UL 710B

STANDARD FOR SAFETY

Recirculating Systems

UL Standard for Safety for Recirculating Systems, UL 710B

Second Edition, Dated September 2, 2011

Summary of Topics

This revision of ANSI/UL 710B, dated October 7, 2021, includes the addition of Ozone Generator requirements; 11.1.1.1, 11.1.6, 42.6.1, Section 64, and Supplement SB.

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 July 30, 2021.

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UL 710B

Standard for Recirculating Systems

First Edition – September, 2004

Second Edition

September 2, 2011

This ANSI/UL Standard for Safety consists of the Second edition including revisions through October 7, 2021.

The most recent designation of ANSI/UL 710B as an American National Standard (ANSI) occurred on October 7, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

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INTRODUCTION

1 Scope

1.1 These requirements cover the following recirculating systems rated 600 volts or less and intended for indoor use:

a) Non-integral recirculating systems for installation in commercial establishments for the preparation of food;

b) Electric commercial cooking appliances provided with integral recirculating systems intended for installation in commercial establishments for the preparation of food; and

c) Vending machines provided with integral recirculating systems.

1.2 These devices incorporate an air filtering system enclosed in a hooded or otherwise contained area intended to capture air from the cooking process area. The hood assembly typically includes a fan, collection hood, or equivalent design and an air filtering system (consisting of a grease filter with or without other filtering means). In addition, except as noted in the Exceptions to 37.1 and 38.1, the hood assembly includes a fire actuated damper, and a fire extinguishing system.

1.3 Recirculating systems covered by these requirements are intended for installation in accordance with:

a) The Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations, NFPA 96;

b) The National Electrical Code, ANSI/NFPA 70; and

c) Other codes such as the International Mechanical Code (IMC), and the Uniform Mechanical Code (UMC).

1.4 Integral recirculating systems shall comply with the requirements for the cooking appliance as noted below, except as modified or superseded by the requirements in this Standard.

a) Commercial electric cooking appliances shall comply with the requirements in the Standard for Commercial Electric Cooking Appliances, UL 197.

b) Vending machines shall comply with the requirements in the Standard for Vending Machines, UL 751.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.2 Except as indicated in this clause, a component of a product covered by this standard shall comply with the requirements for that component. See the Standards for Components appendix for a list of standards covering components generally used in the products covered by this standard.

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

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

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.

5 Glossary

5.1 For the purpose of this Standard the following definitions apply.

5.2 ACCESSIBLE – Able to be contacted by an accessibility probe.

5.3 APPLIANCE – Utilization equipment that uses energy for some function. For the purpose this Standard, the term "appliance" includes recirculating systems.

5.4 AUTOMATICALLY CONTROLLED APPLIANCE – An appliance is determined to be automatically controlled when:

a) The repeated starting of the appliance, beyond one complete predetermined cycle of operation to the point where some form of limit switch opens the circuit, is independent of any manual control;

b) During any single predetermined cycle of operation, the motor is caused to stop and restart one or more times;

c) Upon energizing the appliance, the initial starting of the motor is capable of being intentionally delayed beyond normal, conventional starting; or

d) During any predetermined cycle of operation, automatic changing of the mechanical load reduces the motor speed sufficiently to re-establish starting-winding connection to the supply circuit.

5.5 AUXILIARY CONTROL – A device that is not relied upon to prevent a risk of fire, electric shock, or injury to persons, and does not function to regulate the temperature of the appliance under intended conditions of use.

5.6 CIRCUITS

AUXILIARY – A fire-extinguishing system for the purpose of interrupting the coil circuit of the contactor used to control the source of heat in the appliance. Connection within the appliance is provided by auxiliary circuit terminals (See Section 25, Auxiliary-Circuit Terminals).

BRANCH – The circuit conductors between the final overcurrent device protecting the circuit or appliance and the appliance.

SAFETY – The portion of a primary or secondary circuit that is relied upon to prevent a risk of fire, electric shock, or injury to persons; for example, an interlock circuit.

5.7 CLEANING – A routine task performed by the user on accessible surfaces of the appliance to maintain sanitary conditions.

5.8 CONTROL CIRCUIT – A circuit that carries electrical signals directing the performance of a controller which, in turn, governs power delivered to a motor or other load within the appliance. A control circuit does not carry main power current.

5.9 CONTROL CIRCUIT, TAPPED HIGH-VOLTAGE – A control circuit that is tapped within the appliance from the load side of the overcurrent device for the controlled load.

5.10 COOKING APPLIANCE – A cooking device that has or is capable of having a surface of liquid grease or one in which grease is involved, such as a deep fat fryer, griddle, range, chain broiler, electric char-broiler, wok, tilt skillets, and similar appliances. The protected area is limited to the cooking surfaces of the appliance only.

5.11 CYLINDER – A container that provides storage for the extinguishing agent and expellant gas, or when used at a location remote to the extinguishing system unit, provides storage for expellant gas.

5.12 CYLINDER/VALVE ASSEMBLY – A container that incorporates a valve and that provides storage of the extinguishing agent and expellant gas until the valve is actuated. For cartridge operated units, this assembly includes the extinguishing agent storage container and cartridge mechanism. When actuated, the valve releases the agent into the distribution network of the extinguishing system.

5.13 DISCHARGE NOZZLE – A device that is used to uniformly distribute the extinguishing agent over or into a specific area.

5.14 DISCHARGE RATE – The ratio of the quantity of agent discharged from a nozzle to the discharge time measured within ±1 second. When a minimum discharge rate is indicated, reference is made to the minimum quantity of agent discharged and the time measured within ±1 second.

5.15 DISCHARGE TIME – The time interval between the first appearance of extinguishing agent at the nozzle and the time at which the discharge becomes predominantly gaseous.

5.16 DUCT (OR DUCT SYSTEM) – A continuous enclosed passageway for the transmission of air and cooking vapors.

5.17 DUTY CYCLE – A requirement of service that accounts for the intended use of an appliance at an intermittent load for a limited time, either by the user or by a timer.

5.18 EQUIPMENT

FIXED – An appliance that is intended to be fastened in place or located in a dedicated space and is permanently wired to the branch circuit.

STATIONARY – A cord-connected appliance that is intended to be fastened in place or located in a dedicated space.

5.19 EXPELLANT GAS – Dry nitrogen, dry air, or other gas used to facilitate the discharge of the extinguishing agent.

5.20 EXPOSED – Visible but not necessarily able to be contacted by an accessibility probe.

5.21 EXTINGUISHING SYSTEM UNIT – Identified components that are assembled into a system for the discharge of an extinguishing agent through fixed piping and nozzles for the purpose of extinguishing fires.

5.22 FIELD WIRING TERMINAL – A terminal to which a supply or other wire can be connected by an installer in the field.

5.23 GAS CARTRIDGE – A container that provides storage for an expellant gas.

5.24 GREASE – For test purposes, grease is new vegetable shortening incorporating an antifoaming agent. For hood and duct and broiler testing only, grease is to be new or used vegetable shortening, or rendered animal fat.

5.25 GREASE AIR STREAM – Area between the cooking surface and the discharge side of the last filtration medium.

5.26 GREASE FILTER – A component of a grease vapor removal system that deflects the air and vapors passing through it in such a manner as to result in the grease vapors to concentrate, condense, or both, for the purpose of grease collection.

5.27 HOOD – A device provided as part of an exhaust system to direct and capture grease vapors and cooking effluent from a cooking appliance.

5.28 LOW QUALITY FATTY BEEF STEAKS – Steaks that contain 20 – 30 percent fat or gristle, well marbled, and uniform in size. An example of a cut of meat which meets the requirement is "goose neck round," which is 70 – 80 percent lean.

5.29 LOWER AIRFLOW LIMIT – The minimum airflow where capture will occur, or the minimum airflow that will allow the cooking appliance to operate (see 41.1), whichever is higher.

5.30 MANUAL MEANS OF ACTUATION – A means of system actuation in which the system operator initiates system discharge.

5.31 MEAT CAKES – Ground beef, nominal 70 percent lean, 4 inches (101.6 mm) in diameter, minimum 3/8-inch (9.5 mm) thick and weighing not less than 5 ounces (141.7 grams). The meat cakes are either fresh, frozen, or thawed.

5.32 NONCOMBUSTIBLE MATERIAL – Material that is not capable of being ignited and burned, such as material consisting entirely of, or a combination of, steel, iron, brick, tile, concrete, slate, glass, or plaster.

5.33 OIL OR GREASE FRYING APPLIANCE – An appliance in which oil or grease is placed in a reservoir that is heated as part of the cooking operation.

5.34 OPERATING PRESSURE – The pressure in a fully charged container at 70°F (21°C).

5.35 PLENUM – The volume of enclosed space between the grease filters and the exhaust outlet of the system.

5.36 POLLUTION DEGREES

POLLUTION DEGREE 1 – No pollution or only dry, nonconductive pollution occurs. The pollution has no influence.

POLLUTION DEGREE 2 – Normally, only nonconductive pollution occurs; however, temporary conductivity caused by condensation may be expected.

POLLUTION DEGREE 3 – Conductive pollution occurs, or dry, nonconductive pollution occurs that becomes conductive due to condensation.

5.37 PRE-ENGINEERED SYSTEM – A system that is tested in accordance with the limitations prescribed by the manufacturer for maximum and minimum pipe lengths, accessories, number of fittings, number and types of nozzles and nozzle placement, types of fire risks and their maximum areas, volumes, or both areas and volumes of protection.

5.38 RECIRCULATING SYSTEMS – Systems for control of smoke or grease laden vapor from commercial cooking equipment that do not exhaust to the outside of the building.

INTEGRAL – A recirculating system that forms an integral part of the cooking appliance.

NON-INTEGRAL – A recirculating system intended for installation over specific commercial cooking equipment.

5.39 SIGNAL CIRCUITRY – Circuitry used for signaling purposes that controls no loads other than the control contacts of a switching device or devices.

5.40 SUPPLY CONDUCTORS – Conductors used to supply power to an appliance or other equipment. An equipment grounding conductor does not supply power and is not considered to be a supply conductor.

GROUNDED SUPPLY CONDUCTOR – A supply conductor that is conductively connected to ground through a connection at the service equipment, or at another location as specified by the National Electrical Code, ANSI/NFPA 70, and is therefore nominally at zero volts potential to ground. Also known as the "neutral" conductor or the "identified" conductor.

UNGROUNDED SUPPLY CONDUCTOR – A supply conductor that is not intended to be conductively connected to ground, except through an appliance or other load.

5.41 TEMPERATURE LIMITING CONTROL – A control that functions only under conditions that produce abnormal temperatures. The malfunction of such a control results in a risk of fire or electric shock.

5.42 TEMPERATURE REGULATING CONTROL – A control that functions to regulate the temperature of the appliance under intended conditions of use, and whose malfunction does not result in a risk of fire or electric shock.

5.43 TIMER

SINGLE TIME – A device that controls one complete operating cycle of the appliance and which requires the user to reinitiate.

REPETITIVE CYCLING – A device which controls complete, repetitive operating cycles of the appliance.

5.44 USER SERVICING – Any servicing that might be performed by personnel other than those who are trained to maintain the particular appliance. Some examples of user servicing are:

a) Attaching an accessory by means of an attachment plug and receptacle or by means of other separable connectors;

b) Resetting or replacing any protective device in an appliance or its receptacle circuit that is likely to be overloaded by the user, unless a tool is required to gain access to the device and the cover is marked in accordance with 80.9;

c) Resetting a circuit breaker, or replacing a fuse or lamp that is accessible without the use of a tool;

d) Making a routine operating adjustment necessary to adapt the appliance for a different intended function; and

e) Routine cleaning.

CONSTRUCTION

6 Accessories

6.1 An appliance having provisions for the use of an electrical accessory intended to be attached in the field shall comply with the requirements in this standard, with or without the accessory installed.

6.2 Installation of an accessory by the user shall be by means of a receptacle and plug-in connector.

6.3 When an accessory is to be installed by the user, the appliance shall comply with the requirements in Section 9, Accessibility of Live Parts, during and after the installation of the accessory.

6.4 The installation of an accessory by service personnel shall be by means of receptacles, plug-in connectors, insulated wire connectors, or by connection to existing wiring terminals.

6.5 With reference to 6.4, an installation shall not require the cutting of wiring or the soldering of connections by the installer. Installations shall not require cutting, drilling, or welding in electrical enclosures and in other areas where such operations may damage electrical components and wiring within the enclosure.

6.6 A means for strain relief shall be provided and comply with the strain relief test in Section 53, Strain Relief Test for the wiring in the accessory if there is a possibility of transmitting stress to the terminal connections during installation.

6.7 All terminals and wiring intended to be field connected shall be identified on the accessory, on the appliance if connections are made between the accessory and the appliance, and on the wiring diagram.

6.8 The intended installation of the accessory shall be indicated in the installation instructions included on or with the accessory. See 82.10.

6.9 As part of the investigation, an accessory is to be trial installed to determine that the installation is feasible, the instructions are detailed and correct, and the use of the accessory does not introduce a risk of electric shock, fire, or injury to persons.

6.10 An electrical accessory intended for field installation shall be marked in accordance with 78.18.

7 Mechanical Assembly

7.1 General

7.1.1 An appliance shall be formed and assembled so that it has the strength and rigidity to resist the abuses to which it is subjected, including the vibration of normal operation, without increasing the risk of fire, electric shock, or injury to persons due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

7.1.2 An enclosure, an opening, a frame, a guard, a knob, a handle, or the like shall not be sufficiently sharp to cause a risk of injury to persons in normal maintenance or use.

7.2 Mounting of components

7.2.1 A switch, fuseholder, lampholder, attachment-plug receptacle, motor-attachment plug, or other component that is handled by the user shall be mounted securely and shall be restrained from turning.

Exception: A switch is not required to be restrained from turning when it meets all four of the following conditions:

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

b) The means of mounting the switch makes it unlikely that operation of the switch will loosen the switch.

c) Spacings are not reduced below the minimum required values when the switch rotates.

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

7.2.2 The means to restrain turning required by 7.2.1 is to consist of more than friction between surfaces – for example, a properly applied lock washer is capable of being used as the means to restrain turning of a device having a single-hole mounting means.

7.2.3 Uninsulated live parts shall be secured to the base or surface so that they will be restrained from turning or shifting in position when such motion results in a reduction of spacing below the minimum values specified in Electrical Spacings, Section 32.

7.3 Shipping

7.3.1 A recirculating system shall be completely assembled when it leaves the factory.

Exception No. 1: Minor parts, such as handles, decorative trim, pans, trays, and splash panels, that are not required to prevent a risk of fire, electric shock, or injury to persons during operation of the appliance, are not required to be assembled.

Exception No. 2: The legs or the mounting brackets of a recirculating system may be shipped detached from the remainder of the appliance. See 81.2 and 82.6.

Exception No. 3: A part of an appliance, as described in (a) or (b), marked in accordance with 79.2 and 82.6 is not required to be completely assembled when shipped, or shipped in the same carton, or shipped in cartons secured together.

a) A panel that completes an enclosure that would otherwise be completed by another appliance in an adjacent or stacked installation. See 45.4.5.

b) An electrical subassembly that does not incorporate an automatic control that is affected, such as by temperature, by the remainder of the appliance, when:

1) Interconnecting leads and wiring are housed entirely within the appliance and the electrical connections are made with integral plugs and receptacles arranged so that no uninsulated live part capable of causing electric shock is accessible to unintentional contact when the subassembly is not in place;

2) Internal connection of a permanently connected appliance are made in accordance with the requirements for power-supply connections in 13.1 – 13.5 and 70.7, and field-installed leads are housed entirely within the appliance; or

3) External connections of a permanently connected appliance are made in armored cable or conduit in accordance with the requirements for power-supply connections in 13.1 – 13.5. See 79.7. When armored cable or conduit is permanently attached to one part of the appliance and stranded leads are installed, provision for connection of the leads is made in accordance with 18.5.7 (a) or (c). Solid wire leads need no additional end treatment. The armored cable is to be provided with the appropriate connector and antishort bushing.

Exception No. 4: A device intended to be mounted separately from a permanently connected appliance, such as a contactor actuated by an automatic control that is part of the appliance, is not required to be assembled to or shipped with the appliance when marked in accordance with 79.2 and provided with instructions in accordance with 82.6.

Exception No. 5: A device intended to be mounted to an appliance in the field is not required to be assembled to or shipped with the appliance when marked in accordance with 79.2 and provided with instructions in accordance with 82.6. The device shall meet the requirements of Section 6, Accessories.

Exception No. 6: A wet or dry chemical fire suppression system using an external propellant is not required to be charged at the place of manufacture.

8 Electrical and Fire Enclosures

8.1 General

8.1.1 The enclosure of an appliance shall be of a material acceptable for the application and shall house all electrical parts that present a risk of fire, electric shock or injury to persons under any condition of use. An adjacent wall or adjacent equipment shall not be depended upon to complete an enclosure. An enclosure that serves to confine or convey the exhaust products and houses electrical parts shall meet the requirements of this Section in addition to Section 40, Hood Materials.

Exception: A panel that completes an enclosure is not required when the enclosure is completed by another appliance in an adjacent or stacked installation. See 45.4.5 and 82.6.

8.1.2 When evaluating an appliance in accordance with this Section, a risk of electric shock exists within a circuit unless that circuit meets one of the following criteria, both under normal conditions and under single component fault conditions – See Component failure test, 71.5:

a) The circuit is supplied by an isolating source such that the maximum open circuit voltage potential available to the circuit is not more than 30 V ac or 42.4 V peak; or

b) The circuit is supplied by an isolating source such that the current available through a 1500 ohm resistor connected across any potential in the circuit (including to ground) does not exceed 5 MIU.

8.1.3 For the purpose of this Standard, the secondary circuits that do not involve a risk of electric shock are:

a) A Class 2 circuit (see 29.3);

b) A limited voltage/current circuit (see 29.4); and

c) Other secondary circuits complying with 8.1.2.

8.1.4 When evaluating an appliance in accordance with this Section, a risk of fire exists within a circuit unless that circuit meets one of the following criteria, both under normal conditions and under single component fault conditions – See Component failure test, 71.5:

a) The circuit is supplied by an isolating source such that the maximum open circuit voltage potential available to the circuit is not more than 30 V ac or 42.4 V peak, and the current available is limited to a value not exceeding 8 amperes measured after 1 minute of operation; or

b) The circuit is supplied by an isolating source such that the power available to the circuit is limited to less than 15 watts.

8.1.5 For the purpose of this Standard, the secondary circuits that do not involve a risk of fire are:

a) A Class 2 circuit (see 29.3);

b) A limited voltage/current circuit (see 29.4);

c) A limiting impedance circuit (see 29.7); and

Exception: A limiting impedance circuit that has not been evaluated for operation under single-fault conditions (see Exception No. 1 to 29.7.2) involves a risk of fire.

d) Other secondary circuits complying with 8.1.4.

Exception: Any part that exceeds 121°C (250°F) during the Normal Temperature Test, Section 45, is identified as involving a risk of fire when evaluating the equipment in accordance with this Section, regardless of the circuit in which it is located.

8.1.6 The following factors shall be taken into consideration when an enclosure is being evaluated:

a) Mechanical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Resistance to combustion;

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.

8.2 Metallic enclosures

8.2.1 The minimum thickness of cast metal shall be in accordance with Table 8.1.

Exception: Thinner metal that has been found to be acceptable when the enclosure is evaluated by such factors as those mentioned in 8.1.6 is not required to comply with the minimum thicknesses in Table 8.1. See Section 55, Strength of Enclosures, Frames, and Guards Test.

Table 8.1
Minimum acceptable thickness of cast metal

Metal	Minimum thickness, inch (mm)	
	At reinforced surfaces[a]	At 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)

[a] Includes surfaces that are curved, ribbed, and the like or are otherwise of a shape or size to provide intended mechanical strength.

8.2.2 An enclosure of sheet metal shall be judged with respect to its size and shape, the thickness of metal and its acceptability for the particular application, and the factors described in 8.1.6. The use of sheet steel having a thickness less than 0.026 inch (0.66 mm) if uncoated or electroplated, or 0.029 inch (0.74 mm) if hot-dipped galvanized, or of nonferrous sheet metal having a thickness of less than 0.036 inch (0.91 mm), is not recommended except for a relatively small area or for a surface that is curved or otherwise reinforced and tested under the conditions described in Section 55, Strength of Enclosures, Frames, and Guards Test.

8.2.3 Sheet metal to which a wiring system is to be connected in the field shall have a thickness of not less than 0.032 inch (0.81 mm) if uncoated steel, of not less than 0.034 inch (0.86 mm) if galvanized steel, and of not less than 0.045 inch (1.14 mm) if nonferrous metal.

Exception: Sheet steel not less than 0.026 inch (0.66 mm) thick if uncoated steel, or not less than 0.029 inch (0.74 mm) thick if galvanized steel, is acceptable when the area surrounding a knockout has a thickness of not less than 0.053 inch (1.35 mm).

8.3 Nonmetallic enclosures

8.3.1 A nonmetallic enclosure shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.4 Fire containment – General – Other than hood exhaust system

8.4.1 An opening in the bottom of an appliance shall not be located below an electrical part unless a solid, noncombustible pan complying with Figure 8.1 is interposed between the electrical part and supporting surface. The pan is to have a rim, lip, or other raised edge that is in a horizontal plane and extends all the way around the pan. The bottom of the pan is not required to be flat or any regular shape and the transmission from the bottom to the rim, lip, and the like may have any convenient shape. At every point directly below the electrical part, the floor of the pan is to be 1/8-inch (3.2 mm) or more below the plane of the rim, lip, and the like.

Exception No. 1: The requirement does not apply to components on the load side of an automatic switch in a pop-up toaster.

Exception No. 2: The use of a pan of noncombustible material under a motor is not required when:

a) The motor has no openings below a horizontal plane through the center of the motor;

b) The structural parts of the motor or of the appliance provide the equivalent of the described barrier;

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

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

4) For a permanent-split capacitor motor, capacitor short-circuited. The short circuit is to be applied before the motor is energized and the rotor is to be locked;

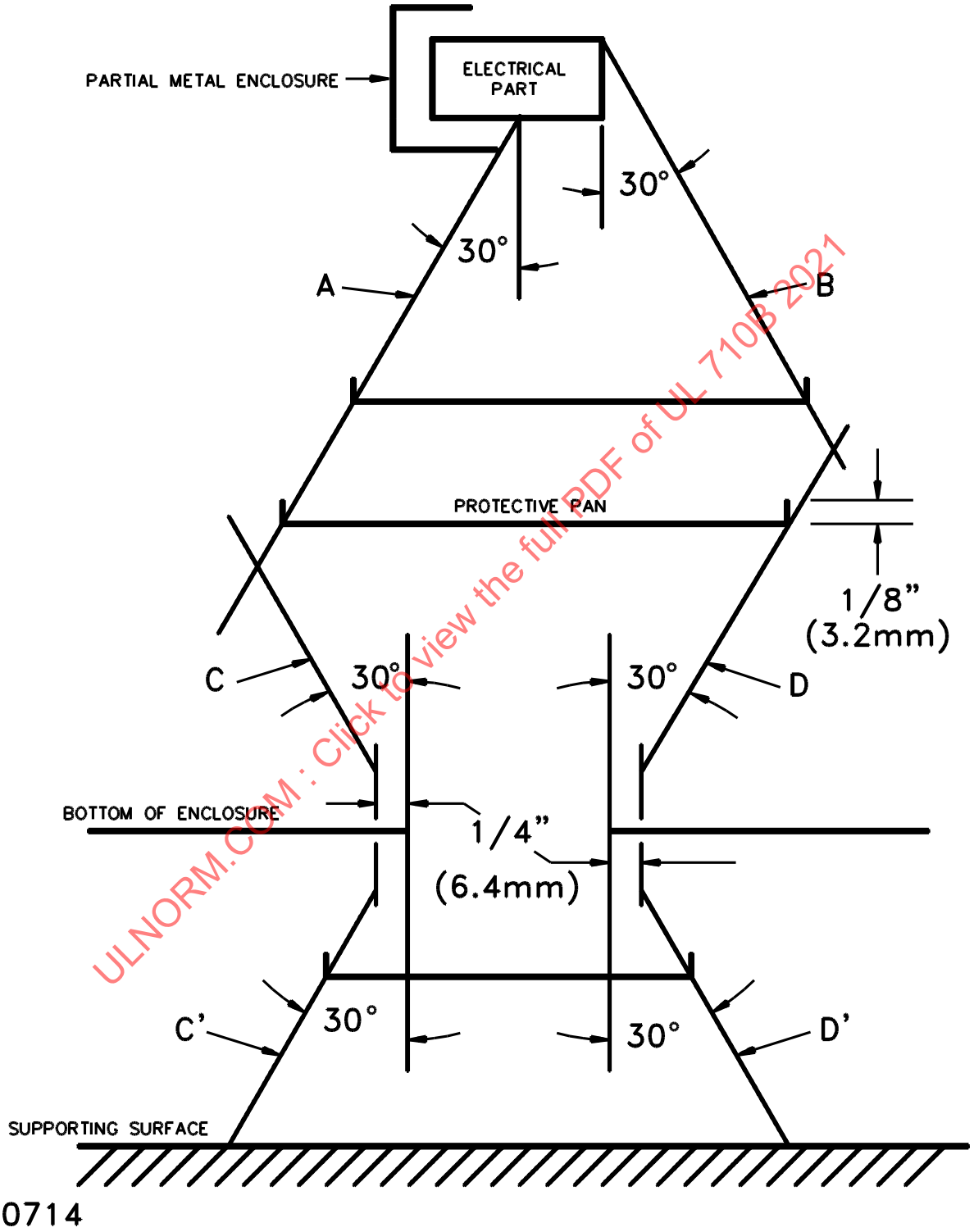
d) The motor is provided with a thermal motor protector – a protective device that is sensitive to temperature and current – that will prevent the temperature of the motor windings from exceeding 125°C (257°F) at the maximum load under which the motor will run without causing the protector to cycle and from exceeding 150°C (302°F) with the rotor of the motor locked; or

e) The motor is impedance protected and the locked-rotor temperature of the motor winding is not more than 150°C (302°F) with the appliance otherwise operating as intended.

Exception No. 3: This requirement does not apply to wiring of the flame-retardant rating VW-1 (FR-1), or wiring contained within sleeving rated VW-1, or the equivalent.

Figure 8.1

Minimum extent of baffle for opening in bottom of enclosure



A, B, C and D are projections that define a volume between an electrical part and an opening. C' and D' are projections that define a volume between an opening and the supporting surface. A protective pan in any horizontal plane between the part and the opening in the supporting surface must be larger than the area defined by projections A, B, C, and D, or projections C' and D', respectively. Three samples of protective pans are illustrated in the figure, two are above the opening and one is below it.

8.4.2 The structure of a part or of the appliance is not prohibited from providing the equivalent of the pan described in 8.4.1 when it complies with Figure 8.1. The raised edge is not prohibited from being incorporated in the opening.

8.4.3 An opening in a surface other than the bottom of an enclosure that contains an arcing part such as a fuse, circuit breaker, or switch shall be provided with a baffle, such as the one illustrated in Figure 8.2, that will prevent the emission of flame, molten metal, burning insulation, or the like.

Exception No. 1: A baffle is not required for an opening in an enclosure that contains arcing parts other than an overcurrent-protective device, such as a fuse or circuit breaker, when:

a) The structure of the part provides the equivalent of a baffle;

b) The distance from the electrical part to the plane of the enclosure is greater than 12 inches (304.8 mm); or

c) No ventilating opening in a vertical wall is more than 3/8-inch (9.5 mm) wide, and the total area of such openings located less than 12 inches (304.8 mm) from the floor in any 1-foot-square area of the enclosure does not exceed 8 square inches (52 cm^2).

Exception No. 2: Louvers are not prohibited from being used in lieu of a baffle (see 8.4.4) to enclose electrical parts other than an overcurrent-protective device, such as a fuse or circuit breaker, when no electrical parts are located within area "A" indicated in Figure 8.3.

Figure 8.2

Relationship of baffle and electrical part to prevent emission

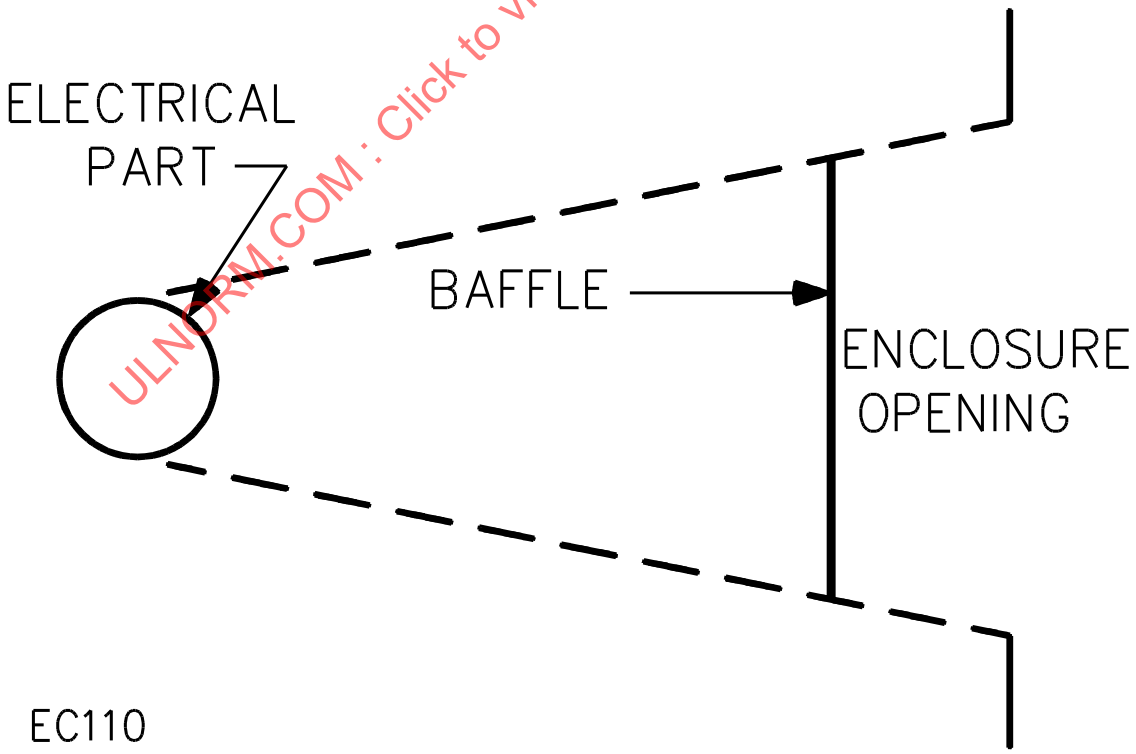
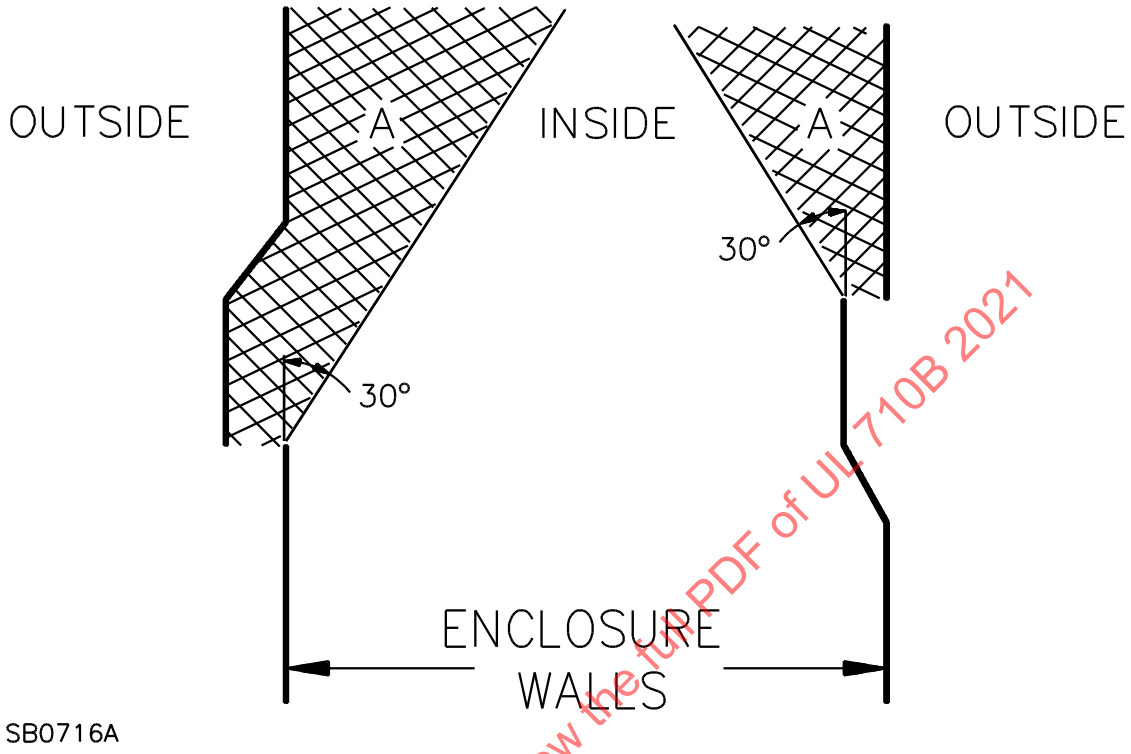


Figure 8.3

Louver designs



8.4.4 An opening in the side of an enclosure shall be so located and of such size that entry of foreign objects which create a risk of fire or electric shock is prevented and contact with internal parts by persons is prevented in accordance with this Section 9, Accessibility of Live Parts and Section 10, Protection of Service Personnel. Louvers are not prohibited from being used when shaped to deflect external falling objects outward. See Figure 8.3.

8.4.5 No opening or joint in the enclosure of an appliance shall be located where spillage from normal operation, cleaning, or user servicing can enter the enclosure and affect the internal wiring or any other electrical component. A part that is removable without the use of tools, such as a grease pan, does not meet the intent of providing such protection.

8.5 Fire containment – Enclosures for overcurrent protective device

8.5.1 A door or cover giving direct access to a fuse or any portion of a circuit breaker or supplementary protector other than the operating handle shall shut closely along all four sides of the door or cover against a 1/4-inch (6.4 mm) rabbet or the equivalent, or shall have one of the following for the full length of all edges:

a) Turned flanges; or

b) Angle strips fastened to it.

A flange or an angle strip shall fit closely with the outside of the wall of the box proper and shall overlap the edges of the box not less than 1/2-inch (12.7 mm). A combination of flange and rabbet or other construction that provides equivalent protection meets the intent of the requirement.

Exception No. 1: This requirement does not apply to a door or cover that gives access to a fuse or circuit breaker, or supplementary protector located in a secondary circuit that is supplied from an isolating transformer or an equivalent source that limits the available short-circuit current.

Exception No. 2: This requirement does not apply to a door or cover where the only fuses enclosed are:

a) Control circuit fuses, when the fuses and control circuit loads (other than a fixed control circuit load, such as a pilot lamp) are within the same enclosure; or

b) An extractor type fuse with its own enclosure that is accessible without exposing live parts other than a fuse contact of the fuseholder, when the fuseholder is located in a circuit with a grounded supply conductor. See 15.2 and 15.3.

8.5.2 A strip used to provide a rabbet and an angle strip fastened to the edges of a door shall be secured:

a) At not less than two points;

b) Not more than 1-1/2 inches (38.1 mm) from each end of each strip; and

c) At points between these end fastenings not more than 6 inches (152.4 mm) apart.

9 Accessibility of Live Parts

9.1 General

9.1.1 The electrical parts of an appliance shall be located or enclosed so that persons are protected against unintentional contact with uninsulated live parts involving a risk of electric shock.

9.1.2 The following are not considered to be uninsulated live parts:

a) A coil of a controller, a relay, a solenoid, and a transformer, when they are provided with insulating overwraps at least 1/32-inch (0.8 mm) thick;

b) Enclosed motor windings;

c) Insulated terminals and splices; and

d) Insulated wire.

9.1.3 An uninsulated live part, such as a terminal or bus bar, and not including film-coated wire, shall not be less than 1 inch (25.4 mm) from any opening in the enclosure of an appliance.

9.1.4 An opening shall not be larger than 3/4-inch (19.1 mm).

Exception No. 1: Except as noted in 9.1.3, an opening larger than 3/4-inch (19.1 mm) meets the intent of this requirement when it does not permit the entrance of a 3/4-inch (19.1 mm) diameter rod and a probe as illustrated in Figure 9.3 which cannot be made to touch any uninsulated live part or enameled wire when inserted into the opening.

Exception No. 2: With respect to a part or wire within the enclosure of a motor, an opening larger than 3/4-inch (19.1 mm) is not prohibited when:

a) A probe as illustrated in Figure 9.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

b) A probe as illustrated in Figure 9.2 cannot be made to touch film-coated wire when inserted through the opening.

Figure 9.1

Probe for uninsulated live parts within a motor

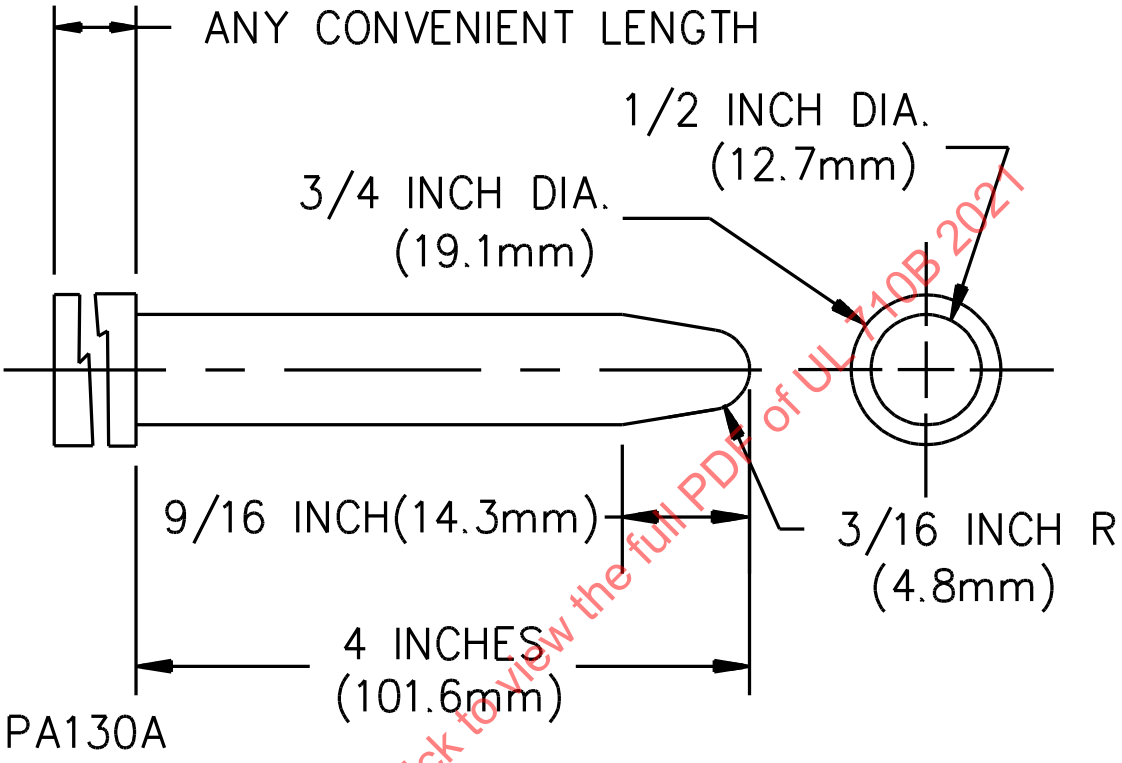


Figure 9.2

Probe for film–coated magnet wire of a motor

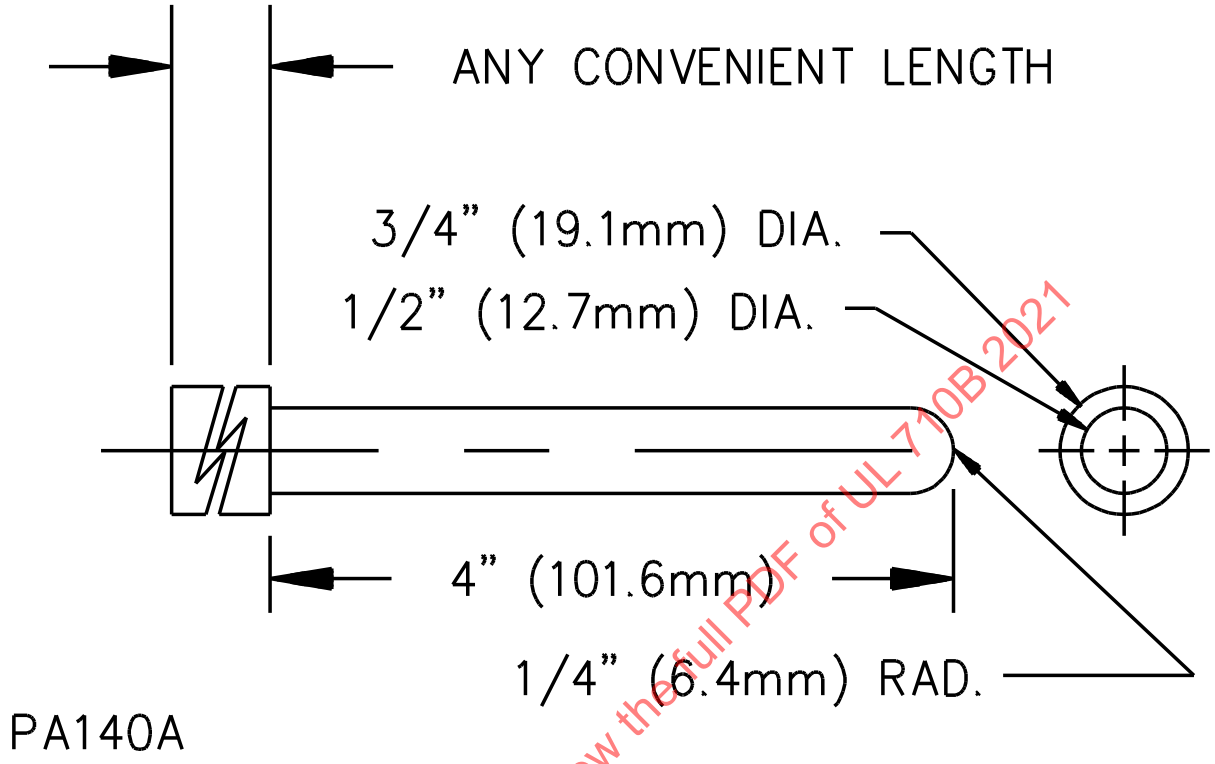
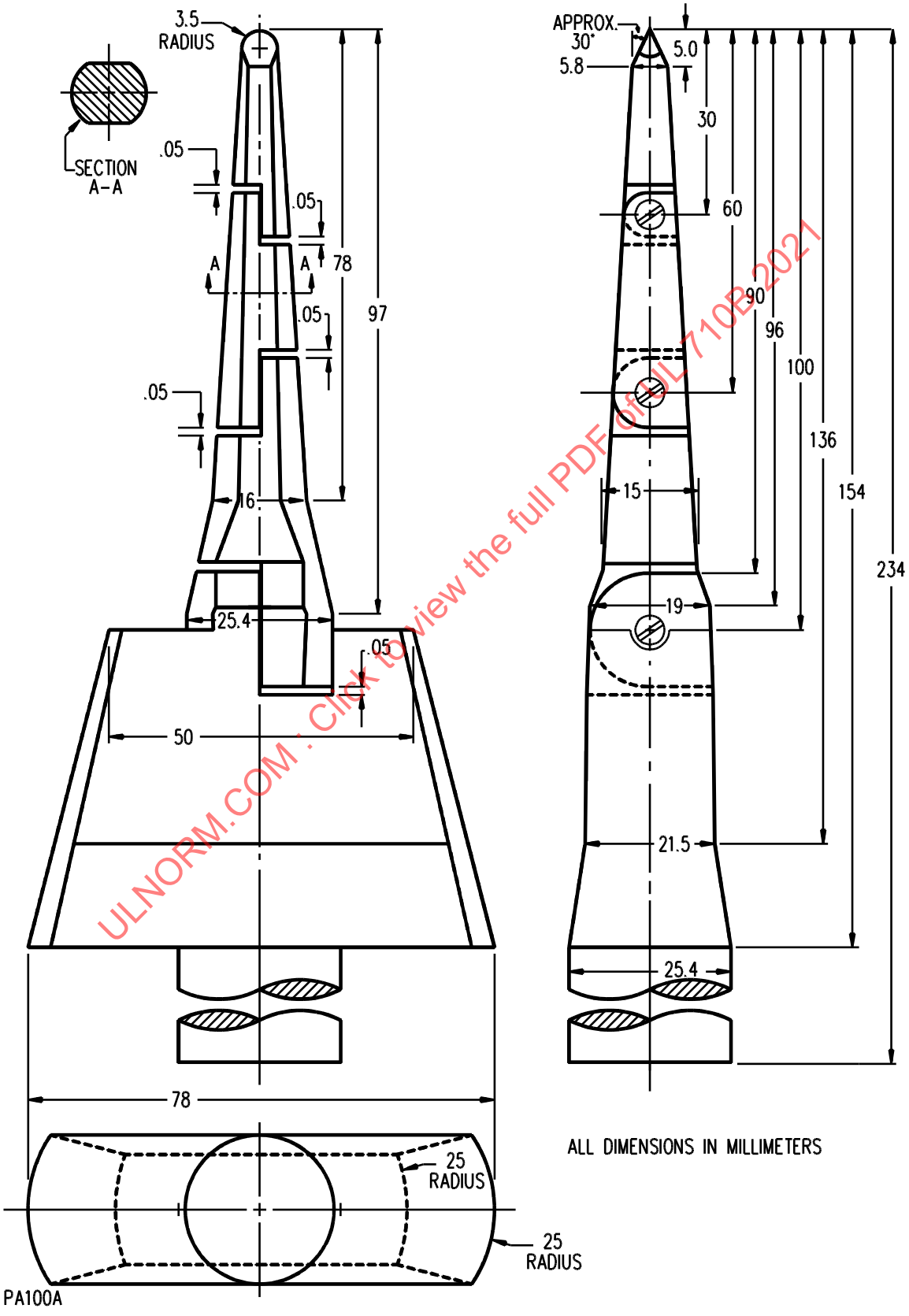


Figure 9.3

Accessibility probe



9.1.5 An opening that will permit entrance of 3/4-inch (19.1 mm) diameter rod is capable of being used when there are no uninsulated live parts:

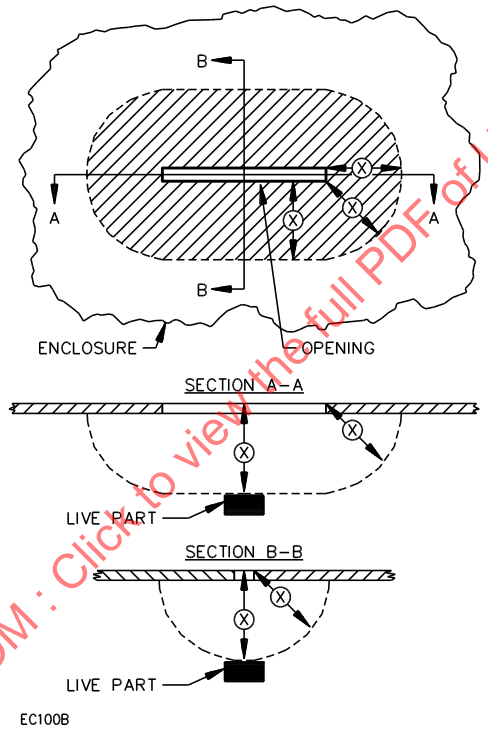
a) Less than X inches (mm) from the perimeter of the opening; and

b) Within the volume generated by projecting the perimeter X inches (mm) normal to its plane – X equals five times the diameter of the largest diameter rod that can be inserted through the opening, and not less than 4 inches (101.6 mm). See Figure 9.4.

Figure 9.4

Opening in an enclosure

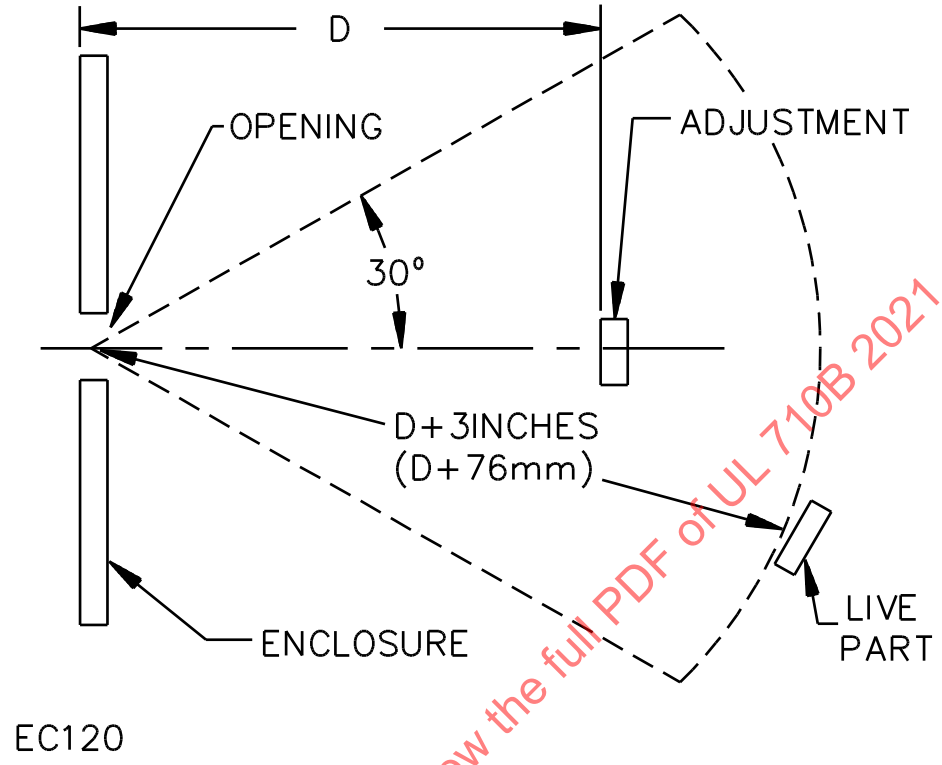
Proportions Exaggerated for Clarity



9.1.6 An uninsulated live part shall not be located behind an opening that may be used to make an adjustment considered to be a function of user servicing if a 1/8-inch (3.2 mm) diameter straight rod can be made to touch the part when the rod is inserted through the opening and moved to all positions possible without producing an angle of more than 30 degrees between the rod and the line drawn between the center of the opening and the center of the face of the adjusting mechanism. The length of the rod beyond the opening is not to exceed the distance between the opening and the face of the adjusting mechanism by more than 3 inches (76.2 mm). See Figure 9.5.

Figure 9.5

Accessibility of live parts through adjustment opening



9.1.7 During the examination of an appliance in connection with the requirements in 9.1.4 – 9.1.6, a part of the outer enclosure that is capable of being removed without the use of tools, or that must be opened or removed for user servicing, is to be disregarded – that is, it shall not be assumed that the part in question affords protection against the risk of electric shock. A warning marking such as that specified in 80.9 does not meet the intent of reducing the risk of electric shock.

Exception: The cover of a compartment that does not enclose user-serviceable parts and that is retained in the closed position by means of a keyed lock is to be retained in place while examining the appliance in accordance with 9.1.4 – 9.1.6 when the marking specified in 78.14 is on or adjacent to the cover.

9.2 Fuses, circuit breakers, supplementary protectors, and manually reset controls

9.2.1 The requirements of 9.2.3, 9.2.4, and 9.2.6 – 9.2.9 do not apply to a fuse or device that is not required by this standard when:

a) The cover/enclosure part giving access to the fuse or device is marked in accordance with 80.9; or

b) The fuse is a non-replaceable type.

9.2.2 A fuseholder, circuit breaker, or supplementary protector shall not be accessible from outside the appliance without opening a door or a cover.

Exception: The operating handle of a circuit breaker, or supplementary protector, and the insulating cap of an extractor-type fuseholder as specified in 9.2.9 (b) or (c) are not prohibited from being accessible from outside of the appliance.

9.2.3 An appliance shall be designed so that fuses can be replaced and manually reset devices reset without removing an enclosure part other than a service cover or panel.

9.2.4 Access for replacing fuses and resetting circuit breakers and supplementary protectors shall not be unduly restricted. Upon removal of the cover or panel referenced in 9.2.3, such devices shall be accessible from outside the unit via a straight line. Fuses and the actuators of circuit breakers and supplementary protectors shall not be recessed more than 12 inches (304.8 mm) behind the perimeter of a floor mounted appliance. See 10.4 – 10.10.

9.2.5 For the purpose of these requirements, the perimeter of the appliance is defined as the vertical surface containing the outermost edges of the appliance, including overhangs and other protrusions such as counter tops that are:

a) Located within 3.0 feet (0.9 m) of the supporting surface; and

b) Within 15 inches (381 mm) to either side of the fuse or actuator or within 5 inches (127 mm) to either side of the fuse/circuit breaker/supplementary protector enclosure, whichever is the greater distance.

Exception: Protrusions which do not exceed 4 inches (10.2 cm) from the edge of an appliance are not required to be defined as the perimeter of an appliance.

9.2.6 An appliance shall be constructed to permit at least a 90 degree opening of all doors and hinged panels which give access to a fuse or the actuator of a circuit breaker or supplementary protector.

9.2.7 A fuseholder, circuit breaker, or other manually reset device shall be located so that a person replacing the fuse or resetting a manually reset device cannot unintentionally touch an uninsulated live part.

Note: A screwshell or extractor-type fuseholder involves a risk of unintentionally touching an uninsulated live part unless power is disconnected to all uninsulated parts of the fuse and all uninsulated removable fuseholder parts before they become exposed when removing the fuse.

Exception No. 1: Uninsulated live parts are not prohibited from being accessible when the unit is marked in accordance with 80.9.

Exception No. 2: For the purpose of this requirement a screwshell or extractor-type fuse holder in a control circuit rated less than 150 volts does not involve a risk of unintentionally touching an uninsulated live part. See 15.3.

9.2.8 Except as indicated in 9.2.9 and 9.2.10, the door or cover of an enclosure shall be retained in place by hinging, pivoting, sliding, or equivalent means when:

a) It gives access to any fuse, circuit-breaker handle, or manually resettable lever of a temperature control in a circuit involving a risk of fire or electrical shock (see 8.1.2 – 8.1.5); and

b) Uninsulated live parts are exposed during the replacement of a fuse or resetting of the manually resetting device.

Such a door or cover shall also be provided with an automatic latch or the equivalent. When live parts other than the screw shell of a plug fuseholder are exposed inside the enclosure, the door or cover shall be provided with a captive screw or equivalent means which require the use of a tool to open and secure the door or cover in place. See 9.2.11 and 9.2.12.

9.2.9 A hinged cover is not required for an enclosure in which the only fuses enclosed are:

a) Control circuit fuses, when the fuses and control circuit loads (other than a fixed control circuit load, such as a pilot lamp) are within the same enclosure;

b) Fuses located in a circuit with a grounded supply conductor, when the fuses are located in extractor-type fuseholders with integral enclosures where the fuse is accessible for replacement without exposing live parts other than a fuse contact of the fuseholder or the fuse itself. See 15.2 and 15.3; and

c) Fuses located in a circuit without a grounded supply conductor, when the fuses are located in specially designed extractor-type fuseholders with integral enclosures where the fuse is accessible for replacement without exposing live parts, including any live part of the fuseholder or fuse, during fuse replacement (for example, a fuseholder that automatically and reliably disconnects power to the fuse and any other conductive parts exposed during fuse replacement before those parts become exposed).

9.2.10 The removable portion of a fused pullout switch that complies with the requirements in 7.1.1 and 8.1 – 8.5, is determined to be an acceptable cover for the fuseholder and is not required to comply with the requirements in 9.2.8.

9.2.11 A spring latch, a magnetic latch, a dimple, or other mechanical arrangement that holds the door closed and requires some effort on the user's part to open is determined to provide the "automatic latching means" for holding the door closed as required in 9.2.8.

9.2.12 A cover interlocking mechanism complies with the requirement for an automatic latch in 9.2.10 and the requirement for a captive screw or equivalent in 9.2.8 when it:

a) Must be engaged in the closed position of the cover before any uninsulated part is energized; and

b) Will secure the cover in the closed position, when provided as the sole means for securing the door or cover closed.

9.2.13 A screw with a knurled and slotted head (for securing with a screwdriver) which can be manually turned does not meet the intent as being a required enclosure securing means.

10 Protection of Service Personnel

10.1 Uninsulated live parts involving a risk of electric shock and moving parts within the enclosure that involve a risk of injury to persons shall be located, guarded, or enclosed as specified in 10.4 – 10.10 to prevent unintentional contact by service personnel performing mechanical service functions that are performed with the equipment energized. See 10.2.

10.2 Mechanical service functions that are typically performed with the equipment energized include the following:

a) Adjusting the setting pressure or vacuum control;

b) Resetting a control trip mechanism;

c) Operating a manual switch; and

d) Adjusting an air-flow damper.

A factory-set-and-sealed control is not considered to be adjustable.

10.3 The requirements in 10.1 are not applicable to mechanical service functions that are not usually performed with the equipment energized. Such functions include adjusting or replacing a drive belt, and similar tasks.

10.4 An adjustable or resettable electrical control or a manual switching device may be located or oriented with respect to uninsulated live parts so that manipulation of the mechanism for adjustment, resetting, or operation can be accomplished in the usual direction of access if uninsulated live parts or moving parts involving a risk of electric shock or injury to persons are:

a) Not located in front – in the direction of access – of the mechanism; and

b) Not located within 6 inches (152.4 mm) on any side or behind the mechanism, unless guarded.

10.5 An electrical control component that requires examination, adjustment, servicing, or maintenance while energized, not including measuring voltage, shall be located and mounted with respect to other components and with respect to grounded metal parts so that it is accessible for electrical service functions without subjecting the serviceman to the risk of electric shock from adjacent uninsulated live parts or to a risk of injury to persons from adjacent moving parts. See 10.9.

10.6 Accessibility and protection against the risk of electric shock and injury to persons may be obtained by mounting the control components in an assembly so that unimpeded access to each component is provided through an access cover or a panel in the outer cabinet and the cover of the control assembly enclosure by the following arrangement (see Figure 10.1):

a) The components are located so that the farthest component in the assembly is not more than 15 inches (381 mm) from the plane of the access opening in the outer cabinet.

b) Uninsulated live parts outside the control assembly projected clear space – except live parts within a control panel – and unguarded moving parts involving a risk of casualty are located not closer than 6 inches (152.4 mm) from any side of the access area. The projected clear space is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or the control enclosure when provided. The access is considered to be bounded on the sides by the projection of the smallest rectangular perimeter surrounding the outside edge of the components or the control enclosure when provided. The access area is considered to be bounded on the sides by the projection of the perimeter of the access opening in the outer cabinet to the closest rectangular perimeter surrounding the outside edge of the component or the control enclosure.

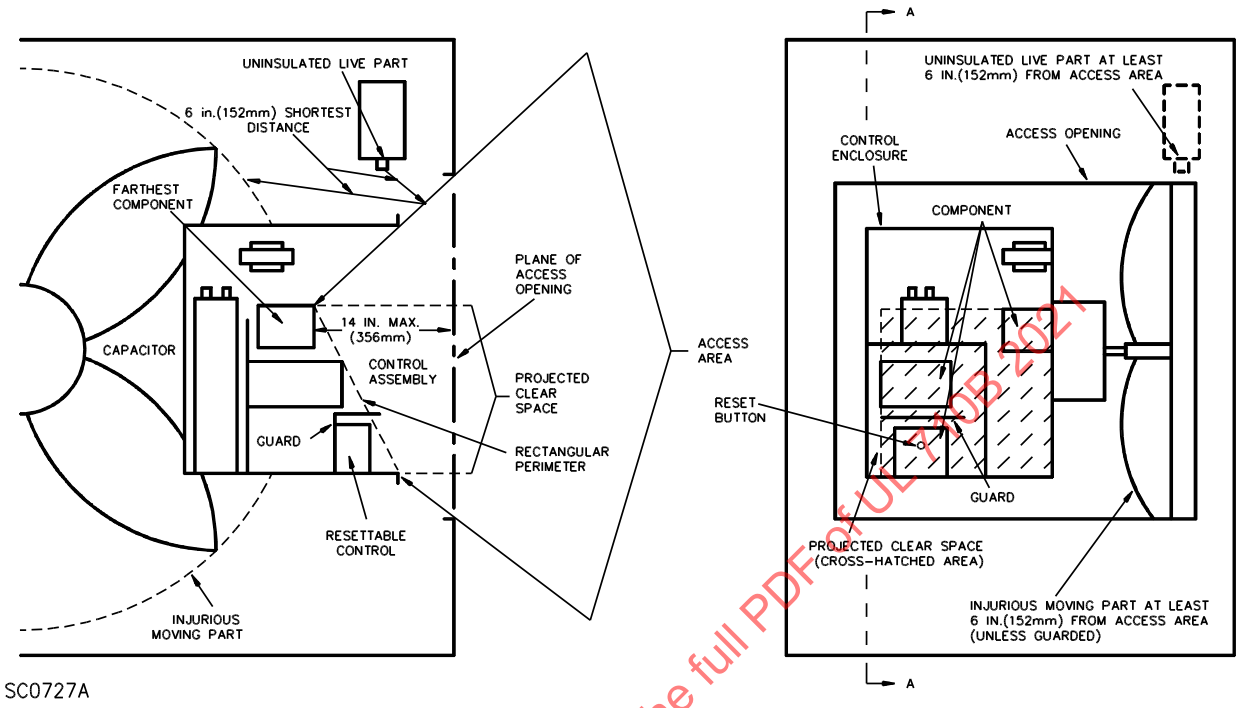
c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet – within the access area – is completely free of obstructions, including wiring.

d) Access to the components in the control assembly is not impeded in the direction of access by other components or by wiring in this assembly.

e) Extractor-type fuseholders and snap switches mounted through the control assembly enclosure are located so that there is unimpeded access to these components through the access opening in the outer cabinet and they are not immediately adjacent to unguarded uninsulated live parts outside the control assembly enclosure. See 10.4.

Figure 10.1

Accessibility and protection



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10.7 Component or control assemblies that are rotated or otherwise displaced for service are acceptable when the electrical control components are accessible for service as indicated in 10.5.

10.8 Other arrangements of components or guarding are also acceptable when electrical control components are accessible for service as indicated in 10.5.

10.9 The electrical components referred to in 10.5 – 10.8 include fuses, adjustable or resettable overload relays, manual or magnetic motor controllers, magnetically operated relays, adjustable or resettable pressure or temperature controllers, manual switching devices, and clock timers. Such components in a low-voltage circuit shall comply with the requirements in 10.5 with respect to:

a) Uninsulated live parts in a line-voltage circuit; and

b) Moving parts involving a risk of injury to persons.

10.10 Electrical components in an appliance shall be located so that access for servicing or replacement will not be unduly restricted. It shall not be necessary to remove one electrical part in order to service or replace another.

11 Interlocks

11.1 General

11.1.1 These requirements apply to an interlock that is required to comply with the requirements of this Standard.

11.1.1.1 Any component, combination of components, or assemblies required to comply with the requirements of this standard (including, but not limited to, Capture Test, Emissions Test, and Fire Testing), shall be interlocked such that the malfunction of any component or assembly shall result in rendering the recirculating and/or cooking appliance(s) inoperable. Any interlock required to comply with the Ozone test shall render the ozone generating portion of the system inoperable in the event of malfunction.

11.1.2 The actuator of an interlock switch shall be located so that unintentional operation does not occur. See 27.3.2 – 27.3.4.

11.1.3 Operation of an interlock in normal use shall not inconvenience the operator so as to encourage deliberate defeat of an interlock. Separate operation(s) adding time and motion to engage or activate an interlock, accessibility/ease of actuating an interlock as well as nuisance operation (or tripping) of the interlock shall be considered in determining "inconvenience" to the operator.

11.1.4 An interlock shall not be defeated by food or cooking materials that could accumulate in normal use.

11.1.5 An interlock system shall comply with Section 68, Endurance Test for Interlock Switches.

Exception: This requirement does not apply to an interlock system in which all components, including the actuation means, have been evaluated for 100,000 cycles.

11.1.6 An electronic interlock circuit shall comply with one of the following requirements:

a) Electronic interlocks shall comply with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. In addition a softwarebased interlock circuit shall comply with the requirements of the Standard for Software in Programmable Components, UL 1998; or

b) Supplement SB – Alternative Path for Electronic Controls Requirements.

11.2 Moving parts

11.2.1 Moving parts involving a risk of injury to persons protected by a service door, shall be interlocked so that such parts are de-energized when the door is opened, and are guarded as intended when one of the following conditions is met:

a) The moving parts stop within 5 seconds after the door is opened; or

b) The interlock prevents the door from being opened until the moving parts stop.

11.2.2 An interlock actuated by movement of a guard shall permit operation of the parts being guarded only when the guard is in place. With the guard removed, the interlock shall comply with the requirement in 11.1.2.

12 Protection Against Corrosion

12.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means when corrosion of such parts results in the risk of fire, electric shock, or injury to persons.

Exception No. 1: This requirement does not apply to surfaces of sheet steel and cast iron parts within an enclosure when the oxidation of iron or steel due to the exposure of the metal to air and moisture is not appreciable – thickness of metal and temperature also being factors.

Exception No. 2: This requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, and similar parts.

13 Electrical Supply Connections

13.1 General

13.1.1 Provisions for connection to the wiring systems specified in the National Electrical Code, ANSI/NFPA 70, shall be provided for the following as suitable for the appliance:

a) Non-integral recirculating systems; and

b) Integral recirculating systems intended for permanent connection to the power supply.

13.1.2 An appliance intended for permanent connection to the building structure shall be provided with means for permanent connection to the branch-circuit supply. An appliance that is connected to the building structure only by flexible hoses is not considered to be permanently connected to the building structure.

13.1.3 An appliance intended to be built-in is allowed to be provided with 3 – 8 feet (0.9 – 2.4 m) of flexible metal conduit of not less than 1/2-inch electrical trade size, with leads and a grounding conductor installed to facilitate servicing and installation. The flexible conduit is not required to terminate in an outlet box at the free end. An antishort bushing is to be installed and retained as intended. See 81.3.

13.1.4 There shall be a flat surface surrounding a knockout or conduit opening. The flat surface shall have an area that permits assembly to the appliance of a length of standard rigid metallic conduit. The diameter of the opening shall accommodate conduit of the trade size for which the opening is intended and either the flat surface and opening shall have a minimum diameter, or the throat shall have a diameter, in accordance with Table 13.1.

Table 13.1
Dimensions associated with openings for conduit

Trade size of conduit, inches	Unthreaded openings				Threaded openings			
	Nominal knockout diameter		Minimum diameter of flat surface at knockout		Minimum throat diameter		Maximum throat diameter	
	Inches	(mm)	Inches	(mm)	Inches	(mm)	Inches	(mm)
1/2	7/8	(22.2)	1.140	(28.96)	0.560	(14.22)	0.622	(15.80)
3/4	1-3/32	(27.8)	1.420	(36.07)	0.742	(18.85)	0.824	(20.93)
1	1-23/64	(34.5)	1.770	(44.96)	0.944	(23.98)	1.049	(26.64)
1-1/4	1-23/32	(43.7)	2.281	(57.94)	1.242	(31.55)	1.380	(35.05)
1-1/2	1-31/32	(50.0)	2.598	(65.99)	1.449	(36.80)	1.610	(40.89)
2	2-15/32	(62.7)	3.175	(80.65)	1.860	(47.24)	2.067	(52.50)
2-1/2	3	(76.2)	3.562	(90.47)	2.222	(56.44)	2.469	(62.71)

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

13.2 Wiring compartment

13.2.1 A terminal compartment intended for connection of a supply raceway shall be attached to the appliance such that it is restrained from turning.

13.2.2 A wiring compartment for field-wiring connections shall be of metal and of a volume that accommodates the wiring of the size indicated in 13.3.12, and conduit and fittings sized for the wire in accordance with the National Electrical Code, ANSI/NFPA 70.

13.2.3 The location of a terminal box or compartment in which branch-circuit connections to a permanently wired appliance are to be made shall be such that the connections can be inspected without disturbing wiring or the appliance after the appliance has been installed as intended.

Exception: Wiring, other than field wiring, is not prohibited from being moved in accordance with the Exception to 13.2.6.

13.2.4 Provision for inspection of connections on the rear or bottom of a floor-mounted recirculating system is not acceptable except that access can be provided on the rear when the recirculating system is integral to a cooking appliance that is provided with casters or is marked to indicate a spacing of not less than 30 inches (762 mm) in accordance with 78.5. Access is to be judged when the appliance is installed in the test arrangement described in 45.4.3.

13.2.5 No internal wiring or component shall be located where it is likely to be unintentionally damaged during installation or inspection of field wiring.

13.2.6 An electrical component shall not be mounted on a part, such as the cover of a wiring-terminal compartment, that must be removed for the purpose of making or inspecting field wiring connections.

Exception: A single electrical component, such as a switch, pilot light, or similar component, is not prohibited from being mounted on a wiring compartment cover when it complies with the following items:

a) The component connecting leads shall be of such a length to provide for the making and examination of field-wiring connections;

b) None of the component connections shall be field wired;

c) Strain relief shall be provided to prevent stress from being transmitted to the component wiring termination and shall comply with the Strain Relief Test, Section 53;

d) The component or cover shall be provided with a separate means for bonding in accordance with Section 14, Bonding for Grounding;

e) The minimum size of the component lead shall be 18 AWG (0.82 mm^2);

f) Wiring terminations on the component shall be recessed or protected by barriers of insulating material or the equivalent that will provide protection from contact with wiring installed in the box, or unintentional contact during installation or inspection of field wiring; and

g) The cover shall be hinged or sliding type, or equivalent, constructed so that it will not be supported by wiring or electrical components during installation or inspection of field wiring connections.

13.2.7 In a terminal box or wiring compartment, the distance between the end of any wire connector or lug and the wall of the enclosure, toward which the conductor is directed or through which the connected conductor passes, shall be as specified in Table 13.2.

Table 13.2
Wire bending space at field wiring terminals

Wire size		Minimum space of terminal to wall	
AWG	(mm^2)	inches	(mm)[a]
14 – 10	(2.1 – 5.3)	Not specified	
8 – 6	(8.4 – 13.3)	1-1/2	(38.1)
4 – 3	(21.2 – 26.7)	2	(50.8)
2	(33.6)	2-1/2	(63.5)
1	(42.4)	3	(76.2)
1/0, 2/0	(53.5, 67.4)	3-1/2	(88.9)

[a] If a conductor is restricted from bending by a barrier or otherwise where it leaves the lug, the distance is to be measured from the end of the barrier.

13.3 Field-wiring terminals and leads

13.3.1 A field-wiring terminal is a terminal to which a supply or other wire can be connected by an installer in the field, unless the wire is provided as part of the appliance and a pressure terminal connector, soldering lug, soldered loop, crimped eyelet, or other means for making the connection is factory-assembled to the wire.

13.3.2 A permanently connected appliance shall be provided with wiring terminals or leads for the connection of conductors having an ampacity at least 125 percent of the current input to the appliance when tested in accordance with the Power Input Test, Section 44, and at least 125 percent of the rated current of the appliance.

Exception: When the appliance is marked with a maximum branch circuit overcurrent protective device current rating (see 24.1.3, 24.1.4, and 80.10), the terminals are not prohibited from being sized for conductors smaller than specified, provided that the terminals are sized for the connection of conductors having an ampacity at least equal to the marked maximum branch circuit overcurrent protective device current rating.

13.3.3 Ampacity of field wiring conductors is to be determined using Table 310-16 of the National Electrical Code, ANSI/NFPA 70. The uncorrected values for 60°C (140°F) conductors shall be used for appliances rated 100 amperes or less, and the uncorrected values for 75°C (167°F) conductors shall be used for appliances rated more than 100 amperes, even when conductors with a higher rating are required by markings or instructions. See 13.3.12 and 79.3 – 79.5.

13.3.4 It is to be assumed that wire having the specified temperature rating will be installed for the power-supply conductors to an appliance marked in accordance with 79.3 and 79.4. Otherwise, it is to be assumed that 60°C (140°F) wire will be used for connection to an appliance rated 100 amperes or less and that 75°C (167°F) wire will be used for an appliance rated more than 100 amperes.

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

13.3.6 A field-wiring terminal shall be restrained from turning or shifting in position by means other than friction between surfaces. This shall be accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug or offset, by a connecting strap or clip fitted into an adjacent part, or by some other equivalent method.

13.3.7 A field-wiring terminal shall be provided with a soldering lug or pressure wire connector firmly bolted or held by a screw.

Exception: A wire binding screw shall not be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor unless upturned lugs, cupped washers or the equivalent are provided to hold the wire in position.

13.3.8 Each upturned lug or cupped washer referred to in the Exception to 13.3.7 shall be capable of retaining a power-supply conductor corresponding in size to that specified in 13.3.2, but not smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

13.3.9 A wire-binding screw at a wiring terminal shall not be smaller than No. 10 (4.8 mm diameter). The threads shall not be finer than that of the national fine thread series for the screw size.

Exception No. 1: A No. 8 (4.2 mm diameter) screw is not prohibited from being used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

Exception No. 2: A No. 6 (3.5 mm diameter) screw is not prohibited from being used for the connection of a 16 or 18 AWG (1.3 mm^2 or 0.8 mm^2) control circuit conductor.

13.3.10 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick.

Exception: A plate is allowed to be not less than 0.030 inch (0.76 mm) thick when the tapped threads have the intended mechanical strength.

13.3.11 There shall not be less than two full threads in the metal of the terminal plate tapped for a wire-binding screw. The metal may be extruded at the tapped hole to provide two full threads.

13.3.12 Field wiring leads provided for connection to the branch-circuit supply shall have an ampacity rating not less than that of a conductor of the next smaller size than that acceptable for the rating of the appliance. See 13.3.3 and 13.3.4. Field wiring leads for connection to the branch-circuit supply shall not be smaller than 18 AWG (0.84 mm^2).

13.3.13 The free length of a lead inside an outlet box or field-wiring compartment shall be 6 inches (152.4 mm) or more.

Exception: This requirement does not apply to field-wiring supply connections enclosed in a motor terminal box or wiring compartment.

13.4 Grounded supply conductor

13.4.1 A permanently connected appliance rated 125 or 125/250 volts (3-wire) or less employing a screw shell lampholder, a single-pole switch, or a single-pole overcurrent-protective device other than an automatic control without a marked off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. (See Section 15, Polarity, and Section 28, Lampholders.)

13.4.2 A field-wiring terminal intended for the connection of a grounded-supply conductor shall be identified by means of a metallic coating that is white in color and shall be easily distinguishable from the other terminals, or proper identification of the terminal for the connection of the grounded conductor shall be clearly shown in some other manner, such as on an attached wiring diagram.

13.4.3 When wire leads are provided instead of terminals, the surface of the lead intended to be connected to the grounded conductor of the supply circuit shall be finished to show white or grey color and shall be easily distinguishable from the other leads.

13.5 Equipment grounding connection

13.5.1 A permanently connected appliance shall be provided with a field-wiring terminal or lead for connection of an equipment-grounding conductor.

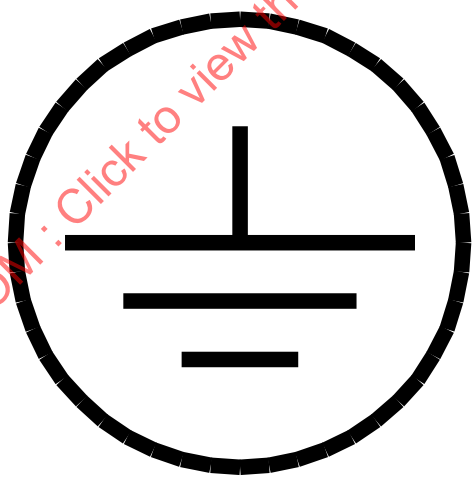
13.5.2 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable for the application. See 13.5.4.

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

13.5.4 A wire binding screw intended for the connection of an equipment grounding conductor shall have a green colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified as such by being marked “G”, “GR”, “GND”, “Ground”, “Grounding”, or the symbol in Figure 13.1 adjacent to the terminal or on a wiring diagram.

Figure 13.1

Grounding symbol



13.5.5 The wire binding screw or pressure wire connector intended for the connection or an equipment-grounding conductor shall be located so that it is not removed during servicing of the appliance.

13.5.6 Sheet metal screws shall not be used for:

a) Field connection of equipment grounding conductors to an enclosure; and

b) Connection of a factory-provided grounding lead to an enclosure.

For the purposes of this requirement, a sheet metal screw is defined as a screw with a thread pitch that exceeds the thickness of the sheet metal and is designed to engage an unextruded, unthreaded hole in the metal.

14 Bonding for Grounding

14.1 All exposed dead metal parts and all dead metal parts inside the enclosure that are exposed to contact during any servicing operation, including maintenance and repair, and that can become energized shall be electrically connected to the equipment-grounding terminal; and to the metal enclosure surrounding a knockout, hole, or bushing provided for field connection of the power supply system. The suitability of this connection shall be determined by the grounding test specified in 48.1.

Exception: A dead-metal part within the enclosure where it is not exposed during user servicing need not be grounded, provided the appliance is marked in accordance with 79.10.

14.2 With reference to the requirements in 14.1, the following dead metal parts are not considered to be parts that can become energized:

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

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

2) Positively separated from all electrical components.

b) A panel or a cover that is insulated from all electrical components by a barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture-resistant insulating material not less than 1/32-inch (0.8 mm) thick and secured in place.

c) A panel or a cover that does not enclose uninsulated live parts and is positively separated from other electrical components.

14.3 The dead metal parts described in 14.1 shall be reliably bonded together by mechanical fasteners or by an individual bonding conductor or strap.

14.4 Bonding shall be by a positive means, such as clamping, riveting, bolted or screwed connections, brazing, or welding. The bonding connection shall penetrate nonconductive coatings such as paint.

14.5 Bonding around a resilient mounting shall not depend on the clamping action of rubber or similar material.

Exception: The clamping action of rubber or similar material meets the intent of bonding when the construction has been shown by investigation to be capable of being used for this purpose. This investigation includes such tests as overload, short-circuit, and aging.

14.6 A bonding conductor shall be of material complying with the requirements for an electrical conductor and protected from corrosion unless inherently resistant to corrosion. An individual bonding conductor or strap shall be installed so that it is protected from mechanical damage.

14.7 Bonding conductors or straps used to provide grounding continuity between stacked ovens are not prohibited from being applied in the field when a marking is provided in accordance with 70.7.

14.8 The size of an individual conductor or strap employed to bond an electrical enclosure or motor frame is to be determined based upon the rating of the anticipated branch-circuit overcurrent protective device for the equipment – see 24.1.3 and 24.1.4 – in accordance with Table 250-95 of the National Electrical Code, ANSI/NFPA 70.

Exception No. 1: A bonding conductor to a motor or other electrical component is not required to be larger than the conductors supplying the motor or other component.

Exception No. 2: A bonding conductor is not prohibited from being smaller than that specified in Table 250-95 if the bonding connection does not open when tested as described in 48.2.1.

Exception No. 3: An equipment grounding conductor is not required to be larger than the circuit conductors supplying the equipment.

14.9 When more than one size branch-circuit overcurrent device is involved, the size of the bonding conductor shall be based on the rating of the overcurrent-protective device intended to provide ground-fault protection for the component bonded by the conductor. For example, the size of a bonding conductor for a motor that is individually protected by a branch-circuit overcurrent device smaller than the overcurrent devices protecting the overall equipment, may be selected on the basis of the overcurrent device intended for ground-fault protection of the motor.

15 Polarity

15.1 When an appliance is connected to a circuit that incorporates a grounded supply (neutral) conductor, the screw shells of lampholders shall be connected:

a) For a permanently connected appliance, to the conductor or terminal intended to be grounded; or

b) For a cord-connected appliance, to the conductor of the supply cord intended to be grounded.

See Section 13, Electrical Supply Connections for Permanently Connected Appliances, and Section 28, Lampholders.

15.2 A fuseholder, a single-pole switch, a single-pole overcurrent-protective device or an automatic control with a marked off position shall be connected to an ungrounded conductor of the supply circuit.

15.3 The screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

15.4 A single-pole overcurrent protective device shall not be connected to the identified grounded (neutral) conductor.

16 Current-Carrying Parts

16.1 The metal employed for a current-carrying part shall be acceptable for the particular application.

16.2 Plated iron or steel is shall not be used for a current-carrying part unless the temperature of that part is higher than 100°C (212°F) during normal operation.

16.3 Unplated iron or steel shall not be used for a current-carrying part.

16.4 Stainless steel and other corrosion-resistant alloys are not prohibited from being used for current-carrying parts regardless of temperature.

17 Attachment-Plug Receptacles

17.1 An attachment-plug receptacle shall be of the grounding type. The grounding contact of the receptacle shall be bonded to the point of connection of the equipment-grounding conductor to the appliance. See Section 48, Grounding and Bonding Test.

17.2 Unless suitable for the fully rated load, a marking shall be provided adjacent to the receptacle specifying the maximum normal load in accordance with 75.8.

17.3 An attachment-plug receptacle is to be treated as a general-use outlet unless it is intended and marked for connection of a part of the appliance or a specific accessory or accessories. See 78.19.

17.4 A permanently connected appliance is not prohibited from being provided with an attachment-plug receptacle rated more than 20 amperes. Unless provided with a dedicated supply source, over-current protection shall be provided as part of the appliance as required by Article 210 of the National Electrical Code, ANSI/NFPA 70.

17.5 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 Internal Wiring

18.1 General

18.1.1 Wire employed for the internal wiring of an appliance shall be acceptable for the application.

18.1.2 Among the factors considered when judging the internal wiring are the temperature and voltage to which it is subjected during normal operation.

18.1.3 Except as noted in 24.5, an appliance shall not employ conductors smaller than 18 AWG (0.81 mm).

Exception No. 1: Short integral leads of small electrical components such as relay coils, clock motors, and indicator lights shall not be smaller than 22 AWG (0.64 mm).

Exception No. 2: The size of conductors is not specified for secondary circuits not involving a risk of fire or electric shock, see 8.1.2 – 8.1.5.

18.1.4 Wiring that is green or green with one or more yellow stripes shall be used only for grounding or bonding conductors, and wiring used for other purposes shall not be so identified.

18.1.5 The internal wiring of an exhaust hood shall not be routed in or through the plenum.

Exception No. 1: This requirement does not apply to wiring enclosed in rigid or liquid-tight flexible metal conduit.

Exception No. 2: This requirement does not apply to wiring routed in metal conduit and connected to a circuit not involving a risk of fire or electric shock, see 8.1.4 – 8.1.6, and which is not a part of a safety circuit.

18.2 Insulation

18.2.1 There is no temperature limit applicable to glass fiber, beads of inorganic material, or the equivalent, employed as conductor insulation.

18.2.2 Internal wiring shall comply with one of the following:

a) Thermoplastic-Insulated Wires and Cables, UL 83;

b) Thermoset-Insulated Wires and Cables, UL 44;

c) Appliance Wiring Material, UL 758;

d) Flexible Cords and Cables, UL 62, types SO, SOW, SOO, SOOW, STO, STOW, STOO, STOOW, SEO, SEOW, SJO, SJOW, SJOO, SJOOW, SJTO, SJTOW, SJTOO, SJTOOW, SJEO, SJEOW, HSO, HSOW, HSOO, HSOOW, HSJO, HSJOW, HSJOO, HSJOOW, or Type G 1 – 4/0 AWG (42.4 – 107.2 mm^2) flexible cable.

18.2.3 Wiring with insulation containing asbestos shall not be used.

18.3 Protection

18.3.1 No wiring shall be located where it must be moved to replace a fuse, operate a circuit-breaker handle, or adjust a manually reset control.

18.3.2 Wiring shall be protected from sharp edges, including screw threads, burrs, fins, and moving parts, that may abrade the insulation on conductors or otherwise damage the wiring. Thermoplastic tape wrapped over a sharp edge does not meet the intent of providing protection against a sharp edge.

18.3.3 An appliance shall be designed so that wires can be pulled through, or the appliance otherwise wired, without damaging the coverings or insulation on the conductors.

18.3.4 A wireway shall be free from burrs and fins. Male screw threads shall not be exposed anywhere inside a raceway or wireway where wire is pulled.

18.3.5 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure of the appliance, shall be provided with a smooth, rounded bushing, or shall have smooth surfaces upon which the wires may bear to prevent abrasion of the insulation (see 18.7).

18.3.6 Wiring shall not be subject to handling during user servicing when such handling could result in reduction of spacings below those required for separation of circuits (see Section 35, Separation of Circuits).

18.4 Wiring in circuits involving a risk of fire or electric shock

18.4.1 The requirements in 18.4.2 – 18.4.10 apply only to wiring in circuits involving a risk of electric shock (see 8.1.2 – 8.1.5).

18.4.2 The wiring and electrical connections between parts of an appliance shall be protected or enclosed, except that a length of flexible cord of a type specified in 18.2.2(d) may be employed for external connections between parts when flexibility is essential. See 18.4.10. Wiring and connections in circuits involving a risk of fire or electric shock (see 8.1.2 – 8.1.5) shall not be subject to handling during user servicing.

18.4.3 With reference to exposure of internal wiring, the protection of wiring required by 18.4.2 is determined to exist, if, when judged as if it were enameled wire, the wiring would be acceptable according to 9.1.3 – 9.1.7.

18.4.4 Internal wiring not protected as specified in 18.4.3, shall be secured within the enclosure so that neither it nor related electrical connections can be subjected to stress or mechanical damage. All wiring

that is accessible to the operator is to be clamped or otherwise secured to prevent it from being unintentionally hooked.

18.4.5 No open wiring – that is wiring that is not separately and immediately enclosed in conduit, armored cable, metal raceway, or a similar location – shall be located where it is contacted during user servicing or cleaning.

18.4.6 Wiring subjected to movement during operation or any user servicing shall be tested in accordance with Section 52, Wiring Endurance Test.

18.4.7 The insulation of internal wiring that is subjected to accumulations of oil or grease, such as that of recirculating system intended for use with a deep-fat fryer or griddle, shall be a type that is not adversely affected under such conditions.

18.4.8 Internal wiring of a recirculating system shall be located so that it is not exposed to the cooking vapors from the protected appliance.

18.4.9 A conductor utilizing beads for insulation shall not be employed outside an enclosure.

18.4.10 A flexible cord used for external interconnection as mentioned in 18.4.2 shall be provided with bushings and strain relief in accordance with 18.6 and 18.7 unless the construction is such that the cord is protected from stress or motion.

18.5 Splices and connections

18.5.1 A splice and a connection shall be mechanically secure and shall provide electrical contact. A soldered connection shall be mechanically secured before being soldered when breaking or loosening of the connection results in a risk of fire or electric shock.

Exception: Printed wiring board joints need not be mechanically secure before soldering.

18.5.2 A soldered lead is mechanically secure when it is:

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

b) Provided with at least one right angle bend when passed through an eyelet or opening; or

c) Twisted with other conductors.

18.5.3 Flexing or movement of internal wiring that occurs during the cooking or cleaning function shall not cause stress on any electrical connection.

18.5.4 A splice shall be provided with insulation equivalent to that on the wires involved.

Exception: This requirement does not apply when permanence of spacing between the splice and other metal parts of the appliance will be maintained.

18.5.5 In determining whether splice insulation consisting of coated-fabric, thermoplastic, or other tubing is capable of being used, consideration is to be given to such factors as its dielectric properties, heat-resistance, and moisture-resistance.

18.5.6 Stranded internal wiring shall be connected to a wire-binding screw or stud-terminal so that no loose strands result.

18.5.7 Compliance with the requirement in 18.5.6 can be accomplished by:

a) Use of pressure terminal connectors, soldering lugs, or crimped eyelets;

b) Soldering all strands of the wire together; or

c) Equivalent means.

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

18.5.9 With reference to 18.5.8, a wire-binding screw or a pressure terminal connector, or other type of connector used as a termination device shall be investigated for use with aluminum under the conditions involved – for example, temperature, heat cycling, and vibration.

18.6 Strain relief

18.6.1 Where required, strain relief shall be provided so that mechanical stress on a flexible cord is not transmitted to terminals, splices, or interior wiring. To determine compliance, the flexible cord shall be tested in accordance with Section 53, Strain Relief Test.

18.6.2 A knot shall not be employed to provide strain relief.

18.6.3 Means shall be provided to prevent the flexible 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 flexible cord or lead to mechanical damage;

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

c) Reducing spacings below the minimum required values; or

d) Damaging internal connections or components.

To determine compliance, the flexible cord or lead shall be tested in accordance with the Push-Back Relief Test, Section 54.

18.7 Bushings

18.7.1 At the point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be substantial, secured in place as intended, and shall have a smooth, rounded surface against which the cord may bear. The heat-resistant properties of a nonmetallic bushing material shall comply with the requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. If the bushing is necessary to meet enclosure requirements of Section 8, Electrical and Fire Enclosures, it shall additionally meet the enclosure requirements of UL 746C.

18.7.2 A smooth, rounded cord hole in wood, porcelain, phenolic composition, or other similar nonconductive material is determined to be the equivalent of a bushing.

18.7.3 Ceramic materials and some molded compositions are generally capable of being used for insulating bushings. Separate bushings of wood, hot-molded shellac-and-tar compositions, or rubber materials are prohibited.

18.7.4 Vulcanized fiber may be employed when the bushing is not less than 3/64-inch (1.2 mm) thick and is formed and secured in place so that it is not adversely affected by conditions of ordinary moisture and temperature.

18.7.5 A separate soft-rubber, neoprene, or polyvinyl chloride bushing is capable of being employed:

a) Anywhere in an appliance when it is used in conjunction with a type of cord for which an insulating bushing is not required and the edges of a hole in which such a bushing is used is free from burrs, fins, and other conditions that can damage the bushing; or

b) In the frame of a motor or in the enclosure of a capacitor attached to a motor when:

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

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

19 Casters

19.1 Recirculating systems shall not be provided with casters.

Exception: A cooking appliance with an integral recirculating system may have casters, provided the casters are used in accordance with the applicable standard for the cooking appliance. See 1.4.

20 Electrical Insulation

20.1 An insulating washer, bushing, lining, barrier, or other similar integral parts of an appliance, and a base or a support for the mounting of live parts, shall be of a moisture-resistant material that is not adversely affected by the temperatures to which it is subjected under conditions of actual use.

20.2 Screws or other fasteners used to mount or support small, fragile, insulating parts, shall not be so tight as to crack or break such parts with expansion and contraction. Such parts are to be slightly loose.

20.3 A material that is used for the direct support of an uninsulated live part shall comply with the Relative Thermal Index (RTI), Hot Wire Ignition (HWI), High-Current-Arc Resistance to Ignition (HAI), and Comparative Tracking Index (CTI) values indicated in Table 20.1. A material is determined to be in direct support of an uninsulated live part when:

a) It is in direct physical contact with the uninsulated live part; and

b) It serves to physically support or maintain the relative position of the uninsulated live part.

Exception No. 1: A generic material provided in the thickness indicated in Table 20.2 is capable of being used for the direct support of uninsulated live parts without additional evaluation.

Exception No. 2: A material without a HWI Performance Level Category (PLC) value, or with an HWI PLC value greater (worse) than the value required by Table 20.1, is not prohibited from being subjected to the end-product abnormal overload test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, as an alternative testing procedure.

Exception No. 3: A material without a HAI PLC value, or with an HAI PLC value greater (worse) than the value required by Table 20.1, is not prohibited from being subjected to the end-product special arcing test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, as an alternative testing procedure.

Exception No. 4: A material that is used in a device not incorporating contacts is not required to comply with the HAI PLC requirements

Exception No. 5: A material that is used in a device that incorporates contacts, and is not used within 1/2-inch (12.7 mm) of the contacts, is not required to comply with the HAI PLC requirements.

Exception No. 6: A material without a CTI PLC value, or with a CTI PLC value greater (worse) than the value required by Table 20.1, is not prohibited from being subjected to the end-product Special Arcing Test specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, as an alternative testing procedure.

Exception No. 7: A material without a CTI PLC value, or with a CTI PLC value greater (worse) than the value required by Table 20.1, is determined to be in compliance with the CTI PLC requirements when:

a) It has a High-Voltage-Arc Tracking (HVTR) PLC value of 1 or less; or

b) The over surface spacings between the uninsulated live parts are at least 1/2-inch (12.7 mm).

Table 20.1
Minimum material characteristics required for the direct support of uninsulated live parts

UL 94 Flame Class	RTI Elec	Performance Level Category (PLC)		
		HWI[b]	HAI[b]	CTI[c]
HB	a	2	1	4
V-2	a	2	2	4
V-1	a	3	2	4
V-0	a	4	3	4

[a] The electrical Relative Thermal Index (RTI) value of a material is to be determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, by test or by use of the generic RTI table. This material characteristic is dependent upon the minimum thickness at which the material is being used and shall not be exceeded during the Normal Temperature Test, Section 45.

[b] The High Current Arc Resistance to Ignition (HAI) and Hot Wire Ignition (HWI) value of a material is to be determined by testing in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. This material characteristic is dependent upon the minimum thickness at which the material is being used.

[c] The Comparative Tracking Index (CTI) PLC value of a material is to be determined by testing in accordance with UL 746A. This material characteristic is not dependent upon the minimum thickness at which the material is being used.

Table 20.2
Generic materials required for direct support of uninsulated live parts

Generic material	Thickness		RTI, °C
	inch	(mm)	
Diallyl Phthalate	0.028	(0.71)	105
Epoxy	0.028	(0.71)	105
Melamine	0.028	(0.71)	130
Melamine-Phenolic	0.028	(0.71)	130
Phenolic	0.028	(0.71)	150
Unfilled Nylon	0.028	(0.71)	105
Unfilled Polycarbonate	0.028	(0.71)	105

Table 20.2 Continued on Next Page

Table 20.2 Continued

Generic material	Thickness inch	Thickness (mm)	RTI, °C
Urea Formaldehyde	0.028	(0.71)	100
Any cold-molded composition (i.e., concrete)	No limit		No limit
Ceramic, Porcelain, and Slate	No limit		No limit
Beryllium Oxide	No limit		No limit
NOTE – Each material shall be used within its minimum thickness, and its Relative Thermal Index (RTI) value shall not be exceeded during the Normal Temperature Test, Section 45.			

20.4 A printed-wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796. A printed wiring board shall be rated V-1 or better.

21 Thermal Insulation

21.1 Thermal insulation shall have a flammability rating of HBF, 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, or shall be tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. Fiberglass insulation is considered to comply with this requirement.

Exception: Thermal insulation which is enclosed in a metal or 5V rated material and is not exposed to electrical parts is not required to possess a flame rating. For the purpose of this requirement, the following components are not to be considered electrical parts:

a) VW-1 wiring;

b) A part enclosed in metal or 5V material; and

c) A component provided with an integral enclosure complying with the enclosure requirements for that component.

21.2 Mineral-wool thermal insulation that contains conductive impurities in the form of slag shall not contact uninsulated live parts.

21.3 A material of asbestos composition shall not be used.

21.4 Insulation shall not be exposed to cooking vapors.

22 Components Located in Grease Airstream

22.1 Blower motors and other electrical components shall not be located in the grease air stream.

Exception No. 1: This requirement does not apply to totally enclosed motors and other electrical components enclosed in a manner equivalent to a totally enclosed motor.

Exception No. 2: This requirement does not apply to motors located in a circuit not involving a risk of fire or electric shock, see 8.1.2 – 8.1.5.

23 Motors and Transformers

23.1 Motors in circuits involving a risk of fire or electric shock

23.1.1 These requirements apply to motors in circuits involving a risk of fire or electric shock. See 8.1.2 – 8.1.5.

23.1.2 A motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1, or the Standard for Overheating Protection for Motors, UL 2111.

23.1.3 A motor shall be capable of being used for its intended application and shall be capable of handling its maximum normal load without creating a risk of fire, electric shock, or injury to persons.

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

23.2 Motor protection

23.2.1 A continuous-duty motor in a permanently connected appliance, an automatically controlled fractional-horsepower motor in an appliance, the motor of an appliance intended to be operated remotely or unattended, a motor – the operation of which or inability to operate is not evident to the operator, and a continuous-duty integral-horsepower motor shall be provided with one of the following types of overload protection:

a) Thermal protection or impedance protection complying with the requirements in the Standard for Overheating Protection for Motors, UL 2111.

b) A suitably rated and connected protective device complying with the requirements for overload relays in the Standard for Industrial Control Equipment, UL 508.

c) Other protection that tests show is equivalent to the protection mentioned in (a).

Exception: A motor that is used for a direct-drive blower or fan is determined to have overload protection when it is protected against locked-rotor conditions only.

23.2.2 Fuses may be used to provide the necessary overload protection when compliance with the requirements is provided by the largest ampere-rated fuse that can be mounted in the fuseholder or when a noninterchangeable fuse is used. The fuse used to provide this protection is not required to be suitable for branch-circuit protection.

23.3 Transformers

23.3.1 Except as noted in 23.3.2, a transformer in a circuit involving a risk of fire or electric shock shall comply with the requirements in the Standard for Specialty Transformers, UL 506, or the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

Exception No. 1: A transformer located within another component (for example, a power supply or temperature control) need not comply with this requirement provided that the overall assembly meets the requirements for that component.

Exception No. 2: A transformer located in a pollution degree 1 or 2 environment (see 34.4) need not comply with this requirement provided that the transformer complies with the requirements in the Standard

for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411.

23.3.2 Neon sign transformers shall comply with the Standard for Neon Transformers and Power Supplies, UL 2161.

24 Short-Circuit and Ground-Fault Protection

24.1 General

24.1.1 When overcurrent protective devices are required by 24.3, 24.4, or 24.5 such devices shall be provided for all ungrounded conductors and have a voltage rating not less than the circuits in which they are used. The devices shall be either:

a) Circuit breakers suitable for branch circuit protection and complying with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489; or

b) Fuses suitable for branch circuit protection, such as Class CC, G, H, J, K, L, RK1, RK5, T, an Edison-base, or a Type S plug fuse.

Exception No. 1: An overcurrent-protective device required by 24.3.2 – 24.3.5 is not required to be suitable for branch-circuit protection when the device meets the requirements of 24.2.

Exception No. 2: Except as required in 24.4, an overcurrent-protective device required by 24.5 is not required to be suitable for branch-circuit protection when the device meets the requirements of 24.2.

Exception No. 3: An overcurrent-protective device is not required in the appliance when it is determined that equivalent or better protection is obtained from the branch-circuit overcurrent-protective device through which the appliance will be supplied, in accordance with 24.1.3 and 24.1.4.

24.1.2 The devices required by this Section (regardless of the type of device used) provide supplementary overcurrent protection, and are not intended to replace the branch-circuit overcurrent-protective device through which the appliance is supplied.

24.1.3 The anticipated current rating of the branch-circuit overcurrent protective device for a permanently-connected appliance is to be 150 percent of the current rating of the appliance. When 150 percent of the appliance current rating does not equal one of the standard overcurrent-protective device ratings (see 24.1.6), the next higher rating for an overcurrent-protective device is to be the anticipated rating.

Exception: When the appliance is marked with a maximum branch circuit overcurrent protective device current rating in accordance with 80.10, the marked rating is the anticipated branch-circuit overcurrent protective device rating. See 24.1.4.

24.1.4 When an appliance is marked with a maximum branch circuit overcurrent protective device rating, the specified rating shall be at least 125 percent of the current rating of the appliance and not higher than the rating calculated in accordance with 24.1.3.

24.1.5 The anticipated rating of the branch circuit overcurrent-protective device for a cord-connected appliance is to be the same as the current rating of the attachment plug.

24.1.6 Standard ampere ratings for overcurrent-protective devices are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 125, 150, 175, 200, 225, 250, 300, 350, and 400.

24.1.7 When a circuit breaker handle is operated vertically, the "up" position shall be the "on" position.

24.1.8 A circuit breaker shall be connected to open all ungrounded conductors of the circuit. Multi-pole circuit breakers shall be the common trip type.

Exception: Single-pole circuit breakers with handle ties, the combination of which complies with the applicable requirements in the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489, are not prohibited from being used as the protection for each ungrounded conductor supplying line-to-line connected loads of a product rated for connection to a circuit of a grounded system.

24.1.9 With respect to the requirements in 24.3 – 24.5, components and wiring in secondary circuits that do not involve a risk of fire or electric shock (see 8.1.2 – 8.1.5) do not require further overcurrent protection in the appliance.

24.2 Supplementary-type overcurrent protective devices used as short-circuit and ground-fault protection

24.2.1 When a supplementary-type overcurrent protective device is used as short-circuit and ground-fault protection, in accordance with the Exceptions to 24.1.1, the device and the appliance in which it is used shall comply with the requirements in 24.2.2 – 24.2.5. See 8.5 and 9.2.

24.2.2 A supplementary overcurrent-protective device as specified in 24.2.1 shall be one of the following:

a) A manual-reset, automatic-trip-free protector complying with the requirements in the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077, for use with motor loads. The device shall have a minimum short-circuit capacity of 1000 A and the following calibration at 77°F (25°C): 100 percent hold, 125 percent/135 percent trip; or

b) A replaceable, supplemental fuse complying with the requirements in the Standard for Low Voltage Fuses – Part 14: Supplemental Fuses, UL 248-14.

24.2.3 When a supplementary-type fuse is used in accordance with 24.2.2, the appliance shall be marked in accordance with 80.10 and 80.11.

24.2.4 A supplementary-type overcurrent-protective device shall not open during the Normal Temperature Test, Section 45.

24.2.5 A supplementary-type overcurrent-protective device shall have a short-circuit rating suitable for the circuit in which it is located. See Table 24.1. When the appliance current rating falls between two values in the table, the larger value is to be used in determining the required short-circuit rating. When different operating conditions of the appliance result in different current ratings, the condition resulting in the maximum total current is to be used as a basis for determining the required short-circuit rating.

Exception: When the maximum available current (including short-circuit current) at the overcurrent protective device is known to be less than the short-circuit rating required by Table 24.1, the short-circuit rating of the overcurrent-protective device need not be higher than the maximum available current.

Table 24.1
Short-circuit ratings of supplementary-type overcurrent protective devices

Rating of appliance, amperes				
Single phase				Short-circuit rating amperes
115 V	208 V	230 – 240 V	277 V	
16 or less	8.8 or less	8.0 or less	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
3 Phase				Circuit capacity amperes
208 V	220 – 240 V	440 – 480 V	550 – 600 V	
3.7 or less	3.5 or less	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

24.3 Protection for circuits including specific components

24.3.1 Auxiliary-Circuit Terminals – An appliance provided with auxiliary-circuit terminals, see Section 25, Auxiliary-Circuit Terminals, shall incorporate an overcurrent-protective device in accordance with 24.4 in each ungrounded conductor to the terminals.

24.3.2 Motor Circuits – A motor circuit in an appliance that is connected to a circuit protected at greater than 20 amperes in accordance with 24.1.3 and 24.1.4 shall be protected by an overcurrent-protective device incorporated in the appliance. The overcurrent-protective device shall have a maximum current rating in accordance with the National Electrical Code, ANSI/NFPA 70, Article 430.

Exception No. 1: A motor protected by an overcurrent-protective device that complies with 24.1.1 and is rated 20 Amps or less is determined to comply.

Exception No. 2: A motor having an inherent thermal protector that complies with the Standard for Overheating Protection for Motors, UL 2111, does not require an additional overcurrent-protective device when, in the appliance, it is connected in series with a branch-circuit overcurrent-protective device of the same type and having a current rating equal to or less than that with which the motor-protector combination was tested during the investigation of the protector.

24.3.3 Transformer Circuits – A transformer circuit in an appliance that is connected to a circuit protected at greater than 20 amperes in accordance with 24.1.3 and 24.1.4 shall be protected by an overcurrent-protective device incorporated in the appliance. The overcurrent-protective device shall have a maximum current rating in accordance with the National Electrical Code, ANSI/NFPA 70, Article 450.

Exception No. 1: Overcurrent protection is not required in the primary of a transformer complying with the requirements for Class 2 transformers in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, or a transformer that is an integral part of a power supply complying with the Standard for Class 2 Power Units, UL 1310, or the requirements for "NEC Class 2" output in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.

Exception No. 2: A transformer located within another component (for example, a power supply or temperature control) does not require an additional overcurrent-protective device when, in the appliance, the component is connected in series with a branch-circuit overcurrent-protective device for which suitability has been determined during the component evaluation.

Exception No. 3: Overcurrent protection is not required in the primary of a transformer complying with the requirements in Section 67, Transformer Burnout Test.

24.3.4 Lampholder Circuits – A lampholder circuit shall have overcurrent protection rated not more than 20 amperes in the appliance. See Section 28, Lampholders.

Exception: This requirement does not apply to a non-replaceable pilot lamp.

24.3.5 Attachment Plug Receptacles – An attachment plug receptacle with a standard NEMA configuration shall have individual (dedicated) overcurrent protection rated not more than the current rating of the receptacle.

Exception No. 1: A duplex 125V, 15A receptacle or multiple 125V, 15A receptacles are not prohibited from being protected at 20A.

Exception No. 2: Multiple 125V, 15A or 20A receptacles are not prohibited from being connected to a single overcurrent-protective device.

24.4 Protection for wiring located outside the enclosure

24.4.1 All internal wiring located outside the appliance enclosure (for example, interconnecting cables), and all output circuits (that is, circuits providing power or control signals to equipment outside the appliance) shall be protected against burnout and damage to the insulation resulting from any overload or short circuit condition that can occur during use of the equipment. See 24.1.9.

24.4.2 The overcurrent protection provided in the primary circuit of a transformer is not protection for the secondary circuit unless it operates to protect the circuit under all overload conditions including short circuit.

24.4.3 A conductor provided with overcurrent protection complying with the National Electrical Code, ANSI/NFPA 70, is determined to comply with 24.4.1. For wiring located in a tapped high-voltage control circuit, a conductor provided with overcurrent protection complying with Table 24.2 is determined to comply with 24.4.1.

Table 24.2
Overcurrent protective device rating for wiring located outside the enclosure

Conductor size, AWG	Maximum rating of overcurrent protective device, amperes	
	Copper	Aluminum[a]
18	7	–
16	10	–
14	45	–
12	60	45
10	90	75
Larger than 10	b	b

[a] Includes copper-clad aluminum.

[b] 300 percent of value specified for 60°C conductors in Table 310-16 of National Electrical Code, ANSI/NFPA 70.

24.4.4 With respect to 24.4.1, additional overcurrent protection is not required for interconnecting cables (cables that connect different portions of the appliance) when the wiring can carry the maximum current available from the power supply or other source without discoloration or softening of insulation. When an

interconnecting cable also supplies an output circuit, the output circuit shall be protected in accordance with 24.4.1.

24.5 Protection for high-voltage control circuits conductors

24.5.1 General

24.5.1.1 These requirements apply to protection of conductors in high-voltage control circuits. Components in these circuits shall be protected in accordance with 24.3. Wiring in these circuits that is located outside the enclosure shall be protected in accordance with 24.4.

24.5.2 Direct-connected high-voltage control circuits

24.5.2.1 Conductors in a direct-connected high-voltage control circuit are not required to be provided with protection within the appliance when the conductors are not smaller than 22 AWG (0.64 mm). For smaller conductors, protection shall be provided in accordance with Table 20.2.

24.5.3 Tapped high-voltage control circuits

24.5.3.1 A control circuit that is tapped from the main power-supply circuit at a point outside the appliance enclosure shall be protected as specified in Column A of Table 430-72(b) of the National Electrical Code, ANSI/NFPA 70.

24.5.3.2 A tapped high-voltage control circuit conductor shall be provided with overcurrent protection. The rating of the overcurrent-protective device or devices shall not exceed the applicable value specified in Table 24.3.

Exception No. 1: A 18, 16, or 14 AWG (0.82, 1.3, or 2.1 mm, respectively) conductor within the appliance enclosure that does not exceed 4 feet (1.2 m) in length between points of opposite polarity is sufficiently protected by an overcurrent-protective device rated 60 amperes or less.

Exception No. 2: An overcurrent-protective device of a higher rating than specified in Table 24.1 or a conductor smaller than specified Table 24.2 may be used provided the conductor complies with the requirements specified in Short-Circuit Tests, Section 50.

Exception No. 3: A lead within the appliance enclosure and 12 inches (304.8 mm) or less in length need not be provided with overcurrent protection, and the size of such a lead is not specified.

Exception No. 4: A control circuit conductor supplied from the secondary of a single phase transformer that is connected so that only a 2-wire (single voltage) secondary is used, may be protected by an overcurrent-protective device or devices located on the primary side of the transformer provided this protection:

a) Complies with the requirements for protection of transformer circuits, 24.3.3; and

b) Does not exceed the applicable value specified in Table 24.3, multiplied by the ratio of secondary to primary rated transformer voltage.

Table 24.3
Overcurrent-protective device rating for control circuit conductors

Control circuit conductor size AWG (mm^2)	Maximum rating of overcurrent-protective device, amperes Conductors contained in control equipment enclosure	
	Copper	Aluminum[a]
18 (0.82)	25	–
16 (1.3)	40	–
14 (2.1)	100	–
12 (3.3)	120	100
10 (5.3)	160	140
Larger than 10	b	b

[a] Includes copper-clad aluminum.

[b] 400 percent of value specified for 60°C conductors in Table 310-17 of the National Electrical Code, ANSI/NFPA 70.

25 Auxiliary-Circuit Terminals

25.1 Auxiliary-circuit terminals shall comply with the requirements for field-wiring terminals. See 16.3 and 16.4.

25.2 Operation of an overcurrent-protective device shall not interfere with the functioning of an auxiliary circuit unless it also opens the heating-element circuit or causes the circuit to be opened.

26 Capacitors

26.1 A capacitor shall be housed within an enclosure or container that protects the plates against mechanical damage and that prevents the emission of flame or molten material resulting from capacitor failure. The container shall be of metal providing the strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm).

Exception: The individual container of a capacitor is not prohibited from being:

a) Sheet metal having a thickness less than that mentioned above; or

b) Material other than metal, when the capacitor is mounted within the enclosure of the unit.

26.2 When the container of an electrolytic capacitor is metal, the container shall be considered a live part and shall be provided with moisture-resistant electrical insulation to isolate it from dead metal parts and to prevent contact during servicing operations. The insulating material shall be not less than 0.028 inch (0.71 mm) thick except as indicated in Section 33, Insulating Barriers.

26.3 A capacitor employing a liquid dielectric medium more combustible than askarel shall be protected against expulsion of the dielectric medium when tested in accordance with the applicable performance requirements of this standard, including faulted overcurrent conditions based on the circuit in which it is used. See Breakdown of Components Test, Section 51.

26.4 Across-the-line and line bypass (line to ground) capacitors shall be subjected to the Dielectric Voltage-Withstand Test, Section 46.

Exception: A capacitor that complies with the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414, is not required to be subjected to this test.

27 Switching Devices

27.1 General

27.1.1 These requirements apply to controls that perform any switching function, either automatically or manually controlled, such as switches, relays, contactors, thermostats, thermal cutoffs, and circuit breakers. They do not apply to a switching device in secondary circuits as described in 29.3 – 29.8 when:

a) The circuit in which the switching device is located is not a safety circuit;

b) The switching device does not have a marked "off" position and is not used as part of the circuit to disconnect power when a switch with a marked "off" position is turned to the "off" position; and

c) The switching device is not part of the circuit to disconnect power under any of the conditions in 27.4.1 – 27.4.4.

27.1.2 All manually operated or adjustable switching devices shall be of the indicating type. The indicating means shall be incorporated on the device or knob, on an attached plate, or on the panel on which the device is mounted.

27.1.3 With reference to 27.1.2, the "on – off" function of a filament or signal lamp is not prohibited from being used as a means of indication when all of the following conditions are met:

a) It is operated at rated voltage; or, for a component with a rated voltage within one of the voltage ranges specified in 75.3, it is operated within that voltage range; and

b) It has an estimated life at the operating voltage of not less than 20,000 hours.

Exception: A neon lamp is not required to demonstrate estimated life.

27.1.4 With reference to 27.1.2 and 27.4, a switching device that has only "on" and "off" positions is not prohibited from being provided with the international symbols "I" and " O " to signify "on" and "off" when the significance of these symbols is explained in the instructions packaged with the appliance.

27.1.5 With respect to switching devices controlling heating functions, "no heat," "cold," “O” and the like are considered to be "off" markings.

27.1.6 When a switching device with a marked "off" position is mounted such that movement of the operating handle is vertical, the lower position shall be the "off" position.

Exception: This requirement does not apply to a switching device having two or more positions in addition to the "off" position, such as a double-throw switch.

27.1.7 A switching device shall be judged with respect to the temperature limitations of the materials employed.

27.2 Electrical ratings

27.2.1 A switching device shall have a current and voltage rating not less than that of the load that it controls when the appliance is operated as described in the Normal Temperature Test, Section 45.

27.2.2 The current rating of a switching device that controls a solenoid, a magnet, a transformer, an electric-discharge-lamp ballast, or any inductive load other than a motor shall be at least twice the rated full-load current of the component that it controls, unless the switch has been found acceptable for the control of an inductive load at least equal to the rated full-load current of the component.

27.2.3 A switching device that controls a motor shall:

a) Have a current rating at least twice the rated full load current of the motor and comply with the requirements in Section 69, Motor Switch Overload Test; or

b) Have a motor rating (full-load/locked rotor amps or horsepower) at last equivalent to the load.

27.2.4 A switching device that controls a screwshell-type lampholder or another tungsten-filament load shall:

a) Have a tungsten-filament lamp rating at least equivalent to the rating of the anticipated load, but not less than 25W;

b) Have a current rating equivalent to at least six times the rating of the anticipated load, but not less than 150 W, for alternating-current circuits; or

c) Have a current rating equivalent to at least ten times the rating of the anticipated load, but not less than 250 W, for direct-current circuits.

Exception: This requirement does not apply to pilot or indicating lamps, or to lampholders for pilot or indicating lamps.

27.2.5 A switching device controlling any combination of a tungsten-filament load, a motor or other inductive load, and a resistive load, shall have a current rating at least equal to the sum of any ratings required by 27.2.2 – 27.2.4, as applicable, and the rated current of the resistive load.

27.2.6 A switching device provided as part of an appliance intended to be connected to a power-supply circuit involving a potential to ground of more than 150 volts shall be acceptable for the maximum potential to ground of the circuit. See 75.4.

27.3 Guarding

27.3.1 A switching device shall be located or protected so that it is not subjected to mechanical damage when used.

27.3.2 When unintentional operation of a switching device results in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such unintentional operation does not occur.

27.3.3 With reference to the requirement in 27.3.2, a switch that is located or guarded so that it cannot be turned on by moving a 2 inch diameter sphere at any angle to the switch or actuator is capable of being used.

27.3.4 The actuator of a switch is allowed to be guarded by recessing, ribs, barriers, or similar means.

27.4 Specific applications

27.4.1 A manually operated motor-control switching device with a marked "off" position shall be provided in a cord-connected appliance that employs a motor rated more than 1/3 horsepower (250 W output). See 27.1.4.

27.4.2 A manually operated motor-control switching device with a marked "off" position shall be provided for any motor that drives a moving part that is capable of injuring a person. See 27.1.4. This switch shall be visible and legible from any anticipated user location.

27.4.3 An automatically reset protective device shall not be employed when automatic resetting results in injury to a person.

27.4.4 The requirement in 27.4.3 necessitates the use of an interlock (See Section 11, Interlocks) in an appliance when moving parts are capable of causing injury to a person upon the automatic restarting of a motor.

28 Lampholders

28.1 A lampholder intended to be connected to a power-supply circuit without a grounded supply conductor shall be located so that a tool is required to change the lamp. The marking specified in 80.9 shall be provided. When a grounded supply conductor is provided, the connection of the lampholder shall comply with the requirements in Section 13, Electrical Supply Connections, and Section 15, Polarity.

Exception: A lampholder is not required to be located so that a tool is required to change the lamp when the lampholder is constructed so that no live parts of the lampholder or the lamp exposed to contact by the accessibility probe shown in Figure 9.3 during relamping.

28.2 When a medium-base or smaller screwshell type lampholder is connected to a circuit with a potential higher than 125V, the marking in 80.3 shall be provided.

28.3 For a screwshell type lampholder, when compliance with 28.1 is dependent upon the type of lamp used (for example, the length or taper of the lamp), the appliance shall be marked in accordance with 80.4.

Exception: The appliance is not required to be marked when all standard lamps intended for the lampholder either:

a) Comply with 28.1; or

b) Do not fit into the space provided.

28.4 A screw shell lampholder for an infrared lamp shall be:

a) Of the unswitched medium-base type; and

b) For use with a 300-watt or smaller lamp.

Exception: A lamp-and-lampholder combination is not required to comply with the requirement when acceptable temperatures are attained on all of the components in the normal temperature test, and when the switching mechanism of a switched lampholder has been investigated and found to meet the applicable requirements.

28.5 A lampholder screw shell of a cord-connected appliance shall not operate at a potential of more than 150 volts to ground. See 75.4.

Exception No. 1: This requirement does not apply to a lampholder for a pilot light or indicating lamp.

Exception No. 2: This requirement does not apply to a lampholder that is constructed so that no live parts of the lampholder or the lamp are exposed to contact by the accessibility probe shown in Figure 9.3 during relamping.

28.6 A lampholder that is exposed to moist vapors during operation of the protected appliance shall not employ a paper liner.

29 Secondary Circuits

29.1 General

29.1.1 Each secondary circuit shall comply with the requirements for line-voltage circuits.

Exception: A secondary circuit is not required to comply with the requirements for line-voltage circuits when all of the following conditions are met:

a) The circuit is not a safety circuit;

b) The circuit complies with the requirements for one of the types of secondary circuits referenced in 29.1.3; and

c) The circuit is separated from other circuits as required in Section 35, Separation of Circuits.

Such circuits shall comply with the requirements in 29.2 for each type of circuit.

29.1.2 A secondary circuit is a circuit that is isolated at all points from the primary branch circuit. This isolation shall be provided by means of a transformer, optical isolator, limiting impedance, electromechanical relay, or power switching semiconductor as described in 31.3.

29.1.3 The following secondary circuits shall comply with the requirements in 29.3 – 29.8:

a) Class 2 circuit (See 29.3);

b) Limited voltage/current circuit (See 29.4);

c) Limited voltage circuit (See 29.5);

d) Limited energy circuit (See 29.6);

e) Limiting impedance circuit (See 29.7); and

f) Safety extra-low voltage (SELV) circuit (See 29.8).

Note: It is possible that the same circuit will meet the requirements for more than one of the above types of circuits.

29.1.4 An overview of the secondary circuits listed in 29.1.3 is given in Table 29.1. This table is for comparison purposes only; special cases and exceptions are not shown.

Table 29.1
Comparison of secondary circuits

Circuit name	Derived directly from component evaluated to standard	Requires isolating transformer or equivalent[a]	Maximum available voltage, Vac/dc[b] (Vmax)[c]	Maximum available current, A	Maximum rated current, A	Maximum rated power, VA	Maximum available power, VA	Requires electrical spacings to ground or enclosure	Needs an electrical enclosure	Paragraph reference
Class 2	UL 5085-1 and UL 5085-3, UL 1310, or UL 60950-1	Yes	0 to 20	8	5	5xVmax	250[f]	No	No	29.2.1, 29.3
			over 20 to 30	8	100/Vmax	100				
			over 30 – 60, dc only	150/Vmax	100/Vmax	100				
Limited voltage/current	UL 506, UL 5085-3, UL 1310, UL 1411, or UL 60950-1	Yes	0 to 20	8	5	5xVmax	250f	No	Yes	29.2.1, 29.4
			over 20 to 30	8	100/Vmax	100				
			over 30 – 60, dc only	150/Vmax	100/Vmax	100				
Limited voltage	UL 506, UL 5085-3, UL 1310, UL 1411, or UL 60950-1	Yes	0 to 30	N/A	N/A	N/A	N/A	No	Yes	29.2.2, 29.5
Limited energy	UL 506, UL 5085-3, UL 1310, UL 1411, or UL 60950-1	Yes	0 to 100	N/A	N/A	N/A	200	Yes	Yes	29.2.3, 29.6
Limiting impedance	N/A	No	N/A	N/A	N/A	N/A	15 watts	No	No[e]	29.2.4, 29.7
Safety extra-low voltage (SELV)[a]	UL 60950-1	Yes	0 to 30 over 30 – 60, dc only	N/A	N/A	N/A	N/A	N/A	Yes	29.2.5, 29.8

[a] UL 60950-1 supply must be isolating type to meet requirements for above circuits requiring isolating transformer.

[b] Voltage ranges shown are for sinusoidal AC and continuous direct current. For non-sinusoidal AC, Vmax (peak) shall be no greater than 1.414 x the rms voltage shown.

[c] Vmax = Maximum output voltage, including open circuit.

[d] Available power downstream of limiting impedance.

[e] See 29.2.4(c).

[f] Non-inherently limited.

29.1.5 Any part that exceeds 121°C (250°F) during the Normal Temperature Test, Section 45, is to be identified as involving a risk of fire when evaluating the equipment in accordance with Section 8, Electrical and Fire Enclosures, regardless of the circuit in which it is located.

29.1.6 Moving parts are to be evaluated with regard to their potential for personal injury regardless of the circuit in which they are located.

29.1.7 When a secondary circuit is connected to the frame of the appliance, the connection shall be made at only one point in the appliance or system.

Exception: A Class 2 circuit (see 29.3) and a Limited Voltage/Current Circuit (see 29.4) are not prohibited from being connected to the frame at more than one point.

29.1.8 Secondary circuits shall comply with the requirements for Short-Circuit and Ground-Fault Protection, Section 24.

29.1.9 A waveform is considered to be direct-current (dc) when the amplitude of the voltage ripple is not more than 10 percent of the peak voltage.

29.1.10 Where separate voltage values are given for rms and peak voltages, both values shall apply to nonsinusoidal waveforms, with the exception of direct-current (dc) waveforms. See 29.1.9.

29.2 Evaluation of the different types of secondary circuits

29.2.1 The following applies to secondary circuits that comply with the requirements for Class 2 circuits (see 29.3) or limited voltage/current circuits (see 29.4):

a) Lithium batteries shall be evaluated in accordance with Section 30, Lithium Battery Circuits. All other components located within these circuits are not required to be evaluated.

b) Spacings located within these circuits and from these circuits to earth ground or to the enclosure are not required to be evaluated. However, spacings from these circuits to other circuits shall comply with Section 35, Separation of Circuits.

c) Except as stated in 29.1.5 and 29.1.6, these circuits are not determined to be a risk of fire, electric shock, or injury to persons when evaluating an appliance in accordance with Section 8, Electrical and Fire Enclosures. Class 2 circuits are not prohibited from being accessible from outside the enclosure or during user servicing. Limited voltage/current circuits shall not be accessible from outside the enclosure or during user servicing.

d) With reference to 29.1.7, these circuits are capable of being used for multiple frame connections, and the frame is not prohibited from use as the return for these circuits.

29.2.2 The following applies to secondary circuits that comply with the requirements for limited voltage circuits (see 29.4):

a) Lithium batteries shall be evaluated in accordance with Section 30, Lithium Battery Circuits. Printed-wiring boards shall be evaluated in accordance with the Standard for Printed-Wiring Boards, UL 796, and shall be rated V-2 or better. Internal wiring shall be evaluated in accordance with Section 18, Internal Wiring. All other components located within these circuits are not required to be evaluated.

b) Spacings located within these circuits and from these circuits to earth ground or to the enclosure are not required to be evaluated. However, spacings from these circuits to other circuits shall be in accordance with Section 35, Separation of Circuits.

c) These circuits shall not be accessible from outside the enclosure or during user servicing. When these circuits provide power to components that extend through the enclosure (such as displays, keypads, and the like), then the ability of these components to serve as an enclosure shall be evaluated.

29.2.3 The following applies to secondary circuits that comply with the requirements for limited energy circuits (see 29.6).

a) Lithium batteries shall be evaluated in accordance with Section 30, Lithium Battery Circuits. Printed-wiring boards shall be evaluated in accordance with the Standard for Printed-Wiring Boards, UL 796, and shall be rated V-2 or better. Wiring shall be evaluated in accordance with Section 18, Internal Wiring. Motors shall be evaluated in accordance with the requirements in Section 23, Motors and Transformers. The effects of heat generating power components on adjacent components such as printed-wiring boards and wiring shall be evaluated in accordance with the requirements in Section 45, Normal Temperature Test. All other components located within these circuits are not required to be evaluated.

b) Spacings located within these circuits are not required to be evaluated. However, spacings from these circuits to earth ground or to the enclosure, and spacings from these circuits to other circuits, shall be in accordance with Section 35, Separation of Circuits.

c) These circuits shall not be accessible from outside the enclosure or during user servicing. When these circuits provide power to components that extend through the enclosure (such as displays, keypads, and the like), then the ability of these components to serve as an enclosure shall be evaluated.

29.2.4 The following applies to secondary circuits that comply with the requirements for limiting impedance circuits (see 29.7):

a) Lithium batteries shall be evaluated in accordance with Section 30, Lithium Battery Circuits. All other components located within these circuits are not required to be evaluated.

b) Spacings located within these circuits, and from these circuits to earth ground or to the enclosure, are not required to be evaluated. However, spacings from these circuits to other circuits shall be in accordance with 29.4.

c) Except as stated in 29.1.5 and 29.1.6, these circuits are not determined to be a risk of fire, electric shock, or injury to persons when evaluating an appliance in accordance with Section 8, Electrical and Fire Enclosures. These circuits are not prohibited from being accessible from outside the enclosure or during user servicing.

Exception: Circuits supplied from a limiting impedance that has not been evaluated for operation under single-fault conditions, as allowed by Exception No. 1 to 29.7.2, are determined to be a risk of fire/electric shock, and shall not be accessible from outside the enclosure or during user servicing. When these circuits provide power to components that extend through the enclosure (such as displays, keypads, and similar components), then the ability of these components to serve as an enclosure shall be evaluated.

d) With reference to 29.1.7, these circuits are not prohibited from being used for multiple frame connections, and the frame is not prohibited from use as the return for these circuits.

Exception: Circuits supplied from a limiting impedance that has not been evaluated for operation under single-fault conditions, as allowed by Exception No. 1 to 29.7.2, shall be connected to the frame at not more than one point. The frame shall not be used as the return for these circuits.

29.2.5 The following applies to secondary circuits that comply with the requirements for safety extra-low voltage circuits (see 29.8):

a) Lithium batteries shall be evaluated in accordance with Section 30, Lithium Battery Circuits. Printed-wiring boards shall be evaluated in accordance with the Standard for Printed-Wiring Boards, UL 796, and shall be rated V-2 or better. Internal wiring shall be evaluated in accordance with Section 18, Internal Wiring. All other components located within these circuits are not required to be evaluated.

b) Spacings located within these circuits and from these circuits to earth ground or to the enclosure are not required to be evaluated. However, spacings from these circuits to other circuits shall be in accordance with Section 35, Separation of Circuits.

c) These circuits shall not be accessible from outside the enclosure or during user servicing. When these circuits provide power to components that extend through the enclosure (such as displays, keypads, and the like), then the ability of these components to serve as an enclosure shall be evaluated.

29.3 Class 2 circuits

29.3.1 A Class 2 circuit shall be supplied by an isolating source that complies with one of the following:

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

b) The requirements for Class 2 transformers in the Standard for Class 2 and Class 3 Transformers, UL 5083-3; or

c) The requirements for "NEC Class 2" output in the Standard for Information Technology Equipment – Safety – Part 1, UL 60950-1.

29.4 Limited voltage/current circuits

29.4.1 A limited voltage/current circuit shall be supplied by an isolating source (for example, the secondary winding of an isolating type transformer) such that the maximum open circuit voltage potential available to the circuit is not more than 30 V rms/42.4 V peak, or 60 V dc, when tested in accordance with the Maximum voltage test 71.2, and the current available is limited to a value not exceeding the values shown in Table 29.1 when tested in accordance with the Maximum current test for inherently limited circuits, 71.3. The maximum volt-ampere capacity available to the circuit shall be 200 volt-amperes or less when measured in accordance with the Maximum power test, 71.6.

Exception: The Maximum Current Test is not required when a secondary circuit protective device is used to limit the available current as specified in 29.4.3.

29.4.2 The rated current for a limited voltage/current circuit shall not exceed the values in Table 29.1.

29.4.3 When a secondary fuse or other such secondary circuit protective device is used to limit the available current in accordance with 29.4.1, it shall be rated in accordance with Table 29.2.

Table 29.2
Rating for fuse or circuit protective device

Maximum available voltage (rms)[a]	Amperes
0 – 20	5.0
Over 20 – 30	100/V[b]

[a] Includes open circuit voltage.

[b] V is defined as the maximum available rms voltage, including open circuit voltage.

29.4.4 When a primary circuit protective device is used to limit the available current in accordance with 29.4.1, there are no restrictions on the current rating of the protective device as long as it limits the available secondary current in accordance with Table 29.2.

29.4.5 A fuse used in accordance with 29.4.3 or 29.4.4 shall be one of the following:

a) A noninterchangeable fuse;

b) The largest fuse that fits in the fuse holder provided; or

c) Not subject to user servicing, see 5.44(b).

29.4.6 When a protective device is used as specified in 29.4.3 or 29.4.4, the device shall comply with the requirements of this Standard and shall be provided with an adjacent replacement marking in accordance with 80.10. The printed-wiring board, wiring, and spacings prior to the point at which the voltage and current are limited shall comply with the requirements for primary circuits.

29.4.7 When a fixed impedance (such as a component or grouping of components in the same circuit) or a regulating network (such as used in a switching type power supply) is provided to limit the voltage and/or the available current in accordance with 29.4.1, the fixed impedance or regulating network shall function to limit the voltage and current to the values given in 29.4.1 under single component fault conditions when tested in accordance with the Component failure test, 71.5.

29.5 Limited voltage circuit requirements

29.5.1 A limited voltage circuit shall be supplied by an isolating source (for example, the secondary winding of an isolating type transformer) that complies with all of the following:

a) The maximum open circuit voltage potential available to the circuit shall not be more than 30 V rms/42.4 V peak, or 60 V dc, without any limitation on the available current or volt-ampere capacity, when tested in accordance with the Maximum voltage test, 71.2; and

b) These circuits shall be used only in a pollution degree 1 or 2 environment.

29.6 Limited energy circuits

29.6.1 A limited energy circuit shall be supplied by an isolating source (for example, the secondary winding of an isolating transformer). The maximum volt-ampere capacity available to the circuit shall be 200 volt-amperes or less when measured in accordance with the Maximum power test, 71.6. The maximum open circuit voltage potential shall be 100 V ac when measured in accordance with the Maximum voltage test, 71.2.

29.6.2 When a primary or secondary circuit fuse or other circuit protective device is used to limit the maximum available volt-ampere capacity in accordance with 29.6.1, the protective device shall comply with the requirements for branch circuit or supplementary overcurrent protective devices and shall be provided with an adjacent replacement marking in accordance with 80.10. There are no restrictions on the current rating of the protective device, when it limits the available secondary volt-amperes in accordance with 29.6.1. The printed-wiring board, wiring, and spacings prior to the point at which the voltage and volt-ampere capacity are suitably limited shall comply with the requirements for primary circuits.

29.6.3 A fuse used in accordance with 29.6.2 shall be one of the following:

a) A noninterchangeable fuse;

b) The largest fuse that fits in the fuseholder provided; or

c) Not subject to user servicing, see 5.44(b).

29.7 Limiting impedance circuits

29.7.1 A limiting impedance circuit shall be supplied by an impedance that complies with the following:

a) The calculated power dissipation of the impedance, when tested in accordance with the Power dissipation test, 71.7, shall be less than or equal to the power rating of the impedance; and

b) The maximum available power immediately downstream of the impedance shall be less than or equal to 15 W when tested in accordance with the Limited power point determination test, 71.4.

Exception No. 1: The calculated power dissipation of the impedance, when tested in accordance with the Power Dissipation Test, is not required to be less than or equal to the power rating of the impedance when the impedance does not open or short while the circuit is subjected to the Component failure test, 71.5.

Exception No. 2: The Limited Power Point Determination Test is not required when one or both of the following conditions exist:

a) There is an additional 10,000-ohm or more series impedance in a circuit in which the voltage is 125 V or less; or

b) There is an additional 20,000-ohm or more series impedance in a circuit in which the voltage is more than 125 V, but not more than 250V.

29.7.2 The limiting impedance referred to in 29.7.1 shall limit the available power to 15 W under single component fault conditions, when tested in accordance with the Component failure test, 71.5.

Exception No. 1: When the circuit that is limited by the impedance is enclosed, the impedance is not required to limit the available power to 15 W under single component fault conditions.

Exception No. 2: A single resistor or resistors serving as a limiting impedance are determined to comply with this requirement without further investigation.

Exception No. 3: A single capacitor serving as a limiting impedance is determined to comply with this requirement without further investigation only when the capacitor complies with requirements in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414.

29.8 Safety extra-low voltage circuits

29.8.1 A safety extra-low voltage circuit shall be supplied by an isolating power source complying with the requirements in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, for a safety extra-low voltage (SELV) power supply, and shall be located only in a Pollution Degree 2 or cleaner environment. See 34.4.

30 Lithium Battery Circuits

30.1 A lithium battery circuit is a primary or secondary circuit that obtains power from lithium batteries.

30.2 A lithium battery circuit shall comply with the following:

a) The requirements in the Standard for Lithium Batteries, UL 1642; and

Exception: A circuit that obtains power solely from a lithium battery (for example, a circuit in which the lithium battery serves as the sole power source as opposed to serving as a back up power source) is not required to be subjected to the requirements in UL 1642.

b) The primary circuit requirements in this Standard or with the requirements for Secondary Circuits, Section 29.

31 Isolating Devices

31.1 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 equal to 1000 V plus twice rated voltage between the input and output circuits.

31.2 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 1000 V plus twice rated voltage for 1 minute.

31.3 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.

32 Electrical Spacings

32.1 General

32.1.1 Other than as noted in 32.1.2 – 32.1.10, spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part, shall not be less than specified in Table 32.1 and Table 32.2.

Exception No. 1: As an alternative approach to the spacing requirements specified in Table 32.1, clearances and creepage distances may be evaluated in accordance with the requirements in Section 34, Clearance and Creepage Distances.

Exception No. 2: For other than providing isolation between different circuits or in a safety circuit, spacings between traces of different potential on a printed-wiring board are not required to comply with Table 32.1 when:

a) The printed-wiring board has a flammability rating of V-0;

b) The printed-wiring board base material has a minimum Comparative Tracking Index (CTI) of 100 volts; and

c) The equipment complies with the Printed-Wiring Board Abnormal Operation Test, Section 70.

Table 32.1
Minimum spacings other than at field-wiring terminals

Potential involved, volts	Minimum spacings, inch (mm)[a]			
	Over surface		Through air	
0 – 50	1/16	(1.6)	3/64	(1.2)
51 – 125	3/32	(2.4)	1/16	(1.6)
126 – 250	1/8	(3.2)[b,c]	3/32	(2.4)[b,c]
	5/32	(4.0)[b,d]	1/8	(3.2)[b,d]
251 – 480	1/4	(6.4)[b]	5/32	(4.0)[b]
481 – 600	3/8	(9.5)[b,e]	1/4	(6.4)[b]

[a] At heating elements, these spacings shall not be less than 1/16-inch up to 300 volts.

[b] Enameled wire is to be considered as if it were an uninsulated live part. However, 3/32-inch and greater spacings over surface and through air are acceptable between dead metal parts and enameled wire that is rigidly supported and held in place on a coil.

[c] Between uninsulated live parts and grounded metal.

[d] Between uninsulated live parts of opposite polarity.

[e] At heating elements this spacing shall not be less than 1/4-inch.

Table 32.2
Minimum spacings at field-wiring terminals

Parts involved	Minimum spacings, inch (mm)[a]			
	0 – 250 volts		251 – 600 volts	
	Through air	Over surface	Through air	Over surface
Between live parts of opposite polarity; and between a live part and a dead metal part other than the enclosure	1/4 (6.4)	3/8 (9.5)	3/8 (9.5)	1/2 (12.7)[b]
Between a live part and the enclosure	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)	1/2 (12.7)

[a] These spacings do not apply to connecting straps or buses extending away from wiring terminals; such spacings are judged under the requirements in Table 32.1.

[b] A spacing of not less than 3/8-inch, over surface, is capable of being used at wiring terminals in a wiring compartment or terminal box that is integral with a motor.

32.1.2 The acceptability of the inherent spacings of a component, such as a switch or motor, shall be based on the requirements that cover the component.

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

32.1.4 Enameled wire is considered to be an uninsulated live part when determining compliance with the spacing requirements in this standard.

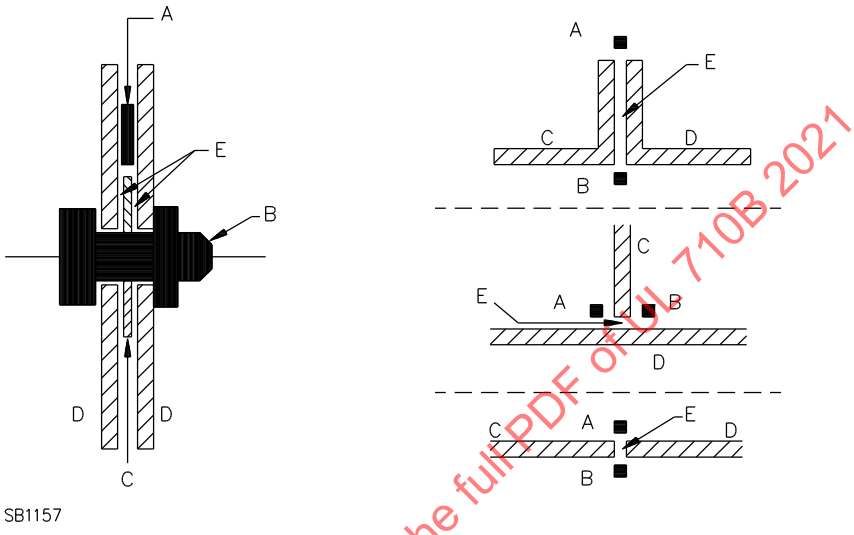
32.1.5 With reference to Table 32.1 and Table 32.2, the measurement of spacings over surface shall include the walls of a groove wider than 5/64-inch (2.0 mm).

32.1.6 Insulating barriers used in lieu of the required spacings shall comply with Section 33, Insulating Barriers.

32.1.7 In the case of a clamped insulating joint, see Figure 32.1, spacings are to be measured through cracks unless the cracks are sealed. Adhesives, cements, sealants, and the like, are used to effect a seal shall comply with the Standard for Polymeric Materials – Used in Electrical Equipment Evaluations, UL 746C.

Figure 32.1

Clamped joint



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Parts A, B – Live parts of opposite polarity, or a live part and grounded metal part with spacing through the crack between C and D shall not be less than required in 32.1.7.

Parts C, D – Insulating barriers.

Part E – The clamped joint.

32.1.8 The spacing from the wire of an open wire heating element to the cover shall not be less than 1/8-inch (3.2 mm).

Exception: At closed-in points only, such as the screw-and-washer construction of an insulated terminal mounted in metal, in an appliance rated 250 volts or less, spacings shall not be less than 3/64-inch (1.2 mm).

32.1.9 The spacing through air between an uninsulated live part and an enclosure panel when tested as described in Section 55, Strength of Enclosures, Frames, and Guards Test, shall not be less than:

a) One-half inch (12.7 mm) for a flat panel having an unsupported area greater than 1 square foot (929 cm^2).

b) 1-1/2 inches (38.1 mm) at a knockout or conduit opening.

c) The minimum through-air spacing between an uninsulated live part and dead metal for other areas.

Exception: This requirement does not apply to the inherent spacing between an uninsulated live part of a component complying with 3.1 and an enclosure panel on which the component is mounted.

32.1.10 At terminal screws and studs to which connection can be made in the field by means of wire connectors, eyelets, or similar means as described in 13.3.1, spacings shall not be less than specified in Table 32.1 with such connecting means in position.

32.2 Secondary circuits

32.2.1 Requirements for primary circuit spacings apply to secondary circuits.

Exception: The requirements for primary circuit spacings do not apply to circuits where all of the following conditions are met:

a) The circuit is not a safety circuit;

b) The circuit complies with the requirements for one of the types of secondary circuits referenced in 29.1.3; and

c) The circuit is separated from other circuits as required in Section 35, Separation of Circuits.

Such circuits shall comply with the requirements in 32.2 for each type of circuit.

33 Insulating Barriers

33.1 Insulating materials used as a barrier in lieu of the required spacings per 32.1 and used as specified in 33.3 – 33.5 shall:

a) Comply with Section 20, Electrical Insulation; and

b) Be at least 0.028 inch (0.71 mm) thick.

Exception No. 1: A material that complies with Section 20 is not required to comply with the thickness limit in 33.1(b) when it can withstand a 5000 V ac dielectric voltage-withstand test in accordance with the internal barrier requirements in the Standard for Polymeric Materials – Use In Electrical Equipment Evaluations, UL 746C without breakdown.

Exception No. 2: A material that complies with Section 20 and is used in addition to not less than one-half the required through air spacings not required to comply with 33.1(b); however, it shall be at least 0.013 inch (0.33 mm) thick. Material utilizing this Exception shall:

a) Have the required mechanical strength when subjected to mechanical damage;

b) Be held in place; and

c) Be located so that it is not adversely affected by operation of the equipment in service.

33.2 The requirements in 33.1 are independent of each other. For example, when a material is determined to comply with Section 20, Electrical Insulation, at a thickness less than that required by 39.1, the material still needs to be provided at a thickness in accordance with 33.1.

33.3 The insulating material shall comply with the requirements in 33.1 when:

a) The material is in direct physical contact with an uninsulated live part;

b) The material serves to physically support or maintain the relative positive position of the uninsulated live part; and

c) The material is used as a barrier in lieu of the required over surface or through air spacings, or both.

33.4 Insulating material that meets the following criteria shall also comply with the requirements in 33.1:

a) The material is in direct physical contact with an uninsulated live part;

b) The material does not serve to physically support or maintain the relative position of the uninsulated live part; and

c) The material is used in lieu of the required over surface or through air spacings, or both.

Exception: A generic insulating material included in Table 33.1 is capable of being used for this application without additional evaluation.

33.5 Insulating material shall also comply with the requirements in 33.1 when:

a) The material is not in direct physical contact with an uninsulated live part;

b) The material does not serve to physically support or maintain the relative position of that uninsulated live part; and

c) The material is used in lieu of the required through air spacings.

Exception No. 1: A generic insulating material specified in Table 33.1 is capable of being used for this application without additional evaluation.

Exception No. 2: A material that is located at least 1/32 inch (0.8 mm) from uninsulated live parts is not required to comply with the HWI, HAI, or CTI PLC requirements.

Exception No. 3: A material that is located at least 1/2-inch (12.7 mm) from uninsulated live parts is not required to comply with either the HWI, HAI, or CTI PLC requirements or with the RTI requirement.

Exception No. 4: Vulcanized fiber not less than 1/64-inch (0.4 mm) thick is capable of being used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Table 33.1
Generic materials suitable for use as a barrier

Generic material[a]	Minimum thickness		RTI, °C
	Inch	(mm)	
Aramid Paper	0.010	(0.25)	105
Cambric	0.028	(0.71)	105
Electrical Grade Paper	0.028	(0.71)	105
Epoxy	0.028	(0.71)	105
Mica	0.006	(0.15)	105
Mylar (PETP)	0.007	(0.18)	105
RTV	0.028	(0.71)	105
Silicone	0.028	(0.71)	105
Treated Cloth	0.028	(0.71)	105
Vulcanized Fiber	0.028	(0.71)	105

[a] Each material shall have at least the minimum thickness specified, and its Relative Thermal Index (RTI) value shall not be exceeded during the Temperature Test.

34 Clearance and Creepage Distances

34.1 As an alternative approach to the spacing requirements specified in Section 32, Electrical Spacings, and other than as noted in 34.2 and 34.3, clearances and creepage distances may be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, as described in 34.4.

34.2 Clearances between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable, shall comply with 32.1.9. The clearances shall be determined by physical measurement.

34.3 The clearance and creepage distance at field wiring terminals shall be in accordance with the requirements in Section 32, Electrical Spacings.

Exception: When the design of the field wiring terminals is such that it precludes the possibility of reduced spacing due to stray strands or improper wiring installation, clearance and creepage distances at the field wiring terminal shall be evaluated in accordance with either Section 32, Electrical Spacings, or the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

34.4 When conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, the following guidelines shall be used:

a) Unless specified elsewhere in this Standard, the pollution degree shall be pollution degree 3;

b) A component that is located within an electrical enclosure without ventilation or other unplugged openings. and is not subjected to grease or steam during cooking or cleaning, is determined to be in a pollution degree 2 environment;

c) A component that is located within an electrical enclosure that includes ventilation or other unplugged openings is determined to be in a pollution degree 2 environment when:

1) All electrical parts of the component, except terminals, are wrapped, encapsulated, or enclosed to prevent contact with dust, accumulated grease, or similar matter;

2) The component is not located within 2 inches (50.8 mm) of any unplugged opening; and

3) The component is not subjected to grease or steam during cooking or cleaning.

d) Pollution degree 2 is determined to exist on a printed-wiring board between adjacent conductive material which is covered by any coating which provides an uninterrupted covering over at least one side and the complete distance up to the other side of conductive material;

e) Any printed-wiring board which complies with the requirements in the Standard for Printed-Wiring Boards, UL 796, shall be determined to provide a Comparative Tracking Index (CTI) of 100, and when it further complies with the requirements for Direct Support in UL 796 then it shall be determined to provide a CTI of 175;

f) For the purposes of compliance with the requirements for coatings of printed-wiring boards used to achieve pollution degree 1 in accordance with UL 840, a coating which complies with the requirements for Conformal Coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is determined to be capable of being used;

g) Pollution degree 1 is also capable of being achieved at a specific printed-wiring board location by application of at least a 1/32-inch (0.79 mm) thick layer of silicone rubber or for a group of printed-wiring boards through potting, without air bubbles, in epoxy or potting material;

h) Evaluation of only clearances, to determine equivalence with current through air spacings requirements, shall be conducted in accordance with Clearance A (Equivalency) of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840. An impulse test potential having a value as determined in UL 840 is to be applied across the same points of the device as required for the Dielectric Voltage-Withstand Test, Section 46;

i) Evaluation of clearances and creepage distances shall be conducted in accordance with the requirements in UL 840 for Clearance B (Controlled Overvoltage), and Creepage Distances;

j) The phase-to-ground rated system voltage used in the determination of clearances shall be the equipment rated supply voltage rounded to the next higher value (in the table for determining clearances for equipment) for all points on the supply side of an isolating transformer or the entire product when no isolating transformer is provided. The system voltage used in the evaluation of secondary circuitry shall be interpolated with interpolation continued across the table for the Rated Impulse Withstand Voltage Peak and Clearance; and

k) Determination of the dimensions of clearance and creepage distances shall be conducted in accordance with the requirements for measurement of clearance and creepage distances in UL 840.

35 Separation of Circuits

35.1 Circuits shall be separated or segregated such that the spacings required by 32.1.1 are maintained.

35.2 A factory installed conductor shall be separated by a barrier or segregated, as specified in 35.3, from:

a) A factory installed conductor used in a different circuit unless the conductors of both circuits are insulated for the maximum voltage of either circuit; and

b) An uninsulated live part connected to a different circuit.

35.3 Segregation of a conductor shall be accomplished by clamping, routing, or equivalent means that provides permanent separation from a conductor or an uninsulated live part of a different circuit.

35.4 A conductor shall be provided with strain relief in accordance with 18.6 when stresses on the conductor cause the conductor to move such that compliance with 35.2 is not maintained.

35.5 An appliance shall be constructed so that a field installed conductor of any circuit is segregated as specified in 35.7 and 32.1.1, or separated by a barrier (see 35.6) from:

a) A field-installed conductor connected to any other circuit unless:

1) Both circuits are Class 2 or Class 3, or both circuits are other than Class 2 or Class 3; and

2) The conductors of both circuits are insulated for the maximum voltage of either circuit;

b) An uninsulated live part of any other circuit; and

c) A factory-installed conductor connected to any other circuit, unless the conductors of both circuits are insulated for the maximum voltage of either circuit.

Exception: Field-installed conductors are not required to be segregated or separated by a barrier when specific installation instructions are included that explain the proper procedure to be followed to install the equipment to achieve required separation.

35.6 With respect to 35.5, when the intended uses of the device are such that in some applications a barrier is required while in other applications no barrier is required, a removable barrier or one having openings for the passage of conductors is not prohibited from being employed. Instructions for the use of such a barrier are to be a permanent part of the device.

35.7 Field-installed conductors may be segregated from each other and from uninsulated live parts or factory-installed conductors of the industrial control equipment connected to different circuits by arranging the location of openings in an enclosure for the various field installed conductors with respect to the terminals or other uninsulated live parts and factory or field installed conductors so that a minimum permanent 1/4-inch (6.4 mm) separation is provided.

36 Gas-Tube Signs

36.1 A gas-tube sign (for example, neon) employed as part of an appliance shall comply with the requirements in the Standard for Electric Signs, UL 48.

37 Fire Extinguishing System Unit

37.1 A fire extinguishing system unit shall be provided and shall include all required wiring, piping, and discharge port(s) oriented for proper operation. The recirculating system shall have provisions for the following:

a) External visibility of the pressure gauge or other device to indicate the proper charge pressure for the stored pressure type extinguishing system units; and

Exception: For vending machines, visibility is only required after the front access door is open.

b) Removal of the fire extinguishing system cylinder assembly and pressurizing cartridge (if provided) for maintenance and recharging.

Exception: Hoods for the following types of appliances are not required to be provided with a fire extinguishing system:

a) A system intended for use with an appliance other than a deep fat fryer, which has an enclosed cooking compartment and is marked in accordance with 78.10;

b) A conveyor style oven that is intended for use with pizza and other bakery products that is marked in accordance with 78.10 and 78.11; or

c) A warming cabinet that does not exceed 212°F (100°C) in the food holding area and is marked in accordance with 78.10.

37.2 In addition to the appliance discharge nozzle(s), sufficient fire extinguishing discharge nozzles shall be installed to extinguish any fire which occurs in any grease filter, grease filtration or odor filtration units and within the exhaust duct of the system.

37.3 In addition to any other fire extinguishing system actuation device, there shall be a fire extinguishing system actuation device installed downstream of any electrostatic precipitator (ESP).

37.4 When tested as described in Section 61, Fire Extinguishment Tests, the extinguishing system unit shall detect and suppress the fire.

37.5 An appliance that develops a fire outside of the cooking area during the Fire Extinguishment Tests, Section 61, shall be provided with one or more extinguishing discharge nozzles within the affected areas.

37.6 When required by 37.5, nozzles provided outside plenum area shall not be required to be installed. All nozzles shall be supplied with the appliance and uninstalled nozzles shall be provided with Instructions for proper field installation.

37.7 The fire extinguishing system unit shall comply with the applicable requirements of the Standard for Dry Chemical Extinguishing Systems, NFPA 17 or the Standard for Wet Chemical Extinguishing Systems, NFPA 17A and the requirements specified in the Standard for Pre-Engineered Dry Chemical Extinguishing System Units, UL 1254, the Standard for Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment, UL 300, or applicable requirements for other systems.

37.8 The extinguishing system shall include a suitable interlock (pressure switch or other device) that is electrically connected to the protected appliance so that actuation of the fire extinguishing system will result in immediate shutdown of the cooking appliance heat source. When a pressure switch is used to meet this requirement, it shall be located in the pressure tank or as close to the tank as practical.

37.9 The interlock specified in 37.8 shall comply with requirements for interlocks, Section 11, Interlocks, except the Interlock Endurance Test is to be conducted for a minimum of 6000 cycles.

37.10 Cord-connected integral recirculating systems, and permanently connected integral recirculating systems with casters, shall be provided with means for manual actuation of the fire extinguishing system. The actuation means shall be located in an area where it is readily accessible in the event of a fire on the cooking surface of the appliance. Such means shall be mechanical and shall not rely on electrical power for actuation. See 82.5.

Exception No. 1: A vending machine is not prohibited from having an accessory cover for the manual actuation means, to prevent malicious operation of the extinguishing system, provided that the following conditions are met:

a) The cover shall be removable with simple tools;

b) The appliance shall comply with the requirements in this Standard both with and without the cover in place;

c) The manual-actuation means shall be accessible, without removing the cover, when the main service door is open; and

d) The appliance shall be marked in accordance with 78.14.

Exception No. 2: A primary electrical means for manual actuation may be used if a battery backup system is provided. The battery backup system shall be provided with a visible means to indicate the condition of the battery. The battery backup system shall incorporate means to restrict the operation of the cooking appliance if the battery voltage drops below the minimum operating voltage of the backup system. See Manual Operation Test, Section 63.

37.11 The actuation means required by 37.10 for a floor supported appliance, shall be located between 42 inches to 60 inches (1066.8 mm to 1524 mm) above the floor.

37.12 When a permanently connected appliance is provided with an integral manual actuation means for the fire extinguishing system, the actuation means shall comply with 37.10 and 37.11.

37.13 The torque created by the actuation of the manual actuation means described in 37.10 – 37.12 shall not cause the unit to topple or move with the appliance at an angle of 10 degrees from the vertical.

37.14 A recirculating system shall have provision for connection of a remote manual actuation means for the fire extinguishing system and shall be marked in accordance with 78.13.

Exception: An appliance provided with an integral manual actuation means is not required to be marked in accordance with 78.13.

38 Fire Actuated Damper Assemblies

38.1 A fire-actuated damper shall be provided as part of the recirculating system, and it shall comply with all of the following requirements:

a) A fire-actuated damper shall be installed at the exhaust outlet of the system.

b) A fire actuated damper assembly employing replacement parts, such as fusible links, shall be accessible without the use of special tools.

c) The load on a fusible link used in a fire actuated damper assembly shall be in accordance with the intended use of the fusible link.

d) The fusible link shall be rated maximum 141°C (286°F) and located in the air stream.

Exception: When the fusible link is rated over 141°C (286°F) or the fusible link is not located in the air stream (e.g. behind an obstruction), the damper shall comply with the Damper fire actuation test, 60.4.

e) A spring and a bearing used in the assembly of a fire actuated damper shall be of material having strength and resistance to atmospheric corrosion equivalent to an alloy containing not less than 85 percent copper or Type 302 or 430 stainless steel. In addition, a spring shall be of a material having spring properties equivalent to stainless steel conforming to the Standard Specification for Stainless Steel Spring Wire, ASTM A313/A313M.

f) The materials used in the fire actuated damper assembly shall comply with Section 40, Hood Materials. The combination of metals used in the assembly of a damper shall not cause galvanic action that may impair the function of any part of the assembly.

Exception: The materials used for the dampers are not required to comply with Section 40, Hood Materials when the damper complies with the Standard for Fire Dampers, UL 555.

g) A fire actuated damper assembly shall comply with the Damper Tests, Section 60.

Exception: These requirements do not apply to an appliance that is not provided with a fire extinguishing system in accordance with the Exception to 37.1.

39 Hood Assembly

39.1 Openings in the grease air stream enclosure provided for passage of extinguishing system unit piping to the discharge nozzle(s) or for passage of electrical conduit shall be provided with fittings that comply with the Standard for Grease Ducts, UL 1978.

39.2 The grease air stream enclosure shall have a liquid tight continuous external weld.

Exception: External seams and joints made with a fastening means other than a liquid tight continuous weld may be employed in hoods that have been subjected to the Fire Extinguishment Tests, Section 61, with no evidence of the passage of grease, smoke, flame, or vapor through the joint.

39.3 Gasket and sealant materials used in an exhaust hood, a damper assembly, and fittings for hood penetrations, that are exposed to cooking smoke and vapor shall be subjected to the Physical and Immersion Tests for Gaskets and Seals, Section 65.

Exception: This requirement does not apply to a sealant used for aesthetics.

39.4 All closure panels that are opened or removed and encompass airflow Sections shall have interlocks that de-energize the heat source for the cooking appliance when the panels are not in place. The interlocks shall comply with Section 11, Interlocks.

39.5 Lighting fixtures located above the cooking surfaces or in the hood area shall comply with the Standard for Luminaires, UL 1598 requirements for Luminaires for use above cooking equipment.

40 Hood Materials

40.1 The hood and other parts of an exhaust hood that serve to confine or convey the exhaust products, including dampers and structural parts, shall be made of materials equivalent in strength and fire resistance to Type 302, 304, or 430 stainless steel not less than 0.037 inch (0.94 mm) or steel not less than 0.043 inch (1.09 mm) thick. Internal ferrous metal parts of the hood shall be made of one of the 300 or 400 series of stainless steel or provided with corrosion protection.

41 Hood Airflow

41.1 A manually resettable device(s) rated at 6,000 cycles or an automatically resettable device(s) rated at 100,000 cycles, and for use as a safety interlock that is covered by the Standard for Limit Controls, UL 353, shall be provided after the last filter component to disable the heating portion of the cooking appliance, if the airflow through the hood drops 25 percent below the system's normal operating flow or 10 percent below the minimum airflow that will capture smoke and grease laden air (see 57.3), whichever is lower. When an automatically resettable device(s) is used, it shall be part of a manually resettable circuit.

42 Filters

42.1 Electrostatic precipitator

42.1.1 When the hood section includes an electrostatic precipitator (ESP), it shall comply with the Standard for Electrostatic Air Cleaners, UL 867.

42.1.2 The power supply for an ESP shall be one in which the voltage falls off as the current draw increases, such as a ferro resonant type transformer.

42.1.3 An appliance that utilizes an ESP shall include a sensor that deactivates the heating portion of the cooking appliance when the ESP performance is not as designed, and also when power to the ESP is lost for more than 2 minutes. This shall be a manual reset device or circuit, and shall comply with the requirements for Interlocks, Section 11.

42.2 Passive air filters

42.2.1 A passive air filter shall comply with the Standard for Air Filter Units, UL 900 (Rated Class I or Class II).

42.3 Odor filters

42.3.1 An odor filter shall comply with the Standard for Air Filter Units, UL 900 (Rated Class I or Class II).

Exception: This requirement does not apply to a charcoal filter that does not ignite during the Fire Extinguishment Tests, Section 61.

42.4 Grease filters

42.4.1 A grease filter complying with the Standard for Grease Filters for Exhaust Ducts, UL 1046, shall be included as the first filter (in the direction of the airflow), and all grease captured shall drain into a container that does not have more than a 1 quart (0.95 l) capacity. A mesh filter shall not be used as a grease filter.

42.4.2 Overflow of grease containers shall not result in a risk of fire or in grease contacting uninsulated electrical parts or internal wiring.

42.4.3 The grease filter shall be installed at an angle not less than 45 degrees from the horizontal and shall be tight fitting.

42.5 Filter interlocks

42.5.1 The grease filter and each filter, including electrostatic precipitators, and odor filters shall be provided with an interlock to determine if the filter is in place and positioned as intended. When the filter is not in place or not positioned as intended, the interlock shall de-energize the heat source for the cooking appliance.

Exception: Secondary filters and filter assemblies (i.e., not nearest to the cooking area) not employed during the Emission test in Section 59 are not required to be interlocked.

42.5.2 The interlocks required by 42.5.1 shall comply with the requirements in Section 11, Interlocks.

42.6 Ozone generators

42.6.1 An ozone generator installed in or for connection to the exhaust duct system shall comply with the following:

a) Ozone generated by UV lights shall comply with the Outline for Ultraviolet Radiation Systems for Use in the Ventilation Control of Commercial Cooking Operations, UL 710C.

b) Ozone generated by high voltage electric fields shall comply with the applicable requirements in the Standard for Electrostatic Air Cleaners, UL 867.

PERFORMANCE – ELECTRICAL TESTS

43 General

43.1 An integral recirculating system shall be tested with each representative cooking appliance model with which it is intended to be used. The integral recirculating system shall be subjected to the applicable tests in the appropriate standard for the cooking appliance, see 1.4, except as modified or superseded by the requirements in this Section.

43.2 A non-integral recirculating system shall be tested with each representative cooking appliance with which it is intended to be used. The tests in Sections 43 – 55 are to be conducted with the recirculating system/hood at the minimum height relative to the appliance. See 78.8.

43.3 The performance of an appliance shall be investigated by subjecting the required number of samples to all the applicable tests described in Sections 37 – 73. Insofar as is practical, the tests shall be conducted in the order in which they are presented.

43.4 An appliance intended for operation on direct current as well as on alternating current is to be tested with a direct current supply. An appliance intended for operation at more than one frequency is to be tested at the most adverse frequency. Where the most adverse frequency is not obvious, more than one test may be needed.

43.5 Unless otherwise specified, the test voltage is to be the higher of the following:

a) The marked voltage rating; or

b) The highest voltage of the applicable range of voltages specified in Section 75, General, when the marked voltage is within one of the voltage ranges specified in Section 75.

43.6 Appliances containing parts that are removable without the use of tools are to be tested in the worst case condition (i.e., with or without the removable part).

44 Power Input Test

44.1 The power or current input to a recirculating system shall not differ from the marked rating by more than +5 or −10 percent, when the appliance is connected to a supply of rated frequency and voltage. See Section 75, General.

44.2 To determine whether an appliance complies with the requirement in 44.1, the power input is to be measured with the appliance at the intended operating temperature under full-load conditions and while connected to a power-supply circuit of rated voltage and frequency. An appliance rated for a voltage range, such as 110 – 120 volts, is to be tested at the mean of the range.

44.3 In addition to the test required by 44.1 and 44.2, the following tests are to be conducted when applicable. Provisions for connection to the source of supply are to be evaluated based upon the rated input current or power, or upon the input current or power measured during these tests, whichever is higher. See 13.3.2 and 24.1.4.

a) When the marked voltage rating of an appliance falls within a voltage range mentioned in 75.3, the input is to be determined at the maximum voltage of the range.

b) When an appliance is rated in watts only, and not in amps, the current input to the appliance is to be measured with the voltage adjusted to cause the appliance to operate at rated wattage.

44.4 When an appliance incorporates a receptacle connected to the same electrical source as that supplying the appliance, which is not intended as a disconnecting means for any part of the appliance, and which is capable of being used as a general-use receptacle, the added load that the receptacle imposes on the appliance – 80 percent of the current rating of the receptacle – and its supply connection shall be taken into consideration when conducting the tests in 44.1 – 44.3.

Exception: When the receptacle is marked for a specific load in accordance with 78.19, the marked load is to be used in calculating the total power or current input.

45 Normal Temperature Test

45.1 General

45.1.1 When a recirculating system is tested under the conditions described in 45.4 and 45.5:

a) The temperature at the heat responsive element shall not exceed the applicable requirements of the Standard for Heat Responsive Links for Fire-Protection Service, UL 33, and the Standard for Automatic Sprinklers for Fire-Protection Service, UL 199;

b) The air temperature at the extinguisher unit shall not exceed the maximum storage temperature for the extinguishing system unit;

c) The temperature at any point shall not adversely affect any materials employed in the appliance; and

d) Temperature rises shall not exceed those specified in Table 45.1 at any time during the test.

Exception: A short length of flexible cord exposed to a temperature higher than the temperature rating of the cord, such as at terminals, but not in a strain relief or similar location where dependence is placed on the mechanical properties of the insulation, is acceptable if supplementary heat-resistant insulation of dielectric strength and temperature rating is employed on the individual conductors of the cord that protects the conductor insulation against deterioration.

Table 45.1
Maximum acceptable temperature rises

	Materials and components	°C	(°F)
1.	Any point within a terminal box or wiring compartment of a permanently connected appliance in which field-installed conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with 79.3.	35	(63)
2.	Any point on a surface adjacent to an appliance, including the surface on which the appliance is mounted[a,b]	65	(117)
3.	Fuses[c]	65	(117)
4.	Vulcanized fiber used as electrical insulation or as a cord bushing.	65	(117)
5.	Wood or other combustible material.	65	(117)
6.	Class 105(A) insulation systems on windings of a relay or a solenoid:		
	Thermocouple method	65[d]	(117)[d]
	Resistance method	85	(153)
7.	Class 105(A) insulation systems on transformers:		
	Thermocouple method	65	(117)
	Resistance method	75	(135)
8.	Class 105(A) insulation systems on a vibrator coil – thermocouple or resistance method.	75	(135)
9.	Class 105(A) insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 inches (178 mm)[e] and of a d-c and a universal motor[f]:		
	A. In an open motor:		
	Thermocouple method	65[d]	(117)[d]
	Resistance method	75	(135)
	B. In a totally enclosed motor:		
	Thermocouple method	70[d]	(126)[d]
	Resistance method	80	(144)
10.	Class 105(A) insulation systems on coil windings of an a-c motor – not including a universal motor – having a frame diameter of 7 inches (178 mm)[e] or less – thermocouple or resistance method:		
	A. In an open motor	75[d]	(135)[d]
	B. In a totally enclosed motor	80	(144)
11.	Class 130(B) insulation systems on coils of relays, solenoids or transformers:		
	Thermocouple method	85[d]	(153)[d]

Table 45.1 Continued on Next Page

Table 45.1 Continued

	Materials and components	°C	(°F)
	Resistance method	105	(189)
12.	Class 130(B) insulation systems on a vibrator coil – thermocouple or resistance method.	95	(171)
13.	Class 130(B) insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 inches (178 mm)[e] and of a d-c and a universal motor[e]		
	A. In an open motor:		
	Thermocouple method	85[d]	(153)[d]
	Resistance method	95	(171)
	B. In a totally enclosed motor:		
	Thermocouple method	90	(162)
	Resistance method	100	(180)
14.	Class 130(B) insulation systems on coil windings of an a-c motor – not including a universal motor – having a frame diameter of 7 inches (178 mm)[e] or less – thermocouple or resistance method:		
	A. In an open motor	95[d]	(171)[d]
	B. In a totally enclosed motor	100	(180)
15.	Class 155(F) insulation system on coil windings of an ac motor having a frame diameter of 7 inches (178 mm)[e] or less (not including a universal motor) – thermocouple or resistance method:		
	A. In an open motor	120[d]	(216)[d]
	B. In a totally enclosed motor	125	(225)
16.	Class 155(F) insulation systems on coils of relays, solenoids or transformers		
	Thermocouple method	110	(198)
	Resistance method	120	(216)
17.	Class 180(H) insulation system on coil windings of an ac motor having a frame diameter of 7 inches (178 mm)[e] or less (not including a universal motor) – thermocouple or resistance method:		
	A. In an open motor	135[d]	(243)[d]
	B. In a totally enclosed motor	140	(252)
18.	Class 180(H) insulation systems on coils of relays, solenoids or transformers		
	Thermocouple method	125	(225)
	Resistance method	135	(243)
19.	Phenolic composition employed as electrical insulation or relied upon to prevent a hazardous condition[g].	125	(225)
20.	A copper conductor (bare or insulated) without a nickel coating or similar protection.	125	(225)
21.	Termination of a copper conductor and a pressure terminal connector without a nickel coating or other similar protection.	125	(225)
22.	Insulated wire or cord	25°C (77°F) less than its temperature rating	
23.	Sealing compound	40°C (104°F) less than its melting point	
24.	On the surface of a capacitor casing:		
	Electrolytic	40[f]	(75)[f]
	Other types	65[h]	(117)[h]
25.	Silicon components[i]	75	(135)
26.	At any point on the inside surfaces of a storage cabinet or drawer.	65[j]	(117)[j]

Table 45.1 Continued on Next Page

Table 45.1 Continued

Materials and components	°C	(°F)
27. Any component or material not specifically identified in 1 – 26	k	k

[a] The surface on which a floor-mounted, permanently connected appliance is mounted may have a maximum temperature of 125°C (225°F) if the appliance is marked as specified in 78.5, and if the manufacturer's base specified in that paragraph is acceptable for the purpose and available with the appliance.

[b] This temperature limit does not apply to surfaces, including the supporting surface, surrounding a stationary appliance marked as specified in 78.6. This temperature limit does not apply to the supporting surface of a floor-mounted, permanently connected, fixed oven employing roll-in racks and/or using the floor to complete the oven cavity when the appliance is marked in accordance with 78.6.

[c] A fuse that has been investigated and found acceptable for use at a higher temperature may be used at that temperature.

[d] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by means of a thermocouple may be higher than the maximum specified by the following amount, if the temperature rise of the coil measured by the resistance method is not higher than the maximum specified.

Items	Additional Temperature Rise
7 and 10(A)	15°C (27°F)
11(A) and 10	5°C (9°F)
14(A)	20°C (36°F)
15(A) and 16	10°C (18°F)

[e] See 23.1.4.

[f] The temperature rise on insulating material integral with the enclosure of an electrolytic capacitor that is integral with or attached to a motor shall not be higher than 65°C (117°F).

[g] The limitation on phenolic does not apply to a compound that has been investigated and found to have acceptable heat-resistant properties.

[h] A capacitor that operates at a temperature rise of more than 65°C (117°F) may be judged on the basis of its marked temperature limit.

[i] Does not apply to a component that has been rated by the component manufacturer for a higher temperature.

[j] Temperatures on a surface marked in accordance with 78.5 are not required to be limited to this temperature.

[k] The maximum acceptable temperature rise of any component shall not exceed the temperature limit of the component minus 25°C.

45.1.2 Integral recirculating systems shall not exceed the temperature limits specified in Table 45.1 during the Normal Temperature Test of the Standard for Commercial Electric Cooking Appliances, UL 197, or the Temperature Test of the Standard for Vending Machines, UL 751, as applicable.

45.1.3 When evaluating components and wiring in secondary circuits, the requirements in 29.2 shall apply. When any component exceeds 121°C (250°F), see 29.1.5.

45.1.4 All values in Table 45.1 are based on an assumed ambient temperature of 25°C (77°F), but a test may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). When the operation of an automatic thermal control during the test limits the temperatures under observation, no temperature higher than 25°C (77°F) plus the specified maximum rise is acceptable.

45.1.5 A thermal or overcurrent-protective device for a motor shall not open the circuit during the Normal Temperature Test, Section 45.

45.2 Surface temperatures

45.2.1 During the temperature test, the temperature of a surface that is contacted by the user shall not be more than the value specified in Table 45.2. The results of a test that is conducted at a room temperature of other than 25°C (77°F) are to be corrected to 25°C (77°F).

Exception: The temperature of a surface marked in accordance with 77.3 is not prohibited from exceeding the values specified in Table 45.2.

Table 45.2
Maximum surface temperatures

Location or type of surface	Composition of surface[a]			
	Metallic		Nonmetallic	
	°C	(°F)	°C	(°F)
Handle or knob grasped for lifting, carrying, or holding	50	(122)	60	(140)
Handle or knob contacted, but not involving lifting, carrying, or holding; other surfaces subject to contact in operation and user maintenance	60	(140)	85	(185)
External surfaces other than as noted above	70	(158)	95	(203)

[a] A material, other than metal, that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is judged as a nonmetallic part.

45.3 Test equipment

45.3.1 Supply conductors used for the normal temperature test of a permanently connected appliance shall have an ampacity of at least 125 percent of the current input of the appliance when tested in accordance with the Power Input Test, Section 44, and shall have a temperature rating in accordance with the temperature marking on the appliance. See 13.3.4 and 79.3 – 79.5.

45.3.2 Temperatures are to be measured by thermocouples except as indicated in 45.3.7. The thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). The thermocouples and related instruments are to be accurate and are to be calibrated in accordance with good laboratory practice. The thermocouple wire is to conform to the requirements specified in the Initial Calibration Tolerances for Thermocouples table in 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.

45.3.3 Whenever referee temperature measurements are necessary, thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer-type indicating instrument are to be used.

45.3.4 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material the temperature of which is being measured. In most cases, thermal contact results from securely taping or cementing the thermocouple in place; when a metal surface is involved, brazing, soldering, or welding the thermocouple to the metal may be necessary.

45.3.5 The temperature of a coil or winding is to be measured by means of thermocouples applied at points accessible to a mercury bulb thermometer. When determining the accessibility of the various parts of a coil, the enclosure is to be disregarded. This limitation on thermocouple location is intended to prevent insertion of the thermocouple into cracks of the coil assembly.

45.3.6 For the thermocouple-measured temperature of a coil of an alternating-current motor – other than a universal motor – having a frame diameter of 7 inches (178 mm) or less, item 10 in Table 45.1, the thermocouple is to be mounted on the integrally applied insulation of the conductor.

45.3.7 When the coil is inaccessible for mounting thermocouples – for example, an encapsulated coil or when the coil wrap includes thermal insulation or more than 1/32-inch (0.8 mm) of cotton, paper, rayon, or similar insulation – the change-of-resistance method is to be used.

45.3.8 When using the change-of-resistance method, the windings are to be at room temperature at the start of the test. The temperature rise of a winding is to be calculated from the formula:

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

in which:

t is the temperature rise in °C;

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

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

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

t_2 is room temperature at the end of the test in °C; and

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

45.4 Procedure

45.4.1 To determine whether an appliance complies with the temperature requirements, the appliance is to be mounted or supported as in actual service and tested under conditions approximating those of normal operation. Temperatures are to be measured on nearby surfaces, on the supporting surface, at points of support, and at other points as required. Operation is to continue until temperatures stabilize.

45.4.2 Except as specified in 45.4.4, 45.4.6 and 45.4.7, a cord-connected appliance is to be supported on a horizontal, softwood surface covered with two layers of white tissue paper. It is to be placed in a wall angle of 90 degrees (test corner) formed by two black-painted, vertical surfaces of a minimum 3/8-inch (9.5 mm) thick (trade size) plywood, having width and height such that they extend not less than 2 feet (610 mm) beyond the physical limits of the appliance. The appliance is to be located as closely to the sides of the test corner as its construction permits and it is to be located so that maximum heating of the walls occurs.

45.4.3 A permanently connected appliance that is designed to rest on a horizontal surface, such as a floor, bench, or shelf, in normal service is to be tested as described in 45.4.2.

45.4.4 An appliance intended to be built-in and an appliance intended to be mounted to a wall or under a cabinet or shelf is to be placed in a test enclosure representative of the intended installation. The test enclosure is to be constructed of minimum 3/8-inch (9.5 mm) (trade size) thick plywood. Internal surfaces and other surfaces exposed to the appliance are to be painted flat black. The appliance is to be mounted at the minimum clearances allowed by the appliance construction.

Exception: An appliance that is intended to be rigidly mounted so that the clearance between it and adjacent surfaces is not likely to change during use or user servicing, and that is marked in accordance with 78.5, is to be located in the test corner with clearances as specified in the marking.

45.4.5 An appliance intended for permanent connection to the source of supply and for use in arrangements that involve horizontally or vertically adjacent installation of equipment is to be tested to represent such installation. The various appliances and arrangements are to be considered and tests are to include combinations judged to produce the highest temperatures within the equipment, on the adjacent alcove walls, and on the supporting surface. Additional tests may be required to cover various possible

configurations. Except as specified in 45.4.6 and 45.4.7, surfaces surrounding the equipment are to be constructed of a minimum trade size 3/8-inch thick black-painted plywood.

45.4.6 A stationary or fixed appliance marked for installation only in noncombustible surroundings, see 78.6, or marked with different clearances to combustible and non-combustible surfaces, see 78.5, is to be tested as specified in 45.4.2 – 45.4.5, except that the test corner or test enclosure is to be constructed of 5/8-inch trade size fire-retardant gypsum wallboard ("drywall") complying with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723. The gypsum wall board is to be painted flat black. The appliance is to be located as close to the test enclosure as the construction permits, unless the appliance complies with 45.4.2 in which case the clearances specified for noncombustible surrounding surfaces are to be used.

Exception: When all involved parties agree, plywood may be used instead of the gypsum wallboard.

45.4.7 A stationary or fixed appliance marked with lesser clearances to noncombustible surroundings than to combustible surroundings is to be tested as described in 45.4.2 – 45.4.5 at the combustible clearances, and as specified in 45.4.6 at the noncombustible clearances.

45.4.8 To determine whether an appliance complies with the requirements in 45.1.1, it is to be operated continuously until constant temperatures have been reached.

45.4.9 Unless a particular test voltage is specified, the test voltage is to be the highest of the following:

a) The marked voltage rating; or

b) The highest voltage of the applicable range of voltages specified in 75.3 when the marked voltage is within one of the voltage ranges included in 75.3.

45.4.10 An attachment plug receptacle that serves as a general-use outlet, see 17.2, shall be loaded in accordance with the anticipated load. See 75.6. The accessory or accessories that provide the heaviest load are to be connected to a receptacle marked for use with an accessory or accessories.

45.5 Normal test conditions

45.5.1 The test described in 45.1 – 45.3 is to be conducted while the unit is located in a draft free room and is operating at the lower airflow limit, see 56.3 and Section 57, Lower Airflow Limit Determination.

45.5.2 In determining whether a recirculating system complies with the requirements in 45.1.1, actual service conditions or an approximation thereof are to be employed. The cooking appliance, see 56.1 and 56.2, is to be operated as described in the following standards as applicable:

a) Normal Temperature Test, the Standard for Commercial Electric Cooking Appliances, UL 197; or

b) Temperature Test, the Standard for Vending Machines, UL 751.

46 Dielectric Voltage-Withstand Test

46.1 General

46.1.1 To determine whether an appliance complies with the requirements in 46.2 – 46.4, it is to be tested by means of a 500 volt-ampere or larger capacity transformer, the output voltage of which can be regulated. The applied potential is to be increased from zero to the required value at a substantially uniform rate as rapid as is consistent with its value being correctly indicated by a voltmeter. The potential is to be held at that value for 1 minute.

46.1.2 When the leakage current across the line, or from line to earth ground, is so large it is impossible to maintain the required AC test potential, the unit or component part (e.g. filter) may be tested using a DC potential of 1.414 times the appropriate AC voltage.

46.1.3 During the test, all contacts energizing current-carrying parts (such as conductors, relays, and thermostats) shall be in the closed position, or isolated circuits shall be tested separately.

46.1.4 Components providing a direct current path in parallel with the insulation to be tested, such as discharge resistors for capacitors and EMI filters, are not prohibited from being disconnected during the test.

46.1.5 When the test equipment measures current as a means of determining whether breakdown has occurred, the "trip" current level is not specified. If breakdown is indicated, the test may be repeated according to 46.1.6. However, when the test in 46.1.6 is used, the same test sample shall be subjected to the Insulation Resistance Test, Section 47, as applicable.

46.1.6 When a referee test is necessary in accordance with 46.1.5, an ammeter is to be placed in series with the dielectric test circuit and the test is to be repeated. A linear increase in current with voltage is acceptable; however, a sudden (nonlinear) increase in current is not acceptable.

46.2 Primary circuits

46.2.1 While at its maximum operating temperature under conditions of intended use, an appliance shall withstand for 1 minute without electrical breakdown the application of a 40 – 70 hertz essentially sinusoidal potential:

a) Between live parts of primary circuits and dead metal parts;

b) Between live parts of different primary circuits;

c) Between terminals of a capacitor used across-the-line (see 26.4); and

d) Between terminals of a capacitor connected between the line and the enclosure (see 26.4).

46.2.2 The test potential shall be 1000 volts for an appliance rate 250 volts or less, and shall be 1000 volts plus twice rated voltage for an appliance rated more than 250 volts.

46.3 Secondary circuits

46.3.1 Secondary circuits shall withstand for 1 minute the application of a test potential as specified in Table 46.1:

a) Between primary and secondary circuits;

b) Between secondary circuits and grounded metal with all chassis-connected components disconnected at the chassis; and

c) Between secondary circuits supplied from separate transformer windings with common connections disconnected.

The appliance is to be at its maximum intended operating temperature during the test.

Exception: This test is not required for circuits that:

a) Are not safety circuits, and

b) Meet the requirements for one of the following types of circuits:

1) Class 2 circuits (see 29.3);

2) Limited voltage/current circuits (see 29.4);

3) Limited voltage circuits (see 29.5);

4) Limiting impedance circuits (see 29.7); and

5) Safety extra-low voltage circuits (see 29.8).

Table 46.1
Magnitude of test potential

Maximum voltage in the circuit	Test voltage
90 or less	Ten times maximum voltage in circuit
More than 90 but not more than 333	1000
More than 333 but not more than 1000	Three times maximum voltage in circuit
More than 1000	1750 plus 1.25 times the maximum voltage in the circuit

46.3.2 A direct current source is to be used for a direct-current circuit. A 40 – 70-hertz sinusoidal voltage is to be used for testing alternating-current circuits.

46.4 Transformers

46.4.1 While at its maximum intended operating temperature, each power transformer shall operate without breakdown while the potential specified in Table 46.1 is induced for 1 minute in each secondary winding that normally operates at a higher potential than the primary winding.

46.4.2 Transformers evaluated in accordance with the requirements for General Purpose Transformers in the Standard for Specialty Transformers, UL 506, or in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, need not be subjected to this test.

46.4.3 A sinusoidal source is to be used for a transformer, and the frequency of the source is to be in the range of 180 to 1000 hertz when required to prevent saturation of the core.

46.4.4 Primary- and secondary-circuit wiring connected to a transformer is to be disconnected for the test required by 46.4.1.

47 Insulation Resistance Test

47.1 A non-integral recirculating system shall have an insulation resistance of not less than 50,000 ohms when tested in accordance with 47.2.

47.2 Insulation resistance is to be determined as follows (see Figure 47.1) or by another method that is equally accurate. A direct current potential of at least 250 volts is to be applied between live parts and interconnected dead metal parts. Two voltmeters are to be used; one voltmeter is to be connected across the supply line and the other connected in series with one of the leads to the appliance being tested. With the supply voltage adjusted so that the difference in the voltage readings of the two meters is at least 250 volts, the insulation resistance is to be calculated using the equation:

$$Insulation\ \ Resistance = \frac{(V_1 - V_2)R_2}{V_2}$$

in which:

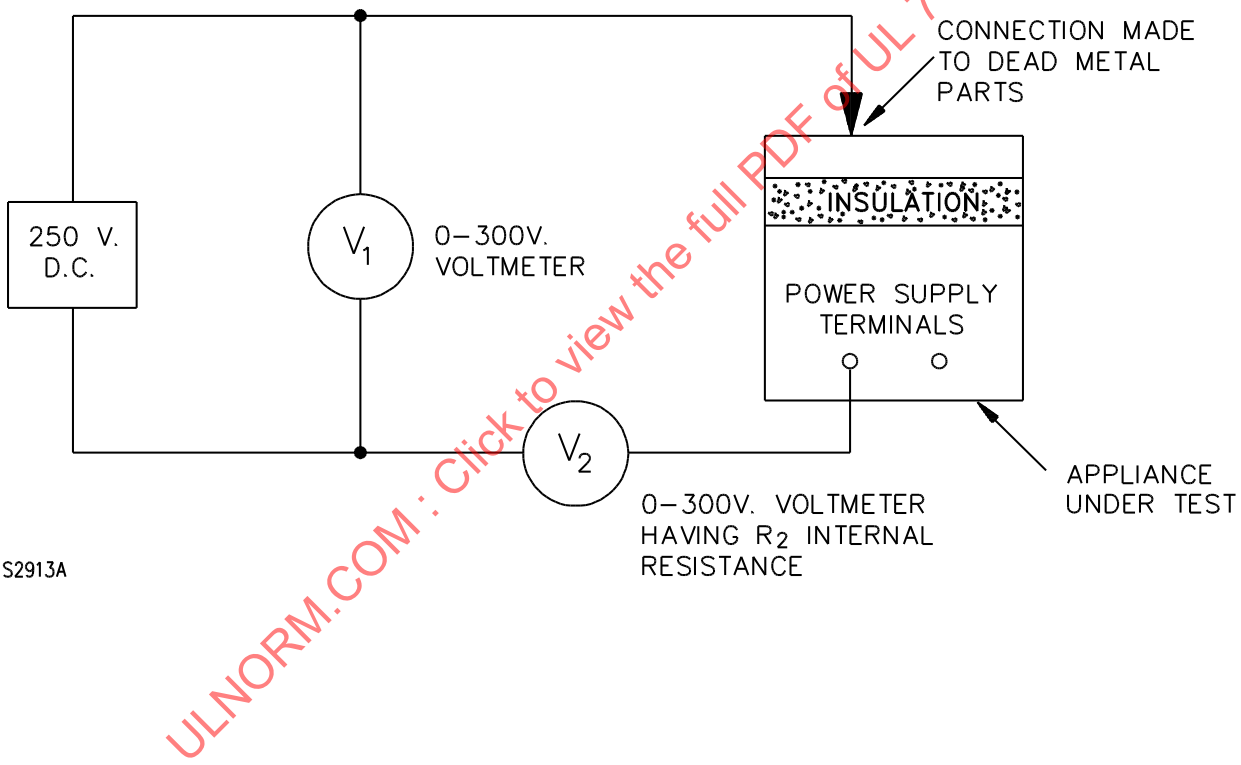
V_1 is the measured supply line voltage, in volts.

V_2 is the voltage measured by a voltmeter in series with one of the leads of the appliance heater being tested, in volts.

R_2 is the resistance of the voltmeter measuring V_2, in ohms.

Figure 47.1

Schematic for determining insulation resistance



48 Grounding and Bonding Test

48.1 Grounding

48.1.1 Exposed dead metal parts mentioned in 14.1 shall be conductively connected as determined by the grounding test in 48.1.3 and 48.1.4.

48.1.2 Any indicating device, such as an ohmmeter, is to be employed during testing.

48.1.3 When tested, the resistance between any point required to be grounded, as noted in 48.1.1 and 14.1, and the equipment grounding terminal in the case of an appliance intended for permanent electrical connection; or the point on the appliance where the grounding conductor of the cord is attached; shall not be more than 0.1 ohm. The resistance is to be determined by any convenient method as noted in 48.1.2,

except that when unacceptable results are obtained, a reference measurement is to be taken in accordance with 48.1.4.

48.1.4 When a reference measurement is required by 48.1.3, either a direct or alternating current equal to the anticipated current rating of the branch-circuit overcurrent-protective device for the appliance – see 24.1.3 and 24.1.4 – is to be passed from the equipment grounding terminal or the point of attachment of the wiring system to the dead metal part, and the resulting drop in potential is to be measured between these two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

48.2 Bonding

48.2.1 When required by Exception No. 2 of 14.8, a bonding connection is to be subjected to the test in 48.2.2. The bonding connection shall not open during the test.

48.2.2 The bonding connection is to be subjected to an alternating current equal to twice the current rating of the anticipated branch circuit overcurrent protective device – see 24.1.3 and 24.1.4 – for the period specified by Table 48.1.

Exception: When overcurrent protection complying with 24.1.1 or 24.2.1 is supplied within the appliance such that the fault current available to the part being bonded is limited, the rating of the internal overcurrent protective device is to be used when determining the test current.

Table 48.1
Duration of current for bonding conductor test

Rating of overcurrent devices, amperes	Minimum duration of current flow, minutes
30 or less	2
31 – 60	4
61 – 100	6

49 Stability

49.1 A freestanding recirculating system shall not overturn when tipped through an angle of 10 degrees from the horizontal as described in 49.2.

49.2 The appliance is not to be energized during the stability test. The test is to be conducted under conditions most likely to cause the appliance to overturn. The following conditions are to be such as to result in the least stability:

a) The position of all doors, drawers, and other movable or adjustable parts;

b) Connection of, or omission of, any attachment made available by or recommended by the manufacturer;

c) Provision of, or omission of, any normal load when the appliance is intended to contain a liquid or other mechanical load; and

d) Direction in which the appliance is tipped.

49.3 The recirculating system is to be tested when installed in accordance with the manufacturer's instructions.

50 Short-Circuit Tests

50.1 Devices and conductors referenced in Exception No. 2 to 24.5.3.2 shall withstand short circuit and ground fault conditions when protected by:

a) A device that is acceptable for branch circuit protection and is located in the heater; or

b) A branch circuit overcurrent protective device of the type and maximum rating specified on the heater nameplate. There shall be no damage to the conductor or its termination, no ignition of the cheesecloth surrounding the enclosure housing the components under test, and no arc-over between line- and low-voltage circuits.

50.2 For the purpose of these tests:

a) Circuit breakers and fuses are not considered to be interchangeable;

b) Fuses of the same rating are considered to be interchangeable;

c) HACR type circuit breakers of the same rating are considered to be interchangeable; and

d) Circuit breakers of other than the HACR type are not considered to be interchangeable with each other or with HACR type circuit breakers.

50.3 Each device and each conductor is to be connected in a circuit having a minimum capacity based on the maximum rated current and voltage of the heater in accordance with Table 50.1. Each concurrent load condition is to be considered separately, and the maximum resulting current employed as the basis of selection of the capacity of the test circuit. The voltage source for the test circuit is to be an alternating voltage and the circuit capacity is to be measured without the devices or the conductors in the circuit.

Table 50.1
Short-circuit test currents

Product ratings, amperes				
Single phase				Circuit capacity amperes
110 – 120 V	200 – 208 V	220 – 240 V	254 – 277 V	
9.8 or less	5.4 or less	4.9 or less	–	200
9.9 – 16.0	5.5 – 8.8	5.0 – 8.0	6.65 or less	1000
16.1 – 34.0	8.9 – 18.6	8.1 – 17.0	–	2000
34.1 – 80.0	18.7 – 44.0	17.1 – 40.0	–	3500
Over 80.0	Over 44.0	Over 40.0	Over 6.65	5000
3 Phase				Circuit capacity amperes
200 – 208 V	220 – 240 V	440 – 480 V	550 – 600 V	
2.12 or less	2.0 or less	–	–	200
2.13 – 3.7	2.1 – 3.5	1.8 or less	1.4 or less	1000
3.8 – 9.5	3.6 – 9.0	–	–	2000
9.6 – 23.3	9.1 – 22.0	–	–	3500
Over 23.3	Over 22.0	Over 1.8	Over 1.4	5000

50.4 Three samples of each conductor are to be subjected to each test condition. A new protective device is to be used for each test condition. Consideration is to be given to both short-circuit and ground-fault conditions.

51 Breakdown of Components Test

51.1 Capacitors, diodes, resistors, or other solid state components are to be short- or open-circuited. As a result, there shall be no emission of flame or molten metal, nor ignition of cotton when loosely placed over all openings of ventilated equipment or totally around open type devices. For a discrete device having more than two terminals (such as a transistor, SCR, triac, or similar device), any combination of two terminals shall be open- or short-circuited. For an integrated circuit device, the following combinations of terminals are to be tested, one combination per trial:

a) Each pair of adjacent terminals shorted;

b) Each input terminal shorted to (referenced) ground terminal;

c) Each output terminal shorted to (referenced) ground terminal;

d) Each input terminal shorted to each power supply;

e) Each output terminal shorted to each power supply; and

f) Each terminal open circuited.

Exception No. 1: The test is not required:

a) When circuit analysis indicates that no other component or portion of the circuit is overloaded as a result of the assumed open circuiting or short circuiting of another component;

b) For components in Class 2 circuits (see 29.3);

c) For components in Limited voltage/current secondary circuits (see 29.4), Limited Energy Secondary Circuits involving open circuit potentials less than or equal to 30 V ac or 42.4 V peak (see 29.6), and Limiting impedance secondary circuits (see 29.7);

d) For solid state devices located within a component complying with the requirements applicable to the component; or

e) For solid state devices in circuits that have been found to be reliable in accordance with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

Exception No. 2: A resistor investigated for compliance with respect to end-use conditions, and incorporating insulation or spacings to reduce the risk of a short circuit or reduction in resistance, is not to be open- or short-circuited.

Exception No. 3: A capacitor, capristor (parallel combination of a capacitor and resistor), or similar circuit component, complying with requirements for antenna coupling and line bypass components described in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414, and investigated for compliance with respect to end-use conditions, is not to be short-circuited.

51.2 During and after the test of 51.1, any malfunction, such as short-circuiting or changing of impedance of a pilot light or indicating lamp, shall not affect the proper functioning of a temperature-control system.

51.3 For the purposes of the test, the series resistor of a gaseous discharge lamp is to be left in the circuit.

52 Wiring Endurance Test

52.1 An appliance in which the cleaning function results in movement of electrical wiring or other insulated live parts shall withstand an endurance test as described in 52.3 and 52.4. There shall be no electrical or mechanical malfunction of the appliance and, after the endurance test, the appliance shall comply with the requirements in the Dielectric Voltage-Withstand Test, Section 46.

52.2 The appliance is to be energized during the test when the motion of the appliance occurs while energized. The voltage supply circuit and the temperature conditions shall be in accordance with the normal temperature test.

52.3 The endurance test required by 52.1 is to consist of 6000 cycles of operation.

52.4 For the endurance test described in 52.3, any mechanical arrangement is to be employed to operate the movable member at a rate of approximately 12 cycles per minute. The cover or movable member is to be operated so that it will reach the limits of travel in both directions during each cycle.

53 Strain Relief Test

53.1 When tested in accordance with 53.2, the strain relief shall withstand for 1 minute, without displacement resulting in stress on internal connections, a direct pull of 35 pounds (156 N) applied to the cord with the connections within the appliance disconnected. The means of affording 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 would have resulted on the connection.

53.2 A 35-pound (15.9-kg) weight is to be suspended on the cord and supported by the appliance so that the strain-relief is stressed from the angle that is permitted by the construction of the appliance and is most likely to cause movement of the cord or strain relief means.

54 Push-Back Relief

54.1 When required by reference to 18.6.3, a cord-connected appliance shall be tested in accordance with 54.2 without occurrence of any of the conditions specified in 18.6.3.

54.2 The flexible cord or lead is to be held 25 mm (1 inch) 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 25 mm (1 inch) 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 27 N (6 pounds-force). The flexible cord or lead within the product is to be manipulated to determine compliance with 54.1.

55 Strength of Enclosures, Frames, and Guards Test

55.1 General

55.1.1 An external enclosure or frame shall comply with 55.2 and 55.3 without permanent distortion, reducing spacings below the values specified in 32.1.9, or transient distortion that results in contact with live parts. Any opening that occurs during application of the force, from the impact, or from damage or breaking of a glass enclosure is to be judged under the requirements in 9.1.3 – 9.1.7.

55.1.2 A guard required by 11.2 shall comply with 55.2 and 55.3 to the extent that:

a) A moving part involving a risk of injury to persons cannot be contacted by the probe illustrated in Figure 9.3; and

b) The appliance complies with Section 46, Dielectric Voltage-Withstand Test.

Exception No. 1: This requirement does not apply to a part known to be acceptable for the application.

Exception No. 2: This requirement does not apply to a component such as a lens or control knob.

55.2 Static force test

55.2.1 The external enclosure shall withstand a force of 20 pounds (89 N). The force is to be applied by means of a 1/2-inch (12.7 mm) diameter rod with a hemispherical end.

55.2.2 When a 20 pound (89 N) force is applied for 1 minute over a 2 inch (50.8 mm) diameter area to any part of a guard for moving parts, spacings shall not be permanently reduced to the degree that the probe shown in Figure 9.3 contacts a portion of a moving part when inserted through any opening in the guard.

55.3 Impact test – frames, guards, and metal enclosures

55.3.1 A frame, guard, or external enclosure of live parts shall withstand an impact applied by means of a solid, smooth, steel sphere 2 inches (50.8 mm) in diameter and weighing approximately 1.18 pounds (535 g). The sphere is to fall freely from rest through a vertical distance of 51 inches (1.3 m). For a part not able to be struck from above by the freely falling sphere, the sphere is to be suspended by a cord and allowed to fall as a pendulum through a vertical distance of 51 inches (1.3 m).

Exception: This test is not required for a polymeric enclosure that has been evaluated in accordance with Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

PERFORMANCE – RECIRCULATING SYSTEM TESTS

56 General

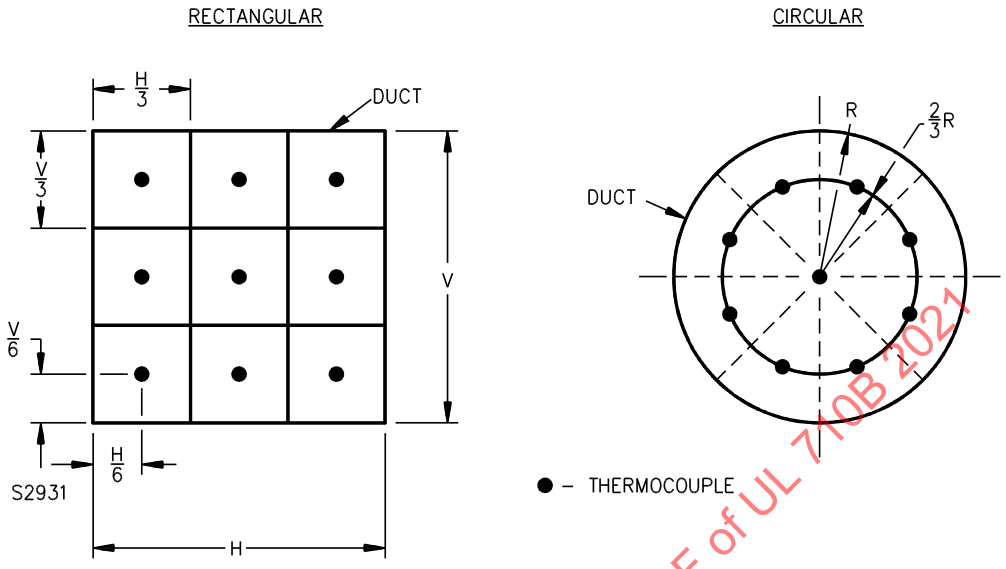
56.1 A non-integral recirculating system shall be tested with each representative appliance model with which it is intended to be used. The tests are to be conducted with the recirculating system/hood at the minimum and maximum height relative to the appliance. See 78.8.

Exception: When the hood and the appliance being protected are supported on the same surface (e.g. floor) so that the height of the hood over the appliance is fixed, the tests need only be conducted at one height.

56.2 Where required, the exit gas temperature is to be measured using a grid of thermocouples of identical length wired in parallel. The thermocouple grid is to be located in a plane perpendicular to the axis of airflow and within 6 inches (152.4 mm) downstream of the exhaust of the recirculating hood. The test collar in which the thermocouple grid is located is to be the same size as the exhaust of the recirculating hood and the cross Section of the test collar is to be divided into equal areas with thermocouples located as illustrated in Figure 56.1.

Figure 56.1

Thermocouple and airflow measurement locations in test duct



Rectangular – Rectangular duct divided into nine equal areas as illustrated with a thermocouple located in the center of each of the resulting nine areas.

Circular – Circular duct divided radially into eight equal areas with thermocouples located as illustrated in each of the eight areas and at the center of the duct.

56.3 Where required, the exhaust airflow is to be measured in the exhaust duct at a distance not less than three times the diameter of the duct from the exhaust collar and/or from any elbows or bends within three diameters upstream or downstream. A minimum of nine measurements at one plane in the duct shall be averaged to determine the airflow rate. The measurements shall be made with a calibrated velometer, thermoanemometer, or other device. The measurements are to be made at various locations within the duct, symmetrically located as shown in Figure 56.1 for measurement locations. The measurements are to be made with the cooking appliance removed from beneath the exhaust hood or in the unheated state.

57 Lower Airflow Limit Determination

57.1 A recirculating system is to be tested as specified in 57.2 and 57.3. The higher of the two airflow rates measured is to be considered the lower airflow limit. See Section 41, Hood Airflow.

57.2 The inlet of the recirculating system is to be fitted with a means to restrict the inlet symmetrically. The recirculating system is to be placed in operation and the restriction is to be gradually increased until the control required by 41.1 operates. The minimum airflow rate that will allow the cooking appliance to operate is to be measured and recorded.

57.3 The appliance is to be operated as specified in the Capture Test, Section 58, and the fan speed is to be reduced (by varying the voltage to the fan or using an integral speed control) to the minimum airflow that will capture smoke and grease laden air. The airflow rate is to be measured and recorded.

58 Capture Test

58.1 During the cooking operation, the hood assembly is to completely capture all emission as determined by visual observation. The appliance is to be observed for the presence of visible smoke and

grease laden air escaping from the hood assembly through the discharge port or through external seams, joints, penetrations, and that portion of the hood that captures grease laden vapors.

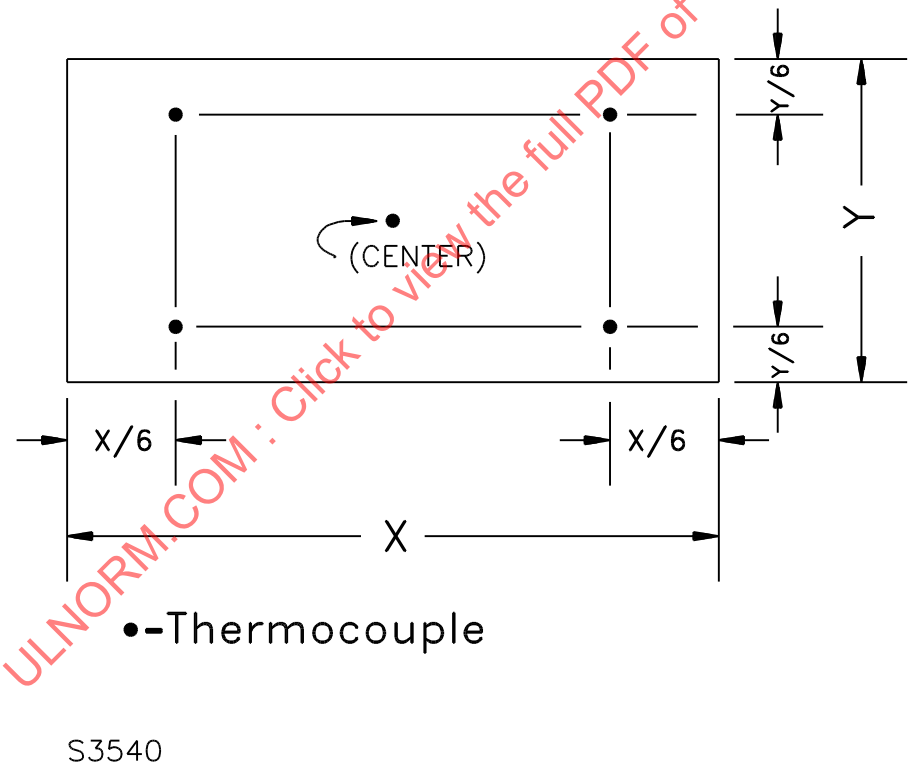
58.2 The test described in 58.3 – 58.11 is to be conducted while the unit is located in a draft free room and is operating at the lower airflow limit.

58.3 For non-integral recirculating systems, the recirculating appliance hood is to be marked for use with the specific appliance(s) and product(s) as specified in 78.8(a). The cooking surface temperature used during testing shall be the maximum temperature the cooking appliance is capable of producing, unless otherwise marked on the recirculating hood.

58.4 When necessary, the temperature measurements of the cooking surfaces are to be at a minimum of five locations on the top of the cooking surface to determine an average temperature. The thermocouples are to be securely held in thermal contact with the cooking surface and located as shown in Figure 58.1.

Figure 58.1

Thermocouple locations on cooking appliance surface



58.5 For non-integral recirculating systems, the cooking appliance shall be installed at the maximum specified distance between the cooking surface and the front lower edge of the recirculating hood. The appliance shall be installed with the minimum specified overhang between the front and side panels of the recirculating exhaust hood and the cooking surface. Exhaust hoods intended for installations with the front edge of the cooking appliance extending outside the front edge of the exhaust hood shall be tested with the cooking surface extended to the maximum specified distance.

58.6 The cooking surface shall be adjusted to the maximum recommended temperature as specified in the end use standard, see 1.4.

58.7 Liquid vegetable oil is to be used when testing a deep fat fryer or other appliance where cooking oil is commonly used in the cooking process.

58.8 The test shall be conducted by loading the maximum amount of the food products noted below, on or in the cooking appliance and cooking the food product until it is overcooked (very well done). The cooking cycle is to be repeated at least once.

a) Deep fat fryers are to be tested with frozen, unbreaded fries intended for deep fat frying;

b) Pressure deep fat fryers are to be tested with frozen, unbreaded chicken pieces;

c) Griddles, broilers and similar appliances are to be tested with thawed ground beef patties made of 73 ±5 percent lean ground beef 4 ±0.25 inches in diameter and weighing 0.25 ±0.02 lb (see Glossary 5.31). The beef patties are to be placed uniformly on the cooking surface. The quantity of patties placed on the cooking surface is to be the maximum permitted by the area of the cooking surface with a maximum of 1.0 inch between any row or the edge of the cooking surface. The patties are to be cooked on one side for 5 minutes, turned over, cooked on the other side for 5 minutes, and removed from the cooking surface;

d) Ovens, roasters and similar appliances are to be tested using 2-1/2 to 3-1/2 lb skin-on and bone-in roasting chickens or quartered chicken pieces, loaded per the cooking appliance manufacturer's instructions;

e) For testing ovens, as an alternate, when chicken does not produce visible cooking smoke and grease laden air, one sheet pan (nominal pan size 18 by 26 inches) filled with 1 lb of pork bacon and coated with one cup of sugar distributed evenly is permitted to be used. The pan shall be placed at the lowest location (rack) of the oven, and the oven run at the maximum temperature for 10 minutes; and

f) Other appliances are to be tested using the food product(s) for which they are designed.

Exception: When one of the appliances specified in (a) – (d) is not intended for cooking the specified food (for example, donut fryers), the appliance is to be tested using the food product for which the appliance is designed.

58.9 Repeating this test with other food loads is to be considered based upon the manufacturer’s instructions.

58.10 Complete capture of smoke and grease laden vapor by visual observation shall be determined in accordance with the following considerations:

a) For tests using open griddle or broiler cooking appliances using beef patties, visual observation of smoke and grease laden vapors shall continue during flipping of the beef patties .

b) For tests using pressure fryers, ovens, or other cooking appliances with doors, visual observation of smoke and grease laden vapors shall continue during the opening of doors as part of the complete cooking cycle,

c) When removing food from the appliance, as required for the cooking operation, or at the end of the test, any residual steam, smoke, or grease laden vapors emitted from the food items are not to be considered for the purpose of this test.

58.11 When the device and cooking process do not produce visible cooking smoke and grease laden air, a smoke generator is to be used and positioned in the cooking area to establish a more visible means for conducting this test.

59 Emission Test

59.1 General

59.1.1 The test described in 59.1.2 – 59.6.3 is to be conducted while the unit is located in a draft free room and operating at the lower airflow limit.

59.1.2 The appliance is to be operated as described in the Capture Test, Section 56, except the cooking cycle is to be repeated for 8 hours.

59.1.3 The grease laden effluent discharged at the exhaust outlet of the system is to be measured as described below. This method was derived from the U. S. Environmental Protection Agency (EPA) Test Method 202, Determination of Condensable Particulate Emissions From Stationary Sources.

59.1.4 The grease laden effluent at the exhaust outlet of the system shall not exceed an average of 5.0 mg/m^3 of exhausted air sampled at a maximum product capacity over a continuous 8 hour test cooking period.

59.2 Test apparatus

59.2.1 The sampling train is to consist of the following:

a) A stainless steel probe nozzle with a sharp tapered leading edge. The size is to be suitable for isokinetic sampling.

b) A glass mat filter without an organic binder.

c) A stainless steel filter holder.

d) A glass or Teflon lined probe extension equipped with a heating system.

e) A type S stainless steel pitot tube suitable for use with a manometer assembly.

f) A temperature sensor which is to be attached to either the pitot tube or to the probe extension.

59.2.2 A system of four impingers, in an ice bath, is to be connected to the probe extension. Both the first and second impingers are to be of the Greensburg Smith design with the standard tip.

59.2.3 A meter system is to consist of a vacuum gauge, leak free pump, thermometers, and a dry gas meter.

59.2.4 A barometer is to be used to measure barometric pressure at the beginning of the test.

59.3 Sampling procedure

59.3.1 The preliminary set up is to be constructed as follows:

a) Construct the stack which is to be used for sampling out of duct sheet metal.

b) Each of the first three impingers is to be filled with 100 ml deionized distilled water. The fourth impinger is to be filled with silica gel. The weight of each impinger is to be determined and recorded.

c) Assemble the train; silicon grease is not to be used.

d) A pre test leak check is to be conducted.

e) Calibrate the system.

59.3.2 The sampling location is to be located at least eight stack diameters downstream and two stack diameters upstream from any flow disturbance. After this criteria is met and a circular stack is used, a minimum of eight traverse points are to be used.

59.3.3 A post test leak check is to be conducted.

59.4 Sample handling

59.4.1 The glass filter is to be removed using a pair of forceps and placed in a clean petri dish. The dish is to be sealed and labeled "sample bottle number one".

59.4.2 A sample of the acetone of the same volume that will be used to rinse out the nozzle and probe is to be placed into a clean sample bottle, sealed, and labeled "sample bottle number two". The level of the liquid in the sample bottle is to be recorded.

59.4.3 The inside of the nozzle and probe is to be rinsed with acetone taking care to collect all the rinse material in a clean sample bottle. The sample bottle is to be sealed, labeled "sample bottle number three", and the level of the liquid in the bottle is to be recorded.

59.4.4 The liquid in the first three impingers is to be measured and the total volume is to be recorded which will be compared to the original volume. The liquid is to be quantitatively transferred to a clean sample bottle.

59.4.5 Each impinger and the connecting glassware including the probe extension is to be rinsed twice with water. The rinse water is to be collected and added to the same sample bottle. The sample bottle is to be sealed, labeled "sample bottle number four," and the level of the liquid in the bottle is to be recorded.

59.4.6 The rinses described in 59.4.5 are to be followed with two rinses of methylene chloride ($MeCl_2$). The rinses are to be recovered in a clean sample bottle. The sample bottle is to be sealed, labeled "sample bottle number five," and the level of the liquid in the bottle is to be recorded.

59.4.7 A volume of water approximately equivalent to the volume of water used in 59.4.5 and a volume of $MeCl_2$ approximately equivalent to the volume of $MeCl_2$ used in 59.4.6 is to be placed in two clean sample bottles. The sample bottles are to be sealed, labeled "sample bottle number six" and "sample bottle number seven" respectively, and the level of the liquid in the bottles is to be recorded.

59.4.8 The fourth impinger containing the silica gel is to be emptied into a capped, sealed sample bottle and labeled "sample bottle number eight".

59.5 Analysis

59.5.1 The liquid level of all the sample bottles is to be measured and compared to the levels recorded in 59.4 to verify that no portion of the sample has been lost.

59.5.2 The filter from sample bottle number one is to be removed and dried to constant weight by means of a desiccator or an oven. The weight of the filter is to be recorded.

59.5.3 The volume of sample bottle number two is to be determined. The liquid is then to be transferred to a beaker and evaporated to dryness. The volume of the liquid and the final weight of the condensable matter are to be recorded.

59.5.4 The volume of sample bottle number three is to be determined. The liquid is then to be transferred to a beaker and evaporated to dryness. The volume of the liquid and the final weight of the condensable matter are to be recorded.

59.5.5 The volumes of sample bottles number four and five are to be measured.

59.5.6 Sample bottles number four and five are to be combined. The organic phase is to be mixed, separated, and then repeated with two $MeCl_2$ washes.

59.5.7 The organic extracts obtained from the procedure in 59.5.6 are to be placed in a beaker and evaporated to a constant weight. The final weight is to be recorded.

59.5.8 The inorganic phase is to be placed in a beaker and evaporated to dryness. The final weight is to be recorded.

59.5.9 The volumes of sample bottles number six and seven are to be determined. Sample bottles six and seven are to be analyzed according to 59.5.8 and 59.5.7 respectively.

59.5.10 The weight of sample bottle number eight (impinger and silica gel) is to be recorded.

59.6 Results

59.6.1 The particulate matter concentration emitted shall not exceed 3.1 x 10^{-7} lb/ft^3 (5.0 mg/m^3):

$$PM = W_g / \text{volume of air during test}$$

59.6.2 The concentration specified in 59.6.1 is determined by:

a) The net weight of particulate in the nozzle and probe (W_n) is calculated by subtracting the weight of sample bottle 2 from that of sample bottle 3:

$$W_n = W_3 - W_2$$

b) The net weight of the impingers (W_i) is calculated by subtracting the sum of sample bottles 6 and 7 from the sum of sample bottles 4 and 5:

$$W_i = (W_4 + W_5) - (W_6 + W_7)$$

c) The mass of grease is calculated as the sum of the filter, impinger and nozzle weight:

$$W_g = W_f + W_i + W_n$$

59.6.3 During the test, temperatures of the airflow and of various surfaces determined to be thermally hot during the cooking operation are to be measured. These temperatures shall not exceed 475°F (246°C).

59.6.4 Tests conducted on pressure fryers are to include operation of the sample in an open fryer mode with the access door remaining open during the test. When normal operation of the product in a pressure operating mode indicates this mode to be worse case in terms of visible emission, the test is to be conducted in both modes of operation.

60 Damper Tests

60.1 General

60.1.1 The maximum size of each damper assembly design shall be subjected to the damper cycling test described in 60.2.

60.2 Cycling test

60.2.1 A fire damper or multiple fire damper assembly intended for use with an actuator (that is, the electric, pneumatic, or hydraulic device used to operate the fire damper) shall function as intended after being mechanically operated for 20,000 full-stroke (that is, close and reopen) operations, while using the specified fire damper actuator and while under static conditions.

Exception: A fire damper intended for use with an actuator that has been evaluated for 20,000 cycles in the intended position (vertical or horizontal) in accordance with the Standard for Fire Dampers, UL 555, is not required to be subjected to this test.

60.2.2 For a fire damper intended for use without an actuator, the number of full-stroke operations is to be 250 and the fire damper is to be cycled manually.

Exception: A fire damper intended for use without an actuator that has been evaluated for 250 cycles in the intended position (vertical or horizontal) in accordance with the Standard for Fire Dampers, UL 555, is not required to be subjected to this test.

60.2.3 All fire dampers are to be cycled at an ambient temperature between 50°F (10°C) and 104°F (40°C) while oriented in the position intended for installation.

60.3 Closure test

60.3.1 With the unit operating at its maximum airflow and the damper's actuating device disabled, the damper is to be manually released. The damper is to fully close as intended. This operation is to be conducted a total of three times.

60.4 Damper fire actuation test

60.4.1 A fire damper as specified in the Exception to 38.1(d), shall be subjected to this test.

60.4.2 The Automatic operation fire test, 61.3, is to be repeated except that the unit is to be operated at its maximum airflow and with the appliance's automatic fire actuating device disabled. The test is to be continued until the fire damper actuates.

60.4.3 The exhaust air shall not exceed 190°C (375°F) when measured as specified in 56.2.

61 Fire Extinguishment Tests

61.1 General

61.1.1 The extinguishing system of a recirculating hood is to be subjected to the Automatic operation fire test, 61.3, and Delayed operation fire test, 61.4 with each type of cooking appliance necessary to determine compliance with these requirements for each type of appliance intended to be used. Specific cooking appliance test methods are contained in 61.5 – 61.12. The cooking appliance shall be installed at

the maximum specified distance between the cooking surface and the front lower edge of the recirculating hood.

61.1.2 The cylinder is to be filled to its rated capacity and the cylinder or gas cartridge pressurized with the expellant gas to the normal operating pressure at 70°F (21°C). The cylinder or gas cartridge used for these tests is to be conditioned, after charging, for at least 16 hours at the minimum storage temperature prior to the test. As an alternative to conditioning at the minimum storage temperature for 16 hours, extinguishing system units that utilize dry nitrogen or dry air as an expellant gas are to be tested by underpressurizing the cylinder or gas cartridge at ambient temperature to simulate the pressure at minimum operating temperature.

61.1.3 Each fire extinguishment test is to be conducted in an environment in which the ambient temperature is not less than 50°F (10°C).

61.1.4 Liquid grease used during the fire extinguishment tests is to have an auto-ignition temperature not less than 685°F (362.8°C).

61.1.5 Hood air passageways and filters are to be coated with lard prior to the fire extinguishment tests. The lard shall be applied with a density of 0.3 pounds per square foot (1.5 kg/m^2), or at a lesser density on filters when required to permit sufficient airflow to prevent the lower airflow control from functioning

61.1.6 Prior to conducting each fire extinguishment test the appliance is to be cleaned and provided with a new fuel loading.

61.1.7 The Automatic Operation Fire test, 61.3, and Delayed Operation Fire Test, 61.4 are permitted to be conducted simultaneously, when the extinguishing unit actuation (for test purposes) provides a visual or audible indication, but bypasses the actual activation of the extinguishing system. The extinguishing system unit is then to be manually actuated after a pre-burn of the time recorded between auto ignition and unit actuation, plus 30 seconds.

61.2 Performance parameters

61.2.1 When tested with a cooking appliance, the extinguishing system unit shall:

a) Cause the flame in the appliance to be completely extinguished upon complete discharge of the extinguishing agent;

b) For deep fat fryers, woks, and cast iron skillets, result in no splashing of burning grease due to the extinguishing system operation, as evidenced by the presence of burning droplets of grease dispersed outside the appliance;

c) For deep fat fryers, woks and ranges, not permit re-ignition of the grease for 20 minutes. Observation for re-ignition shall continue for 20 minutes or until the temperature of the grease decreases at least 60°F (33.3°C) below its observed auto-ignition temperature, whichever is longer;

d) For all appliances other than deep fat fryers, woks and ranges, not permit re-ignition of grease for 5 minutes.

61.2.2 After each fire extinguishment test, the appliance shall comply with the Dielectric Voltage Withstand Test, Section 46.

61.2.3 Flames shall not enter the test collar connected to the exhaust hood. Parts of the recirculating hood, including bodies, shelving, framing, and dampers, shall not warp or otherwise be damaged to the extent that the product increases the risk of fire, electric shock, or injury to persons during continued use.

61.2.4 During the fire extinguishment tests, all flames generated in the cooking area and any flames that occur in the filtering area are to be contained within the hood or the periphery of the appliance bound by the hood and the cooking area. Containment shall include the openings in the grease-air stream enclosure provided for passage of extinguishing system unit piping or for passage of electrical conduit that are provided with fittings.

61.2.5 The appliance shall be installed within a combustible alcove as described in 45.4.1 – 45.4.6.

Exception No. 1: A permanently connected stationary or fixed appliance not provided with casters and marked in accordance with 78.5 is to be spaced away from the test corner in accordance with the marking.

Exception No. 2: When the appliance is intended for use in non-combustible surroundings only, and marked in accordance with 78.6, the appliance is not required to be installed within a combustible alcove.

61.2.6 The surface temperature of a combustible alcove shall not exceed 175°F (79°C) rise during the test.

Exception: After the fire has been completely extinguished, the temperature rise of the surface is not required to be less than 175°F when all of the following conditions are met:

a) The fire was extinguished by only a wet chemical extinguisher;

b) The rise in temperature of the alcove surface is only due to the momentary heat release caused by the initial reaction of the wet chemical agent with the burning fuel;

c) The surface does not exceed a temperature rise of 175°F for more than one minute; and

d) There is no charring or other visible damage to the combustible alcove.

61.2.7 Prior to actuation of the fire extinguishing system, flaming shall not escape the hood and cooking area.

61.2.8 During fire extinguishment, when flaming escapes the hood, cooking area, or both, the duration of the flaming shall not exceed 1 second.

Exception: The one second duration requirement does not apply to recirculating systems that comply with all of the following:

a) The recirculating system is permanently attached to the building structure, marked in accordance with 78.9, and provided with installation instructions in accordance with Section 82, Manufacturer's Literature; and

b) Those recirculating systems in which the fire extinguishment test is conducted with cotton pads placed around the appliance so that the cotton pads do not ignite when:

1) Located away from the appliance at a clearance distance specified by the manufacturer as marked on the product in accordance with 78.9(a); and

2) Placed on the ceiling located at the height specified by the manufacturer as marked on the product in accordance with 78.9(b).

61.2.9 During fire extinguishment, there shall be no splashing of burning grease due to the extinguishing system unit operation, as evidenced by the presence of burning droplets of grease dispersed outside of the fryer.

61.2.10 The cotton pads are to consist of new undyed fibers without any mixture of artificial fibers and are to be free from thread, leaf, and shell fiber dust. The pads are to be 4 inches by 4 inches (10.2 cm by 10.2 cm), approximately 0.8 inches (2 cm) thick, and weighing between 0.10 ounces and 0.14 ounces (3 and 4 grams). They are to be oven dried prior to the test. The pads are to be attached by means of noncombustible wire or clips.

61.3 Automatic operation fire test

61.3.1 The extinguishing system unit is to be allowed to operate automatically and the time between auto ignition and unit actuation is to be determined.

61.3.2 The fire damper shall not operate prior to the automatic actuation of the fire extinguishing system.

61.4 Delayed operation fire test

61.4.1 The extinguishing system unit is to be actuated after a pre-burn of the time recorded for unit actuation during the Automatic operation fire test, 61.3, plus 30 seconds.

61.4.2 The fire damper is to be prevented from closing during the Delayed Operation Fire Test.

61.5 Deep fat fryers and tilt skillets

61.5.1 The fryer or skillet is to be tested with the vat(s) filled to the maximum level recommended by the manufacturer.

61.5.2 Each vat of multiple vat and split vat deep fat fryers is to be tested separately.

61.5.3 When testing multiple vat and split vat fryers, all vats adjacent to the vat to be spontaneously ignited are to be filled with liquid grease and heated to 350 – 375°F (177 – 191°C).

61.5.4 The temperature controls in the fryer or skillet are to be defeated and the liquid grease heated until spontaneous ignition occurs. When testing multiple vat and split vat fryers, only the controls for the vat to be spontaneously ignited are to be disabled.

61.5.5 When a fryer or skillet employs a removable cover that is used while the heater is energized, the fire extinguishment tests are to be conducted with the removable cover positioned to cause the worst case. The product shall be marked in accordance with 77.3(f). The fire extinguishment tests on a pressure fryer are to be conducted with its cover open during the test. If a pressure fryer can be operated with its cover partially open or closed (but not latched), the fire tests shall also be conducted in these modes of operation.

61.5.6 Upon complete discharge of the extinguishing agent, the deep fat fryer shall comply with the requirements in 61.2, Performance parameters.

61.6 Griddle

61.6.1 A pan, constructed of sheet metal at least 0.079 inch (2.01 mm) thick, having the same dimensions as the griddle surface and 1 inch (25.4 mm) deep, is to be placed on the griddle. The pan should be constructed with sufficient rigidity to prevent warping during the fire extinguishment tests.

61.6.2 The pan is to be filled with liquid grease to a depth of 1/4-inch (6.4 mm).

61.6.3 The temperature controls in the griddle are to be defeated and the liquid grease heated by the griddle's heating source until spontaneous ignition occurs.

61.6.4 Upon complete discharge of the extinguishing agent, the griddle shall comply with the requirements in 61.2, Performance parameters.

61.7 Range top

61.7.1 The following test vessels are to be used for the fire extinguishment tests:

a) A cast iron skillet having a diameter of 13 to 14 inches (330 to 356 mm) at the top and having sides 1-1/3 – 2-3/8 inches (44.4 – 60.3 mm) high, measured from the inside of the skillet.

b) A stainless steel pot having a diameter of 10 ±1/4-inches (254 ±6.4 mm) at the top and having sides 7 to 8 inches (178 to 203 mm) high.

61.7.2 Separate fire extinguishment tests are to be conducted using each test vessel.

61.7.3 For the test with the cast iron skillet, the skillet is to be filled with liquid grease to a depth of 1 inch (25.4 mm). For the test with the stainless steel pot, the pot is to be filled with liquid grease to a depth of 4 inches (101.6 mm). The grease level is to be measured when the grease temperature is between 550 – 600°F (288 – 316°C).

61.7.4 The test vessel is to be positioned on a burner location(s) determined to be most difficult to achieve fire extinguishment. For the skillet test, the 10 inch (254 mm) pot is to be located adjacent to the skillet in the location determined most difficult with respect to achieving fire extinguishment. The range top burner temperature control for the test vessel is to be adjusted to maximum intensity and the grease continuously heated until auto-ignition occurs.

61.7.5 Upon complete discharge of the extinguishing agent, the range top shall comply with the requirements in 61.2, Performance parameters.

61.8 Radiant char-broilers

61.8.1 A thin plastic sheet, such as plastic food wrap, containing steaks and grease is to be placed on a flat surface at a location away from the char-broiler. The plastic sheet is to be covered with 1/4-inch (6.4 mm) of semisolid grease. Low-quality fatty beef steaks are then to be placed on top of the plastic sheet and evenly spaced so as to cover an area equal to 80 – 90 percent of the char-broiler grate area. The drip pan is to be filled with 1/8-inch (3.2 mm) of liquid grease.

61.8.2 The char-broiler's radiant panels are to be heated with the burners at their maximum intensity so that they are hot enough to ignite drops of liquid grease. When this occurs, the plastic sheet, grease and steaks are to be placed on the broiler's grill in the normal cooking position. The char-broiler is to become quickly involved in flames.

61.8.3 Upon complete discharge of the extinguishing agent, the radiant char-broiler shall comply with the requirements in 61.2, Performance parameters.

61.9 Lava, pumice, or synthetic rock – char-broilers

61.9.1 The grate is to be covered with lava, pumice, or synthetic rock, in accordance with the manufacturer's instructions. The fire extinguishment tests are to be conducted in the same manner as for the radiant char-broilers, 61.8, except that the lava, pumice, or synthetic rock is to be heated in lieu of heating the radiant panels.

61.10 Upright broiler

61.10.1 The drip pan below the broiler chamber is to be filled with preheated grease. The inner surfaces of the broiling chamber, the exhaust passages, and the grease trap in the back of the broiler are to be coated with liquid grease to obtain a minimum loading of 0.3 pounds per square foot (1.5 kg/m^2).

61.10.2 Following the grease loading, low quality fatty beef steaks are to be placed on the broiler grate and evenly spaced so as to cover an area between 80 and 90 percent of the cooking grate area.

61.10.3 The grease in the drip pan and broiling chamber is to be heated with the broiler's burners and a torch(es) until the broiler is well involved in flames. This usually requires 2 to 3 minutes.

61.10.4 Upon complete discharge of the extinguishing agent, the upright broiler shall comply with the requirements in 61.2, Performance parameters.

61.11 Chain broiler

61.11.1 The drip pan below the broiler chamber is to be filled with preheated grease. The inner surfaces of the broiler chamber, cooking portion, and grease trap are to be coated with liquid grease to obtain a minimum loading of 0.3 pounds grease per square foot (1.5 kg/m). Grease is also to be sprayed on all areas of the chain by causing the chain to rotate. When this is completed, 80 to 90 percent of the chain's cooking area is to be covered with meat cakes and the chain rotation stopped.

61.11.2 The grease in the drip pan and the broiler chamber is to be heated with the broiler's burners and a torch(es) until the broiler is well involved in flames. This usually requires 2 to 3 minutes.

61.11.3 Upon complete discharge of the extinguishing agent, the chain broiler shall comply with the requirements in 61.2, Performance parameters.

61.12 Wok-type appliance

61.12.1 The minimum and maximum wok (pan) sizes specified in the manufacturer's installation, operation and maintenance instruction manual(s) are to be tested. The wok sizes are to be determined by the minimum and maximum height and diameter.

61.12.2 Separate fire extinguishment tests are to be conducted using the smallest and largest representative wok (pan).

61.12.3 Each wok is to be tested with a liquid grease level at a depth that provides a 3 inch (76.2 mm) freeboard measured from the top edge of the wok, or a minimum grease level of 1 inch (25.4 mm), whichever provides greater depth of grease. The grease level is to be measured when the grease temperature is between 550 – 600°F (288 – 316°C).

61.12.4 The wok is to be positioned on a burner location(s) determined to be most difficult to achieve fire extinguishment. For the minimum size wok test, a maximum size wok is to be located adjacent to the test wok representing the location most difficult to achieve fire extinguishment. The range top burner for the test wok is to be adjusted to the maximum intensity position and the grease continuously heated until auto-ignition occurs.

61.12.5 Upon complete discharge of the extinguishing agent, the wok shall comply with the requirements in 61.2, Performance parameters.

62 Cooking Temperature Splash Test

62.1 General

62.1.1 When tested as described in 62.2 – 62.4, an extinguishing system unit shall not splash grease droplets in excess of 3/16-inch (4.76 mm) diameter.

Exception: This test is not required if the extinguishing system complies with the Standard for Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment, UL 300, and is installed in accordance with the manufacturer's instructions.

62.1.2 The test is to be conducted using the maximum discharge rate condition for the discharge nozzle or nozzles. The maximum discharge rate condition is obtained by using the maximum piping diameter, minimum piping length and minimum number of tees and elbows, with the cylinder or gas cartridge conditioned to the maximum operating temperature for at least 16 hours or pressurized to the maximum pressure corresponding to the maximum operating temperature for which the extinguishing system unit is intended.

62.1.3 A flat metallic surface at least 30 inches (762 mm) wide having not more than a 1/16-inch (1.6 mm) deep layer of sodium bicarbonate dry chemical placed on top of the surface is to be prepared around the front and sides of the appliance to detect splashing grease. The liquid grease in the appliance is to be heated by its heating source until a grease temperature of 350 to 375°F (177 to 191°C) is achieved. The extinguishing system is then to be manually discharged.

62.1.4 The discharge effects are to be observed to determine compliance with the requirements in 62.1.1.

62.2 Deep fat fryer

62.2.1 The fryer is to be filled with liquid grease until the grease level is 3 inches (76.2 mm) below the top edge of the fryer. The grease level is to be measured when the grease temperature is between 350 – 375°F (177 – 191°C).

62.3 Range top

62.3.1 The cast iron skillet, specified in 61.7.1 (a), is to be filled with liquid grease until the grease level is 1 inch (25.4 mm) below the edge of the skillet. The grease level is to be measured when the grease temperature is 350 – 375°F (177 – 191°C).

62.3.2 The grease temperature is to be measured using a thermocouple located 1/2-inch (12.7 mm) below the grease surface and not closer than 3 inches (76.2 mm) to the skillet wall.

62.4 Wok

62.4.1 The woks (pans) used for this test are to be as specified in 61.12.1.

62.4.2 The wok is to be filled with liquid grease until the grease level is 3 inches (76.2 mm) below the top edge of the wok. The grease level is to be measured when the grease temperature is 350 – 375°F (177 – 191°C).

62.4.3 The grease temperature during testing is to be measured using a thermocouple located 1/2-inch (12.7 mm) below the grease surface and not closer than 3 inches (76.2 mm) to the test vessel wall.

63 Manual Operation Test

63.1 Electrical actuation

63.1.1 When an extinguishing system employs an electrical means for manual actuation, it shall be tested in accordance with 63.1.2. The extinguishing system shall actuate when the electrical means for manual actuation is powered from the battery backup system. See Exception No. 2 of 37.10.

63.1.2 For this test, the extinguishing system is to be operated by the battery backup system with the primary electrical means for actuation bypassed. The battery voltage is to be at the minimum voltage level specified by the manufacturer and the extinguishing system is checked for proper operation when the electrical means for the manual actuation system is operated.

63.2 Mechanical actuation

63.2.1 When a recirculating system employs a mechanical means for manual extinguishing system actuation, it shall be actuated to demonstrate proper installation. The extinguishing system shall actuate when the manual pull is actuated. With concurrence of all parties involved, this test is not prohibited from being combined with the Delayed operation fire test, 61.4.

64 Ozone Test

64.1 *Deleted*

64.2 *Deleted*

64.3 *Deleted*

64.1 General

64.1.1 Equipment provided with components which produce ozone (electrostatic precipitators, UV-C lights, ozone generators, etc.) shall be tested for peak and time weighted average ozone levels.

64.1.2 The equipment is to be tested in the worst case with respect to ozone generation using new or clean filters. The test is to be conducted using all filters operational that generate ozone and by omitting those filters that are optional, that reduce the overall output of ozone during the equipment operation.

64.1.3 The test is to be conducted in a 1000 ft^3 (28.3 m^3) closed room for a period of 8 hours of continuous operation. The maximum ozone levels permitted are 0.1 ppm time weighted average with a maximum peak concentration of 0.3 ppm.

64.1.4 The test described in 64.3 – 64.4 shall be conducted on one representative sample containing all of the ozone generating equipment which could be installed as part of the overall assembly.

64.1.5 When tested as described in 64.3 – 64.4, a recirculating hood shall not produce a concentration of ozone that exceeds:

a) 0.1 parts ozone per million parts air (PPM) averaged over 8 hours; and

b) The maximum transitory ozone concentration shall not exceed 0.3 parts ozone per million parts air (PPM) when averaged over any 13 consecutive, one minute, readings and shall not exceed 0.8 PPM when averaged over any two consecutive readings.

64.1.6 A product shall be tested in accordance with 64.3 – 64.4 under the most severe conditions for generating the maximum amount of ozone, taking into account all intended operating modes of the product. These conditions shall include the following:

a) High fan speed;

b) Low fan speed;

c) Ambient temperature, unless the unit is provided with a temperature interlock which would not allow the ozone generating equipment to be activated unless a minimum temperature is achieved (see 11.1); and

d) Any other operating conditions that could include, but are not limited to: fan(s) inoperative, emitters(s)/ionizer(s) on, UV lamps on or other special features activated or inactivated.

64.1.7 In reference to 64.2.3, the testing in 64.3 – 64.4 shall include the product operating with:

a) Only one operating mode occurring at a time if the product is intended to operate in this manner; or

b) Multiple operating modes occurring simultaneously if simultaneous operation of the product in different modes is intended and testing the product in multiple operating modes represents the most severe condition(s) for maximizing ozone emission; and

c) All air filter(s) removed unless an interlock switch causes ozone production to stop if the air filter(s) are removed, as specified in 64.1.8.

64.1.8 In reference to 64.1.7(c), for a product having an interlock switch causing ozone production to decrease or stop if an air filter is removed:

a) The testing in 64.3 – 64.4 shall be conducted with the interlock switch bypassed; or

b) The interlock switch shall comply with Section 11, Interlocks, and the operating instructions of the product shall specify the intended filter(s), including replacement filters, in accordance with 77.3.

64.1.9 If ozone-monitoring circuitry is provided as part of the product, the test described in 64.2.2 – 64.2.4 shall be conducted with the circuitry bypassed unless the circuitry complies with the protective control requirements in 11.1.6 or has been investigated as part of the UL 867A Ozone Generating assembly.

64.2 Chamber specifications

64.2.1 The test is to be conducted in a chamber having a volume of 950 – 1100 cubic feet (26.9 – 31.1 m^3) with a minimum side dimension of 8 feet (2.4 m) and a maximum height dimension of 10 feet (3.0 m) without openings. The test chamber walls, ceiling, and floor are to be surface treated (polished) stainless steel or other nonporous and non-reactive material. The suitability of chamber materials shall be validated by the halflife procedure of 64.2.3.

64.2.2 The following test chamber criteria shall be met:

a) The test chamber shall be sufficiently airtight to avoid uncontrolled air exchange. The chamber is considered sufficiently airtight if at least one of the following requirements is fulfilled:

1) the air leakage is less than 0.5 percent of the chamber volume per minute at an overpressure of 1000 Pa; or

2) the air leakage is less than 5 percent of the supply airflow rate when investigated per the Airtightness – Pressurization or Tracer Gas Method of the Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products, ASTM D6670, static condition, at a pressure differential of 10 PA.

b) The test chamber shall have proper mixing verified via the mixing procedure of the Standard Practice for Full-Scale Chamber Determination of Volatile Organic Emissions from Indoor Materials/Products, ASTM D6670, Sections titled Air Distribution in the Chamber and Air-Mixing in a Chamber, and shall not create local airflow across the surface of the product under test exceeding 0.1 m/s; and

c) The test chamber supply air system shall be equipped with sufficient carbon and HEPA media to remove particles, reactive VOCs, and ozone.

64.2.3 Performance of the test chamber shall be verified prior to each test and after any modification or cleaning through:

a) Determination of the chamber ozone half-life at 0 forced air changes,

b) Calculation of the chamber deposition velocity under these conditions using the equation defined in 64.2.4,

c) Calculation of the air exchange rate necessary to maintain an overall chamber ozone removal rate (Napparent) value of 1.33 using the equation defined in 64.2.5, and

d) Verification of the chamber ozone half-life of 31 ±2 minutes under the air exchange rate calculated in c), and if necessary, adjustment of the air exchange rate to achieve an ozone half-life of 31 ±2 minutes, repeating the verification as needed after adjustment of the air exchange rate.

The chamber ozone half-life is determined using an initial steady state concentration of 0.100 to 0.200 ppm ozone. For the purpose of this measurement, steady state is defined as a fluctuation not greater than ±10 percent or 0.0020 ppm, whichever is greater, during a fifteen minute period.

Exception: If the chamber has initially demonstrated compliance with the requirements of steps (a) through (d), and with step (d) in three or more consecutive tests over a twoday minimum time frame, only step (d) need be repeated immediately prior to the testing of each model. However, steps (a) through (d) and three or more consecutive step (d) tests shall be repeated, at a minimum, bi-annually or after any chamber modification or maintenance activities.

64.2.4 The chamber deposition velocity (Vd) is defined by the following equation:

in which:

$$Vd = \left[\left(\frac{Ln\frac{C(t)}{C(0)}}{-t_{1/2}}\right) - AER\right] * \left(\frac{4}{A/V}\right)$$

in which:

Vd = Deposition Velocity (m/h)

C(t) = Ending Ozone Concentration

C(0) = Initial Ozone Concentration

$t_{1/2}$ = Chamber Half-Life (h)

AER = Air Exchange Rate (1/h) = 0

A/V = Chamber Surface Area to Volume Ration (m^2/m^3)

64.2.5 The air exchange rate necessary to maintain an overall chamber ozone removal rate (Napparent) value of 1.33 is defined by the following equation:

$$AER = Napp - Vd * A / V$$

in which:

AER = Air Exchange Rate (1/h)

Napp = Napparent (1/h) = 1.33

Vd = Deposition Velocity (m/h) = Value determined in 64.2.3 and 64.2.4

A/V = Surface Area to Volume Ratio (m^2/m^3)

The chamber air exchange rate is defined as the ratio of the volume of clean air brought into the chamber per hour to the unloaded chamber volume.

64.3 Equipment specifications

64.3.1 Ozone analysis equipment shall meet the following criteria:

a) Ranges of 0.02, 0.04, 0.1, 0.2, and 0.4 mg/m^3 on the full scale (or have auto ranging capability);

b) The capability to detect 4 $\mu g/m^3$ or lower concentration;

c) A precision of ±2 percent from the mean value in the 0 mg/m^3 to 0.2 mg/m^3 range (i.e. 2 $\mu g/m^3$ or 1 percent on the full scale);

d) A sampling rate of not less often than once every 60 seconds;

e) A sampling line of minimum length, not to exceed 13 feet (4 m), made of a flexible material that is inert, such as PTFE.

To prevent impact on the test, the ozone analysis equipment shall be placed outside of the chamber.

64.4 Test method

64.4.1 Prior to testing, the location of the peak ozone emission on a product shall be determined in accordance with 64.4.2 – 64.4.6.

64.4.2 The product shall be located in accordance with 64.4.11 and:

a) Within the test chamber specified in 64.2.1; or

b) In an area where the local airflow across the surface of the product is not greater than 4 inches/s (0.1 m/s) and which has minimum dimensions of 10 feet (3 m) per side and not less than 8 feet (2.4 m) high.

64.4.3 The air stream discharge area shall be determined by measuring the air stream in a plane parallel to and 2 inches (50.8 mm) from the surface of the product air discharge grille. Each ozone sampling point shall be along this plane.

64.4.4 The location and number of ozone sampling points for a product shall be determined based on the discharge area of the air stream and located in-line with the exhaust discharge from the unit. One ozone sampling point shall be located in the geometric center of the air stream discharge area with additional ozone sampling points provided based on the overall area of the air stream discharge of the product as follows:

a) For an air stream discharge area less than 16 in^2 (103 cm^2) – minimum of 4 sampling points.

b) For an air stream discharge area equal to or greater than 16 in^2 (103 cm^2) – minimum of 8 sampling points.

64.4.5 For the sampling points specified in 64.4.4 (a) and (b), the air stream discharge shall be divided into equal sized zones so that the number of ozone sampling points equals the number of zones. The ozone sampling point shall be located in the geometric center of each zone.

64.4.6 The product shall be subjected to a 48 hour run-in period. Run-in and determining the location of peak ozone emission shall be conducted with the room at a controlled temperature in the range of 77 ±9°F (25 ±5°C) and a supply of filtered air.

64.4.7 At the completion of the run-in period, the location of peak ozone emission shall be determined by measuring the emission of ozone at each sampling point for a minimum of 2 minutes. The ozone sampling device shall point directly into the air stream. Ozone values shall be allowed to stabilize between measurements.

64.4.8 The tests in 64.4.9 – 64.4.13 shall be conducted on a product to determine compliance with 64.1.5.

64.4.9 During the test, the test chamber is to be maintained at a temperature of 25 ±2°C (77 ±4°F) and a relative humidity of 50 ±5 percent.

64.4.10 Prior to the start of each test, the ozone background level is to be measured with the product off. The background level shall be subtracted from the maximum measurement during the test. With respect to determining background level, the following measurement criteria shall be applied:

a) The ozone background measurement shall not exceed 0.005 ppm at steady state. Measurements above this value may interfere with emissions determinations.

b) Background measurements within the chamber shall be taken immediately prior to testing of the product.

For the purpose of this measurement, steady state is defined as a fluctuation not greater than ±10 percent or 0.0020 ppm, whichever is greater, during a fifteen minute period.

64.4.11 The product is to be located in the center of the test chamber floor and

a) 30 inches (762 mm) above the floor for table-mounted products.

b) on the floor for floor mounted or supported products.

64.4.12 A single ozone monitor sampling tube is to be positioned with the sample tube opening located 2 inches (50 mm) from the air outlet of the product and at the sampling point that provides the peak ozone emission as determined by 64.4.1 – 64.4.7. The sample tube is to point directly into the air stream.

64.4.13 To determine the concentration of ozone, the ozone emission is to be monitored for not less than 8 hours.

65 Physical and Immersion Tests for Gaskets and Seals

65.1 Tensile strength and elongation

65.1.1 The tensile strength and elongation of gaskets and seals used in the construction of exhaust hoods, fittings, and accessories for use with hoods shall not decrease by more than 50 percent of their original tensile strength and elongation after being subjected to the exposures described in 65.2.2 and 65.2.3. The part shall show no apparent deterioration, such as cracking, hardening, softening, melting, or damage after these exposures.

65.1.2 The average volume change of gaskets and seals used in the construction of exhaust hoods, fittings, and accessories for use with exhaust hoods shall be in the range of minus 1 to plus 50 percent after being subjected to the exposures specified in 65.3.1.

65.1.3 For tensile strength and ultimate elongation determination, nine specimens are to be prepared. The test procedures are to be as outlined in the Section covering the tensile strength and ultimate elongation test in the Standard for Gaskets and Seals, UL 157.

65.2 Aging and immersion

65.2.1 When the size or shape of the gasket or seal is such that tensile strength and elongation specimens cannot be obtained from the part, the complete part, or a Section from the part, the gasket or the seal is to be subjected to the aging and immersion exposures specified in 65.2.2 and 65.2.3.

65.2.2 Three specimens are to be subjected to air oven aging at 277 ±1.8°F (136 ±1°C) for seven days. The test procedures are to be as outlined in the Section covering the accelerated air oven aging test in the Standard for Gaskets and Seals, UL 157.

65.2.3 Three specimens are to be immersed for 70 hours in lard and three specimens are to be immersed in corn oil at 277 ±1.8°F (136 ±1°C). The test procedures are to be as outlined in the Section covering the immersion test and the method for tensile strength and elongation tests in the Standard for Gaskets and Seals, UL 157.

65.3 Volume change

65.3.1 Three specimens from the gaskets or seals are to be immersed for 70 hours in lard and three specimens are to be immersed in corn oil at 277 ±1.8°F (136 ±1°C). The test procedures are to be as outlined in the Section covering the immersion test, method for volume change in the Standard for Gaskets and Seals, UL 157.

PERFORMANCE – COMPONENTS

66 General

66.1 The tests in Sections 67 – 73 are to be conducted in any order on components outside the appliance, or, with the consent of all concerned, in the appliance.

67 Transformer Burnout Test

67.1 The overcurrent protection is not required to be included in the primary of a transformer as specified in Exception No. 3 to 24.3.3, when the transformer is operated as described in 67.2 or 67.3, and when:

a) There is no emission of flame or molten metal from the enclosure of the appliance; and

b) The fuse in the ground connection does not open.

67.2 The circuit on which the transformer is tested is to be protected by fuses rated not less than that required for the appliance. Exposed dead metal parts are to be connected to ground through a 3-ampere fuse. Each accessible fuse provided with the transformer is to be replaced with a dummy fuse, and inaccessible fuses are to remain in the circuit. The test voltage is to be as specified in 45.4.9 and at rated frequency. The load connected to the output terminals is to be as described in 67.3. Operation is to be continued until constant temperatures are indicated by a thermocouple on the transformer coil or until burnout occurs.

67.3 The burnout test is to be conducted with the output terminals of the transformer connected to a resistance of such value that three times the full-load rated current will be drawn from the secondary winding, except that the output is to be short-circuited when such condition results in less than three times rated current being drawn from the secondary. The test may be conducted with the output terminals connected to a motor with the rotor locked. The load imposed on the transformer by the coil of any solenoid, relay, or the like – the largest of such devices when more than one is present – with its armature blocked open is to be determined. The test is to be conducted with an equal resistance load substituted for the coil.

68 Endurance Test for Interlock Switches

68.1 An interlock system as specified in 11.1.5 shall function as intended after 100,000 cycles of operation controlling a load not less than that controlled in the appliance.

69 Motor Switch Overload Test

69.1 A switch that controls a motor and that does not have a horsepower rating for that motor shall be subjected to an overload test consisting of 50 cycles of making and breaking the stalled-rotor current of the motor. There shall be no electrical or mechanical malfunction of the switch, nor any undue pitting or burning of the contacts.

69.2 To determine whether a switch complies with the requirement in 59.1, General, it is to be tested with the rotor of the motor locked and with exposed dead metal parts of the appliance grounded. The appliance is to be connected to a supply circuit of rated frequency and maximum rated voltage. Electrical connections are to be such that a single-pole switch is connected in the ungrounded conductor of the supply circuit. An appliance intended for use on direct current is to be tested with a direct-current supply.

70 Printed-Wiring Board Abnormal Operation Test

70.1 Where required by Exception No. 2 of 32.1.1, printed-wiring boards are to be tested as described in 70.3 – 70.8. As a result of this test:

a) The overcurrent protection in the branch circuit to which the equipment is connected shall not open;

b) When a wire or a printed-wiring board trace opens, the gap is to be electrically shorted and the test continued until ultimate results occur;

c) A flame shall not be emitted from the overall enclosure of the equipment;

d) The cheesecloth or tissue paper shall not glow or flame; and

e) The 3-ampere fuse connected in the equipment grounding circuit shall not open.

70.2 Operation of an overcurrent protection device, other than the branch circuit overcurrent protection device, before any abnormal condition results is acceptable. When an overcurrent protective device opens, the marking specified in 80.10 shall be provided.

70.3 With respect to the limiting impedance circuit requirements in 29.7, a circuit supplied by a limiting impedance shall comply with the following:

a) The supply to the device shall be as specified in the Normal Temperature Test, Section 45.

b) Starting at the input to the circuit, the maximum wattage available to the secondary circuit under consideration is to be measured by connecting a variable resistive load between the load side point of each component in line with the source and the supply return. The variable resistance is to be adjusted to a value which maintains a level of 15 watts as measured by a wattmeter. Each component capable of maintaining 15 watts or more for a period of 5 seconds is to be identified.

c) That portion of the circuit that is supplied by a maximum power availability of 15 watts is considered as a derived low voltage circuit.

70.4 A sample of the equipment employing the printed-wiring board is to be wired as intended to an electrical supply circuit sized and protected to simulate end-use conditions. When the live parts on the printed-wiring board have spacings between them that are less than those specified in Table 32.1, they are to be short-circuited one at a time.

70.5 A 3-ampere fuse is to be connected between the supply circuit pole least likely to arc to ground, and the outer enclosure (if any) and grounded or exposed dead metal parts.

70.6 During the abnormal test, the equipment is to be placed on a softwood surface which is covered with white tissue paper. A single layer of cheesecloth is to be draped loosely over the entire enclosure. Open equipment is to be tested in an enclosure judged to be representative of that likely to be encountered in service. When agreeable to those concerned, tests are not prohibited from being conducted without an enclosure and are determined to be representative of tests conducted using an enclosure. When tests are to be conducted without an enclosure, cheesecloth is to be placed on a wire cage surrounding and in close proximity to the equipment under test in order to simulate the intended enclosure.

70.7 The test is to be continued for 1 hour or until one of the conditions described in 70.1 occurs. However, if at the end of 1 hour none of the conditions described in 70.1 have occurred, and indications are such that a condition will eventually occur, the test is to be continued until ultimate results are obtained.

70.8 When the circuit is interrupted by the opening of a component, the test is to be repeated twice using new components.

71 Secondary Circuits

71.1 General

71.1.1 The following tests are to be conducted as specified in Section 29, Secondary Circuits. Unless otherwise specified, the tests are to be conducted with the supply for the secondary circuit connected to a circuit of rated voltage.

71.2 Maximum voltage test

71.2.1 The maximum available voltage between any two of the source terminals of the secondary circuit shall be measured, with or without any combination of interconnected secondary terminals.

Exception: The secondary terminals are not required to be interconnected during the test when all of the following are met:

a) No more than one secondary circuit is accessible outside the appliance enclosure; and

b) Separation is maintained between the secondary circuits in accordance with Section 35, Separation of Circuits.

71.2.2 The voltage is to be measured in an open-circuit condition. When solid-state limiting circuitry or other considerations result in the maximum voltage being obtained under another loading condition, the voltage is also to be measured with a variable resistive load to determine the maximum available voltage.

71.2.3 Voltage measurements are to be made using a voltmeter having an internal impedance of not less than 3,000 ohms per volt.

71.2.4 The results are determined to comply when the maximum available voltage for a limited voltage/current circuit, a limited voltage circuit, or a limited energy circuit is not more than 30 V rms/42.4 volts peak, or 60 V dc. See 29.1.9 and 29.1.10.

71.3 Maximum current test for inherently limited circuits

71.3.1 The maximum available current in a secondary circuit intended to be inherently current limited shall be tested as described in 71.3.2 – 71.3.7. Multiple secondary windings, if any, shall be interconnected to produce maximum current.

Exception: Multiple secondary windings are not required to be interconnected during the test when all of the following are met:

a) No more than one secondary circuit is accessible outside the appliance enclosure; and

b) Separation is maintained between the secondary circuits in accordance with Section 35, Separation of Circuits.

71.3.2 A resistance load that produces the largest initial value of current (including short circuit) is to be determined. The secondary circuit to be tested is to be loaded with this value of resistance, and the input to the source of that secondary is to be energized at the rated voltage while at room temperature. The current is to be measured as follows:

a) When a separate current limiting impedance is provided [such as a resistor or a positive temperature coefficient device (PTC)], the current is to be measured after 5 seconds of operation; or

b) When no separate current limiting impedance is provided, the current is to be measured after 2 minutes of operation.

71.3.3 The results are in compliance when the measured current does not exceed 8 amps for a limited voltage/current circuit.

71.3.4 The impedance of the short circuit measuring circuit in the secondary is to be limited to 0.03 ohm.

71.3.5 For a transformer, only one secondary circuit of a multiple secondary transformer is to be tested at a time, and all other secondaries not under test are to be loaded as intended. The voltage and current measurements can be made directly across the secondary output terminals of the transformer. When a tapped transformer winding is used to supply a full wave rectifier, the measurements are to be made from either end of the winding to the tap. When the transformer is used as part of a switching type power supply, the voltage and current measurements are to be made after the transformer secondary winding rectification means.

71.3.6 When the current is interrupted by a resettable or replaceable protective device, the test is to be repeated with the protective device shorted.

71.3.7 When the current is interrupted by a nonresettable, nonreplaceable protector or by coil burnout, other samples are to be tested by continuously adjusting the resistance load to hold the current just above the value specified in 71.3.3 for two minutes. The results are acceptable when the circuit is not able to maintain the current given in 71.3.3 for two minutes or when the current is interrupted.

71.4 Limited power point determination test

71.4.1 With reference to 29.7.1(b), a determination shall be made as to which points in the circuit are capable of delivering a power greater than 15 watts for more than 5 seconds into an external variable resistor connected singly between each point in the circuit and its supply return (circuit common). See 71.4.2.

71.4.2 To determine the points capable of delivering a power of more than 15 watts, the external resistor is to be set for maximum resistance before being connected to the circuit under investigation. The external resistor is to be adjusted until the maximum wattage is consumed as indicated by a peak reading of the wattmeter. A reading of greater than 15 watts indicates that the points are capable of delivering greater than 15 watts. The external resistor is to then be moved, point by point, from the point farthest from the load to other points toward the load side of the circuit until a point is reached where the maximum power consumed by the external resistor (as indicated by a peak reading of the wattmeter) is not more than 15 watts. During the test, the appliance is to be connected to a source of supply and operated as specified in the Normal Temperature Test, Section 45.

Exception: When the portion of the appliance in question is tested separately from the main body of the appliance, the source of supply and loading are to be equivalent to those supplied to the circuit within the appliance when the appliance is operated as specified in the Normal Temperature Test.

71.4.3 With reference to 71.4.1, when a thermal or overcurrent protective device operates during the test, a shorting switch is to be connected across the protective device in the closed position. The external resistor is to be adjusted for maximum resistance before being connected in the circuit. The external resistor is to then be adjusted so that the power it dissipates is 15 watts as indicated by the wattmeter reading. The switch across the protective device is to then be opened and the time required for the protective device to open is to be recorded. When the protective device opens the circuit in 5 seconds or less while the resistor is dissipating 15 watts, the first circuit point not capable of delivering more than 15 watts has been located.

71.5 Component failure test

71.5.1 A power supply or other source that is required to limit current or power to a secondary circuit under single-fault conditions (see 29.4.7 and 29.7.2), shall limit the current or power as required with each resistor, capacitor, or other circuit element connected between the power supply and the first point considered part of the limited voltage/current circuit or limiting impedance circuit is to be open or short circuited one at a time. For a discrete device having more than two terminals, (such as a transistor, SCR,

triac, or similar device) any combination of two terminals shall be open or short circuited. For an integrated circuit device, the following combinations of terminals shall be tested:

a) Each pair of adjacent terminals shorted;

b) Each input terminal shorted to (referenced) ground terminal;

c) Each output terminal shorted to (referenced) ground terminal;

d) Each input terminal shorted to each power supply;

e) Each output terminal shorted to each power supply; and

f) Each terminal open circuited.

Exception No. 1: A resistor investigated for compliance with respect to end use conditions and incorporating insulation or spacings to reduce the risk of a short circuit or reduction in resistance is not to be short circuited.

Exception No. 2: A capacitor, capristor (parallel combination of a capacitor and resistor), or similar circuit component, complying with requirements for antenna coupling and line bypass components described in the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414, and investigated for compliance with respect to end use conditions, is not to be short-circuited.

Exception No. 3: Testing of an integrated circuit is to be reduced when the location of points capable of delivering more than 30 Vac, 42 V peak, 60 V dc, or 8 amps after 2 minutes for limited voltage/current circuits or 15 watts for limiting impedance circuits under the conditions in (a) – (f) is capable of being determined by circuit analysis.

71.5.2 With respect to 29.4.7 and 29.7.2, the tests mentioned in 71.5.1 shall be used to modify the determination of the first point of the limited voltage/current circuit or the limiting impedance circuit, when required.

71.5.3 Circuit components which, when taken together are relied upon to limit power in connection with the requirements in this Section, shall be of the fixed type and shall be investigated as a unit with respect to end use conditions.

71.6 Maximum power test

71.6.1 The maximum obtainable output power is not to exceed 200 VA for Limited energy circuits (see 29.6) or Limited voltage/current circuits (see 29.4). Protective devices are to be shorted out during this test. Multiple secondary windings are to be interconnected to produce maximum output power. The maximum output power is to be determined by the steps described in (a) – (g). Different samples are to be used for each condition.

a) The full load secondary voltage (V_{FL}) is to be measured at rated secondary current (I_{FL}).

b) Using the value of the open circuit secondary voltage (V_{OC}) determined as described in 71.2, the internal resistance (R_I) of the transformer is to be calculated using the formula:

$$R_I = V_{OC} - V_{FL}$$

c) The load resistance (R_L) required in (d), (f), and (g) is to be calculated using the formula:

$$R_L = R_I[\% / (1.0 - \%)]$$

In which % is the percent of open circuit secondary voltage (for example, for the value 50, % would be equal to the value 0.5).

d) Starting with the transformer at room temperature, the transformer is to be loaded with a resistance load (R_L), calculated as described in (c), with the percent of open circuit secondary voltage (%) equal to 0.65. The ampere rating of the resistance load (R_L) shall be not less than the maximum secondary output current (I_O). At the end of 2 minutes of operation, the secondary voltage (V_O) and secondary output current (I_O) are to be measured. Once the transformer is energized there shall be no adjustment of the resistance load (R_L).

e) The maximum output power (VA_O) is to be calculated using the formula:

$$VA_O = V_O \times V_O$$

f) When the output power (VA_O) calculated in (e) exceeds 200 VA, the result is unacceptable. When the output power (VA_O) calculated in (e) is not more than 160 VA (80 percent of 200 VA), the result is acceptable. When the output power (VA_O) calculated in 71.6.1(e) is within 40 VA (20 percent) of 200 VA, additional secondary voltage (V_O) and current (I_O) measurements are to be made and the maximum output power (VA_O) is to be calculated with the percent of open circuit secondary voltage (%) equal to 0.6 and 0.7. The results are unacceptable when the calculated output power (VA_O) exceeds 200 VA.

g) When the maximum output power (VA_O) calculated at either the 0.6 or 0.7 level in (f) is greater than that calculated in (e), additional measurements are to be made. The resistance load (R_L) is to be set to the value calculated with the percent of open circuit secondary voltage (%) in (f) which resulted in a calculated maximum output power greater than that calculated in (e). Successive 0.05 increments are to be used to calculate R_L and measurements are to be taken until the calculated output power (VA_O) starts to decline. The results are acceptable when the maximum calculated output power (VA_O) does not exceed 200 VA.

71.7 Power dissipation test

71.7.1 With respect to 29.7.1(a), the power dissipated by the limiting impedance shall not exceed the power rating of the impedance when tested in accordance with 71.7.2.

71.7.2 With the circuit connected and loaded as intended in use, the voltage across the limiting impedance and the current through the limiting impedance are to be measured. These values are to be multiplied together to obtain an approximation of the power dissipation of the impedance. When these values vary based upon control positions, mode of operation, etc., sufficient measurements are to be taken to determine the maximum power dissipation.

72 Parts Subject to Contact with Oil or Other Liquids

72.1 When the deterioration of a liquid container, seal, tubing, hose, or similar item increases the risk of fire, electric shock, or injury to persons, the part in question shall be investigated to determine that it is resistant to deterioration from the liquid intended to be used in contact with it. An enclosure, supporting member, strain relief, or similar part, which is subject to contact with hot oil, shall be investigated to determine whether it is resistant to deterioration caused by exposure to hot oil.

Exception No. 1: When the maximum temperature measured during normal operating conditions does not exceed the previously determined mechanical temperature index of the material, and the material is not

subject to additional degradation by the liquid with which it comes in contact, the component is not required to be further investigated.

Exception No. 2: Tubing which contains water at or below water line pressure, and at or below 40°C (104°F) during normal operation, is provided with a reinforcing outer braid, and has a manufacturer's rating of at least 200 psig, is not required to be further evaluated.

72.2 To determine whether a part made of elastomers, flexible cellular, or thermoplastic material complies with the requirement in 62.1, General, an investigation is to be conducted in accordance with the requirements for tensile strength, elongation, and hardness in the Standard for Gaskets and Seals, UL 157. The material under test is acceptable when these properties are found to be not less than the minimum values specified in Table 72.1.

Exception: When parts are subject to contact with cooking oil, the tests in UL 157 are to be modified to include conditioning in cooking oil at the temperatures specified in the oven aging table of UL 157 rather than in an air oven. The maximum service temperature shall be determined by measuring the maximum temperature on the part, or surfaces in contact with the part, during the Normal Temperature Test, Section 45. However, when hot cooking oil is the major source of heat, the maximum service temperature is allowed to be 204°C (400°F) without further temperature measurement. The cooking oil is to be changed every 7 days during the test.

Table 72.1
Artificial aging tests

Maximum temperature on component during normal temperature test		Duration of test and temperature of air oven	Minimum percent of original (unaged) value for samples		Maximum change from unconditioned value (units)
°C	(°F)		Tensile strength	Elongation	Indentation hardness
60	(140)	Air oven aging for 70 hours at 100 ±2°C (212 ±3.6°F)	60	60	±5
75	(167)	Air oven aging for 168 hours at 100 ±2°C (212 ±3.6°F)	50	50	±5
90	(194)	Air oven aging for 168 hours at 121.0 ±1.0°C (249.8 ±1.8°F)	50	50	±10
105	(221)	Air oven aging for 168 hours at 136.0 ±1.0°C (276.8 ±1.8°F)	50	50	±10
Above 105	(Above 221)	Air oven aging for 168 hours at 31°C (55.8°F) higher than the temperature attained in normal use	50	50	±10

72.3 To determine whether a composite gasket complies with the requirement in 72.1, an investigation is to be conducted in accordance with the requirements for tensile strength in the Standard for Gaskets and Seals, UL 157. Test samples shall be taken from sheets in both the traverse and longitudinal directions.

Exception: When parts are subject to contact with cooking oil, the tests in UL 157 are to be modified to include conditioning in cooking oil at the temperatures specified in the oven aging table of UL 157 rather than in an air oven. The maximum service temperature shall be determined by measuring the maximum temperature on the part, or surfaces in contact with the part, during the Normal Temperature Test, Section 45. However, when hot cooking oil is the major source of heat, the maximum service temperature is allowed to be 204°C (400°F) without further temperature measurement. The cooking oil is to be changed every 7 days during the test.