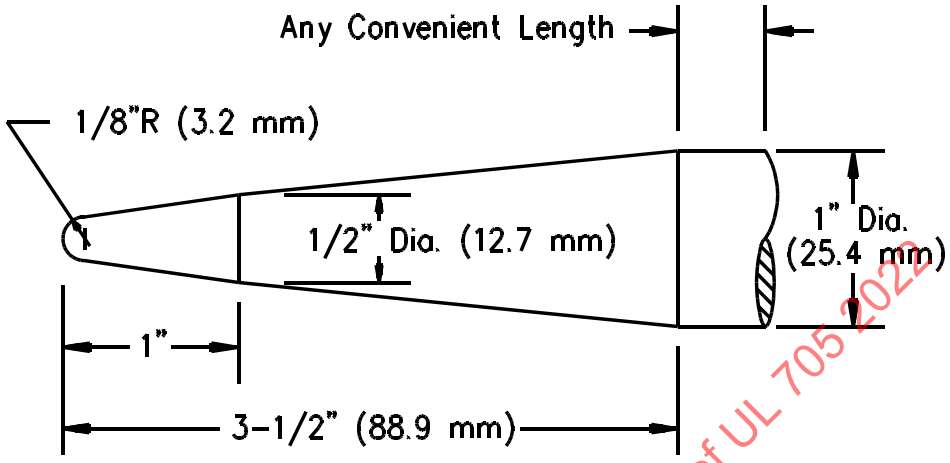


Figure 6.4

Probe

(Moving parts)



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6.5.3 With reference to 6.5.2(b), the probe is to be applied in any possible configuration; and, if necessary, the configuration may be changed after insertion through the opening.

6.5.4 Uninsulated live parts shall be located, guarded, or enclosed so as to reduce the likelihood of unintentional contact that may involve a risk of electric shock to persons performing operations such as oiling motors, replacing filters, or adjusting belts, sheaves, or controls. Parts of the enclosure that would be removed in the performance of these operations and are removable without the use of tools are to be removed to determine whether the ventilator complies with the requirements in 9.5 and 9.6. A warning marking is to be disregarded when determining compliance with these requirements.

6.5.5 The rotor of a motor, pulleys, belts, gears, fan blades, impellers, and the like, of an assembled ventilator shall be enclosed or guarded so as to reduce the risk of injury to persons. See Figure 6.4.

6.5.6 With reference to the requirement in 6.5.5, the degree of protection required of an enclosure depends upon the general configuration and intended use of the ventilator. Among the factors to be taken into consideration in judging the acceptability of exposed moving parts are:

a) The degree of exposure;

b) The sharpness of the moving parts;

c) The likelihood of unintentional contact with the moving parts;

d) The speed of moving parts; and

e) The likelihood of fingers, arms, or clothing being drawn into the moving parts – such as at points where gears mesh, where belts travel onto a pulley, or where moving parts close in a pinching or shearing action.

6.5.7 An overall enclosure for electrical components of a ventilator intended for outdoor exposure shall have provision for drainage. See Section 27, Water Spray Test.

7 Mechanical Assembly

7.1 A ventilator shall be assembled so that it will not be adversely affected by the vibration of normal operation. A brush cap shall be tightly threaded or have other provision so that it is unlikely to become loose.

7.2 A switch, lampholder, attachment plug receptacle, motor attachment plug, or similar component shall be mounted securely and shall be prevented from turning or shifting.

Exception No. 1: A switch need not be prevented from turning if all four of the following conditions are met:

a) The switch is a plunger or other type that does not tend to rotate when operated. A toggle switch is considered to be subject to forces that tend to rotate the switch during the normal operation of the switch;

b) Means of mounting the switch make it unlikely that operation of the switch will loosen it;

c) Spacings are not reduced below the minimum acceptable values if the switch rotates, (see Section 19, Spacings) and

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

Exception No. 2: A lampholder in which the lamp cannot be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, need not be prevented from turning if rotation cannot reduce spacings below the minimum acceptable values. See Section 19, Spacings.

7.3 The means for preventing the turning specified in 7.2 shall consist of more than friction between surfaces. For example, a properly applied lock washer is an acceptable means for preventing a small stem-mounted switch or other component having a single hole mounting means from turning.

7.4 An uninsulated live part shall be secured to the surface on which it is mounted and supporting insulating materials shall be secured in place so that the part will be prevented from turning or shifting in position if such motion may result in a reduction of spacings below the minimum acceptable values specified in Spacings, Section 19.

7.5 Friction between surfaces is not acceptable as a means to prevent shifting or turning of a live part; but a properly applied lock washer is acceptable.

7.6 A ventilator shall be completely assembled when shipped from the factory.

Exception No. 1: A ventilator marked in accordance with 36.15 need not be completely assembled when shipped from the factory.

Exception No. 2: A roof mounted or wall mounted ventilator may be shipped from the factory without the motor and drive assembly when all of the following conditions are met.

a) The motor is the only electrical load for the ventilator.

b) The motor construction complies with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

c) The motor employs thermal protection as referenced in accordance with the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, and the Standard for Thermally Protected Motors, UL 1004-3, if inherently protected.

d) The motor includes an integral field wiring compartment which complies with the applicable paragraphs of Power-Supply Connections, Section 9.

e) The ventilator is marked in accordance with 36.20.

7.7 If a part is shipped disassembled from the ventilator and if it is necessary to make field connections to that part:

a) The ventilator shall be designed so that it can be permanently connected to one of the wiring systems that would be acceptable for the ventilator;

b) Wiring terminals or leads to which the field connections are to be made shall comply with the requirements for field-wiring terminals, including those for spacing;

c) The information required by 36.17 shall be provided; and

d) Means for mounting a disconnect switch assembly that is part of the ventilator shall be provided.

7.8 A disconnect switch assembly that is shipped mounted on the ventilator:

a) Shall be factory-wired to the remainder of the ventilator; or

b) Shall comply with the requirements in 7.7 (a), (b), and (c) and those in 36.17.

8 Protection Against Corrosion

8.1 Metal shall not be used in combinations that may cause galvanic action that will adversely affect an enclosure.

8.2 An iron or steel part shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means.

Exception: The following parts need not be protected against corrosion:

a) A shaft, bearing, lamination, or minor part, such as a washer, screw, and similar parts.

b) A cast-metal part that derives inherent protection by virtue of its thickness.

c) A part, such as a decorative grille, that is not required to form a part of an enclosure.

8.3 A hinge and other attachment shall be resistant to corrosion.

8.4 A sheet steel enclosure shall be protected against corrosion as specified in Table 8.1.

Exception: An enclosure for a duct fan not intended for outdoor exposure shall comply with the requirement in 8.2.

Table 8.1
Protection against corrosion

Enclosure use	Thickness of sheet steel and paragraph reference for type of protection required	
	0.053 inch (1.35 mm) or more	Less than 0.053 inch
Outer enclosure protecting motors, wiring, or enclosed live parts	8.8 or 8.9	8.8
Outer enclosure that is the sole enclosure of live parts	8.8	8.8
Outer enclosure that does not enclose electrical parts	8.8 or 8.9	8.8 or 8.9
Interior enclosure protecting live parts other than motors	8.8 or 8.9	8.8

8.5 Aluminum, brass, copper, or stainless steel may be used without additional protection against corrosion.

8.6 A nonmetallic enclosure intended to be used outdoors shall be judged on the basis of the effect of exposure to ultraviolet light and water.

8.7 An enclosure of cast iron at least 1/8 inch (3.2 mm) thick is considered to be protected by one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint may be determined by consideration of its composition or by corrosion tests if such tests are considered necessary.

8.8 To comply with Table 8.1 referenced to this, one of the following coatings shall be used:

a) Hot-dipped mill-galvanized sheet steel conforming with the Coating Designation G90 in Table I of the Standard for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653 with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron or Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.015 mm) on each surface with a thickness at least 0.00054 inch (0.014 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 28. An annealed coating shall also comply with 8.12.

c) A zinc coating conforming with 8.9 (a) or (b) with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint applied after forming on each surface. The acceptability of the paint may be determined by consideration of its composition or by corrosion tests if such tests are considered necessary.

d) A cadmium coating not less than 0.001 inch (0.025 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic Coating Thickness Test, Section 28.

e) A cadmium coating not less than 0.00075 inch (0.019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established in accordance with the Metallic Coating Thickness Test, Section 28 and the paint shall be as specified in (c).

8.9 To comply with Table 8.1 referenced to this paragraph, one of the following coatings shall be used:

a) Hot-dipped mill-galvanized sheet steel conforming with the Coating Designation G60 or A60 in Table I of the Standard for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653 with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90.

b) A zinc coating, other than that provided on hot-dipped mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.010 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 28.

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint is to be determined by consideration of its composition or by corrosion tests if such tests are considered necessary.

8.10 With reference to 8.8 and 8.9, other finishes, including paints, metallic finishes, and combinations of the two may be accepted when comparative tests with galvanized sheet steel – without annealing, wiping or other surface treatment – conforming with 8.8(a) or 8.9(a), as applicable, indicate they provide equivalent protection. Among the factors that are taken into consideration when judging the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide-sulphur dioxide-air mixtures, moist hydrogen sulphide-air mixtures, ultraviolet light and water.

8.11 If the paint is to be tested, the test specimens of a finish as described in 8.7 or 8.10, 8.8(c), or 8.9(c), are to be consistent with the finish that is to be used in production with respect to the base metal, cleaning or pretreatment method, application method, number of coats, curing method, thickness, and the like.

8.12 A hot-dipped mill-galvanized A60 (alloyed) coating or an annealed zinc coating that is bent or similarly formed after annealing and that is not otherwise required to be painted shall be painted in the bent or formed area if the bending or forming process damages the zinc coating, except that such areas on the inside surface of an enclosure that water does not enter during the rain test need not be painted. The zinc coating is considered to be damaged if flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification. Simple sheared or cut edges and punched holes are not considered to be formed.

9 Power-Supply Connections

9.1 A ventilator shall be constructed so that it can be permanently connected to one of the wiring systems that would be acceptable for the ventilator.

9.2 An outlet or terminal box in which power-supply connections are to be made shall be located so that such connections may be inspected after the ventilator has been installed as intended.

9.3 An outer cover or panel that must be removed in order to inspect field-wiring connections to a roof- or wall-mounted ventilator shall be constructed so that it may be removed with an ordinary tool, such as a screwdriver or pliers.

9.4 It shall not be necessary to dismount an electrical component or disconnect a duct to gain access to a wiring compartment to inspect field-wiring connections.

9.5 An electrical component shall not be mounted on a part, such as the cover of a wiring-terminal compartment, that must be removed to permit field-wiring connections to be inspected.

Exception: A component that has been investigated and found to be acceptable for such mounting may be mounted on a part that must be so removed.

9.6 A terminal compartment intended for the connection of a power-supply raceway that is mounted to the ventilator shall be attached so as to be prevented from turning with respect thereto.

9.7 A conduit opening in an outer enclosure for power-supply or external-control-circuit connection shall be threaded. The metal at a threaded opening for conduit shall not be less than 1/4 inch thick.

Exception No. 1: A conduit opening need not comply if it is on a duct fan that is not intended for outdoor exposure.

Exception No. 2: A conduit opening need not comply if it is located wholly below the lowest uninsulated live part within the enclosure or if its location prevents drainage into the enclosure.

9.8 If threads for the connection of conduit in the exterior of the enclosure are tapped all the way through the hole in a wall of a box or if an equivalent construction is employed, there shall not be less than 3-1/2 threads nor more than that specified in Table 9.1, and the construction shall be such that a conduit bushing can be properly attached. If threads for the connection of conduit are not tapped all the way through a hole in a wall of a box, conduit hub, or the like, there shall not be less than five full threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that provides protection for the conductors equivalent to that provided by a standard conduit bushing. The opening shall have an internal diameter in accordance with Table 9.2.

Table 9.1
Maximum number of threads in a conduit opening

Conduit size, inch	Number of threads per inch	Maximum number of threads
1/2, 3/4	14	7
1, 1-1/4, 1-1/2, 2	11-1/2	8
2-1/2, 3, 3-1/2, 4	8	9

Table 9.2
Dimensions associated with openings for conduit

Trade size of conduit, inches	Unthreaded openings				Threaded openings			
	Nominal knockout diameter, inches (mm)		Minimum diameter of flat surface at knockout, inches (mm)		Throat diameter, inches (mm)			
					Minimum		Maximum	
1/2	7/8	(22.2)	1.152	(29.26)	0.591	(15.01)	0.622	(15.80)
3/4	1-3/32	(27.8)	1.450	(36.83)	0.783	(19.89)	0.824	(20.93)
1	1-23/64	(34.5)	1.804	(45.82)	0.997	(25.32)	1.049	(26.64)
1-1/4	1-23/32	(43.7)	2.309	(58.65)	1.311	(33.3)	1.380	(35.05)

9.9 The diameter of a knockout shall be such that it will accommodate conduit of the trade size for which the knockout is intended as specified in Table 9.2.

9.10 There shall be a flat surface surrounding a knockout. The flat surface shall have a minimum diameter in accordance with Table 9.2.

9.11 The space provided at terminals or leads intended for the connection of supply conductors, or other conductors to be connected at the time of installation, shall be sufficient for acceptable installation including the accommodation of the necessary splices. A trial installation may be performed to determine compliance with these requirements. See 9.12.

9.12 An acceptable installation shall:

a) Be possible using ordinary tools suitable for the installation; and

b) Not require installed conductors to be forced into contact with uninsulated live parts, or with noncurrent-carrying parts likely to be grounded.

9.13 The area of all open holes in a terminal compartment other than one integral with a motor or as noted in 9.14 shall not be more than 1/4 square inch (160 mm^2) in any one side and not more than 3/8 square inch (240 mm^2) in the bottom surface. The total area of such holes shall not be more than 1/2 square inch (320 mm^2).

9.14 A terminal compartment of a duct fan that is exposed to the main air stream shall not have any open holes.

9.15 The overall enclosure of a roof- or wall-mounted ventilator may serve as the compartment for field-wiring terminals if:

a) No part that requires service access – an oil hole, belt, or the like – is located in that compartment; and

b) The total area of openings in the enclosure is not more than 2-1/4 square inches (14.5 cm^2) and no slot is wider than 1/32 inch (0.8 mm).

9.16 A ventilator shall be provided with field-wiring terminals for the connection of conductors having an ampacity acceptable for the ventilator; or it shall be provided with acceptable leads for such connection.

9.17 A field-wiring terminal shall be provided with a pressure terminal connector securely fastened in place; for example, firmly bolted or held by a screw.

Exception: A wire-binding screw or stud-and-nut combination may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position.

9.18 A field-wiring terminal shall be prevented from turning.

9.19 A wire-binding screw or stud-and-nut combination shall not be smaller than No. 10 (4.8 mm diameter).

Exception No. 1: A No. 8 (4.2 mm diameter) screw may be used at a terminal intended only for connection of a 14 AWG (2.1 mm^2) conductor.

Exception No. 2: A No. 6 (3.5 mm diameter) screw may be used at a terminal intended only for connection of a 16 or 18 AWG (1.3 or 0.82 mm^2, respectively) control-circuit conductor.

9.20 A wire-binding screw shall thread into a metal terminal plate not less than 0.050 inch (1.27 mm) thick. There shall not be less than two full threads in the metal of the plate.

9.21 A terminal plate formed from stock not less than 0.050 inch (1.27 mm) thick may have the metal extruded at the tapped hole to provide the two full threads for the wire-binding screw.

9.22 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size specified in 9.16 under the head of the screw or washer.

9.23 A field-wiring terminal intended for the connection of a grounded power-supply conductor shall be of or plated with a metal substantially white in color and shall be readily distinguishable from the other terminals, or proper identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

9.24 A lead intended to be connected to a grounded power-supply conductor shall be finished to show a white or gray color, and shall be readily distinguishable from the other leads.

9.25 The surface of a lead intended for field connection of an equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

9.26 The requirements in 9.23 – 9.25 relating to color coding do not apply to internal wiring that is not visible in a field-wiring compartment.

9.27 The free length of a lead inside an outlet box or wiring compartment shall not be less than 6 inches (152 mm) nor more than 8 inches (203 mm).

Exception: A lead may be less than 6 inches long if it is evident that a longer lead might result in a risk of fire or electric shock.

10 Current-Carrying Parts

10.1 A current-carrying part shall be silver, copper, a copper alloy, or other material acceptable for the application.

10.2 Plated iron or steel may be used for a current-carrying part if it is acceptable in accordance with 5.1.1 or within a motor or associated governor, but the use of iron or steel for current-carrying parts elsewhere in the ventilator is not acceptable.

Exception: Stainless steel may be used anywhere in the ventilator as a current-carrying part.

11 Internal Wiring

11.1 Hazardous voltage internal wiring, connections between parts of a ventilator, and wiring which is part of a safety critical function shall be protected or enclosed.

11.2 Type SE, SJE, SJT, SJO, SJOO, SJTO, SJTOO, SO, SOO, ST, STO, STOO cord or appliance wiring material of equivalent construction may be used in a roof- or wall-mounted ventilator without protection other than that provided by the outer enclosure of the ventilator.

11.3 All wiring is considered to be suitably enclosed when the cabinet or compartment enclosing the wiring has:

a) No louver or openings that will permit the probe of Figure 6.3, when applied in a straight line, to contact wiring, and

b) No openings in the bottom, unless a U-shaped channel or trough is located beneath the wiring, and the wires do not project through the plane of the top of the channel or trough.

Exception: Hazardous voltage and safety circuit wiring, in which the flame test, UL VW-1, or the vertical flame test as described in the Standard for Electrical Wires, Cables, and Flexible Cords, UL 1581, is conducted, is considered to comply with 11.3(b) and need not be isolated by the barriers described.

11.4 Internal wiring consisting of wire or cord other than that specified in 11.2 shall be enclosed in metal, such as conduit, metal-clad cable, or the like. The assembly shall be mechanically secure and shall provide an electrical bond between parts.

11.5 Internal wiring in a duct fan shall not be exposed to the main air stream, and shall be installed in accordance with the requirements for wiring in ducts in the National Electrical Code, ANSI/NFPA 70.

11.6 Internal wiring consisting of individual insulated conductors – either separate or in a harness – shall be protected as though it were enameled wire in accordance with 6.5.2.

11.7 The internal wiring and connections of a ventilator shall be acceptable for the application with respect to:

a) Temperature and voltage;

b) Exposure to oil, grease, or moisture; and

c) Other conditions of service to which they are likely to be subjected.

11.8 Wiring shall be protected from sharp edges, screw threads, burrs, fins, moving parts, and other agents that might abrade the insulation on conductors.

11.9 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure of a ventilator shall be provided with a smooth, rounded bushing or shall have a smooth, rounded surface upon which the wires may bear to prevent abrasion of the insulation.

11.10 Insulated wires may be bunched and passed through a single opening in a metal wall within an enclosure.

11.11 Each splice in wiring shall be located, enclosed, and supported so that it is not subject to damage, flexing, motion, or vibration. A splice is considered to be acceptably enclosed when installed in a junction box, control box, or other enclosed compartment in which the wiring materials, as specified in Table 11.1, may be employed. A splice in an enclosed machinery compartment shall be secured to a fixed member in the compartment so that it is not subject to movement or damage during servicing.

Table 11.1
Typical wiring materials

Type of wire, cord, or cable[a,b]	Wire size		Insulation thickness	
	mm^2	AWG	mm	inch
Thermoplastic appliance wiring material, with insulation thickness shown at the right corresponding to wire sizes indicated; or Type T, TW, or Type[c] AC, ACL, ACT, FFH-2, TF, TFF, TFN, TFFN, SF-2, SFF-2, RH, RHH, RHW, RUH, RUW, THW, XHHW, MTW, THW-MTW, THWN, PF, PGF, PFF, PGFF	5.3 to 0.41	10 to 22	0.8	2/64
	8.4	8	1.2	3/64
	13.3	6	1.6	4/64
	21.2	4	1.6	4/64
	26.7	3	1.6	4/64
	33.6	2	1.6	4/64

Table 11.1 Continued on Next Page

Table 11.1 Continued

Type of wire, cord, or cable[a,b]	Wire size		Insulation thickness	
	mm^2	AWG	mm	inch
	42.4	1	2.0	5/64
	54.0	1/0	2.0	5/64
	67.0	2/0	2.0	5/64
	85.0	3/0	2.0	5/64
	107.2	4/0	2.0	5/64

[a] The designated cord or cable, or types of wire other than appliance wiring material, may be used without regard to the values specified in the Table.

[b] Type CL wire may be used within a separate material enclosure as leads of components.

[c] Wire types included only in the National Electrical Code, ANSI/NFPA 70.

11.12 A soldered connection shall be mechanically secured before being soldered.

11.13 A splice shall be provided with insulation equivalent to that of the wires involved if permanence of spacing between the splice and other metal parts may not be maintained.

11.14 In determining if splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing is acceptable, consideration shall be given to such factors as dielectric properties and resistance to deterioration due to temperature and moisture exposure. Thermoplastic tape wrapped over a sharp edge is not acceptable. An insulated splicing device is acceptable within the limits of its voltage and temperature ratings.

11.15 Wiring shall be located so that it will not be immersed in water as a result of exposure to the weather.

11.16 The means of connecting stranded internal wiring to a wire-binding screw shall be such that loose strands of wire will be prevented from contacting other live parts not always of the same polarity as the wire and from contacting dead metal parts. This may be accomplished by using pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other equivalent means.

11.17 Internal wiring composed of insulated conductors shall comply with the Standard for Appliance Wiring Material, UL 758.

Exception No. 1: Insulated conductors need not comply with UL 758 if they comply with one of the following:

a) Standard for Thermoset-Insulated Wires and Cables, UL 44;

b) Standard for Thermoplastic-Insulated Wires and Cables, UL 83;

c) Standard for Fixture Wire, UL 66; or

d) The appropriate UL standard(s) for other insulated conductor types specified in Chapter 3 (Wiring Methods and Materials) of the National Electrical Code, ANSI/NFPA 70.

Exception No. 2: Insulated conductors for specialty applications (e.g. data processing or communications) and located in a low-voltage circuit not involving the risk of fire or personal injury need not comply with UL 758.

12 Separation of Circuits

12.1 Unless having insulation suitable for the highest voltage involved, insulated conductors of different circuits (internal wiring, including wires in a junction box or compartment) shall be separated by barriers, or shall be segregated, and shall, in any case, be separated or segregated from uninsulated live parts connected to different circuits. Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means that ensures permanent separation from insulated or uninsulated live parts of a different circuit.

12.2 There shall be provision for segregating or separating by barriers field-installed conductors of any circuit from field-installed and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are or will be insulated for the maximum voltage of either circuit.

12.3 Within a compartment that is not a control enclosure junction box or its equivalent, field-installed low-voltage (including Class 2) circuit conductors may be segregated from factory-installed conductors of different circuits by locating field wiring openings, routing factory wiring, and locating electrical components so that the factory conductors are maintained at least 127 mm (5 in) from a line representing intended routing of the low-voltage (including Class 2) circuit conductors. The line shall allow for droop, and shall connect the opening provided for entrance of the low-voltage (including Class 2) conductors to the terminals or leads to which the conductors are attached.

12.4 There shall be provision for segregating or separating by barriers field-installed conductors of a hazardous voltage circuit from:

a) Uninsulated live parts connected to a different circuit, other than wiring terminals; and

b) Any uninsulated live parts of electrical components such as a pressure-limiting device, motor overload protective device, or other protective device where short circuiting or grounding may result in unsafe operation of the equipment, except at wiring terminals.

12.5 There shall be provision for segregating or separating by barriers, field-installed conductors of an low-voltage circuit from:

a) Uninsulated live hazardous voltage circuits; and

b) Wiring terminals and any other uninsulated live parts of hazardous voltage electrical components such as a pressure-limiting device, motor overload protective device, or other protective device where short circuiting or grounding may result in unsafe operation of the unit.

12.6 If a barrier is used to provide separation between the wiring of different circuits, it shall be of metal or of suitable insulating material of adequate mechanical strength, and reliably held in place.

12.7 A metal barrier shall be at least 0.66 mm (0.026 in) thick if of uncoated steel, 0.74 mm (0.029 in) thick if of galvanized steel, and 0.91 mm (0.036 in) thick if of nonferrous metal. A barrier of insulating materials shall be not less than 0.71 mm (0.028 in) thick, and shall be of greater thickness if its deformation could be so readily accomplished as to defeat its purpose.

12.8 If the barrier is removable or has openings for the passage of conductors, it is acceptable provided that instructions for the use of the barrier are a permanent part of the device. In lieu of a barrier, complete instructions may be provided that, when used in conjunction with the wiring diagram, will provide for the separation of the circuits of different voltages.

12.9 Field-installed conductors may be segregated from other field-installed conductors and from uninsulated live parts connected to other circuits by arranging the location of the openings in the enclosure

for the various conductors, with respect to the terminals or other uninsulated live parts, so that conductors or parts of different circuits will not intermingle.

12.10 The output of a transformer device supplying a circuit shall not be interconnected with the output of another such transformer device provided as a part of the equipment, unless the voltage and current measurements at the output terminals of the interconnected devices are low-voltage.

12.11 Two or more transformer devices supplying Class 2 circuits and provided as a part of the equipment, shall be treated as separate circuits. If more than one such circuit is intended to be field-wired, the several circuits shall be segregated or separated by barriers as specified in 12.2, and the transformer output of each circuit shall be marked to warn that the separation shall be maintained.

13 Insulating Material

13.1 Material for mounting uninsulated live parts and for insulating bushings, washers, separators, and barriers shall be porcelain, phenolic composition, or other material acceptable for the application.

13.2 Thermoplastic material may be employed for the sole support of uninsulated live parts if found to have the necessary mechanical strength and rigidity, resistance to flame propagation, dielectric properties, resistance to arcing, thermal endurance, and other properties acceptable for the application.

13.3 A molded part shall be constructed so as to have the necessary mechanical strength and rigidity to withstand the stresses of normal service. Brush caps shall be secured or located so as to be protected from damage that might occur during use.

14 Motors

14.1 General

14.1.1 A motor shall be acceptable for the application and shall be capable of driving the maximum normal load of the ventilator without introducing a risk of fire, electric shock, or injury to persons.

14.2 Enclosure

14.2.1 A roof- or wall-mounted ventilator motor that is exposed to the main air stream shall be totally enclosed.

Exception: A roof- or wall-mounted ventilator that is marked in accordance with 36.16 may employ a motor of other than the totally enclosed type if the motor is provided with inherent overtemperature protection complying with the requirements for running and locked-rotor protection.

14.2.2 A duct-fan motor that is exposed to the main air stream shall be totally enclosed. See 11.5.

14.3 Protection

14.3.1 A ventilator employing a motor that must be cooled by the main air stream to prevent overheating when operating continuously – an air-over motor – shall incorporate automatically reset inherent overtemperature protection.

14.3.2 For a ventilator employing a motor other than as described in 14.3.1, automatically reset thermal or overcurrent motor protection shall be incorporated in the ventilator.

Exception: A ventilator that is marked in accordance with 36.6 need not have thermal or overcurrent motor protection. This exception does not apply to the requirements in 14.2.1.

14.3.3 A motor provided with inherent overtemperature protection complying with the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, and the Standard for Thermally Protected Motors, UL 1004-3; or UL 1004-1, and the Standard for Impedance Protected Motors, UL 1004-2, for an impedance-protected motor; or UL 1004-1, and the Standard for Electronically Protected Motors, UL 1004-7, for an electronically protected motor is considered to comply with the requirements in 14.3.1 and 14.3.2. A motor used with a direct-drive fan or blower need comply only with the requirements for protection during locked-rotor conditions.

Exception: This requirement does not apply to electronic protection that complies with UL 1004-7 and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

14.3.4 Table 14.1 summarizes the requirements relating to motor protection.

Table 14.1
Summary of motor-protection requirements

Motor location	Motor type	Type of fan drive	Minimum type of inherent protection required[a]
Exposed to main air stream	Open[b,c]	Any	Automatically reset, running and locked-rotor
Exposed to main air stream	Totally enclosed air-over	Belt	Automatically reset, running and locked-rotor
Exposed to main air stream	Totally enclosed air-over	Direct	Automatically reset, locked-rotor
Not exposed to main air stream	Open or totally enclosed	Belt	Automatically reset, running and locked-rotor[d]
		Direct	Automatically reset, locked-rotor[d]

[a] See 36.5 for required marking.
[b] If marked in accordance with 36.16.
[c] See 14.2.2.
[d] See Exception to 14.3.2.

14.3.5 The protection of a multispeed motor shall function to accomplish the intended result at each setting of the speed-control device. Tests are ordinarily conducted at the highest and lowest speed settings and at one intermediate speed setting of the controller. However, tests may also be conducted at additional settings if it appears to be necessary.

14.3.6 Electronically protected motor circuits shall comply with the Standard for Tests for Safety-Related Controls Employing Solid State Devices, UL 991. When the electronic circuit is relying on software as a protective component, it shall comply with all of the requirements in the Standard for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software class 1.

Exception: Compliance with UL 991 and UL 1998 is not required for an electronically protected motor circuit if:

a) There is no risk of fire, electric shock or casualty hazard noted during Abnormal testing with the motor electronic circuit rendered ineffective (open or short circuited), or

b) It complies with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 and the Standard for Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9. When the electronic circuit is relying on software as a protective component, it shall comply with all of the requirements in clause H 11.12 of UL 60730-1, if software is relied upon to perform a safety function, it shall be considered software class B, or

c) It is a power conversion controller incorporating overcurrent protection complying with the Standard for Adjustable Speed Electrical Power Drive Systems, UL 61800-5-1 and is rated or set to trip at not more than the 115 percent of the motor nameplate full-load current rating, or

d) Electronic protection complies with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

14.3.7 The requirements in Table 14.2 shall be considered when judging the acceptability of the protective circuit.

Table 14.2
Application of UL 991, UL 1998, UL 60730-1, and UL 60730-2-9

	Application of UL 991 and UL 1998	Application of UL 60730-1, and UL 60730-2-9
1)	Conduct a failure-mode and effect analysis (FMEA) – for the protective circuit identified in 14.3.6.	Conduct a failure-mode and effect analysis (FMEA) – for the protective circuit identified in 14.3.6.
2)	A control becoming permanently inoperative and disconnecting power meets the criteria for electrical supervision of critical components and trouble indication.	A control becoming permanently inoperative and disconnecting power meets the criteria for electrical supervision of critical components and trouble indication.
3)	Assumed temperature ranges are as follows: a) Indoor Use: 0.0 ±2°C (32.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F), b) Outdoor Use: -35.0 ±2°C (−31.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F).	Assumed temperature ranges are as follows: a) Indoor Use: 0.0 ±2°C (32.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F), b) Outdoor Use: -35.0 ±2°C (−31.0 ±3.6°F) and 40.0 ±2°C (104 ±3.6°F).
4)	Cycling test duration shall be 14 days.	Cycling test duration shall be 14 days.
5)	Endurance test duration shall be 100,000 cycles.	Endurance test duration shall be 100,000 cycles.
6)	Radio-frequency electromagnetic field immunity: a) Immunity to conducted disturbances – When applicable test level 3 shall be used, b) Immunity to radiated electromagnetic fields – field strength of 3 V/m shall be used.	Radio-frequency electromagnetic field immunity: a) Immunity to conducted disturbances – When applicable test level 3 shall be used, b) Immunity to radiated electromagnetic fields – field strength of 3 V/m shall be used.
7)	For exposure to humidity, the following conditions shall apply: a) Indoor Use: 21.1 to 26.7°C (70 to 80°F) and minimum 50 percent relative humidity, b) Outdoor Use: minimum 98 percent relative humidity.	For exposure to humidity, the following conditions shall apply: a) Indoor Use: 21.1 to 26.7°C (70 to 80°F) and minimum 50 percent relative humidity, b) Outdoor Use: minimum 98 percent relative humidity.
8)		Surge immunity test – Test with installation Class 3 used for other than outdoor use protective devices. Class 4 shall be used for protective devices intended for outdoor use.
9)	Electrical fast transient/burst immunity such that a test level 3 shall be used for all equipment other than outdoor use equipment. Test level 4 shall be used for outdoor use equipment.	Electrical fast transient/burst immunity such that a test level 3 shall be used for all equipment other than outdoor use equipment. Test level 4 shall be used for outdoor use equipment.
10)		Electrostatic Discharge Test with a Severity Level of 3 having Contact Discharge at 6 kV for accessible metal parts and air discharge at 8 kV for accessible parts of insulating material.

15 Grounding

15.1 All exposed dead metal parts and all dead metal parts within the enclosure that may become energized shall be conductively connected to the point of a metallic enclosure to which the equipment grounding conductor will be connected.

15.2 The means for connecting a bonding jumper shall be bolting, riveting, welding, or other means that will provide positive contact and comply with 8.1.

15.3 A connection that depends upon the clamping action exerted by rubber or similar material is acceptable if:

a) It complies with the requirements in Bonding Connection Test, Section 32 under any degree of compression permitted by the clamping device if the device is variable;

b) It is not adversely affected by oil, grease, moisture, thermal degradation, or other exposure likely to occur in service;

c) It is not adversely affected by disassembly and reassembly for maintenance purposes; and

d) Its construction is such that it is not likely to be reassembled improperly after having been disassembled.

16 Switches and Controllers

16.1 A switch or other control device provided on or with the ventilator shall have a rating not less than the marked rating of the load that it controls.

16.1.1 A motor control device shall comply one of the following:

a) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, in conjunction with the applicable Part 2 from the UL 60730 series,

b) Deleted

c) The Standard for Industrial Control Equipment, UL 508, or

d) The Standard for Adjustable Speed Electrical Power Drive Systems, UL 61800-5-1, or

e) Electronic protection that complies with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

16.1.2 Auxiliary controls shall be evaluated using the applicable requirements of this end product standard and Section 33, Controls – End Product Test Parameters.

Exception: The requirement does not apply to electronic protection that complies with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

16.1.3 Operating (regulating) controls shall be evaluated using the applicable requirements of this end product standard and Section 33, Controls – End Product Test Parameters.

Exception: The requirement does not apply to electronic protection that complies with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

16.1.4 Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the control may result in a risk of safety, such as a speed control unexpectedly changing its output, shall comply with the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and the Standard for Software in Programmable Components, UL 1998; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, or

c) Test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

16.1.5 Protective (limiting) controls shall be evaluated using the applicable requirements of this end product standard and Section 33, Controls – End Product Test Parameters.

Exception: The requirement does not apply to electronic protection that complies with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

16.1.6 Solid-state protective controls that do not rely upon software as a protective component shall comply with the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, except for Controls Using Software, see Clause H.11.12; or

c) Test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

16.1.7 Protective controls that rely upon software as a protective component shall comply with the:

a) Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991; and the Standard for Software in Programmable Components, UL 1998; or

b) Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; or

c) Test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

16.2 A switch intended to be connected to a power-supply circuit having a potential to ground of more than 150 volts shall be acceptable for the maximum potential to ground of the circuit.

Exception: The requirement does not apply to electronic protection that complies with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

16.3 A nominal 208-volt single- or three-phase ventilator is considered to involve a potential to ground of less than 150 volts. Unless a ventilator is marked in accordance with 36.19 two-wire, single-phase, or a three-wire, three-phase ventilator with a rating in the range of 220 – 240 volts is assumed to involve a potential to ground of more than 150 volts.

Exception: The requirement does not apply to electronic protection that complies with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

17 Capacitors

17.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line – such as a capacitor for radio-interference elimination – shall be housed within an enclosure so that mechanical damage to the plates will not occur, and flame or molten material will not be emitted as a result of breakdown of the capacitor. The construction shall comply with one of the following:

a) The enclosure shall be of sheet steel not less than 0.020 inch (0.51 mm) thick or shall be constructed to afford equivalent protection;

b) The enclosure may be of sheet steel thinner than 0.020 inch or of other acceptable material if it is mounted in an enclosure that is acceptable for the enclosure of live parts;

c) The individual enclosure of an electrolytic capacitor with means for venting shall be such as to reduce the likelihood of mechanical damage only, and no minimum enclosure thickness is specified; or

d) The individual enclosure of an electrolytic capacitor not provided with means for venting and with an opening more than 1/16 inch (1.6 mm) wide between the capacitor enclosure and the motor shall comply with the requirements in 29.1.1, and no minimum enclosure thickness is specified.

Exception: The requirement does not apply to capacitors that comply with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

17.2 An oil-filled capacitor, not an electrolytic type, employing a dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium under both normal and abnormal conditions of use and shall be acceptable for a minimum available fault current (AFC) of 5000 amperes.

Exception: The requirement does not apply to capacitors that comply with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

17.3 The motor running capacitor shall comply with the testing requirements of the Standard for Capacitors, UL 810.

Exception: The requirement does not apply to capacitors that comply with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

17.4 The motor starting capacitor shall comply with the construction requirements of the Standard for Capacitors, UL 810.

Exception: The requirement does not apply to capacitors that comply with the test requirements and the circuits requirements of Supplement SB, UL 60335-1 Based Requirements for the Evaluation of Electronic Circuits.

18 Receptacles

18.1 The face of a receptacle shall:

a) Be flush with or project beyond a nonconductive surrounding surface; or

b) Project at least 0.015 inch (0.38 mm) beyond a conductive surrounding surface.

18.2 Receptacles shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

19 Spacings

19.1 The spacing between field-wiring terminals of opposite polarity, and the spacing between a field-wiring terminal and any other uninsulated metal part not of the same polarity, shall not be less than that specified in Table 19.1.

Table 19.1
Spacings at field-wiring terminals

Potential involved, volts	Minimum spacings, inch (mm)					
	Between wiring terminals, through air or over surface		Between terminals and other uninsulated metal parts not always of the same polarity[a]			
			Over surface		Through air	
250 or less	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
More than 250	1/2	(12.7)[b]	1/2	(12.7)[b]	3/8	(9.5)

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

[b] A spacing of not less than 3/8 inch, through air and over surface, is acceptable at field-wiring terminals in a wiring compartment or terminal box if the compartment or box is integral with a motor.

19.2 Other than at field-wiring terminals, the spacing between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall not be less than that specified in Table 19.2. If an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the minimum acceptable spacings will be maintained.

Exception: This requirement does not apply to the inherent spacings of a component of the ventilator such as a snap switch. Such spacings are judged on the basis of the requirements for the component in question.

Table 19.2
Spacings at other than field-wiring terminals or in motors

Potential involved, volts	Minimum spacings, inch (mm)							
	In ventilators employing a motor 7 inches (180 mm) or less in diameter[a]				In ventilators employing a motor more than 7 inches in diameter[a]			
	Over surface		Through air		Over surface		Through air	
0 – 125	3/32	(2.4)[b]	3/32	(2.4)[b]	1/4	(6.4)[c]	1/8	(3.2)[c]
126 – 250	3/32	(2.4)	3/32	(2.4)	1/4	(6.4)[c]	1/4	(6.4)[c]
251 – 600	1/2	(12.7)[c]	3/8	(9.5)[c]	1/2	(12.7)[c]	3/8	(9.5)[c]

[a] This is the diameter, measured in the plane of laminations of the circle circumscribing the stator frame, excluding lugs, fins, boxes, and the like, used solely for motor mounting, cooling, assembly, or connection.

[b] In a ventilator employing a motor rated at 1/3 horsepower (250 W output) or less, these spacings may be not less than 1/16 inch (1.6 mm).

[c] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 inch over surface and through air between film-coated wire rigidly supported and held in place on a coil and a dead metal part is acceptable in a ventilator rated at more than 250 volts or employing a motor having a diameter of more than 7 inches. See note (a).

19.3 The spacings for a motor shall comply with the spacing requirements in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

19.4 In applying 19.2, 19.3, 26.1, and note (b) in Table 19.2 to an appliance employing a motor not rated in horsepower (W output), use is to be made of the appropriate table of the National Electrical Code, ANSI/NFPA 70, that gives the relationships between horsepower and full-load currents for motors.

19.5 At terminal screws and studs to which field connection may be made using wire connectors, eyelets, and the like as described in 2.3, opposite polarity spacings and spacings to dead metal shall not be less than as specified in Table 19.2 with the connectors, eyelets, and the like installed in such position that minimum spacings exist.

19.6 An insulating lining or barrier of vulcanized fiber or similar material employed in lieu of spacings shall be at least 1/32 inch (0.8 mm) thick, and shall be so located or of such material that it will not be adversely affected by arcing.

Exception: Vulcanized fiber not less than 1/64 inch (0.4 mm) thick may be used in addition to an air spacing of not less than 50 percent of the minimum acceptable through air spacing.

19.7 Materials and combinations of materials other than those specified in 19.6 may be used if they have been found to be acceptable based on an investigation of their ability to resist degradation due to:

a) Temperature;

b) Vibration;

c) Thermal cycling; and

d) High humidity.

20 Clearance and Creepage Distances

20.1 As an alternative approach to the spacing requirements specified in Spacings, Section 19, and other than as noted in this Section, is to be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, as described in 20.3.

20.2 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Spacings, Section 19.

20.3 In conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, the guidelines in Table 33.1 – Table 33.3 shall be used.

21 Filters

21.1 A filter shall be tested in accordance with the Standard for Air Filter Units, UL 900.

PERFORMANCE

22 Starting Current Test

22.1 A ventilator shall start and attain normal running speed without opening a fuse when energized on a circuit protected by a fuse of other than the time-delay type. The fuse is to have a current rating

corresponding to that of the motor branch circuit to which the ventilator may be connected in accordance with the National Electrical Code, ANSI/NFPA 70.

Exception: If a ventilator is marked in accordance with 36.13, it shall start and attain normal running speed without opening a fuse on a circuit protected by a time-delay fuse.

22.2 The ventilator is to be started three times when connected to a circuit of minimum rated voltage. Each start of the motor is to be under conditions representing the beginning of normal operation. The motor is to be allowed to come to rest between starts, and is to be restarted immediately. Opening of an overload-protective device provided as part of the ventilator after the first start is acceptable.

23 Input Test

23.1 The current input to a ventilator shall not be more than 110 percent of the rated steady-state full load amperes (FLA) or service factor full load ampere (FLA) if the motor has a service factor value when the ventilator is operated under conditions of actual service and connected to a supply circuit of maximum rated voltage and rated frequency.

23.2 Unless otherwise specified, each ventilator is to be tested at the appropriate potential indicated in Table 23.1, for each test as detailed in the applicable sections.

Table 23.1
Test voltage

Unit rated voltage	Test voltage[a]
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
440 – 480	480
550 – 600	600
Other	Rated

[a] Tolerance ±2 percent.

23.3 For the input test, the ventilator is to be connected to a fitting or structure that can be adjusted to uniformly restrict the air supply. The structure may consist of an inlet duct, with or without air straighteners, connected to the ventilator or to a plenum on which the ventilator is mounted and arranged to avoid undue turbulence of air supply.

23.4 The input is considered to be the maximum input measured while restricting the air-system inlet to not more than one-half the unrestricted cross-sectional area of the ventilator inlet.

23.5 For conducting the input test on a ventilator of the axial type, an inlet duct is to be employed with the air-blocking surface located a distance from the ventilator at least equal to the diameter of the propeller or blade.

24 Temperature Test

24.1 A ventilator shall be tested as described in this section and shall not reach temperatures high enough to cause a risk of fire, to damage materials used, or to exceed the temperature rises specified in Table 24.1. A protective device shall not operate when the ventilator is tested in accordance with 24.2 – 24.12.

Exception: Temperature rises for a duct fan intended for interior use only may be 5°C (9°F) more than specified in Table 24.1 based on a 25°C (77°F) ambient.

Table 24.1
Maximum acceptable temperature rises

	Materials and components	Degrees K	Degrees (R)
1.	Varnished-cloth insulation	55	(99)
2.	Wood or other combustible material	60	(108)
3.	Any point on or within a terminal box		
	A. For a compartment integral with the ventilator	30	(54)
	B. For a remotely mounted compartment	35	(63)
4.	A surface upon which the ventilator may be mounted in service, and surfaces that may be adjacent to the ventilator when so mounted	60	(108)
5.	Class A insulation systems on coil windings of an a-c motor having a diameter of more than 7 inches (178 mm)[a,b] and on reactors:		
	A. In an open motor:		
	Thermocouple method	60	(108)
	Resistance method	70	(126)
	B. In a totally enclosed motor:		
	Thermocouple method	65	(117)
	Resistance method	75	(135)
	C. In a totally enclosed fan-cooled motor:		
	Thermocouple method	65	(117)
	Resistance method	70	(126)
6.	Class A insulation systems on coil windings of an a-c motor having a diameter of 7 inches (178 mm) or less[a,b]:		
	A. In an open motor:		
	Thermocouple or resistance method	70	(126)
	B. In a totally enclosed motor:		
	Thermocouple or Resistance method	75	(135)
7.	Phenolic composition employed as electrical insulation or as a part the breakdown of which would result in a hazardous condition	120[c]	(216)[c]
8.	Rubber- or thermoplastic-insulated conductors	30[c,d]	(54)[c,d]
9.	Capacitors:		
	Electrolytic	35[e]	(63)[e]
	Other types	60[f]	(108)[f]
10.	Sealing compound	g	g
11.	Insulation systems on windings of a relay, and the like:		
	a) Class 105 insulation systems		
	Thermocouple method	60	(108)
	Resistance method	80	(144)
	b) Class 130 insulation systems		
	Thermocouple method	80	(144)

Table 24.1 Continued on Next Page

Table 24.1 Continued

Materials and components	Degrees K	Degrees (R)
Resistance method	100	(180)
12. Class B insulation systems on coil windings of an a-c motor having a diameter of more than 7 inches (178 mm)[a,b]		
a) In an open motor:		
Thermocouple method	80	(144)
Resistance method	90	(162)
b) In a totally enclosed motor:		
Thermocouple method	85	(153)
Resistance method	95	(171)
c) In a totally enclosed fan-cooled motor:		
Thermocouple method	85	(153)
Resistance method	90	(162)
13. Class B insulation systems on coil windings of an a-c motor having a diameter of 7 inches (178 mm) or less[a,b] and on a vibrator coil:		
a) In an open motor:		
Thermocouple or resistance method	90	(162)
b) In a totally enclosed motor:		
Thermocouple or resistance method	95	(171)
14. Class F system on coil windings of an ac motor having a frame diameter of 178 mm (7 inches) or less, not including a universal motor.		
a) In an open motor:		
Thermocouple or resistance method	120	(216)
b) In a totally enclosed motor:		
Thermocouple or resistance method	125	(225)
15. Class F system on coil windings of an ac motor having a frame diameter of more than 178 mm (7 inches), not including a universal motor.		
a) In an open motor:		
Thermocouple method	110	(189)
Resistance method	120	(216)
b) In a totally enclosed motor:		
Thermocouple method	115	(207)
Resistance method	125	(225)
16. Class H system on coil windings of an ac motor having a frame diameter of 178 mm (7 inches) or less, not including a universal motor.		
a) In an open motor:		
Thermocouple or resistance method	135	(243)
b) In a totally enclosed motor:		
Thermocouple or resistance method	140	(252)
17. Class H system on coil windings of an ac motor having a frame diameter of more than 178 mm (7 inches), not including a universal motor.		
a) In an open motor:		

Table 24.1 Continued on Next Page

Table 24.1 Continued

Materials and components	Degrees K	Degrees (R)
Thermocouple method	125	(225)
Resistance method	135	(243)
b) In a totally enclosed motor:		
Thermocouple method	130	(234)
Resistance method	140	(253)
18. Class E system on coil windings of an ac motor having a frame diameter of 7 inches (178 mm)[a,b] or less.		
a) In an open motor:		
Thermocouple or resistance method	80	(144)
b) In a totally enclosed motor:		
Thermocouple or resistance method	85	(153)
19. Class E system on coil windings of an ac motor having a frame diameter of more than 7 inches (178 mm) [a,b].		
a) In an open motor:		
Thermocouple method	70[a,b]	(126)[a,b]
Resistance method	80	(144)
b) In a totally enclosed motor:		
Thermocouple method	75	(135)
Resistance method	85	(153)
c) In a totally enclosed fan-cooled motor:		
Thermocouple method	75	(135)
Resistance method	80	(144)

[a] See Table 19.2, note a.

[b] See 24.3.

[c] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found to have acceptable heat-resistant properties.

[d] Rubber-insulated conductors within a Class A insulated motor and rubber-insulated motor leads may be subjected to a temperature rise of more than 30°K (54°R), provided that an acceptable braid is employed on the conductor of other than the flexible cord.

[e] For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be not more than 60°K (108°R).

[f] A capacitor that operates at a temperature rise of more than 60°K (108°R) may be judged on the basis of its marked temperature limit.

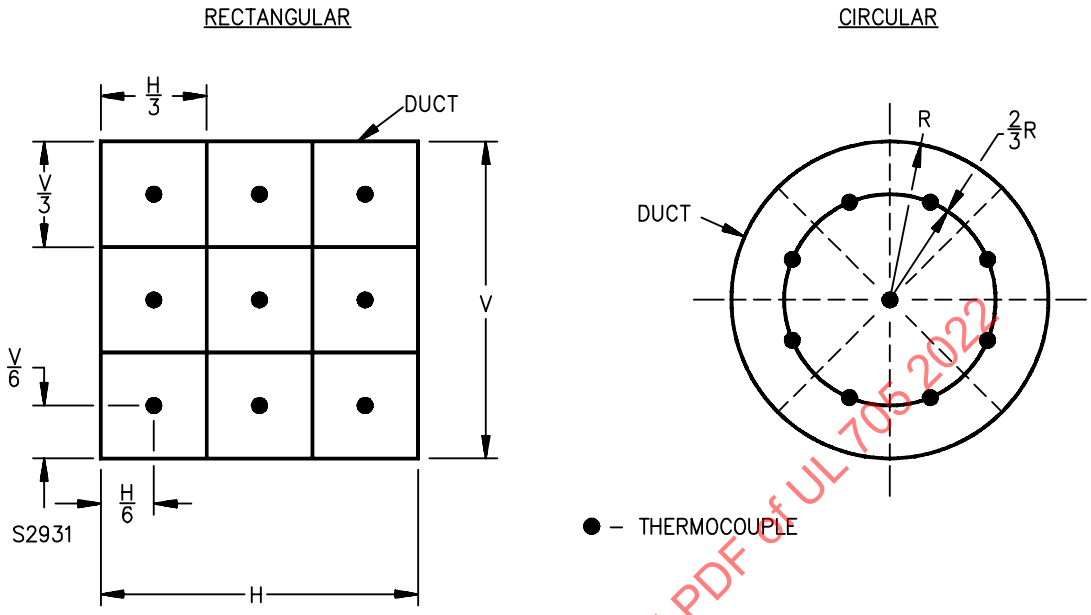
[g] The maximum sealing compound temperature when corrected to a 25°C (77°F) ambient temperature is 15°K (27°R) less than the softening point of the compound as determined by the Standard Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

24.2 A duct fan for moving heated air is to be tested with a heat source capable of supplying air heated to the temperature for which the fan is intended to be used. The temperature at the duct-fan inlet is not to be less than the temperature for which the fan is marked in accordance with 36.10.

24.3 With reference to the requirements in 24.2, the temperature at the inlet is to be determined by a thermocouple grid positioned in a plane perpendicular to the air flow and located 6 inches (150 mm) from the collar of the duct fan. The grid is to be constructed of thermocouples of the same length connected in parallel. The duct is to be divided into equal areas and thermocouples are to be located as illustrated in Figure 24.1. The thermocouple wire shall not be larger than 24 AWG (0.21 mm^2).

Figure 24.1

Thermocouple location in test duct



Duct divided into 9 equal areas as illustrated with a thermocouple located in center of each of the resulting 9 areas.

Duct divided radially into 8 equal areas with thermocouples located as illustrated in each of the 8 areas and at the center of the duct.

24.4 All values of temperature rise in Table 24.1 are based on an assumed ambient temperature of 30°C (86°F). However, tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

24.5 A thermocouple is to be used for determining temperature of a coil or winding if it can be mounted without removal of encapsulating compound or the like on the integrally applied insulation of a coil without a wrap, or on the outer surface of a wrap that is not more than 1/32 inch (0.8 mm) thick and consists of cotton, paper, rayon, or the like, but not of thermal insulation. The change-of-resistance method is to be used if the thermocouple measurement cannot be conducted in accordance with the foregoing considerations. For a thermocouple-measured temperature of a motor coil – items 6 and 13 of Table 24.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor.

24.6 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in good thermal contact with the surface of the material being measured. In most cases, adequate thermal contact will result by 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.

24.7 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2), except that a coil temperature may be determined by the change-of-resistance method under the conditions described in 24.5. Whenever referee temperature measurements by thermocouples are necessary, thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument are to be used.

24.8 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 for Special Tolerances thermocouples as listed 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.

24.9 The resistance method consists of calculation of the temperature rise of a winding using the following equation:

$$\Delta t = \frac{R}{r}(k + t_1) - (k + t_2)$$

in which:

Δt is the temperature rise of the coil in degrees C;

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

r 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; and

k is 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum. Values of k for other conductors are to be determined.

24.10 The ventilator is to be operated with a load as described in 23.4. A multispeed ventilator is to be operated at each speed and a reversible ventilator is to be operated in each direction of rotation. In each instance, operation is to be continued until constant temperatures are attained.

24.11 A temperature is considered to be constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change.

24.12 For the temperature test, the voltage of an alternating-current supply circuit is to be 120, 208, 240, 480, or 600 volts if the ventilator has a nominal voltage rating of 110 or 115, 200 or 208, 220 – 240, 440 – 480, or 550 volts, respectively. If the ventilator has a single frequency rating, the test is to be conducted at that frequency. A ventilator rated ac-dc, dc-60 hertz, or dc-25 – 60 hertz is to be tested on direct current or 60-hertz alternating current, whichever results in higher temperatures. A ventilator rated 50 – 60 hertz is to be tested on 60-hertz alternating current.

25 Undervoltage Test

25.1 Unless a thermally responsive inherent motor protector opens the circuit, the ventilator shall start and operate continually under the conditions described in 23.4 that produce maximum motor loading, but with the voltage reduced to 85 percent of the rated voltage of the motor.

26 Dielectric Voltage-Withstand Test

26.1 The equipment shall withstand without breakdown the following:

a) A potential, as specified below, applied between live parts of hazardous voltage circuits, and dead (grounded) metal parts, for a period of 1 min. AC test potentials are 40 – 70 Hz and DC test potentials represent the peak value of the AC test potentials. For the test, the unit may be in a heated or unheated condition.

1) 1000 V ac or 1414 dc for units rated 250 V or less, and which include a motor rated at 1/2 hp or less.

2) 1000 V ac plus twice the rated voltage or 1414 V dc plus 2.8 times rated voltage for units rated more than 250 V or which include a motor rated larger than 1/2 hp.

3) One thousand volts, or 1000 volts plus twice the rated voltage, depending upon the value of the test potential applied to the ventilator as a whole, between the terminals of a capacitor used for power-factor correction or for radio-interference elimination.

b) Deleted

c) Deleted

26.2 To determine if a ventilator complies with the requirements in 26.1, it is to be tested with a 500-volt-ampere or larger capacity transformer, the output voltage of which can be varied. The applied potential is to be increased gradually from zero to the required test value and is to be held at that value for 1 minute. The increase in potential is to be at a substantially uniform rate and as rapid as is consistent with correct indication of its value by a voltmeter.

27 Water Spray Test

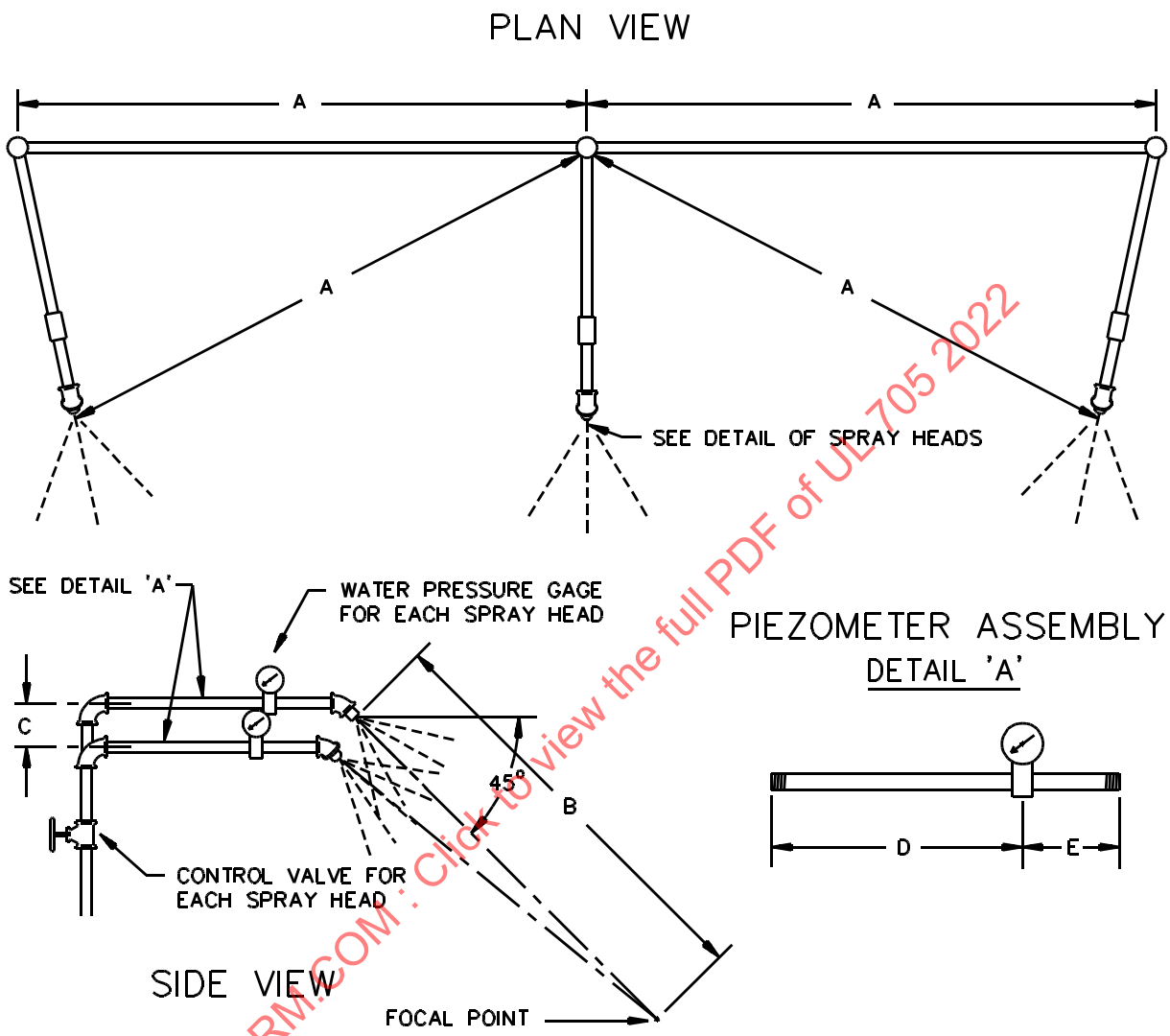
27.1 When tested as described in 27.2 and 27.3, a ventilator intended for outdoor exposure shall have an insulation resistance of 50,000 ohms or more between live parts and interconnected dead metal parts, and shall withstand for 1 minute without breakdown the application of a dielectric voltage-withstand potential of 1000 volts between live parts and interconnected dead metal parts. After the test there shall be no water at any point that may be contacted by a splice in field-installed wiring, and on uninsulated live parts or on film-coated wire other than motor windings.

27.2 A ventilator intended for outdoor exposure is to be mounted as in actual service, and is to be subjected to a water spray as described in 27.3 for 4 hours. The ventilator is not to be operating, unless it is intended to draw air in rather than to expel it, or has louvers that open only when the motor is running. The insulation-resistance and dielectric voltage-withstand tests are to be conducted immediately upon conclusion of exposure to the water spray and are to be repeated 1/2 hour later.

27.3 The test apparatus is to consist of three water spray heads mounted in the piping shown in Figure 27.1. The spray heads are to be constructed in accordance with the details shown in Figure 27.2. The water pressure during the test is to be maintained at 5 psig (34.5 kPa) at each spray head. The distance between the center nozzle and the ventilator is to be approximately 5 feet (1.5 m). The enclosure is to be brought into the focal area of the three spray heads in such a position and under such conditions as are most likely to result in entrance of water into the enclosure. The spray is to be directed at a 45-degree angle to the vertical toward the enclosure.

Figure 27.1

Rain-test spray-head piping

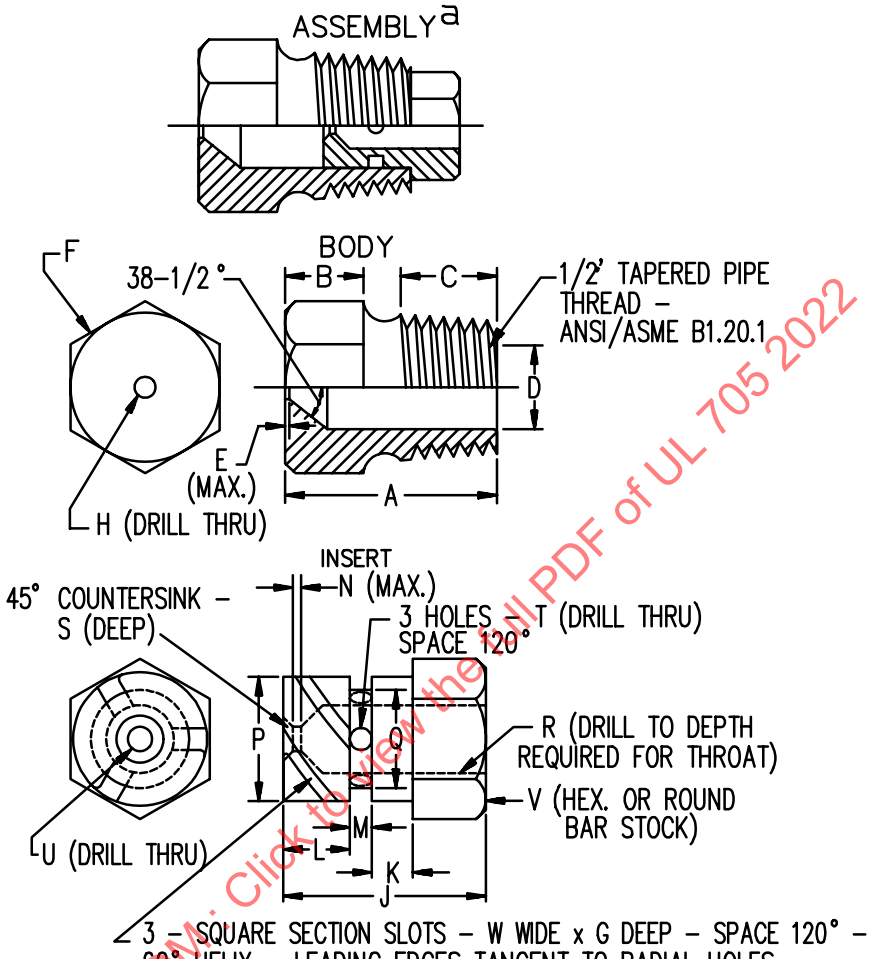


Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

RT101E

Figure 27.2

Rain-test spray head



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

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

[b] ANSI B94.11M Drill Size

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

RT100E

28 Metallic Coating Thickness Test

28.1 The test for determining the thickness of zinc and cadmium coatings is described in 28.2– 28.9.

28.2 The solution to be used for this test is to be made from distilled water and is to contain 200 grams per liter of reagent grade chromic acid (CrO_3); and 50 grams per liter of reagent grade concentrated sulphuric acid (H_2SO_4). The latter is equivalent to 27 milliliters per liter of reagent grade concentrated sulphuric acid, specific gravity 1.84, containing 96 percent of H_2SO_4.

28.3 The test solution is to be contained in a glass vessel such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube of approximately 0.025 inch (0.64 mm) inside bore and 5.5 inches (140 mm) long. The lower end of the capillary tube is to be tapered to form a tip, the drops from which are about 0.025 milliliters each. To preserve an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ±5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

28.4 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, which is to be noted and recorded. The test is to be conducted at an ambient temperature of 21.1 – 32.2°C (70 – 90°F).

28.5 Each sample is to be thoroughly cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed completely by means of solvents. Samples are then to be thoroughly rinsed in water and dried. Care is to be exercised to avoid contact of the cleaned surface with the hands or any foreign material.

28.6 The sample to be tested is to be supported 0.7 – 1 inch (18 – 25 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested is to be inclined about 45 degrees from horizontal.

28.7 The stopcock is to be opened and the time in seconds is to be measured until the dropping solution dissolves the protective metallic coating, exposing the base metal. The end point is the first appearance of the base metal recognizable by the change in color at that point.

28.8 Each sample of a test lot is to be subjected to the test at three or more points, excluding cut, stenciled, and threaded surfaces, on the inside surface and at an equal number of points on the outside surface at places where the metallic coating may be expected to be the thinnest. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation are likely to have thin coatings.

28.9 To calculate the thickness of the coating being tested, select from Table 28.1 the thickness factor corresponding to the temperature at which the test was conducted and multiply it by the time in seconds required to expose base metal as noted in 28.7.

Table 28.1
Coating thickness factors

Temperature,		Thickness factors, 0.00001 inches (0.0003 mm) per second	
°F	(°C)	Cadmium platings	Zinc platings
70	(21.1)	1.331	0.980
71	(21.7)	1.340	0.990
72	(22.2)	1.352	1.000
73	(22.8)	1.362	1.010
74	(23.3)	1.372	1.015
75	(23.9)	1.383	1.025
76	(24.4)	1.395	1.033
77	(25.0)	1.405	1.042
78	(25.6)	1.416	1.050
79	(26.1)	1.427	1.060
80	(26.7)	1.438	1.070
81	(27.2)	1.450	1.080
82	(27.8)	1.460	1.085
83	(28.3)	1.470	1.095
84	(28.9)	1.480	1.100
85	(29.4)	1.490	1.110
86	(30.0)	1.501	1.120
87	(30.6)	1.513	1.130
88	(31.1)	1.524	1.141
89	(31.7)	1.534	1.150
90	(32.2)	1.546	1.160

29 Capacitor Tests

29.1 Burnout on electrolytic capacitor

29.1.1 In a test to determine if an electrolytic capacitor as described in 17.1(d) is acceptable, several samples of the capacitor, mounted in the usual manner and with cotton placed around openings in the enclosure, are to be subjected to such overvoltage as to cause breakdown. If the cotton ignites upon breakdown of the capacitor, the results are not acceptable.

29.2 Leakage current

29.2.1 The total capacitance of capacitors connected from one or more ungrounded sides of the line to the frame or enclosure of a single-phase ventilator shall permit a total of not more than 5.0 milliamperes of leakage current from capacitive and other sources to flow to ground through a 500-ohm noninductive resistor under normal operating conditions at the rated voltage of the ventilator.

30 Overload Test – Switch or Control

30.1 There shall be no electrical or mechanical breakdown or undue pitting or burning of the contacts of a motor switch or control, and the fuse in the grounding connection shall not open during the overload test described in 30.2.

Exception No. 1: A switch that has been investigated and found to be acceptable for the application need not be subjected to the overload test.

Exception No. 2: A switch so interlocked that it will never have to break the locked-rotor motor current need not be subjected to the overload test.

30.2 The ventilator is to be connected to a grounded supply circuit of rated frequency and maximum rated voltage with the rotor of the motor locked in position. During the test, exposed metal parts of the ventilator are to be connected to ground through a 3-ampere plug fuse, and the connection is to be such that any single-pole, current-rupturing switch or control will be located in the ungrounded conductor of the supply circuit. The test is to consist of 50 cycles of operation, making and breaking the locked-rotor current of the controlled motor. The switch or control is to be operated at a rate of not more than 10 cycles per minute, except that a faster rate of operation may be employed if agreeable to those concerned.

31 Permanence of Marking Tests

31.1 General

31.1.1 Unless known to be suitable for the application, a pressure-sensitive label or a label secured by cement or adhesive that is required to be permanent shall be tested as described in 31.1.2.

31.1.2 After being subjected to the conditions described in 31.2.1 – 31.6.1, a pressure-sensitive label or a label secured by cement or adhesive is considered to be permanent if immediately following removal from each test medium and after being exposed to room temperature for 24 hours following removal from each medium:

a) Each sample demonstrates good adhesion and the edges are not curled.

b) The label resists defacement or removal as demonstrated by scraping across the test panel with a flat metal blade 1/32 inch (3.2 mm) thick, held at right angles to the test panel.

c) The printing is legible and is not defaced by rubbing with thumb or finger pressure.

31.2 Oven-aging test

31.2.1 Three samples of the label applied to test surfaces as in the intended application are to be placed in an air oven maintained at the temperature specified in Table 31.1 for 240 hours.

Table 31.1
Oven-aging test temperature

Maximum temperature during normal temperature test of surface to which applied		Oven temperature	
°C	(°F)	°C	(°F)
60 or less	(140 or less)	87	(189)
80 or less	(176 or less)	105	(221)
100 or less	(212 or less)	121	(250)
125 or less	(257 or less)	150	(302)
150 or less	(302 or less)	180	(356)
Over 150	(Over 302)	a	

[a] A label that is applied to a surface attaining a temperature greater than 150°C (302°F), during the normal temperature test, is to be oven-aged at a temperature representative of the temperatures attained by the appliance during normal and abnormal operation.

31.3 Immersion test

31.3.1 Three samples of the label applied to test surfaces as in the intended application are to be placed in a controlled atmosphere maintained at 23 ±2°C (73 ±4°F) with a relative humidity of 50 ±5 percent for 24 hours. The samples are then to be immersed in water at a temperature of 21 ±2°C (70 ±4°F) for 48 hours.

31.4 Standard-atmosphere test

31.4.1 Three samples of the label applied to test surfaces as in the intended application are to be placed in a controlled atmosphere maintained at 23 ±2°C (73 ±4°F) with a relative humidity of 50 ±5 percent for 72 hours.

31.5 Unusual condition exposure test

31.5.1 If a label is exposed to unusual conditions in service, three samples of the label applied to test surfaces as in the intended application are to be placed in a controlled atmosphere maintained at 23 ±2°C (73 ±4°F) with a relative humidity of 50 ±5 percent for 24 hours. The samples are then to be immersed for 48 hours in a solution representative of service use maintained at the temperature the solution would attain in service, but not less than 23 ±2°C (73 ±4°F).

31.6 Outdoor exposure test

31.6.1 If a label is intended to be exposed to the weather, three samples of the label applied to test surfaces as in the intended application are to be subjected to ultraviolet rays and water spray for 720 hours. The test cycle is to consist of exposure to ultraviolet rays for 102 minutes followed by exposure to ultraviolet rays and a fine spray of water for 18 minutes.

31A Ventilator Motors of Permanent Split Capacitor (PSC) or Shaded Pole Type and Provided with Solid-State Speed Controls

31A.1 In addition to the condition described in 24.10, a motor that includes or that is intended for use with a solid-state speed control shall be operated under the following condition in 31A.3.

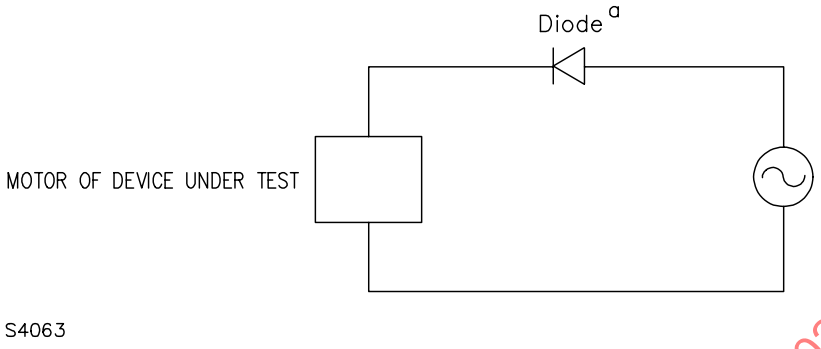
31A.2 A solid-state speed control shall comply with the applicable requirements in the Standard for Solid-State Fan Speed Controls, UL 1917, or the equivalent.

Exception: The spacings of an integral factory wired component solid-state speed control shall comply with either the Standard for Solid-State Fan Speed Controls, UL 1917, or the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series.

31A.3 With the motor connected to an ac supply modified to produce half-wave output. The supply shall be switched from sinusoidal to half-wave output after the motor is operating at maximum speed. If after the supply is switched from sinusoidal to half-wave operation, the motor shaft does not continue to rotate in a manner that is a normal condition, the locked-rotor temperature requirements described in 31A.4 shall be used instead of the maximum temperature specified in Table 24.1. See Figure 31A.1. For the requirements in this Clause and 31A.4, “normal” is defined as operation in excess of 10% of the measured maximum RPM.

Figure 31A.1

Half-wave test circuit



Footnote –

[a] A standard rectifier diode shall be used to produce the half-wave input to the motor of the device under test. The diode shall be sized for the rating of the device under test (at least twice the rating of the motor).

31A.4 When the motor shaft does not rotate or rotates in a manner not determined to be normal after the supply is switched from sinusoidal to half-wave operation as described in 31A.3 or the motor does not restart when operated from a half-wave source after the motor is de-energized, the motor shall comply with the applicable temperature requirements as follows:

a) The temperature of an impedance-protected motor shall comply with the locked-rotor temperature test requirements in Standard for Impedance Protected Motors, UL 1004-2.

b) The temperature of a thermally-protected motor shall comply with the locked-rotor temperature test requirements in Standard for Thermally Protected Motors, UL 1004-3, except:

1) For a motor with an automatic reset type protective device, the temperature criteria shall not be applied during the initial cycle of the thermal protector operation and there shall be no emission of flame or molten metal, or

2) For a motor with a non-replaceable thermal cutoff, the temperature criteria shall not be applied when the thermal cutoff opens within the first hour and there shall be no emission of flame or molten metal.

c) The duration of the test shall be for 15 days. The power supply shall be modified to provide half-wave output directly to the motor and bypassing the integral solid-state speed control.

32 Bonding Connection Test

32.1 The bonding connection between grounded metal and the motor frame shall not open when carrying for 2 minutes a current equal to twice the rated current of the fuse of largest current rating that can be mounted in the fuseholder of the branch circuit to which the ventilator would normally be connected.

Exception: This test need not be conducted if the minimum bonding conductor is:

a) Sized in accordance with Table 250-95 of the National Electrical Code, NFPA 70; or

b) Not smaller than one of the power supply conductors.

33 Controls – End Product Test Parameters

33.1 General

33.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in Controls, Section 16. Where reference is made to declared deviation and drift, this indicates the manufacturer's declaration of the control's tolerance before and after certain conditioning tests.

33.2 Auxiliary controls

33.2.1 Auxiliary controls shall not introduce a risk of electric shock, fire, or personal injury.

33.2.2 Auxiliary controls shall comply with the requirements of this end product standard.

33.3 Operating controls (regulating controls)

33.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. Appendix A provides more examples of controls intended to be used as operating controls:

a) Control Types 1 or 2;

b) Unless otherwise specified in this standard, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions;

c) Installation Class 2 in accordance with Electromagnetic Compatibility (EMC) – Part 4-5: Testing Measurement Techniques – Surge Immunity Test, IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 33.1;

e) For the applicable Material Group, see Table 33.2; and

f) For the applicable Pollution Degree, see Table 33.3.

Table 33.1
Overvoltage categories

Appliance	Overvoltage category
Intended for fixed wiring connection	III
Portable and stationary cord-connected	II
Control located in low-voltage circuit	I
NOTE: Applicable to low-voltage circuits if a short circuit between the parts involved may result in operation of the controlled equipment that would increase the risk of fire or electric shock.	

Table 33.2
Material group

CTI PLC value of insulating materials	Material group
CTI[3] 600 (PLC = 0)	I
CTI[3] 400 < 600 (PLC = 1)	II
CTI[3] 175 < 400 (PLC = 2 or 3)	IIIa
CTI[3] 100 < 175 (PLC = 4)	IIIb
NOTE - PLC stands for Performance Level Category, and CTI stands for Comparative Tracking Index as specified in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.	

Table 33.3
Pollution degree

Appliance control microenvironment	Pollution degree
No pollution or only dry, nonconductive pollution. The pollution has no influence. Typically hermetically sealed or encapsulated controls without contaminating influences, or printed wiring boards with a protective coating can achieve this degree.	1
Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected. Typically indoor appliances for use in household or commercial clean environments achieve this degree.	2
Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation that is expected. Typically controls located near and may be adversely affected by motors with graphite or graphite composite brushes, or outdoor use appliances achieve this degree.	3

33.4 Protective controls (limiting controls)

33.4.1 An electronic control that performs a protective function shall comply with the requirements in Controls, Section 16, while tested using the parameters in this section. Examples of protective controls are: a control used to sense abnormal temperatures of components within the appliance; temperature protection of the motor due to locked rotor, running overload, loss of phase; or other function intended to reduce the risk of electric shock, fire, or injury to persons. During the evaluation of the protective control/circuit, the protective functions are to be verified under normal and single-fault conditions of the control/circuit.

33.4.2 The following test parameters shall be among the items considered when judging the acceptability of an electronic protective control investigated using the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. Appendix A provides more examples of controls intended to be used as protective controls:

a) Failure-Mode and Effect Analysis (FMEA) or equivalent Risk Analysis method;

b) Power supply voltage dips, variation and interruptions within a temperature range of 10°C (50°F) and the maximum ambient temperature determined by conducting the Normal temperature test. See Temperature Test, Section 24;

c) Surge immunity test – installation Class 3 shall be used;

d) Electrical fast transient/burst test, a test level 3 shall be used;

e) Electrostatic discharge test;

f) Radio-frequency electromagnetic field immunity:

1) Immunity to conducted disturbances – When applicable, test level 3 shall be used; and

2) Immunity to radiated electromagnetic fields; field strength of 3 V/m shall be used;

g) Thermal cycling test of clause H.17.1.4.2 shall be conducted at ambient temperatures of 10.0 +2°C (50 +4°F) and the maximum ambient temperature determined by conducting the Normal temperature test. The test shall be conducted for 14 days;

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Temperature Test, Section 24;

i) If software is relied upon as part of the protective electronic control, it shall be evaluated as software Class B.

33.4.3 The test parameters and conditions used in the investigation of the circuit covered by 33.4.1 shall be as specified in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, using the following test parameters:

a) With regard to electrical supervision of critical components, for attended appliances, a motor operated system becoming permanently inoperative with respect to movement of an exposed portion of the appliance meets the criteria for trouble indication. For unattended appliances, electrical supervision of critical components may not rely on trouble indication;

b) A field strength of 3 V per meter is to be used for the Radiated EMI test;

c) The Composite operational and cycling test is to be conducted for 14 days at temperature extremes of 0°C (32°F) and 70°C (158°F);

d) The Humidity Class is to be based on the appliance's intended end use and is to be used for the Humidity test;

e) A vibration level of 5 g is to be used for the Vibration test;

f) When a computational investigation is conducted, Ip shall not be greater than 6 failures/106 hours for the entire system. The Operational test is to be conducted for 14 days;

g) When the Demonstrated method test is conducted, the multiplier for the test acceleration factor is to be 576.30 for intermittent use appliances, or 5763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 25°C (77°F) use ambient;

h) The Endurance test is to be conducted concurrently with the Operational test. The control shall perform its intended function while being conditioned for 14 days in an ambient air temperature of 60°C (140°F), or 10°C (50°F) greater than the operating temperature of the control, whichever is higher. During the test, the control is to be operated in a manner representing normal use;

i) For the Electrical fast transient burst test, test level 1 is to be used;

j) Conduct a failure-mode and effect analysis (FMEA); and

k) If software is relied upon as part of the protective electronic control, it shall be evaluated as software Class 1 in accordance with the Standard for Software in Programmable Components, UL 1998.

33.4.4 Unless otherwise specified in this standard, protective controls shall be evaluated for 100,000 cycles for Type 2 devices, and 6,000 cycles for Type 1 devices, with rated current.

MANUFACTURING AND PRODUCTION TEST

34 Production Dielectric Voltage-Withstand Test

34.1 Each ventilator shall withstand without electrical breakdown as a routine production-line test, the application of a DC potential or an AC potential at a frequency within the range of 40 - 70 hertz:

a) Between the primary winding, including connected components, and accessible dead metal parts that are likely to become energized, and

b) Between primary wiring and accessible low-voltage (42.4 volts peak or less) metal parts, including terminals.

Exception: A ventilator that has no electrical components other than a motor that is acceptable for permanent connection to the power supply, and that has been found to comply with the production dielectric voltage-withstand requirement in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, need not be subjected to this test.

34.2 The production-line test shall be in accordance with either condition A or condition B of Table 34.1.

Table 34.1
Production-line test conditions

Appliance rating, V	Condition A			Condition B		
	Potential, V		Time, s	Potential, V		Time, s
	AC	DC		AC	DC	
250 volts or less with no motor rated more than 1/2 horsepower (370 W)	1000	1400	60	1200	1700	1
More than 250 volts or with a motor rated more than 1/2 horsepower	1000 + 2V	1400 + 2.8V	60	1200 + 2.4V	1700 + 3.4V	1
V = maximum marked voltage						

34.3 The ventilator may be in a heated or unheated condition for the test.

34.4 The test shall be conducted when the ventilator is fully assembled. It is not intended that the ventilator be unwired, modified, or disassembled for the test.

Exception No. 1: A part such as a snap cover or a friction-fit knob that would interfere with performance of the test need not be in place.

Exception No. 2: The test may be conducted before final assembly if the test represents that for the completed ventilator.

34.5 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic reject feature of any unacceptable unit.

34.6 If the output of the test equipment transformer is less than 500 volt-amperes, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

34.7 If the output of the test-equipment transformer is 500 volt-amperes or larger, the test potential may be indicated:

a) By a voltmeter in the primary circuit or in a tertiary-winding circuit;

b) By a selector switch marked to indicate the test potential; or

c) In the case of equipment having a single test-potential output, by a marking in a visible location to indicate the test potential.

When marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

34.8 Test equipment other than that described by 36.6 and 36.7 may be used if found to accomplish the intended factory control.

34.9 During the test, the primary switch is to be in the on position, both sides of the primary circuit of the ventilator are to be connected together and to one terminal of the test equipment, and the second test-equipment terminal is to be connected to the accessible dead metal parts that are likely to become energized.

RATING

35 Details

35.1 A ventilator shall be rated in:

a) Volts.

b) Amperes (motor full-load amperes or service factor full-load amperes).

Exception: The rating may be in watts if the full-load power factor is 0.80 or more.

c) Horsepower, if such rating is 1/8 horsepower or more.

Exception: A ventilator having a shaded pole motor may be rated in watts rather than horsepower.

d) Frequency expressed in one of the following terms: hertz, Hz, cycles-per-second, cps, cycles/second, or c/s.

e) The number of phases, if polyphase.

f) A code letter indicating, in accordance with the National Electrical Code, ANSI/NFPA 70 (see Table 35.1), the locked-rotor motor input for an alternating-current motor rated 1/2 horsepower (373 W output) or more.

Table 35.1
Locked-rotor indicating code letters*

Code letter	Kilovolt-amperes per horsepower with locked rotor
A	0 – 3.14
B	3.15 – 3.54
C	3.55 – 3.99
D	4.0 – 4.49
E	4.5 – 4.99
F	5.0 – 5.59
G	5.6 – 6.29
H	6.3 – 7.09
J	7.1 – 7.99
K	8.0 – 8.99
L	9.0 – 9.99
M	10.0 – 11.19
N	11.2 – 12.49
P	12.5 – 13.99
R	14.0 – 15.99
S	16.0 – 17.99
T	18.0 – 19.99
U	20.0 – 22.39
V	22.4 and up

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MARKING

36 Details

36.1 A ventilator shall be legibly and permanently marked, where visible after installation, with:

a) The manufacturer's name, trade name, trademark, or other descriptive marking by which the organization responsible for the product may be identified;

b) The date or other dating period of manufacture not exceeding any three consecutive months which may be abbreviated or in a nationally accepted conventional code, or in a code affirmed by the manufacturer;

c) A distinctive catalog or model number or the equivalent; and

d) The electrical rating.

36.2 The repetition time cycle of a date code shall not be less than 26 years. The date code shall not require reference to the manufacturer's records to determine when the ventilator was manufactured.

36.3 If the motor is the only electric-energy-consuming component of the ventilator, the electrical rating given on the motor nameplate need not be shown elsewhere on the ventilator if this nameplate is visible on the motor after the ventilator has been installed as intended.

36.4 The markings required by 36.3, 36.5, and 36.6 are visible on a roof- or wall-mounted ventilator if they are plainly visible upon removal of an outer cover or panel that is removable in accordance with the requirements in 9.3.

36.5 A ventilator that incorporates motor-overload protection shall be marked to indicate the presence of such protection.

36.6 A ventilator that does not incorporate motor-overload protection shall be marked:

a) To indicate that the ventilator should be installed with remote motor-overload protection; and

b) To provide such motor-rating data– voltage, frequency, horsepower, and full-load current per phase – so that proper protection may be determined.

36.7 A ventilator that employs a dual-voltage motor that is wired for a particular voltage when shipped from the factory shall be marked to indicate the voltage for which it is connected. In addition, the motor shall be marked with instructions or a wiring diagram for connecting the motor to the other voltages. The marking need not be permanent. The marking may be in the form of wired-on tags, instruction sheets, decalcomanias, or the like.

36.8 A ventilator having one motor with other loads or more than one motor with or without other loads shall be marked with one of the following:

a) The minimum circuit size and maximum current rating of the overcurrent-protective device unless both are 15 amperes or less; or

b) The rating of the largest motor in volts and amperes, and the rating of any other loads in volts and either amperes or watts.

Exception: The current value of a motor rated 1/8 horsepower (93 W output) or less, or a nonmotor load 1 ampere or less may be omitted unless either load constitutes the principal load.

36.9 A ventilator shall be permanently marked where readily visible during installation to indicate the direction of rotation of the impeller.

36.10 A duct fan intended to move heated air shall be permanently marked "Do not use with heated air in excess of ____°C (____°F)" or with an equivalent statement. The temperature value in the statement shall not exceed that at which the fan was tested. See 24.2 and 24.3.

36.11 A duct fan not intended for outdoor exposure shall be marked "For interior use only" or with an equivalent statement.

36.12 If a manufacturer produces or assembles ventilators at more than one factory, each finished ventilator shall have a distinctive marking to identify it as the product of a particular factory.

36.13 A ventilator that will not start and attain normal running speed when connected to a circuit protected by a fuse of other than the time-delay type as described in the Exception to 22.1 shall be plainly marked, "When connected to a circuit protected by fuses, use time-delay fuses" or with an equivalent statement.

36.14 If during the temperature test, any point within a terminal box or wiring compartment of a ventilator in which field-installed conductors are intended to be connected, including such conductors, attains a temperature rise of more than 30°C (54°F) for a compartment integral with the ventilator or 35°C (63°F) for a remotely mounted compartment, or for a duct fan intended for interior use, the ventilator shall be marked with the following statement or the equivalent, "For supply connections, use wires rated for at least ____°C

(____°F)." The temperature value used in the statement shall be in accordance with Table 36.1. The marking shall be located at or near the point where supply connections are to be made, and located so that it will be visible during installation.

Table 36.1
Outlet-box marking

Temperature rise during test in terminal box or compartment				Temperature marking	
Integral		Remotely mounted[a]			
31 – 45°C	(56 – 81°F)	36 – 50°C	(65 – 90°F)	75°C	(167°F)
46 – 60°C	(82 – 108°F)	51 – 65°C	(91 – 117°F)	90°C	(194°F)

[a] Applies to a duct fan intended for interior use.

36.15 Any electrical part of a ventilator not assembled to the remainder of the unit when shipped from the factory shall be plainly marked – such as with the catalog number or model designation of the ventilator – to indicate clearly the unit with which it is designed for use and shall also be marked with the manufacturer's name. The markings shall be applied directly to the part by a gummed or decalcomania transfer, pressure-sensitive sticker, stenciling or stamping with ink or paint, or by equivalent durable means.

36.16 A ventilator employing other than a totally-enclosed motor that is in the main air stream shall be plainly marked, "For general ventilating use only – do not use to exhaust dirt-, dust-, grease-, or lint-laden air," or with an equivalent statement. See 14.2.1.

36.17 If connections between components of a ventilator are to be made in the field, information shall be provided on a wiring diagram on the ventilator indicating:

a) Which components and connections are factory-installed and which are to be field installed; and

b) Any special requirement for the point of connection of the supply circuit and for field wiring of the interconnections – such as the necessity of moisture-resistant wire insulation, the size of wire necessary, and the like.

36.18 A ventilator that relies on the height of the installation to reduce the likelihood of exposure to moving parts per 6.5.6 shall be marked with the word "CAUTION" and the following or equivalent wording: "MOUNT WITH THE LOWEST MOVING PARTS AT LEAST 2.4 m (8 ft) ABOVE FLOOR OR GRADE LEVEL", or the equivalent.

36.19 A 2-wire, 220 – 240 volt ventilator intended for connection to a circuit operating at 150 volts or less to ground shall be marked with the word "WARNING" and the following or its equivalent: "To Reduce The Risk Of Electric Shock – Do not connect to a circuit operating at more than 150 volts to ground."

36.20 A ventilator that is shipped from the factory without the motor and drive assembly shall be plainly marked as shown in (a) – (e).

a) Identification of all motors suitable for installation on the ventilator. Identification shall include manufacturer's name, model or cat. no., and electrical rating as required by 35.1 (a) – (f).

b) Motors which incorporate motor-overload protection shall be so identified per 36.5.

c) Motors which do not incorporate motor-overload protection (not marked "thermally protected") shall be so identified to indicate that remote motor-overload protection is required per 36.6.

d) The marking shall include:

1) A provision for marking on the unit to indicate which motor has been installed; and

2) The following instruction: "Mark the motor list to indicate which motor has been installed by (include specific method). For dual voltage motors, indicate the voltage for which the motor is connected." (Equivalent wording may be employed).

These markings are for use by the manufacturer's designated organization (such as a distributor) who is responsible for installing the motor and drive assembly.

e) The marking shall include a reference to enclosed installation or operating instructions for identification of the proper drive assembly to be installed.

36.21 A ventilator employing more than one power source shall be provided with a disconnect for each power supply and the following warning; “WARNING: RISK OF ELECTRIC SHOCK. CAN CAUSE INJURY OR DEATH: THIS UNIT SUPPLIED BY MULTIPLE SOURCES, DISCONNECT All REMOTE ELECTRIC POWER SUPPLIES BEFORE SERVICING”, in letters not less than 3.2 mm (1/8 in) high, or the equivalent. This marking shall be located on all panels providing access to hazardous voltage uninsulated live parts.

36.22 Connection points intended for Class 2 connections shall be marked “CLASS 2” or the equivalent.

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SUPPLEMENT SA – DRYER EXHAUST DUCT POWER VENTILATORS (DEDPV) FOR SINGLE RESIDENTIAL DRYERS

INTRODUCTION

SA1 Scope

SA1.1 This Supplement covers permanently-connected and cord-connected dryer exhaust duct power ventilators serving a single residential dryer. These products are rated to 250 volts or less. The requirements in this Supplement are in addition to the requirements in Sections 1 – 36.

SA2 Glossary

SA2.1 INTERLOCKED VENTILATOR – A dryer exhaust duct power ventilator used in conjunction with controls that will de-energize the clothes dryer if the dryer exhaust duct power ventilator fails to operate as intended.

SA2.2 DRYER EXHAUST DUCT POWER VENTILATOR (DEDPV) – An air-moving appliance consisting of an impeller – which may be of the centrifugal, axial, or propeller type – and an integral driver, fitted with duct flanges for connection to a 4-inch (101.6-mm) residential dryer exhaust duct, to maintain airflow to extend the length of the dryer exhaust duct.

SA2.3 EQUIVALENT DUCT LENGTH – The length of straight duct which offers the same resistance to air flow as a specific duct system with fittings such as bends and transition pieces.

CONSTRUCTION

SA3 General

SA3.1 The motor of a dryer exhaust duct power ventilator for installation within the airstream of the clothes dryer exhaust duct, shall be:

a) A totally enclosed thermally protected motor;

b) Provided with an insulation system of Insulation Class “B” , “F” or “H” suitable for the application; and

c) Supplied with motor lead wires that are rated for a minimum of 105°C (221°F) and rated VW-1.

SA3.2 A dryer exhaust duct power ventilator shall be provided with at least one of the following:

a) Means to sense the operation of the clothes dryer, which automatically turns on the dryer exhaust duct power ventilator as required in Section SA7, Operation of Controller and Interlock; or

b) An interlocking device, which prevents the clothes dryer from being energized if the dryer exhaust duct power ventilator fails to operate as intended.

SA3.3 A dryer exhaust duct power ventilator shall have provisions for access to the motor impeller, inlet and outlet ducts for periodic cleaning.

SA3.4 A dryer exhaust duct power ventilator, complying with SA3.2(a), shall also be provided with a means to operate a visual error indicator and/or an audible alarm if the dryer exhaust duct power ventilator fails to start or malfunctions, causing an abnormally high static pressure in the inlet duct of the ventilator. The alarm or visual error indicator shall be activated not more than 4 minutes after the static pressure in the inlet duct of the ventilator reaches 0.16 inches (4.0 mm) of water column or more, as required in Section SA9, Operation of Audible Alarm or Visual Error Indicator Test for Controllers and Shut-Down for Interlocking Device.

SA3.5 A notification/annunciator panel shall be provided for dryer exhaust duct power ventilators complying with SA3.2(a) and such panel shall incorporate an audible or visual indicator in accordance with SA3.6 and shall display the wording in SA17.2 (a), (b), or (c), respective to the notification scheme.

SA3.6 The notification/annunciator panel shall meet the following requirements:

a) A permanent label or marking on the back of the panel shall state the installation location requirements in accordance with SA18.5(a)(3).

b) Screw(s) shall be used for attachment to the wall.

c) Battery powered notification/annunciator panels shall not be permitted.

d) For audible notification schemes:

1) The audible notification shall be capable of annunciating for a minimum of 1 hour, at a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 70 decibels (db) at 10 feet (3.05 m) with two reflecting planes assumed.

2) Audible signals shall continue to sound until the system resumes proper operation, or until the end of the dryer cycle, whichever occurs first.

3) Audible notifications shall notify the dryer operator of normal dryer exhaust duct power ventilator function at the beginning of each dryer cycle, in addition to notification of failure.

e) For visual notification schemes:

1) Visual notifications shall be clearly noticeable in daylight.

2) Visual notifications shall notify the dryer operator of normal dryer exhaust duct power ventilator function by constant illumination of the visual indicator.

3) The visual notification shall notify the dryer operator of a failure of the dryer exhaust duct power ventilator. The visual notification shall consist of a series of flashes and shall continue after completion of a dryer cycle. A lack of illumination of an indicator light shall not be depended upon as a notification of dryer exhaust duct power ventilator failure.

4) Visual notifications shall continue showing notifications of failure until the system resumes proper operation, or power to the dryer exhaust duct power ventilator is disconnected, whichever occurs first. If a failure occurs, the light shall remain flashing after the end of a dryer cycle.

SA3.7 A dryer exhaust duct power ventilator shall de-energize in the event of a fire in the dryer. The de-energizing of the dryer exhaust duct power ventilator shall occur when the air stream temperature exceeds 260°C (500°F) at the duct inlet with an airstream velocity of 1200 feet per minute (6.1 meters per second). The dryer exhaust duct power ventilator shall turn off within 15 seconds as required in Section SA10, High Temperature Turn Off.

SA3.8 The dryer exhaust duct power ventilator shall maintain a minimum air velocity of 1200 feet per minute (6.1 meters per second) at the outlet for the longest permitted equivalent duct length as specified by the manufacturer.

SA3.9 The dryer exhaust duct power ventilator shall limit the air velocity to a maximum of 2200 feet per minute (10.2 meters per second) at the outlet for the shortest permitted equivalent duct length as specified by the manufacturer.

SA3.10 Dryer exhaust duct power ventilators shall be located within a minimum and maximum distance from the dryer as specified by the manufacturer.

SA3.11 A mechanical switch intended to interlock with the dryer shall be suitable for 100,000 cycles of operation. Electronic interlock controls shall be evaluated to demonstrate reliability as a protective control, defined as compliance with the applicable requirements of the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991 considering single-fault tolerance, the Standard for Software in Programmable Components, UL 1998 for Software Class 1, or the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 considering a Class B control function, whichever applies.

SA3.11.1 A mechanical switch (e.g., pressure switch) intended only to turn the dryer exhaust duct power ventilator on or off shall be suitable for at least 6,000 cycles of operation. Electronic controls used in conjunction with this mechanical switch shall be evaluated as an operating control with the applicable requirements of the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1 considering a Class A control function.

SA3.12 A dryer exhaust duct power ventilator is not required to be provided with a means for permanent electrical connection when it is provided with a supply cord that:

a) Is not longer than 6 feet (1.82 m) measured from the point at which the cord emerges from the unit to the face of the attachment plug;

b) Is Type SJ or equivalent;

c) Is permanently attached to the dryer exhaust duct power ventilator;

d) Has three conductors, one being the equipment grounding conductor; and

e) Complies with the requirements of SA3.13 – SA3.17.

SA3.13 The flexible cord shall be rated for use at a voltage not less than the rated voltage of the appliance, and shall have an ampacity not less than the current rating of the appliance.

SA3.14 The voltage rating of the attachment plug shall not be less than that of the appliance.

SA3.15 The current rating of the attachment plug for an appliance rated 12 amperes or less shall not be less than the current rating of the appliance. For an appliance rated more than 12 amperes, the current rating of the attachment plugs shall not be less than 125 percent of the current rating of the appliance.

SA3.16 Strain relief shall be provided so that the mechanical stress on the flexible cord is not transmitted to terminals, splices, or internal wiring as required in Section SA14, Strain-Relief Test.

SA3.17 Means shall be provided to prevent the supply cord or lead from being pushed into the enclosure of an appliance 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.

To determine compliance, the supply cord or lead shall be tested in accordance with Section SA15, Push Back Relief Test.

SA3.18 Polymeric impellers shall comply with the applicable mechanical property considerations, flammability, and thermal requirements for the airstream for which they are exposed as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

SA3.19 The dryer exhaust duct power ventilator shall have dryer exhaust duct connections of 4 inch nominal diameter. The dryer exhaust duct power ventilator enclosure shall be constructed of galvanized steel or aluminum with a minimum thickness of 0.016 inch (0.406 mm).

SA3.20 The dryer exhaust duct power ventilator shall be supported by a means other than the dryer exhaust duct. The acceptability of the mounting means shall be determined by Section SA11, Static Load Test.

PERFORMANCE

SA4 General

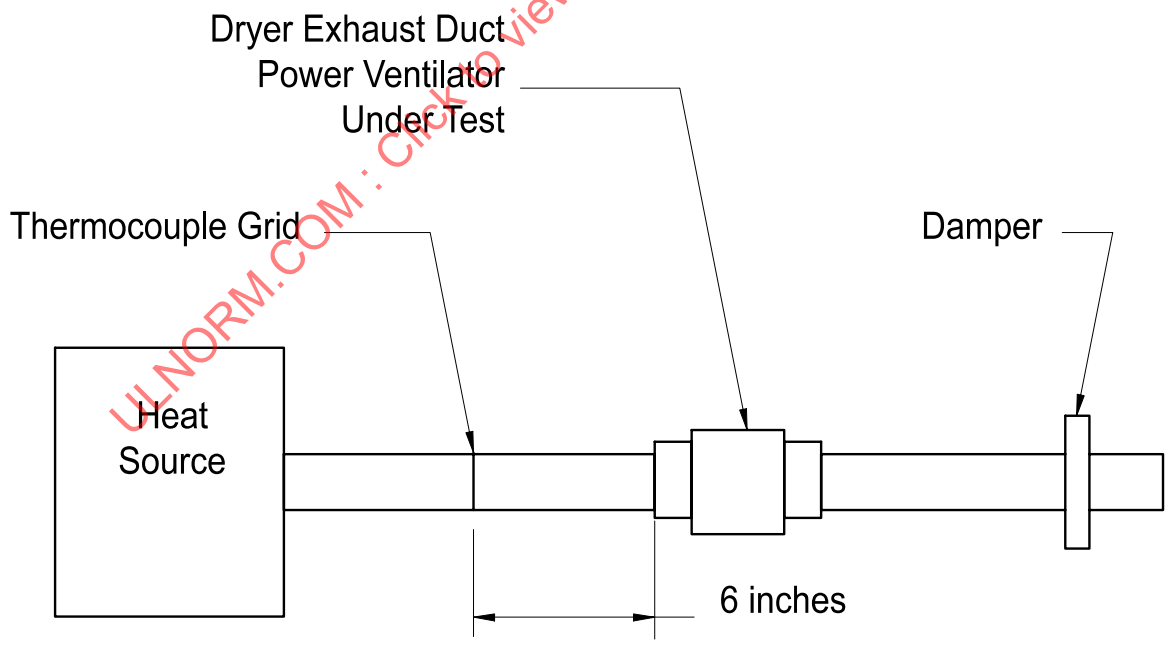
SA4.1 A dryer exhaust duct power ventilator shall be subjected to the applicable tests of SA5 – SA13, and applicable tests of UL 705.

SA5 Temperature (Normal)

SA5.1 A dryer exhaust duct power ventilator shall be subjected to the test specified in Section 24 after being subjected to the Lint Test in SA13. The test shall be conducted with an inlet air temperature corresponding to the manufacturer's specified caution marking of SA17.1, as shown in Table SA18.1. A thermocouple grid as identified in 24.3 having an accuracy of ±1°C (±2°F) shall be used to measure the airstream temperature. The thermocouple grid shall be located 6 inches (150 mm) upstream from the dryer exhaust duct power ventilator inlet. See Figure SA5.1.

Figure SA5.1

Temperature test



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SA6 Humidity Conditioning

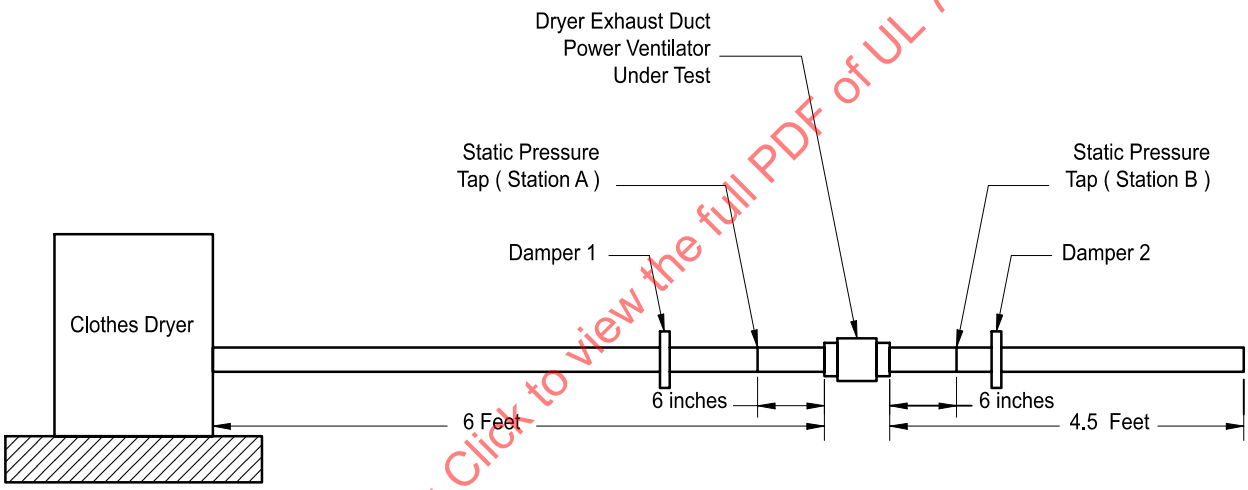
SA6.1 A dryer exhaust duct power ventilator shall be subjected to the humidity conditioning test of the Standard for Electric Fans, UL 507, except that the conditioning shall be done at a relative humidity of 93% ± 2%.

SA7 Operation of Controller and Interlock

SA7.1 The dryer exhaust duct power ventilator shall be connected to a dryer with a 4-inch (101.6-mm) diameter, galvanized rigid metal duct in accordance with Figure SA7.1. The inlet duct length shall be 6 feet (1.8 meters) and the outlet duct length shall be 4.5 feet (1.4 meters). Four pressure taps, installed in accordance with Figure SA7.2, shall be located at Station A and Station B. A single damper (Damper 1) shall be located in the inlet duct and a single damper (Damper 2) shall be located in the outlet duct.

Figure SA7.1

Controller and interlock test[a]



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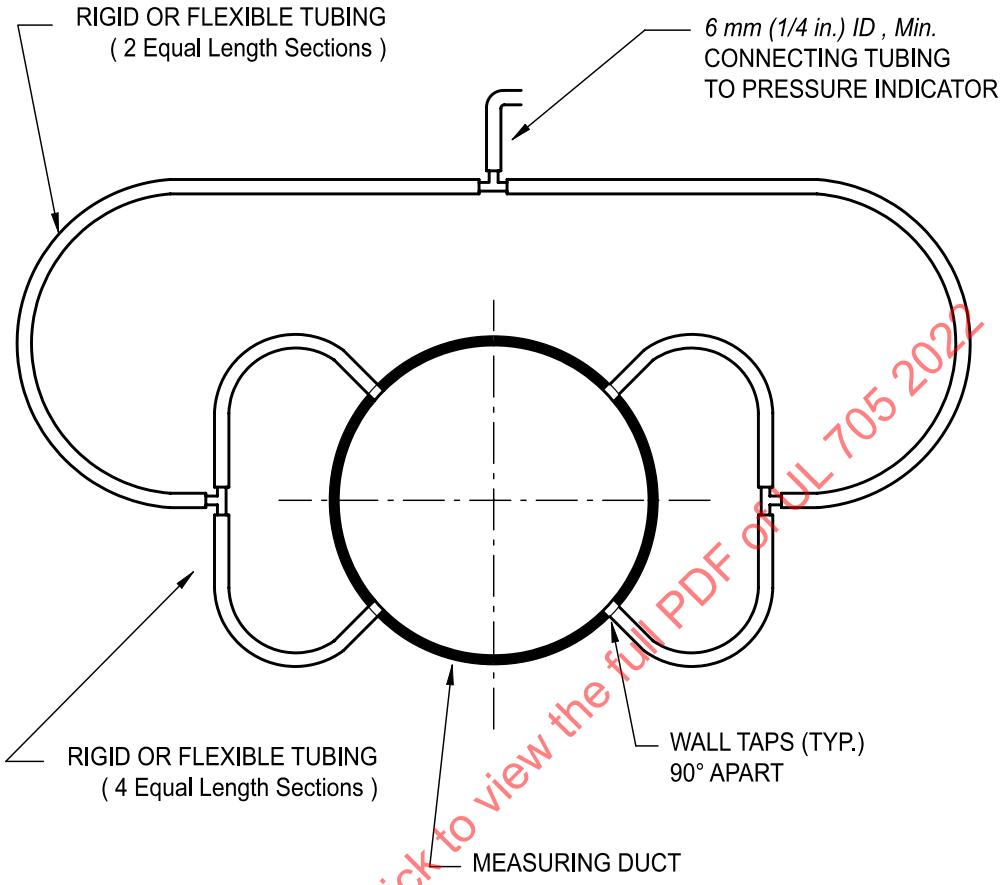
[a] With the permission of ASHRAE, this Figure is reproduced from the ASHRAE Standard 51-1999, with dimensional values modified.

Figure SA7.2

Duct pressure measuring assembly[b]



NOTES: 1. Manifold tubing internal area shall be at least 4 times that of a wall tap.
2. Connecting tubing to pressure indicator shall be 6 mm (1/4 in.) or larger in ID.
3. Taps shall be within ± 13 mm (1/2 in.) in the longitudinal direction.

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[b] With the permission of ASHRAE, this Figure is reproduced based on the original ASHRAE content, from the ASHRAE Standard 51-1999.

SA7.2 With the clothes dryer running, Damper 1 closed and Damper 2 open – gradually opening Damper 1, the controller or interlock shall automatically operate the dryer exhaust duct power ventilator within 1 minute when a static pressure at Station A of 0.08 inches (2.0 mm) water column or less is achieved.

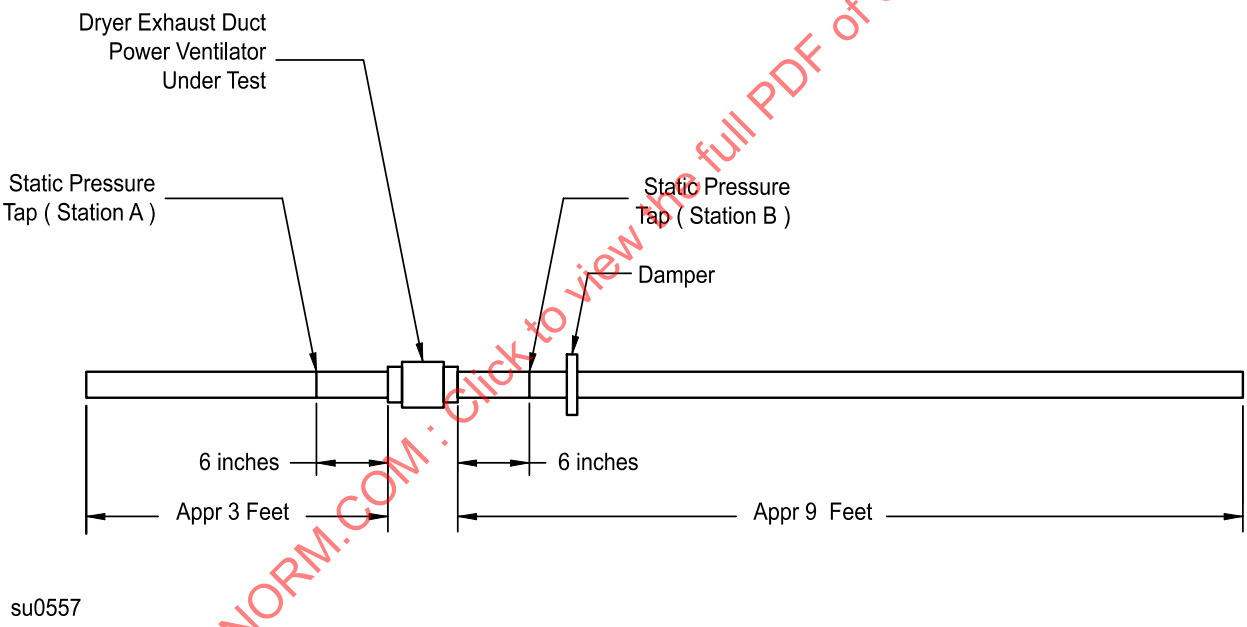
SA7.3 For dryer exhaust duct power ventilator with an interlock, the dryer shall be turned off. The dryer exhaust duct power ventilator shall turn off within 5 minutes.

SA8 Minimum and Maximum Air Velocity

SA8.1 The dryer exhaust duct power ventilator shall be connected to a 4-inch (101.6-mm) diameter, galvanized rigid steel duct, approximately 12 feet (3.7 meters) in length in accordance with Figure SA8.1, without connection to clothes dryer. The inlet duct length shall be approximately 3 feet (1 meter) and the outlet duct length shall be approximately 9 feet (2.7 meters). Four pressure taps shall be installed approximately 6 inches (150 mm) from the inlet and outlet of the ventilator in accordance with Figure SA7.2.

Figure SA8.1

Duct velocity test assembly



SA8.2 A damper shall be installed at the outlet of the discharge duct. The damper shall be adjusted to give a differential pressure across the dryer exhaust duct power ventilator equal to the rated equivalent minimum duct length as indicated in the manufacturer's installation and operation manual in accordance with SA18.4(g). The measured air velocity in the duct shall not exceed 2200 fpm (11.2 m/s) measured at the center of the duct after the differential pressure across the dryer exhaust duct power ventilator is set.

SA8.3 The dryer exhaust duct power ventilator shall be removed and replaced with the sample that was subjected to the Lint Test in SA13. The damper shall be readjusted to give a differential pressure across the dryer exhaust duct power ventilator equal to the rated equivalent maximum duct length as indicated in the manufacturer's installation and operation manual in accordance with SA18.4(f). The measured air

velocity in the duct shall be not less than 1200 fpm (6.1 m/s) measured at the center of the duct after the differential pressure across the dryer exhaust duct power ventilator is set.

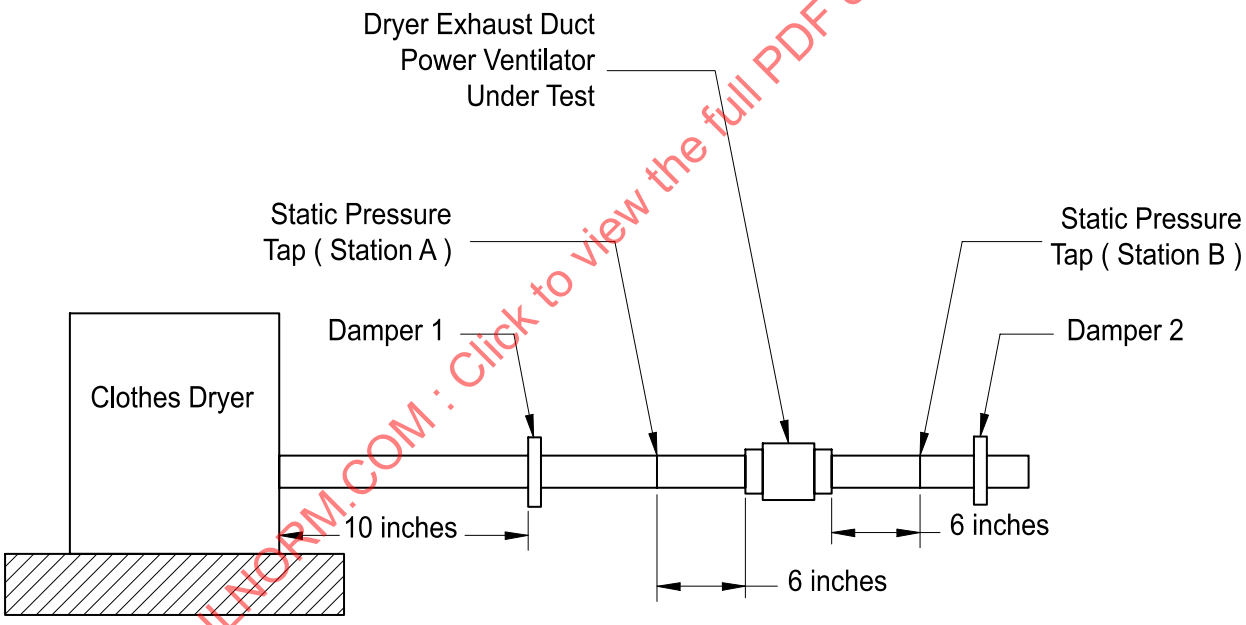
Note: The differential pressure across the dryer exhaust duct power ventilator is based on the Friction Chart for Round Duct, Figure 9 of the 2001 ASHRAE Fundamental Handbook. For a 4-inch (101.6-mm) diameter galvanized steel duct at an air velocity of 1200 fpm (6.1 m/s), the differential pressure is equal to 0.65 inches of water column per 100 linear feet (16.5 mm of water column per 30.5 linear meters). For example, a dryer exhaust duct power ventilator with a rated equivalent duct length of 40 feet, the differential pressure used for the test will be 40/100 x 0.65 = 0.26 inches of water column. To measure differential pressure across the dryer exhaust duct power ventilator, the positive pressure side (outlet) of the dryer exhaust duct power ventilator is to be connected to the positive pressure side of a pressure meter and the negative pressure side (inlet) of the dryer exhaust duct power ventilator is to be connected to the negative pressure side of the same pressure meter.

SA9 Operation of Audible Alarm or Visual Error Indicator Test for Controllers and Shut-Down for Interlocking Device

SA9.1 A dryer exhaust duct power ventilator shall be installed in the duct with pressure adjusting dampers as described in SA7 and Figure SA9.1. Damper 1 shall be in the fully opened position and Damper 2 shall be adjusted to give a static pressure at Station B of 0.39 inches (10 mm) of water column.

Figure SA9.1

Controller and shut-down test[a]



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[a] With the permission of ASHRAE, this Figure is reproduced from the ASHRAE Standard 51-1999, with dimensional values modified.

SA9.2 With the clothes dryer operating, the dryer exhaust duct power ventilator's inlet static pressure shall be increased by gradually reducing the dryer exhaust duct power ventilator's speed until 0.16 ±0.02 inches of water column (4.0 ±0.5 mm of water column) is reached, and within 4 minutes, the alarm and/or visual error indicator shall operate or the interlocking device shall shut down the dryer.

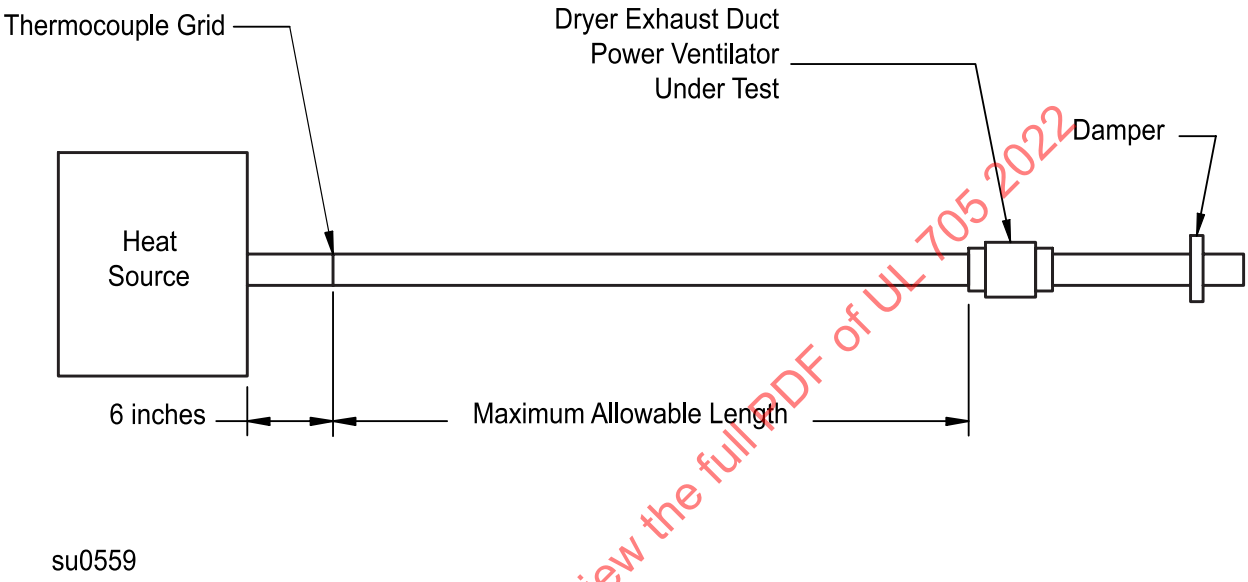
SA10 High Temperature Turn Off

SA10.1 The dryer exhaust duct power ventilator shall be connected to a 4-inch (101.6-mm) diameter, galvanized rigid steel duct. A heater shall be connected to the inlet of the steel duct. The distance between

the dryer exhaust duct power ventilator and the heater shall be the maximum allowable length that the dryer exhaust duct power ventilator is permitted to be installed from the dryer connection as stated in the manufacturer's installation instructions as specified in SA18.4(e). A thermocouple grid shall be located in the steel duct a distance of 6 inches (150 mm) downstream from the heater in accordance with Figure SA10.1. The thermocouple grid shall measure the air stream temperature to an accuracy of ±1°C (±2°F).

Figure SA10.1

High temperature test



SA10.2 The heater shall be adjusted to raise the air stream temperature to 260°C (500°F) with the dryer exhaust duct power ventilator operating. The dryer exhaust duct power ventilator shall turn off or reduce the flow of air to 7 cfm or less within 15 seconds of the air stream temperature reaching 260°C (500°F) at an airstream velocity of 1200 feet per minute (6.1 meters per second ± 5%).

SA11 Static Load Test

SA11.1 A dryer exhaust duct power ventilator shall be subject to a static load test. When subjected to the test specified in SA11.2 and SA11.3, a dryer exhaust duct power ventilator shall comply with the following:

a) The security of the attachment of the appliance to the stud or joist shall not be adversely affected;

b) There shall be no evidence of a risk of fire or electric shock;

c) The insulation resistance between live and dead-metal parts shall not be less than 50,000 ohms; and

d) The appliance shall withstand for 1 minute without breakdown the application of a 60-hertz essentially sinusoidal potential of 1000 volts between live and dead-metal parts.

SA11.2 The dryer exhaust duct power ventilator shall be mounted in accordance with the installation instructions provided by the manufacturer on nominal 2 by 4-inch wood studs/joists. The mounting parts are to be used as specified in the instructions.

SA11.3 After installation, the dryer exhaust duct power ventilator shall be subjected to a static load. The load is to be applied so as to transmit the maximum amount of stress to the mounting means and is to be increased during a 5 to 10 second interval, until a load equal to the weight of the product plus a force of 3 times the weight of the product, but not less than 10 pounds (45 N), is applied to the mounting system. The load is to be maintained for 1 minute.

SA12 Sound Output Measurement Test

SA12.1 The sound power output of the audible notification shall be measured in a reverberation room using procedures outlined in Acoustics Determination of Sound Power Levels of Noise Sources using Sound Pressure Precision Method for Reverberation Rooms, ANSI/ASA 12.51. The sound power in each 1/3 octave band shall be determined using the comparison method. The A-weighting factor shall be added to each 1/3 octave band. The total power is to be determined on the basis of actual power. The total power is then to be converted to an equivalent sound pressure level for a radius of 10 feet (3.05 m). An additional 6 db is to be added to allow for two reflecting planes.

SA12.2 Each audible notification panel shall be mounted on a 3/4 inch (19.1 mm) plywood board measuring 2 by 2 feet (610 by 610 mm), supported in a vertical plane, and positioned at an angle of 45 degrees to the walls of the reverberation room. For testing, the alarm horn duty cycle shall be defeated, emitting a continuous tone.

SA12.3 The audible notification shall be capable of providing a sound output equivalent to that of an omnidirectional source with an A-weighted sound pressure level of at least 70 decibels (db) at 10 feet (3.05 m) with two reflecting planes assumed for a minimum of 1 hour.

SA13 Lint Test

SA13.1 One sample of the dryer exhaust duct power ventilator (DEDPV) shall be subjected to the test sequence of SA13.2 – SA13.7 until lint weighing a minimum of 1.26 ounces (36 grams) has accumulated in the post-DEDPV lint filter. Upon completion of the test, the sample shall comply with the minimum air velocity requirements of SA8 (for maximum duct length).

SA13.2 The dryer exhaust duct power ventilator shall be installed with the ventilator inlet located 5 linear feet (1.524 m) from the dryer with one 90° facing elbow located between the dryer outlet and the ventilator. Rigid steel 4-inch (101.6-mm) duct shall be connected to the ventilator inlet and outlet, no screws shall be used in the installation. The total equivalent duct length from dryer outlet to duct termination shall be 40 feet (12.2 m). The clothes dryer and associated duct installation shall be cleaned thoroughly, to remove lint accumulation, prior to the initiation of the test.

SA13.3 The clothes dryer duct shall terminate in a lint trap measuring 12 inches (305 mm) wide, 12 inches (305 mm) long, and 12 inches (305 mm) high. The lint trap construction shall consist of a frame made of 3/8 inch square wooden dowels wrapped in 0.25 mm ± 0.02 mm diameter wire steel mesh with 0.8 mm square openings. One side of the lint trap shall include the male end of the duct connector mounted to 3/8 inch plywood.

SA13.4 During the test, the test room shall be maintained at a temperature of 25 ± 5°C (77 ± 9°F) and 50 ± 20% relative humidity.

SA13.5 One load of new terry cloth towels weighing 7 ± 0.2 pounds (3.15 ± 0.1 kg) shall be subjected to a wash cycle described in Table SA13.1. The load is to consist of 5 pieces measuring 30 inches (762 mm) by 54 inches (1372 mm), one piece measuring 16 inches (406 mm) by 26 inches (660 mm), and one piece measuring 12 inches (305 mm) by 12 inches (305 mm).

Table SA13.1
Wash cycle details

Detail	Setting
Machine Cycle	Normal/Cotton
Washing Temperature	60° ±3°C (140° ±5° F)
Water Level	18 ±1 gallons
Agitator Speed	179 ±2 spm
Washing Time	12 minutes
Spin Speed	645 ±15 rpm
Final Spin Time	6 minutes
Detergent	66 ±1 grams of 1993 AATCC Standard Reference Detergent

SA13.6 The washed load of terry cloth shall be placed in the clothes dryer with the dryer lint filter removed. The dryer cycle controls shall be set to generate the conditions described in Table SA13.2, and shall be operated for a minimum of 60 minutes prior to cool down.

Table SA13.2
Dryer cycle details

Detail	Setting
Exhaust Temperature	66° ±5°C (150° ±10°F)
Cool Down Time	10 minutes
Note: Exhaust temperature shall be verified by placing four pound of dry ballast in the dryer and setting the timer to 30 minutes. Temperatures as close as possible to the back of the machine shall be continuously monitored for 15 minutes. Peak cycle temperatures shall be as defined in Table SA13.2 ±5° C.	

SA13.7 While the first load of terry cloth is in the clothes dryer, a second load of terry cloth – terry cloth load 2, as described in SA13.5 shall be subjected to the wash cycle described in Table SA13.1. Upon completion of this wash cycle, terry cloth load 2 shall be transferred to the tumble dryer with dryer cycle controls set to generate the conditions described in Table SA13.2. Terry cloth load 1 shall be subjected again to the wash cycle described in Table SA13.1. Lint shall be removed from the lint trap and weighed after each drying cycle. This sequence shall be repeated until the total weight of the lint collected is as described in SA13.1.

SA14 Strain-Relief Test

SA14.1 The strain relief means provided on a flexible cord shall withstand for 1 minute without displacement a direct pull of 35 pounds (155.68 N) applied to the cord with the connections within the appliance disconnected. The strain relief is not acceptable when, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress on the connections have resulted.

SA15 Push Back Relief Test

SA15.1 A cord-connected dryer exhaust duct power ventilator shall be tested in accordance with SA15.2. without occurrence of any of the following conditions:

a) Mechanical damage to the supply cord or lead;

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

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

d) Damage to internal connections or components.

SA15.2 The supply cord or lead is to be held 1 inch (25 mm) from the point where the cord or lead emerges from the product and is then to be pushed back into the product. When a removable bushing which extends further than 1 inch (25 mm) is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, the test is to be carried out by holding the bushing. The cord or lead is to be pushed back into the product in 25-mm (1-inch) increments until the cord buckles or the force to push the cord into the product exceeds 6 pounds-force (27 N). The supply cord or lead within the product is to be manipulated to determine compliance with SA15.1.

SA16 Leakage Current Test

SA16.1 A cord-connected product rated for a nominal 240-volt or less supply shall be tested in accordance with SA16.3 – SA16.6. Leakage current shall not exceed 0.75 milliampere.

SA16.2 Leakage current refers to all currents, including capacitively coupled currents, that are conveyed between exposed conductive surfaces of an appliance and ground or other exposed conductive surfaces of an appliance.

SA16.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure determined to reduce the risk of electric shock. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that are not considered to involve a risk of electric shock. When all accessible surfaces are bonded together and connected to the grounding conductor of the power-supply cord, the leakage current can be measured between the grounding conductor and the grounded supply conductor.

SA16.4 When a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using metal foil having an area of 3.9 by 7.9 inches (10 by 20 centimeters) in contact with the surface. When the surface has an area of less than 3.9 by 7.9 inches (10 by 20 centimeters), the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the appliance.

SA16.5 The measurement circuit for leakage current is to be as illustrated in Figure SA16.1. The measurement instrument is defined in (a) – (d). The meter that is actually used for a measurement need not only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used is not required to have all the attributes of the defined instrument:

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

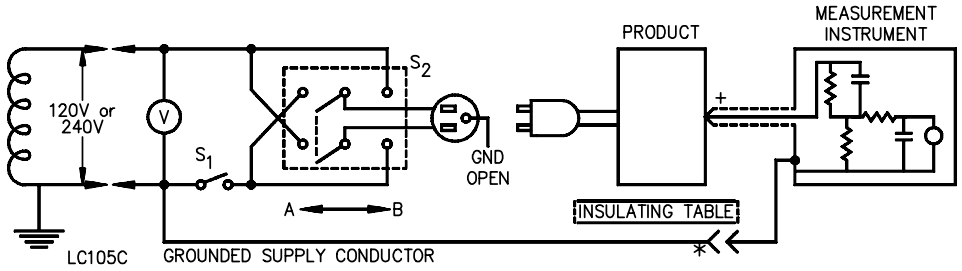
b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of the voltage across the resistor or current through the resistor.

c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 milliampere, the measurement is not to have an error of more than 5 percent at 60 hertz.

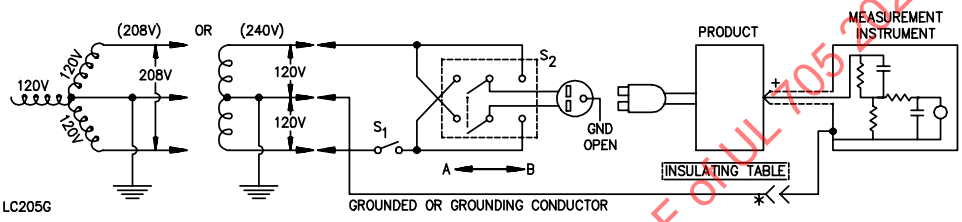
d) Unless the meter is being used to measure leakage from one part of an appliance to another, the meter is to be connected between the accessible parts and the grounded supply conductor.

Figure SA16.1

Leakage current measurement circuits



Product intended for connection to a 120-V or an end-grounded 2-wire 240-volt power supply



Product intended for connection to a 3-wire 208-volt or a 3-wire 240-volt grounded neutral power supply

NOTES:

+ – Probe with shielded lead.

* – Separated and used as a clip when measuring current from one part of appliance to another.

SA16.6 A sample of the appliance is to be tested for leakage current in the as-received condition, without prior energization except as occurs as part of the production line testing, but with the grounding conductor open at the attachment plug. The supply voltage is to be adjusted to the values specified in Table 23.1 (ie. nominal system voltage). The test sequence, with reference to the measuring circuit, Figure SA16.1, is to be as follows:

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

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

c) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the normal temperature test.

SA16.7 Normally the complete leakage current test, as described in SA16.6, is to be conducted without interruption for other tests. However, with the concurrence of those concerned, the leakage current test is not prohibited from being interrupted to conduct other nondestructive tests.

MARKING

SA17 Details

SA17.1 A dryer exhaust duct power ventilator shall be marked in a permanent manner in a place where the details will be readily visible with the following:

a) Applicable caution marking in accordance with Table SA18.1;

b) Direction of the airflow; and

c) A caution statement that the ventilator shall not be used in conjunction with high output dryers.

SA17.2 Dryer exhaust duct power ventilators which comply with SA3.2(a) shall also have a warning on the notification/annunciator panel. The text on the notification panel shall be in accordance with a, b or c, respective of the notification scheme. Text shall be in contrasting color to the background. The signal words “WARNING: RISK OF FIRE” in the following text shall be located at the beginning of a paragraph, in upper case letters not less than 3/32 inch (2.4 mm) high.

a) The verbatim text for audible notification shall be as follows: “WARNING: RISK OF FIRE. This clothes dryer installation incorporates a dryer exhaust duct power ventilator (DEDPV). A continuous or cycled alarm sounding or lack of short alarm sound at beginning of each dryer cycle indicates failure of the DEDPV. Immediately stop using clothes dryer until the DEDPV has been serviced. A short alarm sound at the beginning of each dryer cycle indicates normal DEDPV operation. DO NOT REMOVE OR COVER THIS PANEL.”

b) The verbatim text for visual notification shall be as follows: “WARNING: RISK OF FIRE. This clothes dryer installation incorporates a dryer exhaust duct power ventilator (DEDPV). A flashing light or no light indicates failure of the DEDPV. Immediately stop using the clothes dryer until the DEDPV has been serviced. A constantly illuminated light indicates normal DEDPV operation. DO NOT REMOVE OR COVER THIS PANEL.”

c) The text for systems with audible and visual indicators, or where the notification scheme varies from (a) or (b), shall consist of the following text in the order listed and upper case when so noted:

– “WARNING: RISK OF FIRE. This clothes dryer installation includes a Dryer Exhaust Duct Power Ventilator (DEDPV).”

– Description of indication of failure of the DEDPV.

– “Immediately stop using clothes dryer until DEDPV has been serviced, repaired or replaced.”

– Description of indication of proper operation.

– “DO NOT REMOVE OR COVER THIS PANEL.”

INSTRUCTIONS

SA18 Instruction Manual

SA18.1 A dryer exhaust duct power ventilator shall be provided with an instruction manual containing installation and operating instructions.

SA18.2 The heading “IMPORTANT SAFETY INSTRUCTIONS” or the equivalent shall precede the list of instructions of the instruction manual, and the statement “SAVE THESE INSTRUCTIONS”, or the equivalent, shall either precede or follow the list of instructions.

SA18.3 The words “READ AND SAVE THESE INSTRUCTIONS” shall appear in the installation and operating instructions.

SA18.4 The installation instructions shall contain the following:

a) Applicable caution marking in accordance with Table SA18.1;

b) A statement that the ventilator shall be accessible after installation;

c) Guidelines for the installation and location of the ventilator in the exhaust duct of the dryer;

d) A statement indicating that the installation must comply with local electrical and mechanical, fuel gas, or building codes, and must be inspected and accepted by local authorities having jurisdiction;

e) A statement indicating the minimum and maximum distance to install the dryer exhaust duct power ventilator from the clothes dryer;

f) The equivalent maximum duct length of the dryer exhaust duct power ventilator in feet (meters), based on a minimum duct velocity of 1200 fpm (6.10 m/s) for a 4-inch (101.6-mm) diameter metal duct;

g) The equivalent minimum duct length of the dryer exhaust duct power ventilator in feet (meters), based on a maximum duct velocity of 2200 fpm (11.2 m/s) for a 4-inch (101.6-mm) diameter metal duct;

h) A statement indicating that insulated dryer exhaust duct shall not be used upstream of the ventilator; and

i) A caution statement that the ventilator must not be used in conjunction with high output dryers.

SA18.5 The operation instructions shall contain the following:

a) For ventilators that are not interlocked – The important safety instructions for a dryer exhaust power ventilator shall include the following warning and instructions verbatim and in the order shown: “WARNING – TO REDUCE THE RISK OF FIRE, ELECTRIC SHOCK, OR INJURY TO PERSONS, OBSERVE THE FOLLOWING: (1) Your clothes dryer installation incorporates a dryer exhaust power ventilator (DEDPV) which may be in a different location than your dryer, such as in an attic, crawl space or basement. (2) Your clothes dryer depends on the DEDPV for its safe and efficient operation. Operating your dryer without a functional DEDPV will result in inefficient dryer operation, excess energy consumption and a possible fire hazard. See warning on the alarm notification panel. (3) The notification/annunciator panel shall be permanently installed within the space in which the clothes dryer is installed. In the case of a dryer installed in an alcove provided

with a door or doors the notification/annunciator panel shall be installed within the alcove or be installed immediately adjacent to the doors of the alcove. The notification/annunciator panel shall be located where it will be readily visible after the dryer is installed without having to open any doors other than those necessary to access the dryer."

b) For ventilators that are not interlocked – explanation and description of the function and operation of the error sensing mechanism (pressure or electrical switch);

c) For interlocked ventilators – explanation and description of the function and operation of the interlocking mechanism; and

d) Cleaning instructions of the dryer exhaust duct power ventilator.

Table SA18.1
Temperature ratings and caution markings

Minimum Distance from Clothes Dryer	Caution Markings	Inlet Air Temperature to Dryer Exhaust Duct Power Ventilator for Temperature (Normal) Test
5 feet (1.524 m)	"CAUTION: Do not install less than 5 feet from clothes dryer exhaust outlet" or equivalent. and "CAUTION: Do not exhaust air in excess of 167°F" or equivalent.	≥ 75°C (167°F)
10 feet (3.048 m)	"CAUTION: Do not install less than 10 feet from clothes dryer exhaust outlet" or equivalent. and "CAUTION: Do not exhaust air in excess of 158°F" or equivalent.	≥ 70°C (158°F)
15 feet (4.572 m)	"CAUTION: Do not install less than 15 feet from clothes dryer exhaust outlet" or equivalent. and "CAUTION: Do not exhaust air in excess of 149°F" or equivalent.	≥ 65°C (149°F)

SUPPLEMENT SB – UL 60335-1 BASED REQUIREMENTS FOR THE EVALUATION OF ELECTRONIC CIRCUITS

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INTRODUCTION

SB1 Scope

SB1.1 Throughout the Supplement, when reference is made to requirements in "this Standard," the reference is to requirements in the main body of the Standard and not to other requirements of the Supplement.

SB1.2 These requirements provide alternate requirements for the investigation of electronic controls and other circuits used in appliances covered by this standard.

SB1.3 Thermal motor protectors in direct contact with motor windings and intended for direct control of the motor supply are outside the scope of this Supplement even if they incorporate one or more electronic components.

SB2 General

SB2.1 The requirements of this Supplement are intended to apply to the electronic circuit and how it is integrated in the appliance. The overall appliance construction, performance testing and marking requirements are applicable as specified in this Standard except as cited in the following requirements.

SB2.2 DANGEROUS MALFUNCTION – Unintended operation of the appliance that may impair safety. Operating control functions whose failure would result in a dangerous malfunction would be considered safety critical functions. See 2.11.

Note – Control functions whose failure might result in a dangerous malfunction would include:

a) Unexpected operation of the appliance where the operation would result in risk of electric shock, fire or mechanical hazard.

b) Unattended energization of a heating appliance where the user has placed flammable materials near the appliance based on the assumption the appliance would remain off.

SB2.3 ELECTRONIC DISCONNECTION – The de-energizing of the functional load of the appliance by an electronic device of a circuit with no air gap.

SB2.4 INTENTIONALLY WEAK PART – A part intended to rupture under conditions of abnormal operation to prevent the occurrence of a condition which could impair compliance with this standard.

SB2.5 LOW-POWER CIRCUIT – A circuit or parts of circuits farther from the supply source than a low-power point.

SB2.6 LOW-POWER POINT – A point closest to the supply source in an electronic circuit where the maximum available power to an external load at the end of 5 seconds does not exceed 15 watts.

SB2.7 PROTECTIVE ELECTRONIC CIRCUIT (PEC) – An electronic circuit that prevents a hazardous situation under abnormal operating conditions. The function of a protective electronic circuit would be considered a safety critical function. See 2.11.

SB2.8 RISK OF ELECTRIC SHOCK – A risk of electric shock is considered to exist within a circuit unless the circuit meets one of the following criteria. The circuit shall be supplied by an isolating source such that:

a) The voltage does not exceed 30 V rms;

b) The voltage does not exceed 42.4 V peak;

c) The voltage does not exceed 60 V dc continuous; or

d) The voltage does not exceed 24.8 V peak for DC interrupted at a rate of 200 Hz or less with approximately 50 percent duty cycle.

e) When protective impedance is used, the current available through a 1500 ohm resistor between the part or parts and either pole of the supply source does not exceed 0.7 mA peak or 2 mA DC;

1) For frequencies exceeding 1 kHz, the limit of 0.7 mA (peak value) is multiplied by the value of the frequency in kHz but shall not exceed 70 mA peak;

2) For voltages over 42.4 V peak and up to and including 450 V (peak value) the capacitance shall not exceed 0.1 µF.

SB2.9 RISK OF FIRE – A risk of fire is considered to exist at any two points in a circuit where a power of more than 15 watts can be delivered into an external resistor connected between the two points.

CONSTRUCTION

SB3 Components

SB3.1 Capacitors

SB3.1.1 A capacitor connected between two line conductors in a primary circuit, or between one line conductor and the neutral conductor or between primary and accessible secondary circuits or between the primary circuit and protective earth (equipment grounding conductor connection) shall comply with one of the subclasses of the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, and shall be used in accordance with its rating.

Note – Details for damp heat, steady state test can be found in 4.12 of UL 60384-14.

SB3.2 Isolation devices

SB3.2.1 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this Standard shall be constructed in accordance with the Standard for Optical Isolators, UL 1577, and shall be able to withstand for 1 minute, without breakdown, an ac dielectric voltage withstand potential of 2500 volts as specified in 26.1 between the input and output circuits.

SB3.2.2 A power switching semiconductor device that is relied upon to provide isolation to ground shall be constructed in accordance with the Standard for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted at a dielectric potential of 2500 volts as specified in 26.1 for 1 minute.

SB3.2.3 A power switching semiconductor device that is relied upon to provide isolation between primary and secondary circuits or between other circuits shall be a device (such as a solid state motor controller) that complies with the Standard for Industrial Control Equipment, UL 508.

Exception: A power switching semiconductor device located within a component that has been separately evaluated to the requirements for that component is not required to be further evaluated, provided the component is used within its established ratings and limitations.

SB3.2.4 A relay that is relied upon to provide isolation between primary and secondary circuits shall comply with the Standard for Industrial Control Equipment, UL 508.

SB3.3 Printed wiring boards

SB3.3.1 Printed wiring boards shall comply with the Standard for Printed-Wiring Boards, UL 796, and shall have a flammability rating and other characteristics as specified in this Standard.

Exception: A printed circuit board solely in a Low-Power Circuit and whose failure would not constitute a risk of electric shock need not comply with UL 796.

SB3.3.2 Any printed wiring board that complies with the requirements for Direct Support in the Standard for Printed Wiring Boards, UL 796, is considered to provide an insulating base with a Comparative Tracking Index (CTI) of minimum 100.

SB3.4 Switch mode power supplies

SB3.4.1 Bridging components – switch mode power supplies

SB3.4.1.1 Components connected between the primary and secondary circuits of an isolating device such as a switching transformer or between primary and secondary earth reference points shall be evaluated to provide the specified level of isolation for the application under normal and abnormal (single component fault) conditions.

SB3.4.1.2 A capacitor connected between primary and accessible secondary circuits shall comply with Capacitors, Section SB3.1. This shall consist of a single Class Y1 capacitor or two Class Y2 capacitors connected in series.

SB3.4.2 Switch mode power supply insulation system

SB3.4.2.1 Insulation used within a transformer of switch mode power supply shall comply with the Standard for Systems of Insulating Materials – General, UL 1446, for the specified temperature class of the insulation system or the Standard for Single- and Multi-Layer Insulated Winding Wire, UL 2353.

SB4 Identification of Safety Critical Circuit Functions

SB4.1 General

SB4.1.1 Electronic circuits or parts of circuits shall be analyzed to determine if the function of the control is necessary for compliance with this Standard. A function is considered a Safety Critical Function (SCF) if failure (loss or malfunction) of its functionality would result in the risk of fire, electric shock, mechanical hazard or a Dangerous Malfunction.

SB4.1.2 Safety critical functions shall be identified as either protective electronic circuits as detailed in Section SB4.2 or as those of operating circuits that mitigate dangerous malfunctions as detailed in Section SB4.3.

SB4.1.3 In the evaluation of electronic circuits, all the contacts of relays or contactors that cycle during the Temperature Test, Section 24, shall be simultaneously short-circuited.

SB4.2 Protective electronic circuits

SB4.2.1 An electrical component shall not be connected across the contacts of a protective electronic circuit.

Exception: Electrical components may be connected across the contacts provided that any single component fault does not result in a loss of protective function.

SB4.2.2 Protective electronic circuit functions are as specified in Appendix A, Example of controls Performing as Operating or Protective Controls.

SB4.3 Operating circuits that mitigate a dangerous malfunction of the appliance

SB4.3.1 The suitability of stand-by or electronic disconnect circuits shall be as specified in this Standard.

SB4.3.2 An electronic disconnection circuit whose failure could result in a dangerous malfunction shall have at least two components whose combined operation provides the load disconnection.

SB4.3.3 Operating circuits whose functions are relied upon to mitigate dangerous malfunctions of the appliance are as specified in Appendix A, Example of controls Performing as Operating or Protective Controls.

SB5 Evaluation of the Different Types of Electronic Circuits

SB5.1 All types of circuits

SB5.1.1 All circuit functions mandated by this standard shall be validated. This includes operating functions not designated as safety critical functions.

SB5.1.2 All circuits shall be evaluated to determine the effects of electronic circuit faults.

SB5.1.3 When the applicable component/hardware faults specified in SB8.10 are imposed one at a time they shall not result in:

a) The appliance presenting a risk of fire, electric shock or mechanical hazard , or

b) The loss of any safety critical function either in that circuit or others.

SB5.1.4 The risk of electrically generated fire from the faults of Section SB8 is considered to be mitigated in low-power circuits.

SB5.2 Circuits that provide safety critical functions

SB5.2.1 In addition to the requirements of Section SB5, circuits that provide safety critical functions shall incorporate measures to control the fault/error conditions that would impair the safety functions.

SB5.2.2 The evaluation of the programmable component shall be in accordance with Annex R of the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, Edition 5.

SB5.2.3 Circuits that provide Safety Critical Functions that rely upon a programmable component for one or more of its safety functions shall be subjected to the test of the Programmable Component Reduced Supply Voltage Test, Section SB9, unless restarting at any point in the operating cycle after interruption of operation due to a supply voltage dip will not result in a hazard. The test is carried out after removal of all batteries and other components intended to maintain the programmable component supply voltage during mains supply voltage dips, interruptions and variations.

SB5.2.4 Circuits that provide safety critical functions shall maintain their required functions when subjected to the EMC related stresses specified in the Electromagnetic Compatibility (EMC) Requirements – Immunity, Section SB10.

SB5.2.5 The tests of Section SB10 are carried out with surge protective devices disconnected, unless they incorporate spark gaps.

PERFORMANCE

SB6 General Conditions for the Tests

SB6.1 Details

SB6.1.1 An electronic control shall be tested in the appliance under the Performance test conditions and order of tests specified in this Standard.

Exception: Except as noted elsewhere in this Supplement, upon the agreement of the manufacturer and with due consideration of the relevant compliance criteria, an electronic control may be tested outside of the appliance.

SB6.1.2 Cumulative stress resulting from successive tests on electronic circuits is to be avoided. It may be necessary to replace components or to use additional samples.

SB6.1.3 User adjustable electronic controls shall be adjusted to their most unfavorable setting.

SB6.2 Intentionally weak parts

SB6.2.1 If a conductor of a printed circuit board or other component becomes open-circuited, the appliance is considered to have withstood the particular test, provided both of the following conditions are met:

a) The base material of the printed circuit board withstands the test of Needle-Flame Test (NFT) of Annex E of the Standard for Safety of Household and Similar Electrical Appliances, Part 1: General Requirements, UL 60335-1, and

b) Any loosened conductor does not reduce electrical spacings (clearances or creepage distances) between live parts and accessible metal parts below the values specified in this Standard.

c) The same result is obtained when the test is run three times.

Exception: The base material of the printed wiring board need not comply with the Needle-Flame Test of (a) if the base material has a flammability rating of V-0 and a CTI of minimum 100.

SB6.3 Test results determined by overcurrent protection operation

SB6.3.1 If compliance with these requirements under any of the fault conditions depends on the operation of an overcurrent device incorporated within the electronic control, the fuse and/or circuit breaker shall comply with the requirements for that component.

SB6.3.2 If compliance with the requirements of this standard depends upon the operation of a miniature fuse-link complying with IEC 60127-1, Miniature Fuses – Part 1 Definitions for miniature fuses and general requirements for miniature fuse-links, during any of the fault conditions specified in SB8.10, the test is repeated but with the miniature fuse-link replaced by an ammeter. If the current measured:

a) Does not exceed 2.1 times the rated current of the fuse-link, the circuit is not considered to be adequately protected and the test is carried out with the fuse-link short-circuited;

b) Is at least 2.75 times the rated current of the fuse-link, the circuit is considered to be adequately protected;

c) Is between 2.1 times and 2.75 times the rated current of the fuse-link, the fuse link is short-circuited and the test is carried out:

1) For the relevant period or for 30 min, whichever is the shorter, for quick acting fuselinks;

2) For the relevant period or for 2 min, whichever is the shorter, for time lag fuse-links.

SB6.3.3 In case of doubt, the maximum resistance of the fuse-link has to be taken into account when determining the current.

SB6.3.4 The verification whether the fuse-link acts as a protective device is based on the fusing characteristics specified in IEC 60127-1, Miniature Fuses – Part 1 Definitions for miniature fuses and general requirements for miniature fuse-links, which also gives the information necessary to calculate the maximum resistance of the fuse-link.

SB6.3.5 Fuses other than as noted in SB6.3.2 are considered to be Intentionally Weak Parts in accordance with Section SB6.2.

SB7 Low-Power Circuit Determination

SB7.1 The appliance shall be supplied at rated voltage and a variable resistor, adjusted to its maximum resistance, is connected between the point to be investigated and the opposite pole of the supply source. The resistance is then decreased until the power consumed by the resistor reaches a maximum. Points closest to the supply source at which the maximum power delivered to this resistor does not exceed 15 W at the end of 5 s are called Low-Power Points. The part of the circuit farther from the supply source than a low-power point is considered to be a Low-Power Circuit. See Figure SB7.1.

Figure SB7.1

Example of an electronic circuit with low-power points