UL 197

STANDARD FOR SAFETY

Commercial Electric Cooking Appliances

UL Standard for Safety for Commercial Electric Cooking Appliances, UL 197

Tenth Edition, Dated March 17, 2010

Summary of Topics

This revision to ANSI/UL 197 dated April 7, 2023 includes the addition of UL 62368-1 as an alternative to UL 60950-1; 28.3.3, Table 34.1, 34.3.1 and 34.8.1.

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated March 3, 2023.

No Text on This Page

MARCH 17, 2010
(Title Page Reprinted: April 7, 2023)

ANSI/UL 197-2023

UL 197

Standard for Commercial Electric Cooking Appliances

First Edition – January, 1952
Second Edition – October, 1960
Third Edition – June, 1972
Fourth Edition – November, 1974
Fifth Edition – April, 1978
Sixth Edition – March, 1982
Seventh Edition – July, 1987
Eighth Edition – June, 1993
Ninth Edition – March, 2003
Tenth Edition March 17, 2010

Tenth Edition

March 17, 2010

This ANSI/UL Standard for Safety consists of the Tenth edition including revisions through April 7, 2023.

The most recent designation of ANSI/UL 197 as an American National Standard (ANSI) occurred on April 7, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 197 on January 28, 1976. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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PART 1 – ALL APPLIANCES

INTRODUCTION

1 Scope

1.1 These requirements cover commercial electric cooking appliances rated 600 volts or less, intended for indoor use, and intended for use in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements cover coffee makers, conductive cookers, food warmers, fryers, griddles, steam kettles, steam cookers, nut warmers, popcorn machines, ranges, utensil warmers, and other appliances found in commercial kitchens, restaurants, or other business establishments where food is dispensed.

1.3 These requirements do not cover vending machines, cooking appliances intended for household use, commercial cooking appliances rated more than 600 volts, or microwave cooking appliances.

1.4 An appliance designed so that it can be mounted and supported at an outlet box, such as a food warmer, is judged on the basis of compliance with the requirements in this Standard and with the mounting and weight requirements for electric lighting fixtures.

1.5 An appliance that utilizes heat produced by a means other than electrical (for example, gelled or liquid fuel, coal, gas, or oil) is also investigated with respect to the additional risk of fire.

1.6 An appliance that utilizes heat produced by gelled or liquid fuel is also investigated with the appliance operating with the specific fuel(s) which it intended to be used.

1.7 Commercial cooking equipment employing integral systems for limiting the emission of grease laden air are intended to be installed in accordance with the Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations, NFPA 96, and shall comply with the requirements of this Standard. Additionally, the effluent emitted from the system shall not exceed 5 mg/m^3 as measured in accordance with the U. S. Environmental Protection Agency (EPA) Test Method 202, Determination of Condensible Particulate Emissions From Stationary Sources.

1.8 Commercial cooking equipment employing integral recirculating systems shall comply with the requirements of this Standard and the requirements in the Standard for Recirculating Systems, UL 710B.

2 Glossary

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

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

2.3 APPLIANCE – Utilization equipment that uses electrical energy for some function.

2.4 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.

2.5 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.

2.6 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 29, 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.

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

2.7.1 COMPONENT –A device or fabricated part of the appliance covered by the scope of a safety standard dedicated to the purpose. When incorporated in an appliance, equipment otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as thermoplastic or copper, are not considered components.

2.8 CONTINUOUS DUTY – A requirement of service which demands operation at a substantially constant load for a period of at least 3 hours.

2.9 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.

2.10 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.

2.11 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.

2.12 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.

PORTABLE – An appliance that is:

a) Cord-connected;

b) Intended to be transported for use at various locations; and

c) Designed to be carried by hand or provided with integral casters, wheels, and the like, or a cart to make it mobile.

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

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

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

2.15 LEAKAGE CURRENT – Electric current which flows through a person upon contact between accessible parts of an appliance and:

a) Ground; or

b) Other accessible parts of the appliance.

2.16 MEASUREMENT INDICATION UNIT (MIU) – The output voltage across the meter, in milli-volts RMS, in the measurement instrument in Figure 46.2, divided by 500 ohms. (The instrument indication is equal to the RMS value in milli-amperes when the frequency is 60 Hz (sinusoidal current). The reading may not be a direct indication of the RMS or other common amplitude quantifier of leakage current when the leakage current is of complex waveform or frequency other than 50 or 60 Hz.)

2.17 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.

2.18 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.

2.19 PANELBOARD – A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and equipped with or without switches for the control of electric circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition of an appliance and accessible only from the front. Examples of a panelboard range from a 200 amp service panel to a 6x6x4 steel control box with permanent or DIN rail mounted components.

2.20 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.

2.21 PRESSURE VESSEL – A closed tube or cavity in which air, liquid, or gas is stored.

2.22 PRESSURE VESSEL, FIRED – A pressure vessel in which air, liquid, or gas is heated; steam is generated; steam is super heated; or any combination thereof, under pressure or vacuum by the direct application of heat. In the case of an electrically heated vessel, if the heat source is internal to the vessel (for example, an immersion heating element) this constitutes the direct application of heat; however, if the heat source is external to the vessel, such as an external heating element or an external induction heat

source, this does not constitute the direct application of heat. A vessel heated solely by an external electric source is not a fired pressure vessel.

2.23 PRESSURE VESSEL, UNFIRED – A pressure vessel in which air, liquid, or gas is subjected to pressure or vacuum from an external source, without the direct application of heat (see 2.22, PRESSURE VESSEL, FIRED, for further clarification).

2.24 REMOTELY CONTROLLED APPLIANCE – An appliance that is out of sight of an operator who is at the starting device.

2.25 SHEATHED HEATING ELEMENT – A metal enclosure surrounding and containing a resistance element that is usually encased in magnesium oxide or a similar insulating material.

2.26 SERVICE EQUIPMENT – The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

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

2.28 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.

2.29 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.

2.30 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.

2.31 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.

2.32 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 86.13.

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.

2.33 WORKING PRESSURE – The maximum system pressure of an appliance measured during normal operating conditions. When more than one pressurized system is provided in an appliance, the appliance is capable of having multiple working pressures.

3 Components

Section 3 deleted

4 Units of Measurement

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

5 Undated References

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

CONSTRUCTION

5A General

5A.1.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as indicated in the individual section covering that component;

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

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

d) Additionally comply with the applicable requirements of this end product Standard; and

e) Not contain mercury, unless used within a fluorescent, high intensity discharge, or neon lamp bulb.

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

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

b) Is superseded by a requirement in this Standard; or

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

Exception No. 2: A component complying with a component standard other than those cited in this Standard is acceptable if:

a) The component also complies with the applicable component standard indicated in this Standard; or

b) The component standard:

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

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

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

5A.1.2 A component that is also intended to perform other functions, such as over current protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable UL standard that cover devices that provide those functions.

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

5A.1.3 A component not anticipated by the requirements of this end product standard, not specifically covered by the component standards noted in this Standard, and that involves a risk of fire, electric shock, or injury to persons, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 5A.1.1 (b) – (e).

5A.1.4 With regard to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is suitable where that standard anticipates normal and abnormal use conditions consistent with the application of this end product Standard.

5A.2 Ground-fault, arc-fault, and leakage current detectors/interrupters

5A.2.1 Ground-fault circuit-interrupters (GFCI) shall comply with the Standard for Ground-Fault Circuit-Interrupters, UL 943. The following statement, or equivalent, shall be included as a marking near the GFCI, or as an instruction in the manual: "Press the TEST button (then RESET button) every month to assure proper operation."

5A.2.2 Appliance-leakage-current interrupters (ALCI) shall comply with the Standard for Appliance-Leakage-Current Interrupters, UL 943B. An ALCI is not considered an acceptable substitute for a GFCI when a GFCI is required by the National Electrical Code, NFPA 70.

5A.2.3 Equipment ground-fault protective devices shall comply with the Standard for Ground-Fault Sensing and Relaying Equipment, UL 1053, and applicable requirements of the Standard for Ground-Fault Circuit-Interrupters, UL 943.

5A.2.4 Arc-fault circuit-interrupters (AFCI) shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699.

5A.2.5 Leakage-current detector-interrupters (LCDI) and any shielded cord between the LCDI and appliance shall comply with Standard for Arc-Fault Circuit-Interrupters, UL 1699.

5A.2.6 An arc-fault circuit-interrupter (AFCI) or leakage-current detector-interrupter (LCDI), when used on equipment having a power supply cord and plug, shall be installed as an integral part of the attachment plug or located in the supply cord within 4 inches (102 mm) of the attachment plug.

5A.2.7 Arc fault detection testing shall include the applicable tests required for cord-type arc-fault circuit-interrupters, as in the Standard for Arc-Fault Circuit-Interrupters, UL 1699.

Exception: The carbonized path arc clearing time test is not applicable for LCDIs that are provided with shielded power-supply cords.

5A.3 Surge protective device

5A.3.1 A device providing surge protection or transient suppression shall comply with the Standard for Surge Protective Devices, UL 1449.

5A.4 Terminal blocks

5A.4.1 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059. If used for field-wiring, a terminal block shall also be suitably rated for field-wiring. Field-wiring terminals shall also comply with 16.3, of UL 197.

Exception: A fabricated part performing the function of a terminal block need not comply with UL 1059, if the part complies with the requirements of Electrical Supply Connections for Permanently Connected Appliances, Section 16 (if used for Field-Wiring); Current-Carrying Parts, Section 20; Electrical Insulation, Section 24; and Electrical Spacings, Section 37, of this end product Standard.

5A.5 Quick-connects

5A.5.1 Quick-connect type wire connectors shall be suitable for the wire size, type (solid or stranded), conductor material (copper or aluminum) and the number of conductors terminated. If insulated, they shall also be rated for the voltage and temperature of the intended use. They shall be applied per the installation instructions of the wire connector manufacturer.

5A.5.2 Quick-connect type wire connectors shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

5A.6 Insulating tape and tubing

5A.6.1 When relied upon to comply with requirements in this Standard:

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

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

5A.7 Programmable controllers

5A.7.1 A programmable controller shall comply with the Standard for Programmable Controllers – Part 2: Equipment Requirements and Tests, UL 61131-2. Depending on the specific functions the controller provides (i.e. temperature control, timing, etc.) addition requirements in this end use Standard may also be applicable.

Exception: A programmable controller is not required to meet UL 61131-2 if it has been evaluated to requirements elsewhere in this Standard for the application and function it provides.

5A.8 Fabricated polymeric parts

5A.8.1 A part relied upon for compliance with this Standard, when fabricated from polymeric materials, shall have clear traceability as to composition, ingredients, and processing for the fabricated part to the extent that the composition, ingredients, or process impacts the compliance of the product. Fabricated parts complying with the Standard for Polymeric Materials – Fabricated Parts, UL 746D, meets this requirement.

5A.9 Door latch release

5A.9.1 Unless provided with other means of exit, door(s) intended for entrance of persons into the heated compartment of an appliance; including a door panel assembly door, shall be able to be opened from the inside by a force applied outwardly to the door or to a release actuator. Doors shall comply with the Door Opening Test, 65B. In addition, doors with an interior latch release device shall comply with the Door Latch Release Test, 65A.

5A.9.2 If the door is provided with a key lock, it shall be constructed such that the lock can be opened from the interior without using a key or tool.

5A.9.3 Interior latch release actuators shall function with the appliance in its intended operating position and shall be operable from all spaces that are directly accessible when the door(s) is opened.

5A.9.4 A latch release device shall not depend on an electrical source for operation.

5A.9.5 A latch release device shall be constructed so that spillage of foods, or cleaning in accordance with the manufacturer's recommendations will not affect compliance with the requirements of the Door Latch Release Test, Section 65A.

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 An appliance having provisions for the use of gelled or liquid fuel shall comply with the requirements in the Standard for Unvented Alcohol Fuel Burning Decorative Heating Appliances, UL 1370, and the requirements in this Standard, with or without the gelled or liquid fuel in place.

6.3 An appliance having provisions for the use of gelled or liquid fuel shall be provided with a means for maintaining the fuel container in a dedicated fixed location on the appliance such that it cannot be moved or relocated from the factory-assembled position.

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

6.5 When an accessory is to be installed by the user, the appliance shall comply with the requirements in Section 10, Accessibility of Live Parts, during and after the installation of the accessory.

6.6 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.

6.7 With reference to 6.6, 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.

6.8 A means for strain relief shall be provided and comply with the strain relief test in Section 60, Strain Relief Test for the wiring in the accessory if there is a possibility of transmitting stress to the terminal connections during installation.

6.9 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.

6.10 The intended installation of the accessory shall be indicated in the installation instructions included on or with the accessory. See 91.11.

6.11 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.

6.12 An electrical accessory intended for field installation shall be marked in accordance with 86.14.

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.

Exception: This requirement does not apply to a sharp edge that must be exposed to enable the appliance to perform its intended function.

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 37.

7.3 Shipping

7.3.1 An appliance 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: A cord set, a heating element with integral blades for plugging into a receptacle, a heating element intended for use in a radiant-heat food warmer, and the legs or the mounting brackets of an appliance may be shipped detached from the remainder of the appliance if packed in the same overall carton of if the separate cartons are secured together – such as by steel strapping or strong tape – so that they do not become separated during the shipment. See 88.2 and 91.1.

Exception No. 3: A screw shell heat lamp is not required to be supplied or shipped with an appliance.

Exception No. 4: A part of an appliance, as described in (a) or (b), marked in accordance with 88.2 and 91.1 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 50.4.5.

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; or

2) Internal connection of a permanently connected appliance are made in accordance with the requirements for power-supply connections in 16.1 – 16.5 and 88.7, and field-installed leads are housed entirely within the appliance.

3) External connections of a cord-connected appliance are made by a connecting cord, of a type specified in 17.1.1, with integral plugs and receptacles arranged so that no uninsulated live part capable of causing electric shock is accessible to unintentional contact if disconnected; or

4) External connections of a permanently connected appliance are made in armored cable or conduit in accordance with the requirements for power-supply connections in 16.1 – 16.5. See 88.7. 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 22.5.7 (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. The requirements in this clause are not intended to preclude the use of an external interconnecting cord of a type specified in 17.1.1 if flexible cord is needed for the prevention of transmission of noise or vibration or for facilitating the removal of a part of the appliance for maintenance or repair.

Exception No. 5: 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 88.2 and provided with instructions in accordance with 91.1.

Exception No. 6: 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 88.2 and provided with instructions in accordance with 91.1. The device shall meet the requirements of Section 6, Accessories.

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, except a supply cord, 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.

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 50.4.5 and 91.2.

8.1.2 When evaluating an appliance in accordance with Section 8, Electrical and Fire Enclosures, 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, 73.5:

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 34.3);

b) A limited voltage/current circuit (see 34.4);

c) Other secondary circuits complying with 8.1.2.

8.1.4 When evaluating an appliance in accordance with Section 8, Electrical and Fire Enclosures, 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, 73.5:

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 34.3);

b) A limited voltage/current circuit (see 34.4);

c) A limiting impedance circuit (see 34.7);

Exception: A limiting impedance circuit that has not been evaluated for operation under single-fault conditions (see Exception No. 1 to 34.7.2) involves a risk of fire.

d) Other secondary circuits complying with 8.1.4.

Exception: Any part that exceeds 121°C during the Normal Temperature Test, Section 50, is 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.

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 63, Strength of Enclosure, 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 63, 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

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;

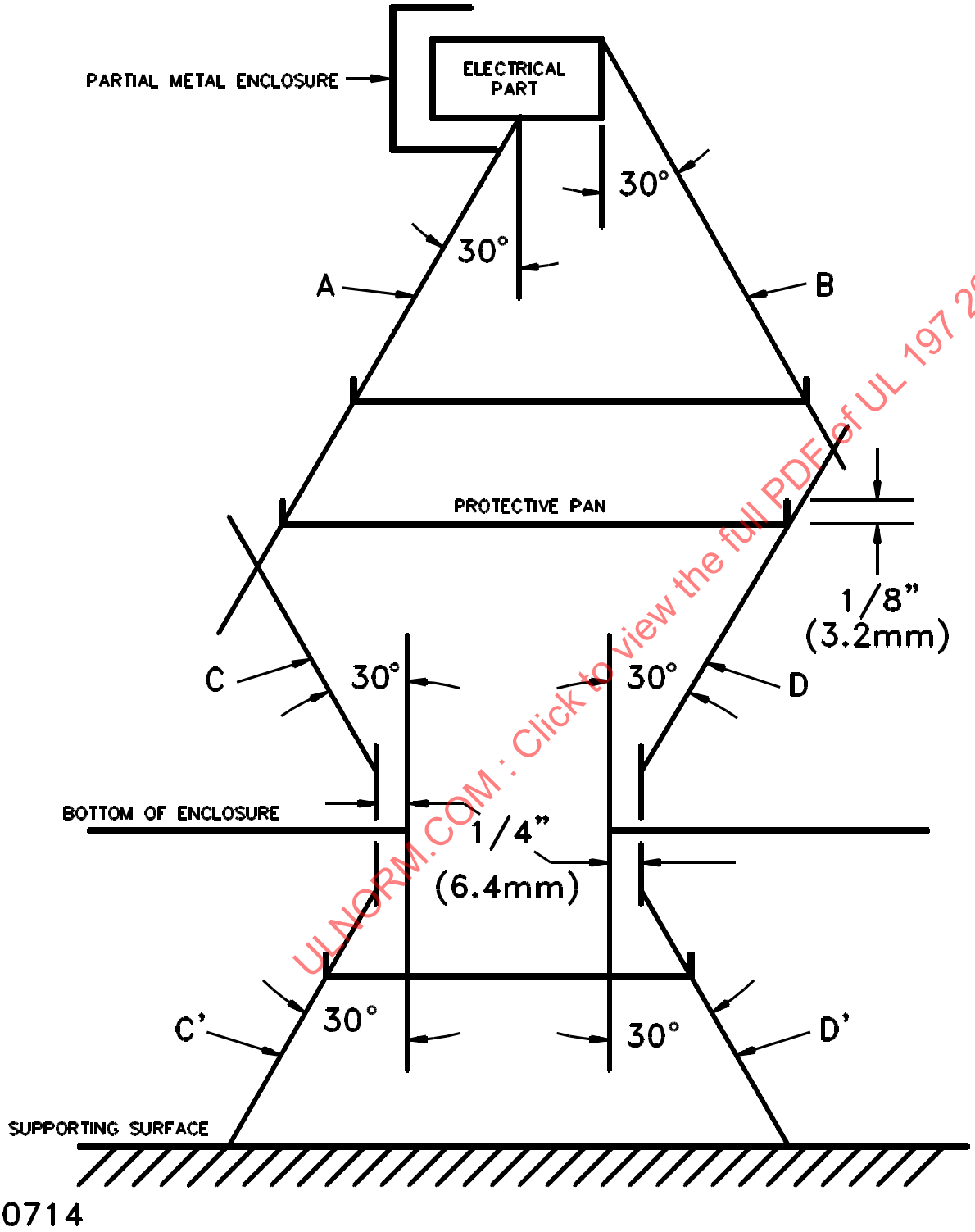
d) The motor is provided with a thermal motor protector – a protective device that is sensitive to temperature and current – that will prevent the temperature of the motor windings from exceeding 125°C (257°F) at the maximum load under which the motor will run without causing the protector to cycle and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

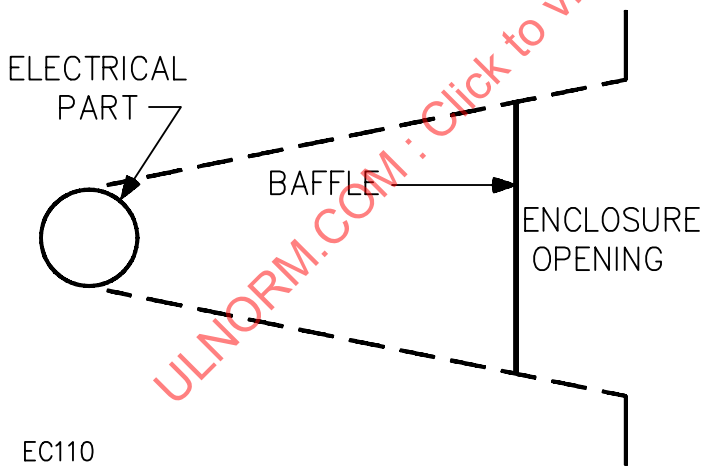
b) The distance from the electrical part to the plane of the enclosure is greater than 12 inches (305 mm); or

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 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

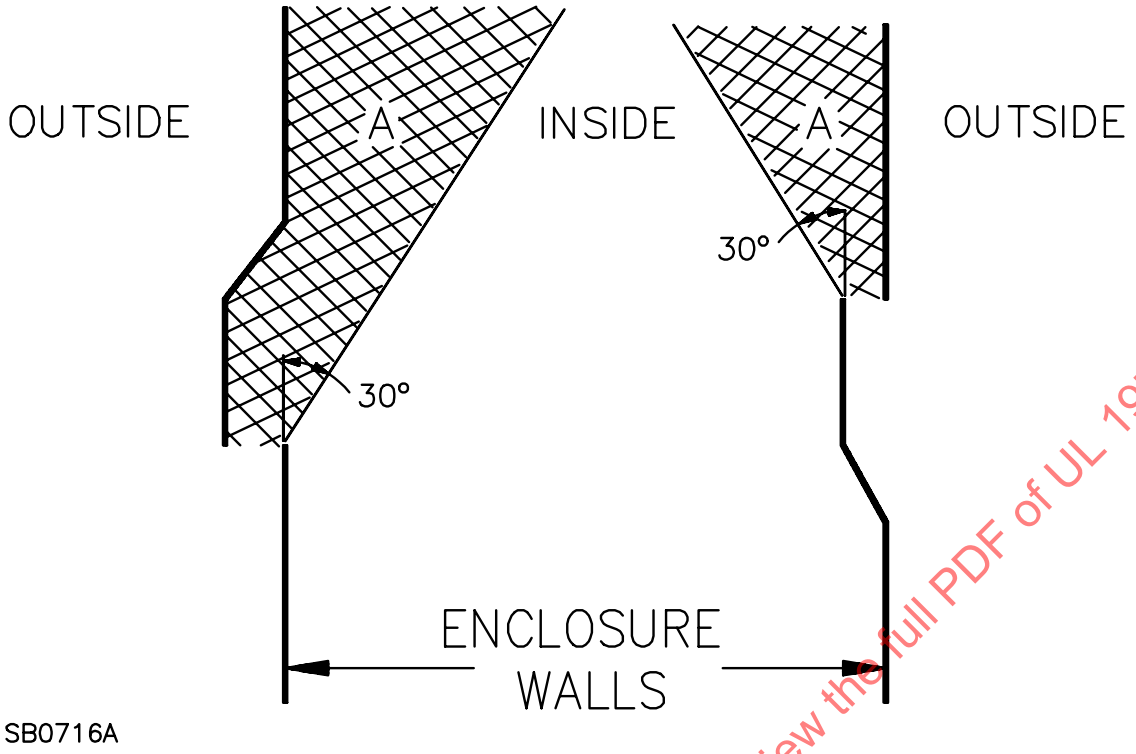
Relationship of baffle and electrical part to prevent emission



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 Section 10, Accessibility of Live Parts, 11.1 and Section 13, Protection of Service Personnel. Louvers are not prohibited from being used when shaped to deflect external falling objects outward. See Figure 8.3.

Figure 8.3

Louver designs



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) Fuses located in extractor-type fuseholders with integral enclosures.

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 mm) apart.

8.6 Grease troughs and pans

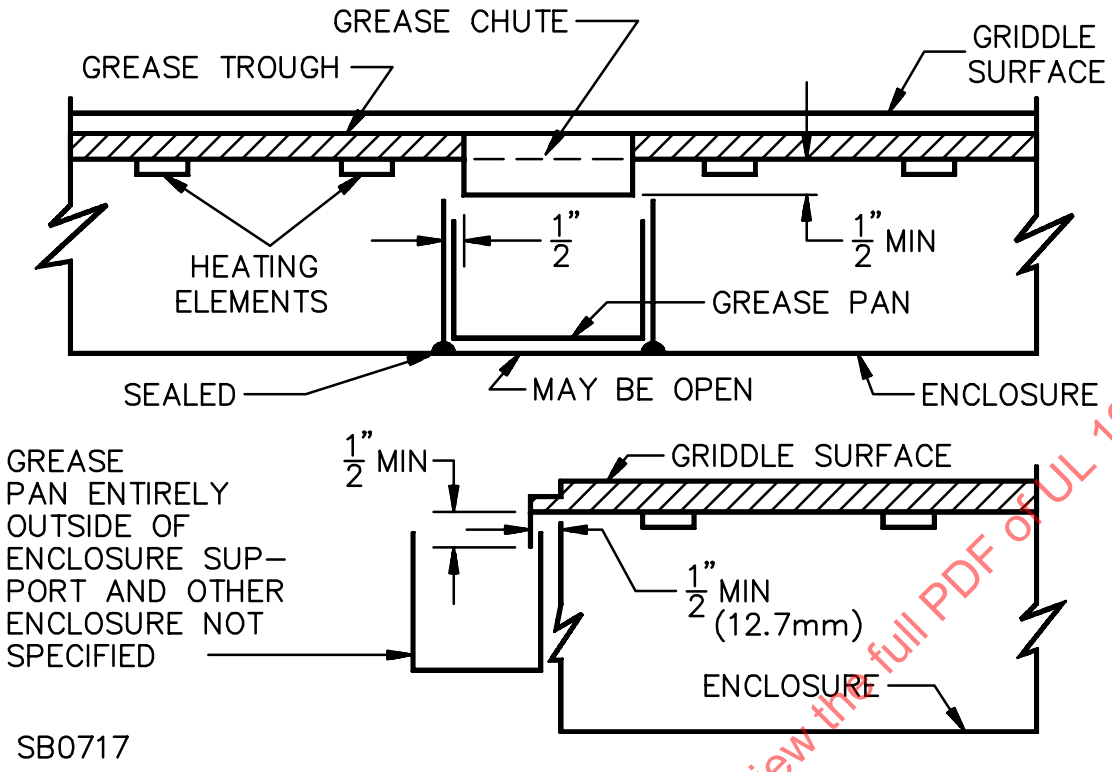
8.6.1 An appliance shall be constructed so that grease spillage does not enter the enclosure and contact live parts or wiring.

8.6.2 An appliance, such as a grill, that has a flat, unenclosed cooking surface and that is intended to be used with grease or oil in the usual cooking operation shall be provided with a trough, grease-collecting pan, or the equivalent to reduce the likelihood of the accumulation of grease on walls, counters, and other nearby surfaces when the appliance is operated.

8.6.3 An opening in the trough of a griddle for drainage to a grease pan or receptacle shall have a drip edge at least 1/2 inch (12.7 mm) long. The opening for the pan or receptacle shall be enclosed on all sides to minimize entrance of grease to the interior of the appliance. Figure 8.4 illustrates some acceptable constructions.

Figure 8.4

Grease chutes for griddles



9 Outer Cabinetry/ Enclosures

9.1 A nonmetallic outer cabinet or enclosure, and a nonmetallic part of an outer cabinet or enclosure, shall comply with the requirements for Enclosure Flammability – Large Mass Considerations in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception: The requirements of 9.1 do not apply to canopies, bags, decorative covers and other similar parts constructed of three layers or less of woven cotton, polyester, or similar material.

10 Accessibility of Live Parts

10.1 General

10.1.1 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.

10.1.2 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.

10.1.3 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.

10.1.4 An enclosure opening shall be sized and located such that:

a) It will not permit the entrance of a 3/4-inch (19.0-mm) diameter rod; and

b) A probe as illustrated in Figure 10.3 cannot be made to touch any uninsulated live part or enameled wire when inserted into the opening.

Exception No. 1: With respect to a part or wire within the enclosure of a motor, an opening larger than 3/4 inch (19.0 mm) is not prohibited when:

a) A probe as illustrated in Figure 10.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

b) A probe as illustrated in Figure 10.2 cannot be made to touch film-coated wire when inserted through the opening.

Exception No. 2: An opening that will permit the entrance of a 3/4-inch (19.0-mm) diameter rod is acceptable 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 (102 mm). See Figure 10.4.

Figure 10.1

Probe for uninsulated live parts within a motor

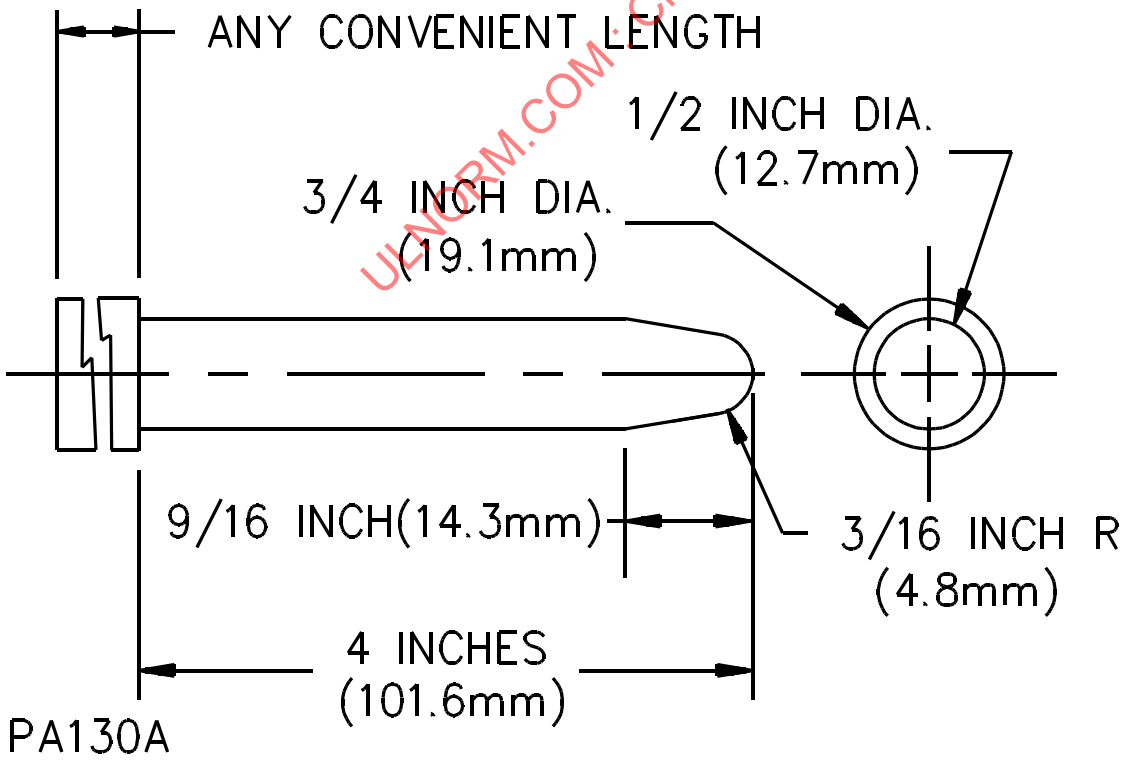


Figure 10.2

Probe for film-coated magnet wire of a motor

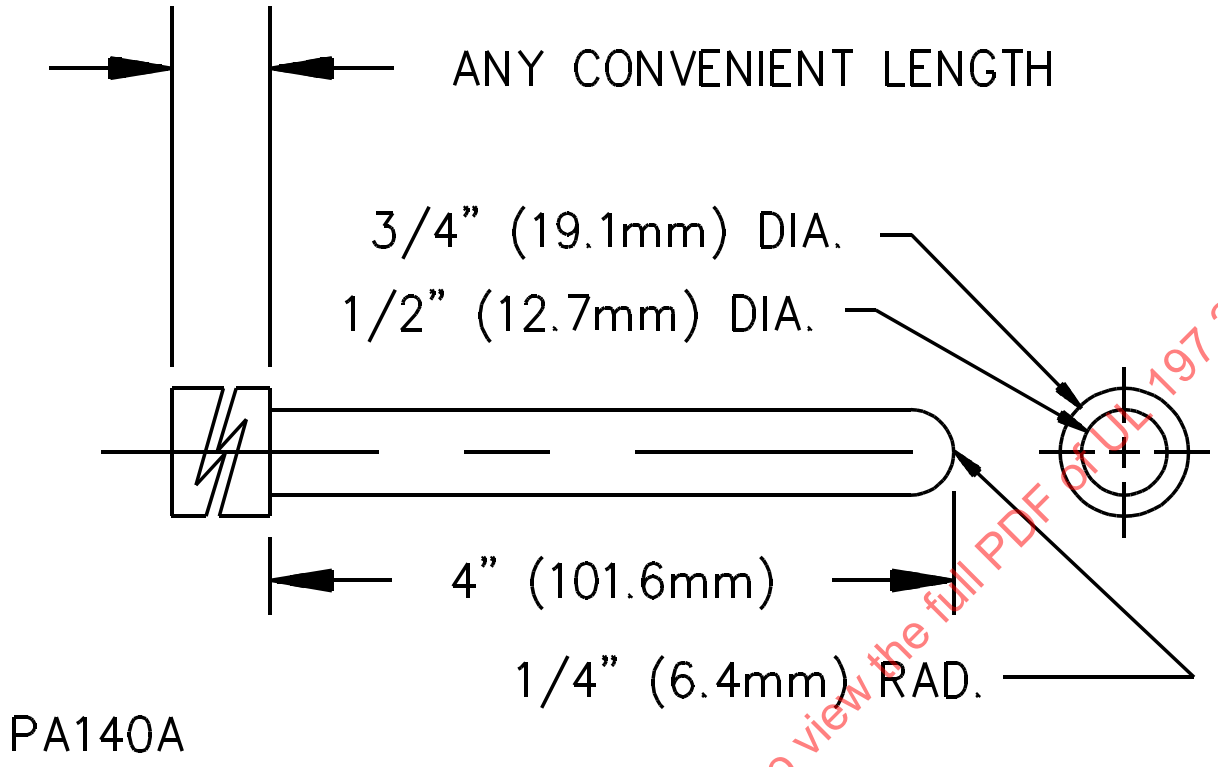


Figure 10.3

Accessibility probe

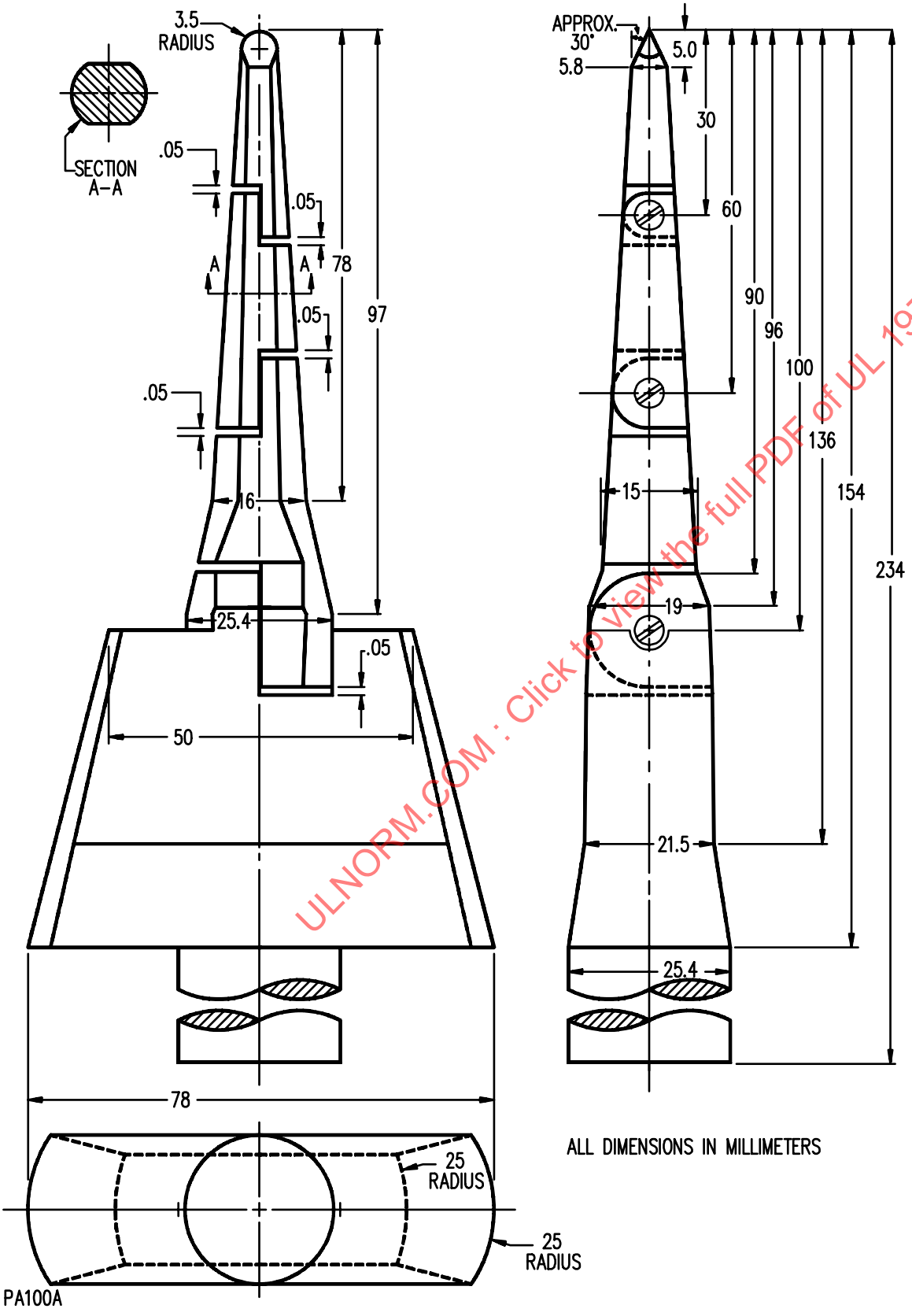
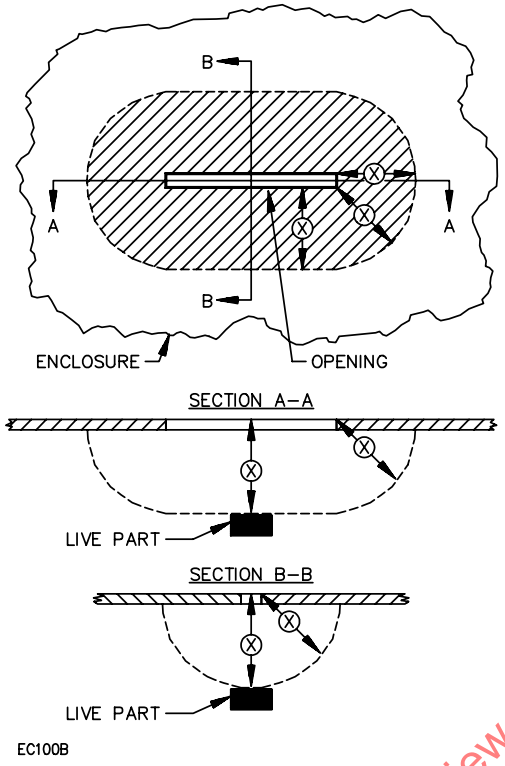


Figure 10.4

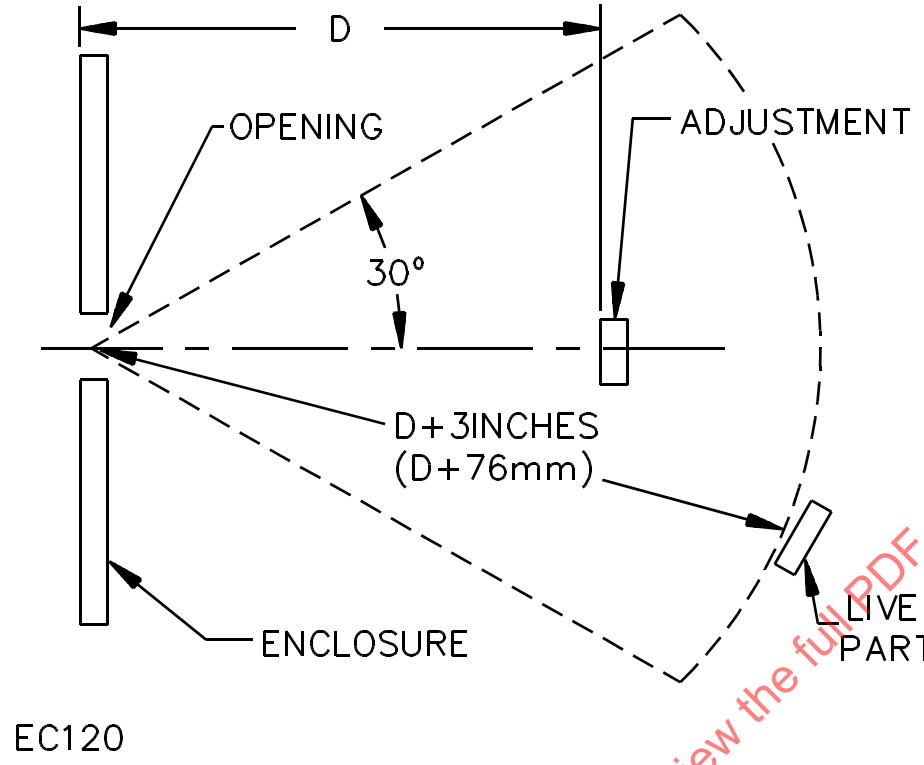
Opening in an enclosure



10.1.5 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 mm). See Figure 10.5.

Figure 10.5

Accessibility of live parts through adjustment opening



10.1.6 During the examination of an appliance in connection with the requirements in 10.1.4 – 10.1.5, 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 89.10 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 10.1.4 – 10.1.5 when the marking specified in 86.13 is on or adjacent to the cover.

10.2 Open wire heating elements

10.2.1 A cover or enclosure of an open-wire element shall not be perforated or otherwise constructed so that complete protection against contact with the element is not provided.

10.2.2 An exposed open-wire element in an appliance shall not be accessible to contact by the user.

Exception No. 1: This requirement does not apply to a toaster with the minor dimension of the slot opening less than 1-1/2 inch and designed for operation on a circuit involving a potential to ground of 250 volts or less.

Exception No. 2: This requirement does not apply to the rotating head of a cotton-candy maker designed to rotate at 3000 revolutions per minute or more, provided the heating element can only be contacted through the opening into which sugar is poured.

10.3 Lamps, quartz enclosed heating elements, and similar components

10.3.1 A lamp, a quartz-enclosed heating element, or a similar component shall be installed or guarded so that it is not broken by utensils, such as pans or trays, inserted in an oven or similar compartment. The acceptability of a guard provided for protection is to be evaluated by impacting the guard as specified in 63.1.2.

10.3.2 A guard constructed of polymeric material shall comply with the enclosure requirements in accordance with the Standard for Polymeric Materials – Use in Electrical Evaluations, UL 746C.

10.3.3 Except as indicated in 10.3.4, the surface of a component as mentioned in 10.3.1 shall not be contacted when a 3/4 inch (19 mm) diameter rod, 3 inches (76 mm) long and supported vertically, is moved in any direction in a horizontal plane.

10.3.4 When more than one-half of the cylindrical or spherical surface of a lamp is recessed above the plane of the top of a compartment, the remaining lamp surface shall not be unguarded unless no portion projects more than 3/4 inch (19 mm) below the top.

10.3.5 A lens, shield, or shade employed as the guard required by 10.3.1 shall not be supported by a lamp, a quartz-enclosed heating element, or a similar component, and shall be made of material that will not be adversely affected by the temperature encountered in normal operation.

10.3.6 A lamp, a quartz-enclosed heating element, or a similar component in a radiant-heat food warmer shall be recessed so that no part of the component extends below the guard or shade.

10.3.7 A lampholder – including one for a quartz-enclosed heating element – shall be so located so that a person replacing the lamp cannot unintentionally touch an uninsulated live part.

10.3.8 The requirement in 10.3.7 does not apply to the screw shell or center contact of a screw shell lampholder or a fuseholder or to the clips of a fuseholder or a quartz-enclosed heating element that is associated with the component being replaced.

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

10.4.1 The requirements of 10.4.3, 10.4.4, 10.4.6, and 10.4.9 – 10.4.11 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 86.13; or

b) The fuse is a non-replaceable type.

10.4.2 A fuseholder, circuit breaker, supplementary protector, or manually reset thermostat 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, reset means of a manually reset thermostat and the insulating cap of an extractor-type fuseholder as specified in 10.4.11 (b) or (c) are not prohibited from being accessible from outside of the appliance.

10.4.3 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.

10.4.4 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 10.4.3, 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 (305 mm) behind the perimeter of a floor mounted appliance. See 13.4 – 13.10.

10.4.5 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 (380 mm) to either side of the fuse or actuator or within 5 inches (130 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 cm) from the edge of an appliance are not required to be defined as the perimeter of an appliance.

10.4.6 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.

10.4.7 When a panelboard is provided as a part of an appliance, it shall comply with the Standard for Panelboards, UL 67, and be installed in accordance with the following:

a) The panelboard shall be mounted vertically;

b) Any opening giving access to a panelboard shall be at least as wide and high as the deadfront of the panelboard;

c) No part of the appliance shall obstruct the space between the panelboard and any opening giving access to the panelboard;

Exception: A panelboard is not prohibited from being located behind a door or cover when the construction complies with 10.4.8.

d) The panelboard shall be marked in accordance with 86.23; and

e) The face of the panelboard shall be directed outward and shall not be recessed more than 6 inches (150 mm) behind the perimeter of the appliance.

Exception: This requirement does not apply when:

1) Accessibility for servicing of another part of the overall appliance would be impeded by locating the panelboard as specified;

2) The panelboard is located to provide access to the fuses and/or actuators in accordance with 10.4.4 (for example, with the front of the panelboard located perpendicular to and immediately behind an access opening);

3) When the panelboard is provided with a door, the panelboard door is hinged on the side away from the direction of access;

4) At least one edge of the panelboard is located within 6 inches (150 mm) of the perimeter of the appliance in the direction of access; and

5) When the panelboard is located behind a door or cover, see 10.4.8, at least one edge of the panelboard is located within 1 inch (25 mm) behind the plane created by the inside of the door or cover.

10.4.8 When a panelboard is located behind another door or cover:

a) The construction of the appliance shall permit at least a 90 degree opening of all doors and hinged panels which give access to the panelboard.

b) The opening giving access to the panelboard shall be at least as wide and high as the deadfront of the panel board.

c) The door or cover shall be constructed so that the panelboard is accessible without the use of tools; and

d) The space between the door or cover and the face of the panelboard shall be open; that is, no part of the appliance shall be located within that space, and the cabinet or enclosure shall be constructed so that the space is restricted from use as a storage space.

10.4.9 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 89.10.

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 19.4.

10.4.10 Except as indicated in 10.4.11 and 10.4.12, 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 10.4.13 and 10.4.14.

10.4.11 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 19.3 and 19.4;

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).

10.4.12 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 10.4.10.

10.4.13 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 10.4.10.

10.4.14 A cover interlocking mechanism complies with the requirement for an automatic latch in 10.4.12 and the requirement for a captive screw or equivalent in 10.4.10 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.

10.4.15 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.

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

10.4.17 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and the applicable Part (e.g., the Standard for Fuseholders – Part 9: Class K, UL 4248-9).

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

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

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

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

10.4.21 Fusing resistors shall comply with the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

11 Guarding of Moving Parts

11.1 General

11.1.1 Moving parts capable of causing injury to persons shall be enclosed or guarded.

Exception: Moving parts are not required to be enclosed for an appliance that is provided with an on-off control that is readily accessible from the operating position, and when complete guarding of a moving part that obviously involves a risk of injury to persons would defeat the utility of the appliance.

11.1.2 An opening in a guard or enclosure around a moving part that involves a risk of injury to persons shall not permit the probe illustrated in Figure 10.3 to contact the part.

Exception: In a convection oven, an air-circulating fan provided with a guard that does not permit the entrance of a 3-inch (76 mm) diameter probe meets the intent of this requirement.

11.1.3 A lid or a door, such as a motor-operated cover on a pressure cooker, that can entrap a person, shall be guarded or be actuated by a momentary contact switch that, when released prior to full closure of the lid or cover, reverses the closing operation.

11.1.4 The following factors shall be considered when an exposed moving part is being evaluated:

a) Degree of exposure necessary to perform its intended function;

b) Sharpness of the moving part;

c) Likelihood of unintentional contact therewith;

d) Speed of the moving part; and

e) Likelihood that a part of the body would be endangered or that clothing would be entangled by the moving part.

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

11.1.5 The adequacy of a guard, a safety release, an interlock, and the like and whether or not such a device is required, are to be determined from a study of the complete appliance, its operating characteristics, and the likelihood of a risk of injury to persons resulting from a cause other than gross negligence (see 14.2.1). The investigation is to include consideration of the results of breakdown or malfunction of any one component; but not more than one component at a time, unless one event contributes to another. If the study shows that malfunction of a particular component can result in a risk of injury to persons, that component is to be investigated for acceptability.

11.1.6 Spring loaded levers employed in espresso machines shall be provided with the marking described in 85.3 when operation without coffee in the holder results in a risk of injury to persons.

11.2 Materials

11.2.1 When the breakage or damage of a guard results in a risk of injury to persons, the material shall have such properties as to meet the demand of expected loading conditions. See Section 63, Strength of Enclosures, Frames, and Guards Test. A guard constructed of polymeric material shall comply with the enclosure requirements in accordance with the Standard for Polymeric Materials – Use in Electrical Evaluations, UL 746C.

11.2.2 The requirements in 11.2.1 apply to those portions of a part adjacent to a moving part or an exposed live part determined to present a risk of injury to persons.

12 Protection Against Injury to Persons

12.1 When operation, maintenance, or reasonably foreseeable misuse of an appliance by the user involves a risk of injury to persons, protection shall be provided for the reduction of such risk to an acceptable degree.

12.2 There are risks of injury to persons inherent in some appliances that, when completely eliminated, would defeat the utility of the appliance. The requirements in this section are intended to minimize such risks, while retaining the intended function of such appliance.

12.3 Specific tests, constructions, markings, and guards are detailed for some appliances. Such detailed requirements apply to common constructions; specific features and appliances not covered herein are to be given appropriate consideration.

13 Protection of Service Personnel

13.1 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 13.4 – 13.10 to prevent unintentional contact by service personnel performing mechanical service functions that are performed with the equipment energized. See 13.2.

13.2 Mechanical service functions that are typically performed with the equipment energized include: adjusting a water-control valve; adjusting the setting of a temperature or a pressure control with or without marked dial settings; resetting a control trip mechanism; operating a manual switch; adjusting an air-flow damper. A factory-set-and-sealed control is not considered to be adjustable.

13.3 The requirements in 13.1 are not applicable to mechanical service functions that are not usually performed with the equipment energized. Such functions include opening a drain plug, adjusting or replacing a drive belt, and similar tasks.

13.4 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 mm) on any side or behind the mechanism, unless guarded.

13.5 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 13.9.

13.6 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 13.1):

a) The components are located so that the farthest component in the assembly is not more than 15 inches (356 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 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.

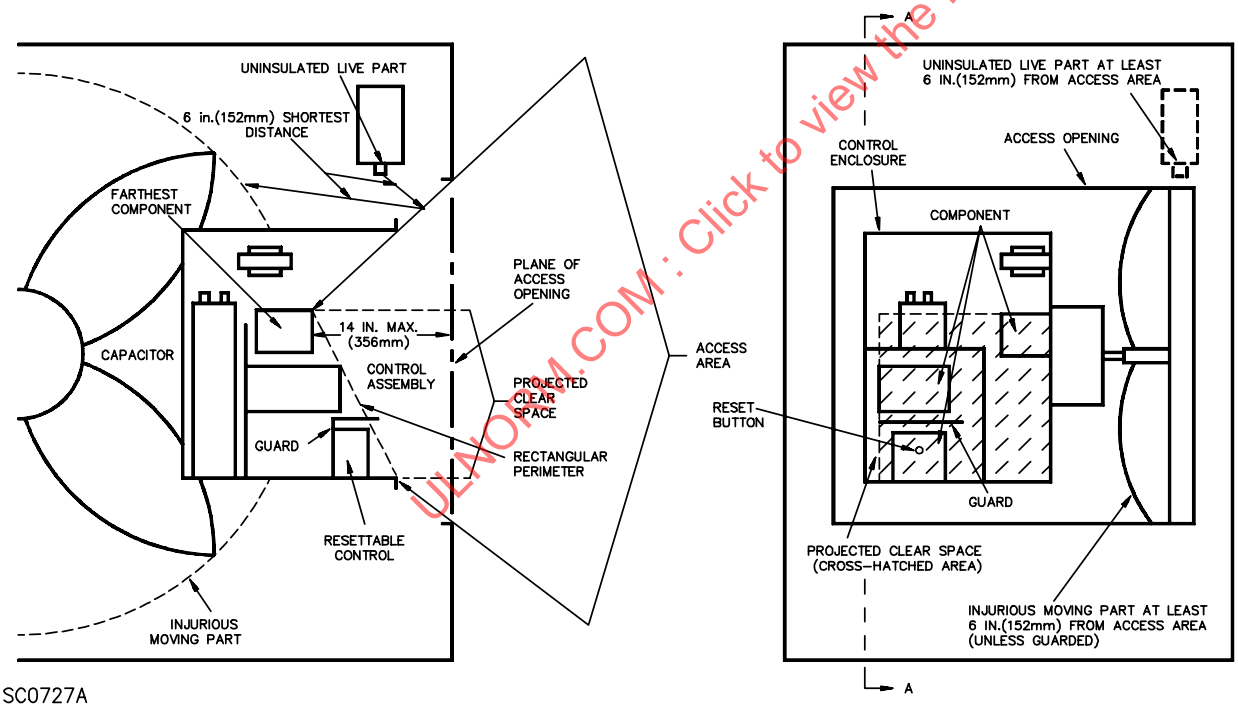
c) The volume generated by the projected clear space of the control assembly to the access opening in the outer cabinet – within the access area – is completely free of obstructions, including wiring.

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 13.4.

Figure 13.1

Accessibility and protection



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13.7 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 13.5.

13.8 Other arrangements of components or guarding are also acceptable when electrical control components are accessible for service as indicated in 13.5.

13.9 The electrical components referred to in 13.5 – 13.8 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 are to comply with the requirements in 13.5 with respect to:

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

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

13.10 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.

14 Interlocks

14.1 General

14.1.1 The requirements in 14.1 and 14.2 apply to an interlock that is necessary to comply with Section 8, Electrical And Fire Enclosures, Section 10, Accessibility of Live Parts, or Section 11, Guarding of Moving Parts.

14.1.2 The actuator of an interlock switch shall be located so that unintentional operation does not occur. See 31.3.2 – 31.3.4.

14.1.3 Operation of an interlock in normal use shall not inconvenience the operator so as to encourage deliberate defeat of an interlock.

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

14.1.5 An interlock system shall comply with Section 69, 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.

14.1.6 An electronic interlock circuit shall comply with the requirements of the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. In addition a software-based interlock circuit shall comply with the requirements of the Standard for Software in Programmable Components, UL 1998.

14.2 Moving parts

14.2.1 Moving parts involving a risk of injury to persons protected by a service or loading door, interlocked so that such parts are de-energized when the door is opened, 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.

14.2.2 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 14.1.2.

15 Protection Against Corrosion

15.1 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.

Exception No. 3: This requirement does not apply to a sheath of a heating element of other than an immersion-type heater.

16 Electrical Supply Connections for Permanently Connected Appliances

16.1 General

16.1.1 An appliance intended for permanent connection to the power supply shall have provisions for connection to at least one of the wiring systems specified in the National Electrical Code, ANSI/NFPA 70 as suitable for the appliance.

Exception: This requirement does not apply to an appliance designed to be mounted to and supported by an outlet box.

16.1.2 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.

Exception: A stationary appliance that is connected to the building structure only by plumbing such as inlet pipes, vent pipes, or drains, is not prohibited from being cord connected when:

a) The appliance is rated 125 volts, 20 amps maximum; and

b) The appliance is provided with a type SO, SOO, STO, STOO, SEO, HSO, or HSOO power supply cord with an attachment plug cap and strain relief means.

16.1.3 An appliance intended to be built-in or recessed 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 88.3.

16.1.4 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 16.1.

Table 16.1
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	(80.64)	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)

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

16.1.6 A permanently connected appliance provided with casters or wheels on all legs of the appliance shall be provided with a means for securing the appliance to the building structure to limit the movement of the appliance so that stress is not transmitted to the electrical supply conduit. The appliance shall be marked in accordance with 88.14 and provided with the installation instructions specified in 91.8.

16.2 Wiring compartment

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

16.2.2 A wiring compartment for field-wiring connections shall be of metal and of a volume that will accommodate the wiring of the size indicated in 16.3.14, and conduit and fittings sized for the wire in accordance with the National Electrical Code, NFPA 70.

16.2.3 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 16.2.6.

16.2.4 Provision for inspection of connections on the rear or bottom of a floor-mounted appliance is not acceptable except that access can be provided on the rear when the appliance is either provided with casters or is marked to indicate a spacing of not less than 30 inches (762 mm) in accordance with 86.5. Access is to be judged when the appliance is installed in the test arrangement described in 50.4.3 and when applicable, 50.4.5.

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

16.2.6 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 in Section 60;

d) The component or cover shall be provided with a separate means for bonding in accordance with Section 15, Bonding for Grounding;

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

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.

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.

16.2.7 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 16.2.

Table 16.2
Wire bending space at field-wiring terminals

Wire size		Minimum space, 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.

16.3 Field-wiring terminals and leads

16.3.1 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.

16.3.2 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 47, 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 28.1.3, 28.1.4, and 86.10), 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.

16.3.3 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 16.3.14 and 88.3 – 88.5.

16.3.4 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 88.3 and 88.4. 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.

16.3.5 Wiring terminals or leads suitable for conductors having an ampacity less than specified in 16.3.2, but at least equal to the rated current of the appliance and at least equal to the current input of the appliance, when tested in accordance with the Power Input Test, Section 47, shall comply with (a) and (b). Note that this calculation is to be used to determine suitable power-supply connection means and suitable branch-circuit overcurrent-protective device (BCOPD) ratings only and not to determine the current rating of the appliance.

a) When the appliance is operated per the Input Averaging Test, Section 48, the average current input to the appliance shall be 80 percent or less of the anticipated BCOPD current rating. This rating is to be calculated as follows:

1) The average current is to be multiplied by 1.25.

2) The next-higher standard BCOPD rating above the result from (1) is to be determined (see 28.1.6). Except as noted in (3) and (4), this is determined to be the anticipated BCOPD rating.

3) When the result of (2) is less than the rated current of the appliance, the next-higher standard BCOPD rating above the rated current of the appliance is to be determined (see 28.1.6). Except as noted in (4), this is determined to be the anticipated BCOPD rating.

4) The manufacturer has the option to specify a higher rating than that calculated using (1) – (3). When the manufacturer chooses to specify a higher rating, the manufacturer's specified rating is determined to be the anticipated BCOPD rating.

b) The wiring terminals or leads shall be suitable for conductors having an ampacity of at least the anticipated branch-circuit overcurrent-protective device current rating.

The appliance shall be marked as described in 86.10.

16.3.6 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.

16.3.7 When terminals of unequal sizes are provided because of unbalanced loads, each terminal shall be sized to accept a conductor required for the current that is carried by the conductor connected to that terminal, as determined in accordance with 16.3.2 or 16.3.5. See 88.4.

16.3.8 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.

16.3.9 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.

16.3.10 Each upturned lug or cupped washer referred to in the Exception to 16.3.9 shall be capable of retaining a power-supply conductor corresponding in size to that specified in 16.3.2, but not smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

16.3.11 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.

16.3.12 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.

16.3.13 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.

16.3.14 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 16.3.3 and 16.3.4. Field-wiring leads for connection to the branch-circuit supply shall not be smaller than 18 AWG.

16.3.15 The free length of a lead inside an outlet box or field-wiring compartment shall be 6 inches (152 mm) or more.

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

16.4 Grounded supply conductor

16.4.1 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 19, Polarization, and Section 33, Lampholders.)

16.4.2 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.

16.4.3 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.

16.5 Equipment grounding connection

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

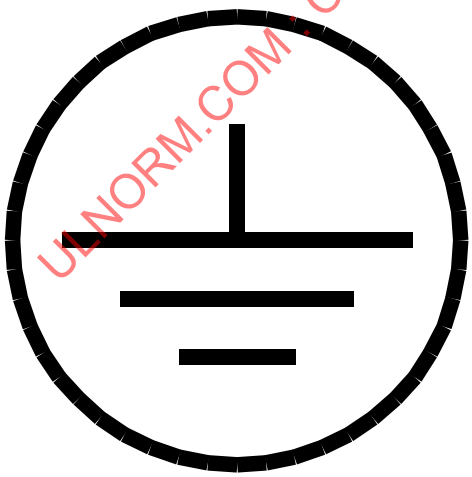
16.5.2 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable for the application. See 16.5.4.

16.5.3 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.

16.5.4 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 16.1 (IEC417, Symbol 5019), adjacent to the terminal or on a wiring diagram.

Figure 16.1

Grounding Symbol



16.5.5 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.

16.5.6 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.

17 Electrical Supply Connections for Cord-Connected Appliances

17.1 General

17.1.1 A power-supply cord shall be Type 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.

Exception No. 1: Type HPN cord is not prohibited from being used when:

a) The appliance is intended for counter-top or chain-suspended use; and

b) The weight of the appliance is not more than 15 pounds (6.8 kg).

Exception No. 2: Type W 1 – 4/0 AWG (42.4 – 107.2 mm^2) flexible cable is not prohibited from being used when provided with a grounding conductor.

17.1.1.1 A cord set or power supply cord shall comply with the Standard for Cord Sets and Power-Supply Cords, UL 817.

17.1.1.2 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62. Flexible cord and cables are considered to fulfill this requirement when preassembled in a cord set or power supply cord complying with the Standard for Cord Sets and Power Supply Cords, UL 817.

17.1.2 The length of attached cord or separable cord set shall be within the limits specified in Table 17.1.

Exception: A wall-mounted fixed appliance that must employ cord to permit servicing, such as a wall-mounted coffee maker, meets the intent of the requirement when provided with a flexible cord not more than 18 inches (457 mm) long and an attachment plug for supply connection. The investigation of such a feature shall include consideration of the utility of the appliance and the necessity of having it detachable from its source of supply by means of the plug.

Table 17.1
Length of supply cord

Type of Appliance		Minimum Acceptable Length		Maximum Acceptable Length	
		Feet	(mm)	Feet	(mm)
Counter top or table top	Coffee or other liquid heating appliance with a pouring spout arranged so that to pour the liquid, the unit must be lifted from or tilted with reference to supporting surface	2.0	(610)	3.0	(914)
	All counter top or table top appliances not covered above	2.0	(610)	6.0	(1829)
Floor-mounted		3.0	(914)	10.0	(3048)
NOTE – Applies to an attached cord or a separable cord set.					

17.1.3 The current and voltage rating of the cord and the fittings (including the attachment plug) shall not be less than that of the appliance and shall not be less than the maximum current input of the appliance when tested in accordance with the Power Input Test, Section 47.

17.1.4 The current rating of the attachment plug of an appliance rated more than 15 amperes shall not be less than 125 percent of the maximum current input of the appliance when tested in accordance with the Power Input Test, Section 47 and not less than 125 percent of the rated current of the appliance.

Exception: The attachment plug is not required to be rated as specified in 17.1.4 when all of the following items (a) through (c) are met. The attachment plug shall comply with 17.1.3 in any case.

a) It is rated not less than the current and voltage rating of the appliance;

b) It is rated not less than the maximum current input of the appliance when tested in accordance with the Power Input Test, Section 47; and

c) When operated per the Input Averaging Test in Section 48, the average current input to the appliance is 80 percent or less of the attachment plug rating.

When this Exception is used, the appliance shall be marked as described in 86.9 to indicate that a dedicated branch circuit is to be used.

17.1.5 The power supply cord shall be terminated by an attachment plug that is of a grounding type.

Exception No. 1: Units rated more than 150 volts and provided with a power supply cord are not required to terminate in an attachment plug when the power supply cord is marked in accordance with 90.4.

Exception No. 2: The power supply cord for portable appliances marked as double insulated in accordance with Section 125 shall be terminated by a non-grounding type polarized attachment plug.

17.1.5.1 Attachment-plugs and appliance inlets (motor attachment lugs) shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

Exception: Attachment plugs and appliance couplers integral to cord sets or power supply cords are investigated in accordance with the requirements of the Standard for Cord Sets and Power-Supply Cords, UL 817, and need not comply with UL 498.

17.1.6 Supplementary insulation employed on a flexible cord shall not extend under the strain relief and shall be prevented from fraying or raveling.

17.1.7 A detachable cord shall not be employed for making the power-supply connection to an appliance.

Exception: A suitable detachable cord is not prohibited from being provided when the following conditions are met:

a) The cord type is one of the types specified in 17.1.1;

b) The cord set length complies with Table 17.1;

c) The attachment plug for connection to the appliance is suitable for the appliance rating; and

d) The appliance is marked as specified in 89.14; and

e) The appliance is provided with instructions in accordance with 91.7.

17.1.8 The cord of a hand-held appliance (e.g. ice cream scoop) that is subjected to movement during normal operation or any user servicing shall be tested in accordance with Section 59, Cord Endurance Test – Hand-Held Appliances.

17.2 Strain relief

17.2.1 Strain relief shall be provided so that mechanical stress on a flexible cord will not be transmitted to terminals, splices, or interior wiring. To determine compliance, the supply cord is to be tested in accordance with Section 60, Strain Relief Test.

17.2.1.1 Insulating bushings serving as strain relief shall comply with the Standard for Insulating Bushings, UL 635. Tests specified in this Standard (e.g. Strain Relief Test) may still need to be performed to confirm that the combination of the insulating bushing and the supporting part are suitable.

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

Exception: A knot in the cord is capable of being used for strain relief at the outlet box end of a cord-suspended appliance, such as a food warmer, when:

a) A Type 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, or HSJOOW cord is used;

b) The appliance weighs 10 pounds (4.5 kg) or less; and

c) A cross-bar with smooth edges for the cord to bear against is provided

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

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

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

c) Reducing spacings (such as to a metal strain-relief clamp that is not insulated as specified in the Exception to 17.3.1) below the minimum required values; or

d) Damaging internal connections or components.

To determine compliance, the supply cord or lead shall be tested in accordance with the Push-Back Relief Test of Section 61.

17.3 Bushings

17.3.1 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. A bushing used with Type HPN cord shall be of insulating material.

Exception: An insulated metal grommet is not prohibited from use with HPN cord, when the insulating material used is not less than 1/32 inch (0.8 mm) thick and completely fills the space between the grommet and the metal in which it is mounted.

17.3.1.1 In addition to the requirements in 17.3.1, insulating bushings shall comply with the Standard for Insulating Bushings, UL 635.

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

17.3.3 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.

17.3.4 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 be adversely affected by conditions of ordinary moisture and temperature.

17.3.5 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.

17.4 Grounding

17.4.1 The power-supply cord of an appliance shall include a grounding conductor.

Exception: The power supply-cord of an appliance marked as double insulated in accordance with Section 126 shall not be provided with a grounding conductor.

17.4.2 The grounding conductor of a flexible cord shall be:

a) Green with or without one or more yellow stripes;

b) Connected to the grounding blade of an attachment plug of the grounding type; and

c) Connected to the enclosure of the appliance by means of a screw or threaded stud and nut that is not removed during any servicing not involving the supply cord. Rivets, solder, and other non-replaceable connection means are not acceptable for making this connection. If the grounding conductor is attached to the same screw or stud as a bonding conductor(s), the grounding conductor shall be the first conductor attached and have its own attachment nut. See Figure 17.1.

Exception No. 1: When an EMI filter complying with the Standard for Electromagnetic Interference Filters, UL 1283, is employed in an appliance, the equipment grounding connection is allowed to be made directly to the filter. The equipment grounding connection and the connection between the filter and the chassis shall be made in accordance with the manufacturer's instructions for the EMI filter.

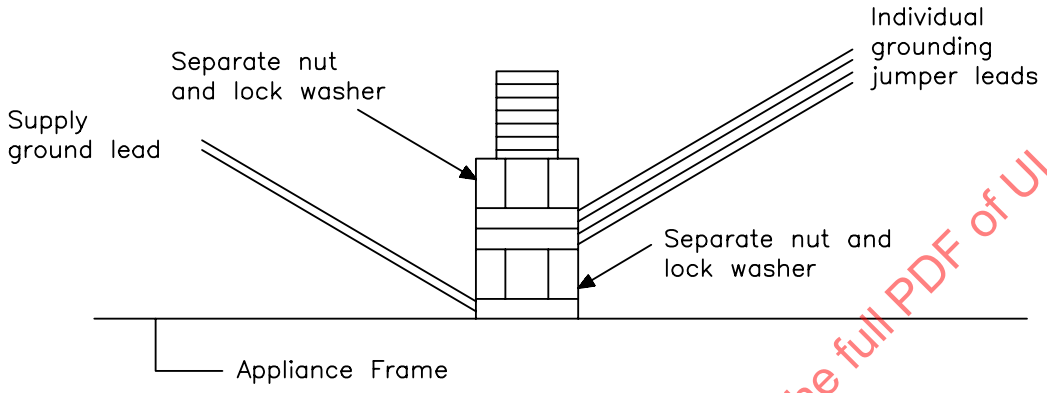
Exception No. 2: The grounding conductor is allowed to be connected directly to a terminal block when the following conditions are met:

a) The supply side of the terminal block is used only for connecting the power supply cord; and

b) A bonding conductor sized in accordance with 18.8 is provided between the power supply cord grounding conductor terminal block and the enclosure. The bonding conductor shall be connected to the enclosure of the appliance by means of a screw that is not removed during servicing. No other grounding or bonding connections shall be made to the terminal block.

Figure 17.1

Securement of equipment grounding and bonding conductors to a single bolt or threaded stud



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17.5 Multiple power supply cords

17.5.1 Cord connected equipment shall not be provided with more than one power supply cord unless all of the following conditions are met:

a) Not more than two cords are provided;

b) Each flexible cord is of the type, size, and rating required for the type of product and the load supplied;

c) Each attachment plug cap is sized based on 17.1.3 or 17.1.4;

d) The total current input per Section 47, Power Input Test, or Section 48, Input Averaging Test, (including current through all cords) is not more than 80 percent of the branch circuit supply for the single branch circuit to which it is connected (based on the plug configuration);

Exception No. 1: The current is not required to be less than 80 percent of the single branch circuit when the plugs are supplied by separate branch circuits, evidenced by any of the following:

a) The attachment plugs are not the same configuration or rating and the instructions contain the information in 91.6 (a) and (b);

b) The rating of either or both plugs is greater than 20 Amps; or

c) The product is marked in accordance with 86.18 or 86.20, and the instructions contain the information in 91.6 (a) and (c).

Exception No. 2: The current is not required to be less than 80 percent of the branch circuit rating when:

a) Both attachment plugs are rated 15 Amps or less; and

b) The total current input is equal to or less than the attachment plug rating.

e) With reference to Exception No. 1(a) of item (d), where detachable power supply cords are used, both the attachment plugs and the means of connecting the cord to the appliance shall have different configurations.

f) The product is provided with a single accessible control or switch with a marked "off" position that disconnects all ungrounded conductors of the product;

Exception: The appliance is not required to have a single disconnect when multiple disconnect means are provided in accordance with any of the following:

a) There is a control or switch for each of the two power supply cords, and the controls or switches are grouped and identified;

b) Both power supply cords are of the detachable type, the only supplied loads are receptacles, and the cord attachment points are grouped and identified;

c) The product is provided with a mechanical or electrical interlock system that results in all ungrounded conductors of the supply being disconnected in the event that either cord is disconnected; or

d) A marking is provided and located adjacent to each switch in accordance with 86.22.

g) The appliance is rated in accordance with 83.9;

h) The product contains the markings in 86.17; and

i) The appliance is provided with instructions as indicated in 91.6.

17.5.2 For the purpose of this requirement, banked or stacked appliances that are provided with separate controls and are not electrically interconnected except for signal circuitry (see 2.27) are judged as separate appliances. However, the marking in 86.21 shall be provided.

18 Bonding for Grounding

18.1 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; or to the grounding conductor of a supply cord. The suitability of this connection shall be determined by the grounding test specified in 54.1.

Exception No. 1: Bonding of exposed dead metal parts is not required on an appliance marked as double-insulated in accordance with Section 126.

Exception No. 2: 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 88.15.

18.2 With reference to the requirements in 18.1, 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.

18.3 The dead metal parts described in 18.1 shall be reliably bonded together by mechanical fasteners or by an individual bonding conductor or strap.

18.4 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.

18.5 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.

18.6 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.

18.7 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 88.7.

18.8 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 28.1.3 and 28.1.4 – in accordance with Table 250-122 of the National Electrical Code, 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 54.2.1.

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

18.9 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.

18.10 Exposed dead metal parts that are capable of becoming energized and are not secured to the remainder of the appliance, such as a griddle plate, shall be electrically connected to the appliance frame. A separate, stranded, grounding wire, not smaller than 14 AWG (2.1 mm^2), shall be used unless the part weighs 50 pounds (22.7 kg) or more. For a part weighing 50 pounds or more, the grounding wire described above shall be provided or the part shall be supported by sharp edges or by one or more sharp-pointed leveling screws. If sharp edges or leveling screws are intended to be used for grounding, the supporting surface shall not be painted, enameled, or otherwise treated to result in a high-resistance connection between the frame and the exposed dead metal part.

18.11 Upon insertion of a removable heating element or other removable part, the grounding connection shall be made before any other electrical connection, and, upon removal, the grounding connection shall be broken after the electrical connection.

Exception: This requirement does not apply to a soup warming cup with an insulating handle and a shield between the handle and cup, if the cup is constructed so that contact between the metal cup and a grounded metal stand will be provided when the cup is inserted into the receptacle in a direction parallel to the terminal pins of the cup.

19 Polarity

19.1 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 16, Electrical Supply Connections for Permanently Connected Appliances, and Section 33, Lampholders.

19.2 When there is no grounded supply conductor, as mentioned in 19.1 and when two lampholders are connected in series, the lampholder screw shells shall be common and the center contacts of the lampholders shall be connected toward the supply.

19.3 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.

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

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

20 Current-Carrying Parts

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

20.2 Plated iron or steel 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.

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

Exception: Unplated iron or steel is not prohibited from use as a terminal rod or a terminal plate of a heating element.

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

21 Attachment-Plug Receptacles

21.1 An appliance is not prohibited from being provided with an attachment-plug receptacle intended for general use. Unless suitable for the fully rated load, a marking shall be provided adjacent to the receptacle specifying the maximum normal load in accordance with 86.15.

21.2 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 86.16.

21.3 A permanently connected appliance is not prohibited from being provided with an attachment-plug receptacle rated more than 20 amperes and intended for general use. 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, NFPA 70.

21.4 An attachment-plug receptacle intended for general use 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 54, Grounding and Bonding Test.

21.5 A 125-volt, single-phase, 15- or 20-ampere receptacle intended for general use shall have ground-fault circuit-interrupter protection for personnel.

21.6 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.

21.7 Attachment-plug receptacles shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

22 Internal Wiring

22.1 General

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

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

22.1.3 Except as noted in 28.5, an appliance shall not employ conductors smaller than 18 AWG (0.82 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.

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.

22.1.4 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.

22.2 Insulation

22.2.1 There is no temperature limit applicable to glass fiber, beads of inorganic material, or the equivalent, employed as conductor insulation but asbestos insulation shall not be used where exposed to moisture produced by the appliance.

22.2.2 Internal wiring shall comply with the Standard for Thermoplastic-Insulated Wires and Cables, UL 83; the Standard for Thermoset-Insulated Wires and Cables, UL 44; or the Standard for Appliance Wiring Material, UL 758.

22.2.3 Wiring with insulation containing asbestos shall not be used.

22.3 Protection

22.3.1 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.

22.3.2 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.

22.3.3 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.

22.3.4 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.

22.3.5 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 17.3).

22.3.6 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 40).

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

22.4.1 The requirements in 22.4.2 – 22.4.11 apply only to wiring in circuits involving a risk of electric shock (see 8.1.2 – 8.1.5).

22.4.2 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 17.1.1 may be employed for external connections between parts when flexibility is essential. See 22.4.8. 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.

22.4.3 With reference to exposure of internal wiring, the protection of wiring required by 22.4.2 is determined to exist, if, when judged as if it were enameled wire, the wiring would be acceptable according to 10.1.3 – 10.1.6.

22.4.4 Internal wiring not protected as specified in 22.4.3, 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.

22.4.5 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.

Exception: This requirement does not apply to wiring to a surface element that is contacted by the user or operator during user servicing when the wiring is secured to the panel in which the element is mounted.

22.4.6 Internal wiring to a surface element is considered to be protected when it is routed and secured so that the wiring will return to its intended position following any movement associated with a user servicing operation involving the surface elements. See 2.32.

22.4.7 Wiring subjected to movement during operation or any user servicing shall be tested in accordance with Section 58, Wiring Endurance Test.

22.4.8 The insulation of internal wiring that is subjected to accumulations of oil or grease, such as that of a deep-fat fryer or griddle, shall be a type that will not be adversely affected under such conditions.

22.4.9 Internal wiring shall be located so that it will not be exposed to the vapors from a vented oven of an appliance.

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

22.4.11 A flexible cord used for external interconnection as mentioned in 22.4.2 shall be provided with bushings and strain relief in accordance with 17.2 and 17.3 unless the construction is such that the cord will be protected from stress or motion.

22.5 Splices and connections

22.5.1 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.

22.5.2 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.

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

22.5.4 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.

22.5.5 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.

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

22.5.7 Compliance with the requirement in 22.5.6 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.

22.5.8 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.

22.5.9 With reference to 22.5.8, 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.

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

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

22.5.12 Single and multi-pole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory assembly to copper or copper alloy conductors, or for factory assembly to printed-wiring boards, shall comply with the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977. See 22.5.13.

22.5.13 Female devices (such as receptacles, appliance couplers, and connectors) that are intended, or that may be used, to interrupt current in the end product, shall be suitably rated for current interruption of the specific type of load, when evaluated with its mating plug or connector. For example, an appliance coupler that can be used to interrupt the current of a motor load shall have a suitable horsepower rating when tested with its mating plug.

23 Heating Elements

23.1 A heating element shall comply with the Standard for Sheathed Heating Elements, UL 1030, or the Standard for Electric Heating Appliances, UL 499.

Exception No. 1: This requirement does not apply to insulated wiring material used as a heater when:

a) The wiring material complies with the Standard for Appliance Wiring Material, UL 758; and

b) The temperature of the wire insulation does not exceed its rating during the tests specified in 50, 56, 57, and 73.5.

Exception No. 2: This requirement does not apply to tungsten heat lamps, Halogen lamps, quartz heater, and the like.

Exception No. 3: This requirement does not apply to semiconductor-type heating elements. See Part .

23.2 A heating element shall be supported in the intended manner.

23.3 A movable heating element shall be protected against damage caused by contact with other parts of the appliance when the element is moved.

23.4 An appliance in which the heating element is designed for operation only in an air blast shall be electrically connected or controlled so that the element operates only when the source of the air blast is energized.

Exception: This requirement does not apply to an appliance which complies with the Normal Temperature Test, Section 50, without the air blast energized.

23.5 An appliance in which the heating element is designed for operation only with the cooling effect of a part in motion shall be electrically connected or controlled so that the element operates only when the part in motion is energized.

Exception: This requirement does not apply to an appliance that complies with the Normal Temperature Test, Section 50, without the part in motion energized.

23.6 The sheath employed to enclose a heating element of an immersion heater shall be of a metal resistant to corrosion by the liquid in which the heater is intended to be immersed.

23.7 The voltage rating of a heating element shall not be less than the voltage rating of the circuit in which the heating element is connected.

Exception No. 1: A heating element having a voltage rating within an applicable range of voltages specified in 83.3 is suitable for the application when the voltage rating of the appliance is within that range.

Exception No. 2: The voltage rating of an element that is connected in series is to be compared with the applied voltage.

24 Electrical Insulation

24.1 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.

24.2 Some materials that are not acceptable for general use, such as magnesium oxide, are acceptable when used in conjunction with other insulating materials or when located and protected so that mechanical damage is prevented and the absorption of moisture is minimized.

24.3 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.

24.4 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 24.1. 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 24.2 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 24.1, 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 24.1, 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 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 24.1, 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 24.1
Minimum material characteristics required for the direct support of uninsulated live parts

UL 94 Flame Class	RTI Elec	Performance Level Category (PLC)		
		HWI[b]	HWI[b]	CTI[c]
HB	a	2	2	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 50.

[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 24.2
Generic materials required for direct support of uninsulated live parts[a]

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
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

[a] 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 50.

24.5 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.

Exception: For a printed-wiring board with an isolated secondary circuit as specified in 34.2.2(a), 34.2.3(a), or 34.2.5(a), the printed-wiring board shall be rated V-2 or better.

24.6 Film-coated wire (magnet wire)

24.6.1 Film-coated wire in intimate combination with one or more insulators, and incorporated in an insulation system rated Class 120 (E) or higher, shall comply with the magnet wire requirements in the Standard for Systems of Insulating Materials – General, UL 1446.

25 Thermal Insulation

25.1 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 Tests for Surface Burning Characteristics for 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.

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

25.3 A material of asbestos composition shall not be used.

Exception: The use of asbestos cement is not prohibited when it is used in accordance with, and meets the requirements of Commercial Cooking, Rethermalization, and Powered Hot Food Holding and Transport Equipment, ANSI/NSF 4.

26 Motors and Transformers

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

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

26.1.2 A motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

26.1.3 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.

26.2 Motor protection

26.2.1 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 overload protection types specified in 26.2.1.1 – 26.2.1.4.

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.

26.2.1.1 Thermal protection devices integral with the motor shall comply with one of the following:

a) The Standard for Overheating Protection for Motors, UL 2111;

b) The Standard for Thermally Protected Motors, UL 1004-3; or

c) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Thermal Motor Protectors, UL 60730-2-2; in conjunction with the Standard for Thermally Protected Motors, UL 1004-3, (to evaluate the motor-protector combination).

26.2.1.2 Impedance protection shall comply with one of the following:

a) The Standard for Overheating Protection for Motors, UL 2111; or

b) The Standard for Impedance Protected Motors, UL 1004-2.

26.2.1.3 Electronic protection integral to the motor shall comply with the Standard for Electronically Protected Motors, UL 1004-7.

26.2.1.4 Except as indicated in 26.2.1.3, electronically protected motor circuits shall comply with one of the following:

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. When the protective electronic circuit is relying upon software as a protective component, it shall comply with the requirements in the Standard for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1;

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1. If software is relied upon to perform a safety function, it shall be considered software Class B; or

c) The Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1.

Exception: Compliance with the above standards are not required for an electronically protected motor circuit if there is no risk of fire, electric shock, or injury to persons during abnormal testing with the motor electronic circuit rendered ineffective; compliance with the applicable requirements of this end product Standard is then required.

26.2.2 Fuses are not prohibited from being used to provide the necessary overload protection when compliance with the requirements will be 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.

26.3 Transformers

26.3.1 Except as noted in 26.3.2, a transformer in a circuit involving a risk of fire or electric shock shall comply with the requirements in the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, or 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 39.4) 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.

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

27 Temperature Controls

27.1 A temperature-regulating control shall comply with the requirements in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

Exception: A temperature-regulating control located in a Class 2 circuit is only required to comply with the endurance test requirements in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

27.2 A temperature-limiting control shall comply with the requirements for temperature-limiting controls in the Standard for Temperature-Indicating and Regulating Equipment, UL 873, or the Standard for Limit Controls, UL 353; or with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

27.3 As part of the evaluation to the Standard for Temperature-Indicating and Regulating Equipment, UL 873, or the Standard for Limit Controls, UL 353, a temperature control and a temperature control assembly shall be rated for the number of cycles of endurance specified in Table 27.1 and at a rating no less than the rated current of the heater and/or other load controlled during normal operation. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills the UL 873 requirements.

Exception No. 1: A temperature-regulating control that has not previously been evaluated for the number of cycles specified in Table 27.1 shall be subjected to the endurance test specified in 68.2 consisting of the number of cycles of operation specified in Table 27.1.

Exception No. 2: A single-operation device (SOD), evaluated as a temperature-limiting control in accordance with UL 873, is not required to be rated for the number of cycles specified in Table 27.1. Compliance with the Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

27.4 The endurance test requirement of 27.3 also applies to magnetic contactors, auxiliary equipment, solid state relays, or similar components, when used in conjunction with the temperature controls.

27.5 When a temperature control in fixed or stationary equipment has a marked "off" position (see 31.1.5), and the control is set to the "off" position:

a) Lowering of temperature or loss of capillary tube pressure shall not cause the contacts to close; and

b) The heating element circuit shall not produce heat.

27.6 The bulb and capillary tubing of a temperature-regulating or -limiting control of an appliance shall be located or shielded so that it is protected from mechanical damage.

27.7 The reset button of a manually reset temperature control shall be protected from mechanical abuse.

Table 27.1
Number of cycles for temperature controllers

Type of temperature control	Automatic reset control (cycles)	Manual reset control	Calibration needed[a]
Mechanical or solid state temperature regulating control for use in a non-oil or non-grease frying appliance.	30,000	To be made the subject of an investigation. No value is specified because of unlikely occurrence.	No
Mechanical or solid state temperature regulating control for use in an oil or grease frying appliance.	100,000	To be made the subject of an investigation. No value is specified because of unlikely occurrence.	No

Table 27.1 Continued on Next Page

Table 27.1 Continued

Type of temperature control	Automatic reset control (cycles)	Manual reset control	Calibration needed[a]
Mechanical or solid state temperature limiting control, except as noted below.	100,000	1000 cycles under load and 5000 cycles without load.	Yes
Manually reset temperature limiting control for use in an oil or grease frying appliance, where the control operates during the test specified in 104.1.	N/A	30,000	Yes
Manually reset temperature limiting control where a temperature limiting control test switch is provided. See 101.6.	N/A	30,000	Yes

[a] Calibration refers to the Operations Test in the Standard for Limit Controls, UL 353, or the Calibration Verification Test in the Standard for Temperature-Indicating and Regulating Equipment, UL 873, as applicable. See 27.2. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

27.8 A temperature control or auxiliary control device, such as provided in an automatic toaster, shall disconnect the element or elements that it controls from all conductors of the power-supply circuit unless there will be no live parts exposed to unintentional contact when the auxiliary control device is open.

27.9 When malfunction of a temperature-regulating control results in a risk of fire or electric shock (as described in 56.1.3 and 56.1.4) when tested in accordance with 56.3.1 – 56.3.3, a temperature-limiting control shall be provided. The suitability of this control and its location is to be evaluated by the test in 56.3.

27.10 The operation of a thermal cutoff shall not involve a risk of fire or electric shock as described in 56.1.3 and 56.1.4.

27.11 A thermal cutoff shall be reliably secured in place.

27.12 The temperature-limiting control circuit, see 2.29, shall be separate from the temperature-regulating control circuit so that malfunction of any component in one circuit will not adversely affect the operation of the other circuit.

27.13 The temperature sensors for the temperature regulating and limiting controls shall not be located such that disabling of one heating element prevents both temperature controls from operating to protect the unit as intended, unless the disabling of that element reduces the available heat and reduces the risk of fire under the conditions specified in 56.7.12, Abnormal Heating Test – Appliances with Multiple Heating Elements.

28 Short-Circuit and Ground-Fault Protection

28.1 General

28.1.1 When overcurrent protective devices are required by 28.3, 28.4, or 28.5 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 28.3.2 – 28.3.4 or 28.3.6 is not required to be suitable for branch-circuit protection when the device meets the requirements of Section 28.2.

Exception No. 2: Except as required in 28.4, an overcurrent-protective device required by 28.5 is not required to be suitable for branch-circuit protection when the device meets the requirements of Section 28.2.

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 a and 28.1.4.

28.1.2 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. When the devices required by this Section are located within a panelboard, the appliance shall be marked in accordance with 89.16.

28.1.3 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 28.1.6), 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 86.10, the marked rating is the anticipated branch-circuit overcurrent protective device rating. See 28.1.4.

28.1.4 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 28.1.3.

Exception: The marked rating is not required to be at least 125 percent of the current rating of the appliance when the appliance is subjected to the Input Averaging Test, Section 48. In this case, the marked rating shall be not less than the next-higher standard rating (see 28.1.6) above the highest of the following ampere values:

a) Average input current (as determined by the Input Averaging Test, Section 48) multiplied by 1.25;

b) Appliance current rating as marked on the the appliance, where applicable;

c) Maximum measured current input as determined by the Input Test, Section 47.

28.1.5 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.

Exception: A cord-connected appliance with an attachment plug rated 125V, 15A is assumed to be connected to a circuit protected at 20A.

28.1.6 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.

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

28.1.8 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.

28.1.9 With respect to the requirements in 28.3, 28.4, and 28.5, 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.

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

28.2.1 When a supplementary-type overcurrent protective device is used as short-circuit and ground-fault protection, in accordance with the Exception to 28.1.1, the device and the appliance in which it is used shall comply with the requirements in 28.2.2 – 28.2.5. See 8.5 and 10.4.

28.2.2 A supplementary overcurrent-protective device as specified in 28.2.1 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.

28.2.3 When a supplementary-type fuse is used in accordance with 28.2.2, the appliance shall be marked in accordance with 89.11 and 89.12.

28.2.4 A supplementary-type overcurrent-protective device shall not open during the Normal Temperature Test, Section 50.

28.2.5 A supplementary-type overcurrent-protective device shall have a short-circuit rating suitable for the circuit in which it is located. See Table 28.1. 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 28.1, the short-circuit rating of the overcurrent-protective device need not be higher than the maximum available current.

Table 28.1
Short-circuit ratings of supplementary-type overcurrent protective devices

Rating of appliance, Amperes				
Single phase				Short-circuit rating amperes
115V	208V	230 – 240 V	277V	
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

28.3 Protection for circuits including specific components

28.3.1 Auxiliary-Circuit Terminals – An appliance provided with auxiliary-circuit terminals, see Section 29, Auxiliary-Circuit Terminals, shall incorporate an overcurrent-protective device in accordance with 28.4 in each ungrounded conductor to the terminals.

28.3.2 Motor Circuits – A motor circuit in an appliance that is connected to a circuit protected at greater than 20 amperes in accordance with 28.1.3 and 28.1.4 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 28.1.1 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.

28.3.3 Transformer Circuits – A transformer circuit in an appliance that is connected to a circuit protected at greater than 20 amperes in accordance with 28.1.3 and 28.1.4 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, or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

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.

28.3.4 Lampholder Circuits – A lampholder circuit shall have overcurrent protection rated not more than 20 amperes in the appliance. See Section 33, Lampholders.

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

28.3.5 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.

28.3.6 Heating Element Circuits – An appliance employing resistive heating elements, including halogen lamp heating elements, rated more than 48 amperes shall have the heating elements on subdivided circuits. The load on each circuit shall not exceed 48 amperes, and each circuit shall be protected at not more than 60 amperes unless required to be protected at a lower level in accordance with 28.3.7. The protective device shall be:

a) Factory installed within or on the appliance enclosure; or

b) Provided as a separate assembly by the appliance manufacturer.

Exception: An appliance employing metal-sheathed heating elements is not required to be subdivided as stated in 28.3.6 when:

a) The elements are integral with and enclosed within a cooking surface;

b) The elements are contained within an enclosure or other heating compartment, under normal operating conditions, which are identified as suitable for use, in accordance with Section 8, Electrical and Fire Enclosures. For the purpose of this requirement, an oven door is not prohibited from completing the enclosure; or

c) The elements are contained within an ASME rated and stamped vessel

However, such heating elements shall be subdivided into circuits not exceeding 120 amperes and protected at not more than 150 amperes.

28.3.7 Surface Heating Elements – Exposed metallic-sheathed surface heating elements intended for direct contact with cooking utensils shall have overcurrent protection rated not more than 50 amperes in the appliance unless the appliance is connected in accordance with 28.1.3 to a branch circuit rated 50 amperes or less.

28.4 Protection for wiring located outside the enclosure

28.4.1 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 28.1.9.

28.4.2 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.

28.4.3 A conductor provided with overcurrent protection complying with the National Electrical Code, ANSI/NFPA 70, is determined to comply with 28.4.1. For wiring located in a tapped high-voltage control circuit, a conductor provided with overcurrent protection complying with Table 28.2 is determined to comply with 28.4.1.

28.4.4 With respect to 28.4.1, 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 28.4.1.

Table 28.2
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.

28.5 Protection for high-voltage control circuits conductors

28.5.1 General

28.5.1.1 These requirements apply to protection of conductors in high-voltage control circuits. Components in these circuits shall be protected in accordance with 28.3. Wiring in these circuits that is located outside the enclosure shall be protected in accordance with 28.4.

28.5.2 Direct-connected high-voltage control circuits

28.5.2.1 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 24.2.

28.5.3 Tapped high-voltage control circuits

28.5.3.1 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.

28.5.3.2 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 28.3.

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 24.1 may be used provided the conductor complies with the requirements specified in the Limited Short-Circuit Test, Section 49.

Exception No. 3: A lead within the appliance enclosure and 12 inches (305 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, 28.3.3; and

b) Does not exceed the applicable value specified in Table 28.3, multiplied by the ratio of secondary to primary rated transformer voltage.

Table 28.3
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.

29 Auxiliary-Circuit Terminals

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

29.2 Auxiliary-circuit terminals shall be connected to:

a) A contactor that complies with the requirements in 27.3 and 27.4 for an automatic reset temperature-limiting control;

b) A shunt-trip circuit breaker; or

c) A switching device of equivalent reliability.

29.3 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.

30 Capacitors

30.1 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.

30.2 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 38, Insulating Barriers.

30.3 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 57.

30.4 Across-the-line and line bypass (line to ground) capacitors shall be subjected to the Dielectric Voltage-Withstand Test, Section 51.

Exception: A capacitor that complies with the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, or the Standard for Capacitors, UL 810, is not required to be subjected to this test.

31 Switching Devices

31.1 General

31.1.1 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 Sections 34.3 – 34.8 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 31.4.2 – 31.4.7, 31.4.10, or 102.1.

31.1.1.1 Switches and switchgear shall comply with one of the following, as applicable:

a) *Deleted*

b) The Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1;

c) The Standard for Low-Voltage Switchgear and Controlgear – Part 1: General rules, UL 60947-1;

d) The Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters, UL 60947-4-1; or

e) The Standard for Low-Voltage Switchgear and Controlgear – Part 5-2: Control circuit devices and switching elements – Proximity switches, UL 60947-5-2.

Exception: Switching devices that comply with the applicable UL standard for specialty applications (e.g. transfer switch equipment), industrial use (e.g. contactors, relays, auxiliary devices), or are integral to another component (e.g. switched lampholder) need not comply.

31.1.1.2 A clock-operated switch, in which the switching contacts are actuated by a clock-work, by a gear-train, by electrically-wound spring motors, by electric clock-type motors, or by equivalent arrangements shall comply with one of the following:

a) The Standard for Clock-Operated Switches, UL 917; or

b) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7.

31.1.2 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.

31.1.3 With reference to 31.1.2, 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 83.3, 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; and

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

31.1.4 With reference to 31.1.2 and 31.4, 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.

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

31.1.6 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.

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

31.2 Electrical ratings

31.2.1 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 50.

31.2.2 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.

31.2.3 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 70, Motor Switch Overload Test; or

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

31.2.4 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 25 W; or

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.

31.2.5 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 31.2.2 – 31.2.4, as applicable, and the rated current of the resistive load.

31.2.6 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 83.4.

31.3 Guarding

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

31.3.2 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.

31.3.3 With reference to the requirement in 31.3.2, 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.

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

31.4 Specific applications

31.4.1 A switching device in a fixed or stationary appliance that controls a heating element and has a marked "off" position, see 31.1.4, shall open all ungrounded conductors of the heating-element circuit or cause the conductors to be opened.

31.4.2 A switching device controlling an exposed open-wire element shall be of such a type and so connected that it disconnects the element or elements from all conductors of the power-supply circuit. This applies to a switch in the "off" position or any other position of the switch in which the element is not heated.

31.4.3 A switching device controlling an exposed open-wire element in the rotating head of a cotton candy maker shall be of such type and so connected that it disconnects the element from all conductors of the power-supply circuit when power to the drive mechanism for the rotating head is interrupted.

31.4.4 A switching device controlling one or more plug-in or movable surface heating elements of a permanently connected appliance shall open all ungrounded conductors of the heating element or elements that it controls or cause the conductors to be opened.

31.4.5 A manually operated switching device with a marked "off" position shall be provided for the control of each section, such as an oven or a warming unit, of a permanently connected appliance. See 31.1.4 and 31.4.1.

31.4.6 A switch or other means of control intended to permit the use of a limited number of elements at one time shall be so located or of such type that the user cannot readily change the connections to permit the use of more elements than intended.

31.4.7 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 31.1.4.

31.4.8 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 31.1.4. This switch shall be visible and legible from any anticipated user location.

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

31.4.10 The requirement in 31.4.9 necessitates the use of an interlock (See Section 14, Interlocks)in an appliance when moving parts are capable of causing injury to a person upon the automatic restarting of a motor.

32 Components Containing Liquid Metal

32.1 Components containing liquid metal (mercury, sodium, and/or potassium) shall not be located above or adjacent to food preparing/cooking areas. Components containing liquid metal located in circuits other than those described in 34.3 – 34.8 shall be investigated in accordance with the Standard for Industrial Control Equipment, UL 508, or the Standard for Temperature Indicating and Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

Exception: Components containing liquid metal are not prohibited from being located above or adjacent to food preparing/cooking areas when an enclosure or guard is located to prevent the liquid metal form

reaching the food preparing/cooking area in the event of breakage of the component. See Components Containing Liquid Metal Test, Section 71.

33 Lampholders

Section 33 deleted

33A Light Sources and Associated Components

33A.1 Lampholders and indicating lamps with integral lamp/lampholder (e.g. neon pilot lamp) shall comply with the Standard for Lampholders, UL 496.

Exception: Lampholders forming part of a luminaire that complies with an appropriate UL luminaire standard are considered to fulfill this requirement.

33A.1.2 Lighting ballasts shall comply with one of the following:

a) The Standard for Fluorescent-Lamp Ballasts, UL 935; or

b) The Standard for High-Intensity-Discharge Lamp Ballasts, UL 1029.

Exception No. 1: Ballasts forming part of a luminaire that complies with an appropriate UL luminaire standard are considered to fulfill this requirement.

Exception No. 2: Ballasts for other light sources shall comply with the appropriate UL standard.

33A.1.3 Light emitting diode (LED) light sources shall comply with the Standard for Light Emitting Diode (LED) Equipment for Use In Lighting Products, UL 8750.

Exception No. 1: LED light sources forming part of a luminaire that complies with an appropriate UL luminaire standard are considered to fulfill this requirement.

Exception No. 2: Individual LED light sources mounted on printed-wiring boards and intended for indicating purposes need not comply with UL 8750, but shall comply with the applicable requirements of this end product Standard.

33A.2 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 89.10, shall be provided. When a grounded supply conductor is provided, the connection of the lampholder shall comply with the requirements in Electrical Supply Connections for Permanently Connected Appliances, Section 16, Electrical Supply Connections for Cord-Connected Appliances, Section 17, as applicable, and Polarity, Section 19.

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 10.3, during relamping.

33A.3 When a medium-base or smaller screwshell type lampholder is connected to a circuit with a potential higher than 125 V, the marking in 89.3, shall be provided.

33A.4 For a screwshell type lampholder, when compliance with 33A.2, 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 89.4.

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

a) Comply with 33A.2; or

b) Do not fit into the space provided.

33A.5 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.

33A.6 A lampholder screw shell of a cord-connected appliance shall not operate at a potential of more than 150 V to ground. See 83.4.

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 10.3, during relamping.

33A.7 A female screw shell used as a holder for a heating element shall be of copper or a copper base alloy and shall be plated with nickel or an equivalent oxidation-resistant metal.

33A.8 Current-carrying parts of a lampholder in an oven of an appliance shall be of a material such as copper or a copper-base alloy plated with nickel, stainless steel, or an equivalent oxidation-resistant metal. Aluminum shall not be employed.

33A.9 A lampholder that is exposed to moist vapors during the operation of the appliance shall not employ a paper liner.

34 Secondary Circuits

34.1 General

34.1.1 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 34.1.3; and

c) The circuit is separated from other circuits as required in Section 40, Separation of Circuits.

Such circuits shall comply with the requirements in Subsection 34.2 for each type of circuit.

34.1.2 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 36.3.

34.1.3 The following secondary circuits shall comply with the requirements in 34.3 – 34.8:

a) Class 2 circuit (See 34.3);

b) Limited voltage/current circuit (See 34.4);

c) Limited voltage circuit (See 34.5);

d) Limited energy circuit (See 34.6);

e) Limiting impedance circuit (See 34.7); and

f) Safety extra-low voltage (SELV) circuit (See 34.8).

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

34.1.4 An overview of the secondary circuits listed in 34.1.3 is given in Table 34.1. This table is for comparison purposes only; special cases and exceptions are not shown.

Table 34.1
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, UL 5085-2, UL 5085-3, UL 1310, UL 60950-1, or UL 62368-1	Yes	0 to 20	8	5	5xVmax	250[f]	No	No	34.2.1, 34.3
			over 20 to 30	8	100/Vmax	100				
			over 30 – 60, dc only	150/Vmax	100/Vmax	100				
Limited voltage/current	UL 5085-1, UL 5085-2, UL 5085-3, UL 1310, UL 1411, UL 60950-1, or UL 62368-1	Yes	0 to 20	8	5	5xVmax	250[f]	No	Yes	34.2.1, 34.4
			over 20 to 30	8	100/Vmax	100				
			over 30 – 60, dc only	150/Vmax	100/Vmax	100				
Limited voltage	UL 5085-1, UL 5085-2, UL 5085-3, UL 1310, UL 1411, UL 60950-1, or UL 62368-1	Yes	0 to 30	N/A	N/A	N/A	N/A	No	Yes	34.2.2, 34.5
Limited energy	UL 5085-1, UL 5085-2, UL 5085-3, UL 1310, UL 1411, UL 60950-1, or UL 62368-1	Yes	0 to 100	N/A	N/A	N/A	200	Yes	Yes	34.2.3, 23.3
Limiting impedance	N/A	No	N/A	N/A	N/A	N/A	15 watts	No	No[e]	34.2.4, 34.7
Safety extra-low voltage (SELV)[a]	UL 60950-1 or UL 62368-1	Yes	0 to 30 over 30 – 60, dc only	N/A	N/A	N/A	N/A	N/A	Yes	34.2.5, 34.8

Table 34.1 Continued on Next Page

Table 34.1 Continued

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

[a] UL 1950 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 34.2.4(c).

[f] Non-inherently limited.

34.1.5 Any part that exceeds 121°C during the Normal Temperature Test, Section 50, 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.

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

34.1.7 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 34.3) and a Limited Voltage/Current Circuit (see 34.4) are not prohibited from being connected to the frame at more than one point.

34.1.8 Secondary circuits shall comply with the requirements for Short-Circuit and Ground-Fault Protection, Section 28.

34.1.9 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.

34.1.10 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 34.1.9.

34.2 Evaluation of the different types of secondary circuits

34.2.1 The following applies to secondary circuits that comply with the requirements for Class 2 circuits (see 34.3) or limited voltage/current circuits (see 34.4):

a) Lithium batteries shall be evaluated in accordance with Section 35, 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 40, Separation of Circuits.

c) Except as stated in 34.1.5 and 34.1.6, 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 34.1.7, 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.

34.2.2 The following applies to secondary circuits that comply with the requirements for limited voltage circuits (see 34.5):

a) Lithium batteries shall be evaluated in accordance with Section 35, 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 22, 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 40, 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.

34.2.3 The following applies to secondary circuits that comply with the requirements for limited energy circuits (see 34.6).

a) Lithium batteries shall be evaluated in accordance with Section 35, 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 22, Internal Wiring. Motors shall be evaluated in accordance with the requirements in Section 26, Motors. 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 50, 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 40, 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.

34.2.4 The following applies to secondary circuits that comply with the requirements for limiting impedance circuits (see 34.7):

a) Lithium batteries shall be evaluated in accordance with Section 35, 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 34.4.

c) Except as stated in 34.1.5 and 34.1.6, 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 34.7.2, 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 34.1.7, 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 34.7.2, shall be connected to the frame at not more than one point. The frame shall not be used as the return for these circuits.

34.2.5 The following applies to secondary circuits that comply with the requirements for safety extra-low voltage circuits (see 34.8):

a) Lithium batteries shall be evaluated in accordance with Section 35, 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 22, 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 40, 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.

34.3 Class 2 circuits

34.3.1 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 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

c) The requirements for "NEC Class 2" output in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

34.4 Limited voltage/current circuits

34.4.1 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 in 73.2, and the current available is limited to a value not exceeding the values shown in Table 34.1 when tested in accordance with the Maximum Current Test in 73.3. 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 in 73.6.

Exception: The Maximum Current Test is not required when a secondary circuit protective device is used to limit the available current as specified in 34.4.3.

34.4.2 The rated current for a limited voltage/current circuit shall not exceed the values in Table 34.1.

34.4.3 When a secondary fuse or other such secondary circuit protective device is used to limit the available current in accordance with 34.4.1, it shall be rated in accordance with Table 34.2.

Table 34.2
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.

34.4.4 When a primary circuit protective device is used to limit the available current in accordance with 34.4.1, 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 34.2.

34.4.5 A fuse used in accordance with 34.4.3 or 34.4.4 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 2.32(b).

34.4.6 When a protective device is used as specified in 34.4.3 or 34.4.4, the device shall comply with the requirements of this Standard and shall be provided with an adjacent replacement marking in accordance with 89.11. 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.

34.4.7 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 34.4.1, the fixed impedance or regulating network shall function to limit the voltage and current to the values given in 34.4.1 under single component fault conditions when tested in accordance with the Component Failure Test in 73.5.

34.5 Limited voltage circuit requirements

34.5.1 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 in 73.2; and

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

34.6 Limited energy circuits

34.6.1 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 in 73.6. The maximum open circuit voltage potential shall be 100 V ac when measured in accordance with the Maximum Voltage Test in 73.2.

34.6.2 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 34.6.1, 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 89.11. There are no restrictions on the current rating of the protective device, when it limits the available secondary volt-amperes in accordance with 34.6.1. 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.

34.6.3 A fuse used in accordance with 34.6.2 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 2.32(b).

34.7 Limiting impedance circuits

34.7.1 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 in 73.7, 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 in 73.4.

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 in 73.5.

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 250 V.

34.7.2 The limiting impedance referred to in 34.7.1 shall limit the available power to 15 W under single component fault conditions, when tested in accordance with the Component Failure Test in 73.5.

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 Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14.

34.8 Safety extra-low voltage circuits

34.8.1 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, or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, for a safety extra-low voltage (SELV) power supply, and shall be located only in a pollution degree 2 or cleaner environment. See 39.4.

35 Lithium Battery Circuits

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

35.2 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 34.

36 Isolating Devices

36.1 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.

36.2 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.

36.3 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.

37 Electrical Spacings

37.1 General

37.1.1 Other than as noted in 37.1.2 – 37.1.10, 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 37.1 and Table 37.2.

Exception No. 1: As an alternative approach to the spacing requirements specified in Table 37.1, clearances and creepage distances may be evaluated in accordance with the requirements in Section 39, 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 37.1 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 72.

Table 37.1
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 37.2
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 37.1.

[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.

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

37.1.3 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.

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

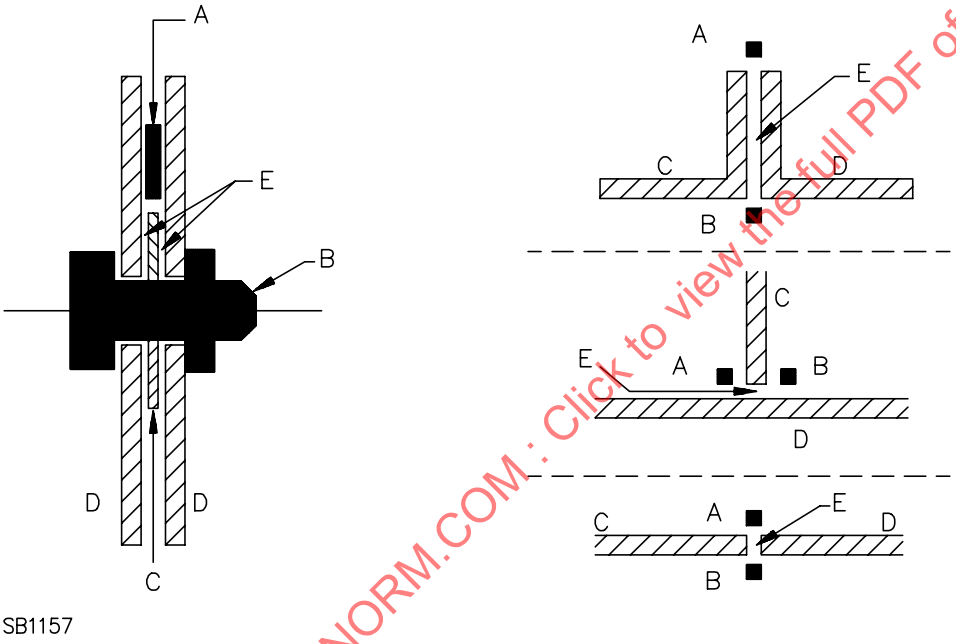
37.1.5 With reference to Table 37.1 and Table 37.2, the measurement of spacings over surface shall include the walls of a groove wider than 5/64 inch (2.0 mm).

37.1.6 Insulating barriers used in lieu of the required spacings shall comply with Section 38, Insulating Barriers.

37.1.7 In the case of a clamped insulating joint, see Figure 37.1, 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 37.1

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 37.1.7.

Parts C, D – Insulating barriers.

Part E – The clamped joint.

37.1.8 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).

37.1.9 The spacing through air between an uninsulated live part and an enclosure panel when tested as described in Section 63, 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) 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 5A.1.1 – 5A.1.4, and an enclosure panel on which the component is mounted.

37.1.10 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 16.3.1, spacings shall not be less than specified in Table 37.1 with such connecting means in position.

37.2 Secondary circuits

37.2.1 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 34.1.3; and

c) The circuit is separated from other circuits as required in Section 40, Separation of Circuits.

Such circuits shall comply with the requirements in Subsection 34.2 for each type of circuit.

38 Insulating Barriers

38.1 Insulating materials used as a barrier in lieu of the required spacings per 37.1 and used as specified in 38.3 – 38.5 shall:

a) Comply with Section 24, Electrical Insulation; and

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

Exception No. 1: A material that complies with Section 24 is not required to comply with the thickness limit in 38.1(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 24 and is used in addition to not less than one-half the required through air spacings not required to comply with 38.1(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.

38.2 The requirements in 38.1 are independent of each other. For example, when a material is determined to comply with Section 24, Electrical Insulation, at a thickness less than that required by 38.1, the material still needs to be provided at a thickness in accordance with 38.1.

38.3 The insulating material shall comply with the requirements in 38.1 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.

38.4 Insulating material that meets the following criteria shall also comply with the requirements in 38.1:

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 38.1 is capable of being used for this application without additional evaluation.

38.5 Insulating material shall also comply with the requirements in 38.1 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 38.1 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 38.1
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.

39 Clearance and Creepage Distances

39.1 As an alternative approach to the spacing requirements specified in Section 37, Electrical Spacings, and other than as noted in 39.2 and 39.3, clearances and creepage distances may be evaluated in accordance with the requirements in the Standard for Insulation Coordination Including Clearance and Creepage Distances for Electrical Equipment, UL 840, as described in 39.4.

39.2 Clearances between an uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable, shall comply with 37.1.9. The clearances shall be determined by physical measurement.

39.3 The clearance and creepage distance at field-wiring terminals shall be in accordance with the requirements in Section 37, 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 37, Electrical Spacings, or the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

39.4 When conducting evaluations in accordance with the requirements in the Standard for Insulation Coordination Including Clearance 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 commercial electric cooking appliance is to be categorized as Overvoltage Category II.

c) 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;

d) 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.

e) 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;

f) 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;

g) 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;

h) 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.

i) Evaluation of only clearances, to determine equivalence with current through air spacings requirements, shall be conducted in accordance with Section 4, 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 51;

j) 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;

k) 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

l) 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.

40 Separation of Circuits

40.1 Circuits shall be separated or segregated such that the spacings required by 37.1.1 are maintained.

40.2 A factory installed conductor shall be separated by a barrier or segregated, as specified in 40.3, 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.

40.3 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.

40.4 A conductor shall be provided with strain relief in accordance with Section 17.2 when stresses on the conductor cause the conductor to move such that compliance with 40.2 is not maintained.

40.5 An appliance shall be constructed so that a field-installed conductor of any circuit is segregated as specified in 40.7 and 37.1.1, or separated by a barrier (see 40.6) 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.

40.6 With respect to 40.5, 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.

40.7 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.

41 Parts Subject to Pressure

41.1 General

41.1.1 A part supported or actuated hydraulically shall not present a risk of injury to persons due to pressure loss.

41.1.2 A pressure vessel shall be designed so that:

a) A lid or door does not open until steam pressure is released; and

b) Steam released under pressure is directed away from the operator.

41.1.3 A means for draining oil or other cooking substances from an appliance that operates under pressure other than normal atmospheric pressure shall be designed so that drainage is not directed toward the operator.

41.1.4 A pressure vessel or boiler shall be certified by the National Board of Boiler and Pressure-Vessel Inspectors and marked with the appropriate boiler and pressure vessel code symbol of the American

Society of Mechanical Engineers (ASME) for a working pressure not less than the maximum anticipated pressure determined in accordance with 41.1.8.

Exception No. 1: This requirement does not apply to a pressure vessel meeting any of the following criteria; however, the pressure vessel shall be designed and constructed so that it complies with the requirements in 41.1.7:

a) A pressure vessel not covered by the inspection procedure of the ASME code because of its application;

b) An unfired pressure vessel (see 2.23):

1) Having an inside minor dimension of 6 inches (152 mm) or less; or

2) Subject to a maximum anticipated pressure of 15 psig (102 kPa) or less.

c) A fired pressure vessel (see 2.22) where the pressurized medium is contained solely within the appliance during normal use (for example, the sheath of a steam kettle or the kettle of a pressure fryer):

1) Having an inside minor dimension of 6 inches (152 mm) or less; or

2) Subject to a maximum anticipated pressure of 15 psig (102 kPa) or less

d) Except as noted in 41.1.6, a fired pressure vessel (see 2.22) where the liquid, vapor, or gas under pressure is used outside the vessel to directly produce a food or drink product (for example, a vessel from which water is drawn to produce a beverage or from which steam is drawn to froth milk for a beverage), where the vessel has:

1) An inside minor dimension of 6 inches (152 mm) or less;

2) A tank volume of not more than 1-1/2 cubic feet; and

3) A maximum anticipated pressure of not more than 30 psig (204 kPa).

Exception No. 2: This requirement does not apply to a premixed-beverage container that is replaced when renewing the beverage supply.

41.1.5 With reference to Exception No. 1 to 41.1.4, vessels that operate independently of each other with regard to pressure are to be evaluated separately, even when one is located partially or completely within the other.

41.1.6 A fired pressure vessel with a power input rating greater than 48 kW to the vessel shall be evaluated to the following portions of the Standard for Heating, Water Supply, and Power Boilers – Electric, UL 834:

a) Types of Water Boilers of UL 834

b) Special Designation of a Boiler Assembly of UL 834

c) Limit Controls section of UL 834

d) Low Water Cutoff section of UL 834

e) Terminals and Sensing Elements of Operating and Limit Controls section of UL 834

f) Pressure-Relieving Devices section of UL 834

g) Limit Control Cutout Test section of UL 834

h) Continuous Operation Test section of UL 834

i) Pump-Failure Test section of UL 834

j) Blocked-Flow Test section of UL 834

k) Low Water Abnormal Test section of UL 834

l) Marking Requirements of UL 834

m) Instruction Manual Requirements section of UL 834

41.1.7 A part or an assembly that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid, during normal or abnormal operation shall withstand without malfunction a pressure equal to five times the maximum anticipated pressure, see 41.1.8, as determined by the Hydrostatic Pressure Test, Section 75:

Exception No. 1: A section of a pressure system constructed of tubing is determined to comply with the requirements when the maximum pressure obtained during normal or abnormal operation is not greater than the values specified in Table 41.1 for a given diameter and thickness. The tubing is to be continuous or lengths of tubing are to be connected by hard-soldered, brazed, or welded joints, or flared type compression fittings.

Exception No. 2: This requirement does not apply to a pressure vessel bearing the ASME code inspection symbol when that vessel is marked with a value of working pressure not less than that to which it is subjected during normal or abnormal operation.

Exception No. 3: Tubing intended for use as a pressure relief means need only withstand a pressure equal to 1-1/2 times the maximum anticipated pressure of the part being protected. See 41.1.8.

41.1.8 The maximum anticipated pressure is defined as the highest pressure selected from the following choices (as applicable):

a) The pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but not more than the marked maximum supply pressure from an external source and not more than the pressure setting of a pressure-relief device provided as a part of the assembly.

b) The marked maximum supply pressure from an external source, but not more than five times the pressure setting of a pressure-relief device provided as a part of the assembly, as determined by the Start-to-Discharge Test, Section 76.

c) The pressure setting of a required pressure-relief device, as determined by the Start-to-Discharge Test, Section 76.

d) The maximum pressure that can be developed by an air compressor that is part of the assembly, unless the pressure is limited by a pressure-relief device provided as part of the assembly.

e) The maximum working pressure marked on the part.

Exception: The Start-to-Discharge Test is not required when the device bears the ASME code inspection symbol. In this case, the marked operating pressure is the pressure setting of the device.

Table 41.1
Maximum pressure for tubing

Outside diameter		Minimum wall thickness		Maximum pressure to which tubing is subjected, psig (MPa)					
inch	(mm)	inch	(mm)	Seamless copper		Butt-welded steel		Seamless steel	
3/8 or smaller	(9.5)	0.016	(0.41)	500	(3.45)	600	(4.14)	1000	(6.90)
1/2	(12.7)	0.016	(0.41)	400	(2.76)	480	(3.31)	800	(5.52)
5/8	(15.9)	0.016	(0.41)	320	(2.21)	384	(2.65)	640	(4.42)
5/8	(15.9)	0.021	(0.53)	420	(2.90)	504	(3.48)	840	(5.80)
3/4	(19.0)	0.021	(0.53)	360	(2.48)	432	(2.98)	720	(4.97)
3/4	(19.0)	0.025	(0.64)	420	(2.90)	504	(3.48)	840	(5.80)
1	(25.4)	0.021	(0.53)	260	(1.79)	312	(2.15)	520	(3.59)
1	(25.4)	0.025	(0.64)	320	(2.21)	384	(2.65)	640	(4.42)

41.2 Pressure relief means

41.2.1 A part in which pressure might be generated by an external fire shall be provided with a means of safely relieving pressure such as a pressure-relief device (see 41.3.6) a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent pressure-relief means.

41.2.2 There shall be no shut-off valve between the pressure-relief means and the parts that it is intended to protect.

41.3 Pressure relief devices

41.3.1 A vessel having an inside minor dimension of more than 3 inches (76 mm) and subject to air or steam pressure generated or stored within the appliance shall be protected by a pressure-relief device.

41.3.2 A gasket shall not be used as the pressure-relief device required by 41.3.1.

41.3.3 Each pressure relief valve shall be set to function at a pressure no greater than the maximum allowable working pressure marked on any part of the protected system, where applicable. See Section 76, Start-to-Discharge Test.

Exception: The Start-to-Discharge Test is not required when the device bears the ASME code inspection symbol. In this case, the marked operating pressure is the pressure setting of the device.

41.3.4 A pressure-relief device shall comply with all of the following:

a) Be connected as close as possible to the pressure vessel or parts of the system that it is intended to protect;

b) Be installed so that it is readily accessible for inspection and repair and cannot be readily rendered inoperative;

c) Have its discharge opening located and directed so that:

1) The risk of scalding is reduced to an acceptable degree; and

2) Operation of the device does not result in the deposit of moisture on bare live parts or on insulation or components detrimentally affected by moisture.

d) Have a discharge rate adequate to relieve the pressure as determined by the Relief Device Maximum Pressure Test, Section 77.

Exception: A relief device that is stamped "ASME" and can be clearly shown by ASME calculations to have the flow capacity and relief pressure sufficient for the application is not required to be tested in accordance with the Relief Device Maximum Pressure Test, Section 77.

41.3.5 A pressure-relief device having an adjustable setting is to be judged on the basis of its maximum setting unless the adjusting means is sealed at a lower setting.

41.3.6 A pressure-relief device is evaluated as a pressure-actuated valve or rupture member designed to relieve excessive pressures automatically.

41.4 Pressure Controls

41.4.1 A pressure control is required to regulate the pressure in the vessel to 90 percent or less of the pressure relief device setting under all conditions of operation as defined by Section 50, Normal Temperature Test. The control, including pressure sensing means, shall be subjected to the Pressure Controls Endurance Test, Section 78.

Exception No. 1: A pressure control is not required to be tested in accordance to Section 78, Pressure Controls Endurance Test, if the system demonstrates during the Normal Temperature Test, Section 50, to operate below 90 percent or less of the pressure relief device setting.

Exception No. 2: The Pressure Controls Endurance Test is not required when all of the following conditions are met:

a) The control complies with the endurance requirements for a temperature-regulating control in the same environment. See 27.3 and 27.4; and

b) A separate limiting device is provided that limits the pressure to 90% or less of the relief-device setting (See Section 76, Start-to Discharge Test) under all intended conditions of operation. This control shall comply with the endurance requirements for a temperature-limiting control in the same environment. See 27.3 and 27.4.

Exception No. 3: The Pressure Controls Endurance Test is not required when the control used to regulate the pressure in the vessel meets the requirements for Limit Controls, UL 353 or has been evaluated for 100,000 cycles endurance in accordance with the requirements for Industrial Control Equipment, UL 508.

42 Stability

42.1 An appliance equipped with wheels, casters, or the like shall have at least two manually operated locks for the wheels, a floor lock, or the equivalent.

42.2 A drawer shall have a means, such as a mechanical stop, to prevent inadvertent removal of the drawer from its frame, when inadvertent removal could result in a risk of injury to persons.

Exception: A grease drawer having a dimension more than 12 inches (305 mm) from front to back is not required have a mechanical stop.

43 Surface Mounted Appliances

43.1 General

43.1.1 These requirements for surface mounted units apply to appliances that are normally installed on a counter but have an option to be mounted to a wall or to a similar structural surface.

43.1.2 An appliance that can be mounted to a wall or under a cabinet or shelf shall comply with 43.2, 43.3, Section 64, Mounting Means Test, and shall be provided with installation instructions in accordance with 91.10.

Exception No. 1: An appliance either designed only for wall mounting or marked for wall mounting only in accordance with 88.13 is not required to comply with 43.3.

Exception No. 2: An appliance either designed only for under cabinet or shelf mounting or marked as such in accordance with 88.13 is not required to comply with 43.2, Section 64, Mounting Means Test, or 91.10.

43.2 Wall mounting

43.2.1 In determining compliance with the requirements of this section, the weight of the appliance shall be determined by weighing the complete appliance with the exception of the mounting hardware. When a shelf, bowl, hook or any means of support of any object is provided, the weight of the intended object shall be included.

43.2.2 A wall appliance shall comply with the conditions specified in Table 43.1.

Exception: A wall appliance is not prohibited from complying with the conditions applicable to a heavier appliance.

Table 43.1
Mounting requirements

Maximum weight		
Pounds	(kg)	Conditions
2-1/4	(1.0)	(A or B) and (C or D)
4-1/4	(1.9)	[(A or B) and D] or E
Greater than 4-1/4	(1.9)	F

A – A wall-mounted appliance shall not project more than 7-1/2 inches (190 mm) from a flat vertical wall on which the appliance is mounted in the intended manner. The projection is to be measured to the farthest point on the lampholder with an adjustable lamp adjusted to the position that gives the maximum projection from the wall.

B – The center of gravity of a wall-mounted appliance shall not be more than 3 inches (76.2 mm) from the vertical wall on which the appliance is hung in the intended manner, the center of gravity being determined with any adjustment that gives a maximum projection from the wall.

C – An appliance is provided with either a ring-hanger, keyhole slot(s), or notch(es).

D – An appliance is provided with mounting hardware consisting of at least two No. 6 Type A sheet metal screws of sufficient length that the screws, when installed in the mounting holds, will penetrate the mounting surface by not less than 3/4 inch (19 mm).

E – An appliance is provided with mounting hardware consisting of at least two No. 10 – 24 machine screws with mating hollow-wall anchors, or wing or expansion bolts. The screws shall be of sufficient length to permit the anchors, or wing or expansion bolts to be installed through the mounting holes and a 3/4-inch (19-mm) thick wall.

F – An appliance is to be provided with mounting hardware that complies with the Mounting Means Test, Section 64.

43.2.3 A wall appliance is not prohibited from being provided with a separable bracket used to secure the appliance to a vertical mounting surface in accordance with 43.2.2.

43.2.4 The wall appliance shall comply with the requirements for Electrical and Fire Enclosures in Section 8 and the requirements for Accessibility of Live Parts, Section 10, without dependence on the intended mounting surface or any separable bracket.

43.2.5 When provided with a power supply cord, the cord shall exit the appliance from a surface other than the one abutting the vertical wall.

43.3 Under cabinet units

43.3.1 An appliance intended to be mounted under a cabinet, shelf, or similar structural surface shall be provided with means for mounting and instructions in accordance with 43.2 and 91.10 except as follows:

a) Only Conditions C and F from Table 43.1 are applicable. The keyhole slots in Condition C are capable of being opened to facilitate mounting in place and tightening of mounting screws.

b) Each term "wall mounted appliance" shall be replaced with "under cabinet mounted appliance" and each term "vertical" that references the mounting surface shall be replaced with "horizontal" in Subsection 43.2 and Section 64, Mounting Means Test.

c) The Exception to 64.2 does not apply and the surface mounted instructions in 91.10 shall specify the intended mounting surface.

d) The weight specified in 64.3 is to be applied to the point most likely to cause unacceptable results.

44 Gas-Tube Signs

44.1 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.

PERFORMANCE – COMPLETE APPLIANCE

45 General

45.1 The performance of an appliance shall be investigated by subjecting the required number of samples to all the applicable tests described in Sections 46 – 65. Insofar as is practical, the tests shall be conducted in the order in which they are presented.

45.2 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.

Exception: When an appliance contains components that are not affected by changes in frequency, these components are not prohibited from being energized at any convenient rated frequency during the tests.

45.3 When a pressure gauge is required, it is to be attached so as to prevent leakage. Special fittings for direct connection to the system or commercial tubing or pipe may be employed for gauge connections. Volume of the pressure-measuring gauge and lines shall be held to a minimum relative to pressure vessel size.

45.4 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 83.3 when the marked voltage is within one of the voltage ranges specified in 83.3.

45.5 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).

Exception: When the appliance is marked in accordance with 85.7, the removable part is to be secured in place during the Normal Temperature Test, Section 50.

46 Leakage Current Test

46.1 A cord-connected appliance rated for a nominal 250-volt or less single phase supply shall be tested in accordance with 46.2 – 46.9. Leakage current shall not be more than:

a) 0.5 MIU for a three-wire (including grounding conductor) cord-and plug-connected portable appliance; and

b) 0.75 MIU for a three-wire (including grounding conductor) cord- and plug-connected appliance:

1) Employing a standard attachment plug rated 20 amperes or less; and

2) Intended to be fastened in place or located in a dedicated space.

Exception No. 1: The leakage current of an appliance incorporating a sheath type heating element is to be monitored during heat-up and cool-down. The maximum allowable leakage current for periods not exceeding 5 minutes during heat-up and not exceeding 5 minutes during cool-down, after reaching the leakage current limit of 0.5 MIU or 0.75 MIU, as applicable, is 2.5 MIU. For all other periods of operation, the leakage current shall be not more than the 0.5 MIU or 0.75 MIU limit, as applicable.

Exception No. 2: Conductive parts of an appliance that comply with the following conditions (1) – (4) and that have a leakage current greater than specified in (a) or (b) shall have a leakage current from simultaneously accessible parts to the grounded supply conductor no greater than 3.5 MIU. The leakage current between simultaneously accessible parts shall not exceed 0.5 MIU.

1) The appliance requires electromagnetic interference (EMI) suppression filtering for compliance with other requirements, such as Federal Communications Commission (FCC) Regulations;

2) There is a low probability that a path for available current through the body exists in the expected environment. If the available current flows to ground, this will involve consideration of the probability that the user will be grounded during the use of the product;

3) There is a low probability that high leakage conductive parts will be contacted during normal use of the appliance; and

4) The probability of injury resulting from an involuntary reaction is small.

Exception No. 3: For an appliance that upon loss of grounding, dependably disconnects all sources that can produce leakage current, the leakage current to ground shall not exceed 5 MIU with the grounding conductor open and with the loss-of-grounding circuit disabled. The leakage current between simultaneously accessible parts on the appliance shall not be more than 5 MIU.

46.2 All accessible conductive parts are to be tested for leakage currents. Leakage currents from these parts are to be measured to the grounded supply conductor individually as well as collectively when simultaneously accessible, and from one part to another when simultaneously accessible. A part is determined to be accessible unless it is guarded by an enclosure that is intended for protection against the risk of electric shock as defined in Section 10, Accessibility of Live Parts. Conductive parts are determined to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that do not involve a risk of electric shock. When all accessible conductive parts are bonded together and connected to the grounding conductor of the power-supply cord, the leakage current is to be measured between the grounding conductor of the product and the grounded supply conductor.

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

46.4 An appliance employing water or other liquid is to be tested with a hard water solution of 0.5 grams of calcium sulphate ($CaSo_4$) per liter of distilled water (0.07 ounces $CaSo_4$ per gallon of distilled water).

Exception: The composition of the water solution is not specified when it is determined by engineering evaluation that the leakage current will not be affected.

46.5 Typical measurement circuits for leakage current with the ground connection open are illustrated in Figure 46.1. The measurement instrument is defined in Figure 46.2. The meter that is used for a measurement is only required to indicate the same numerical value for a particular measurement as would the defined instrument; it is not required to have all the attributes of the defined instrument. Over the frequency range 20 Hz to 1 MHz with sinusoidal currents, the performance of the instrument is to be as follows:

a) The measured ratio V1/I1 with sinusoidal voltages is to be as close as feasible to the ratio V1/I1 calculated with the resistance and capacitance values of the measurement instrument shown in Figure 46.2.

b) The measured ratio V3/I1 with sinusoidal voltages is to be as close as feasible to the ratio V3/I1 calculated with the resistance and capacitance values of the measurement instrument shown in Figure 46.2. V3 is to be measured by the meter M in the measuring instrument. The reading of meter M in RMS volts can be converted to MIU by dividing the reading by 500 ohms and then multiplying the quotient by 1,000. The mathematic equivalent is to simply multiply the RMS voltage reading by 2.

46.6 Unless the measurement instrument is being used to measure leakage current from one part of an appliance to another, it is to be connected between accessible parts and the grounding and supply conductor connected to ground (the grounded or grounding conductor) that has the least extraneous voltages introduced from other equipment operated on the same supply. For products rated 120 volts or 240 volts, with one supply conductor grounded, this is likely to be the grounded supply conductor.

46.7 Prior to the test specified in 46.8, an appliance utilizing one or more sheathed heating elements is to be conditioned for 24 hours in a chamber having a temperature of 30 ±5°C (86 ±9°F) and a relative humidity of 50 ±5 percent, followed by conditioning for 48 hours in a chamber having a temperature of 30 ±5°C (86 ±9°F), and a relative humidity of 90 ±5 percent. The test in 46.8 is to be conducted as soon as is practical after the conditioning, but in no case more than 24 hours after the appliance is removed from the conditioning chamber.

Exception No. 1: The entire appliance is not required to be conditioned if the sheathed heating elements are removed from the appliance and conditioned as stated. The elements are to be re-installed in the appliance before the test is conducted.

Exception No. 2: The conditioning is not required if all sheathed heating elements in the appliance comply with the requirements of the Resistance to Moisture Test in the Standard for Sheathed Heating Elements, UL 1030.

46.8 A sample of the appliance, conditioned as specified in 46.7, where required, is to be tested for leakage current starting with the as-received condition – the as-received condition being without prior energization, except as may occur as part of the production-line testing. The supply voltage is to be adjusted to rated voltage.

The test sequence is to be as follows, with reference to the measurement circuit shown in Figure 46.1:

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

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

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

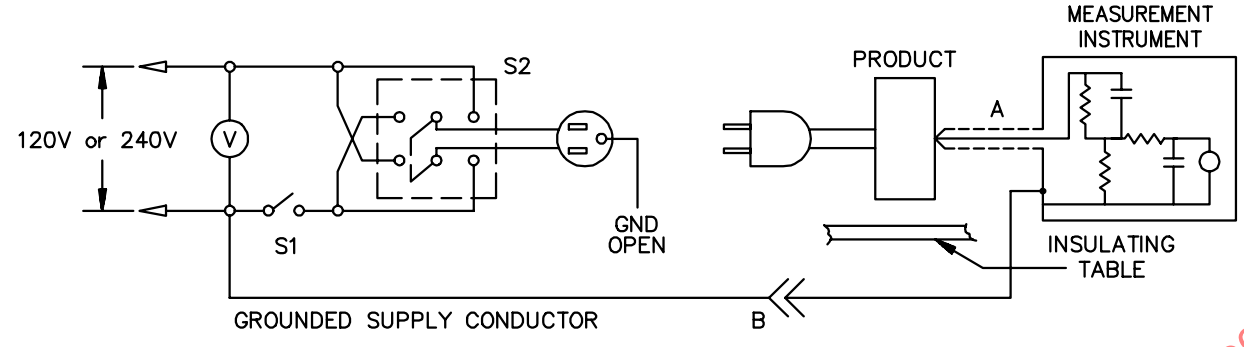
d) The leakage current is also to be monitored with switch S1 open while the appliance is at operating temperature and while cooling.

46.9 A sample is to be subjected to the entire leakage current test, as specified in 46.8, without interruption for other tests.

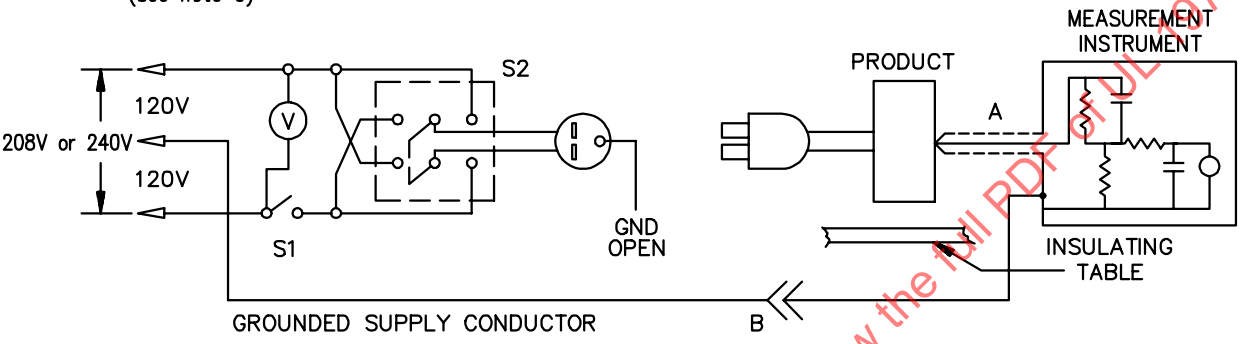
Exception: With the concurrence of those concerned, the leakage current test is not prohibited from being interrupted to conduct other nondestructive tests.

Figure 46.1

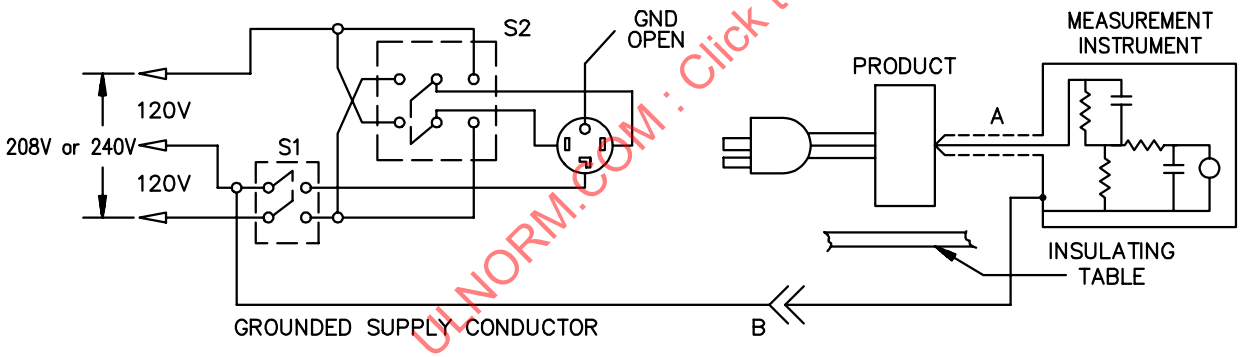
Typical leakage-current measurement circuits



Equipment intended for connection to a 120–volt or an end–grounded 2–wire, 240–volt power supply (see note C)



Equipment intended for connection to a 2–wire grounded–neutral 208–volt or 240–volt power supply (see note C)



Equipment intended for connection to a 3–wire grounded–neutral 208–volt or 240–volt power supply

A – Probe with shielded lead.

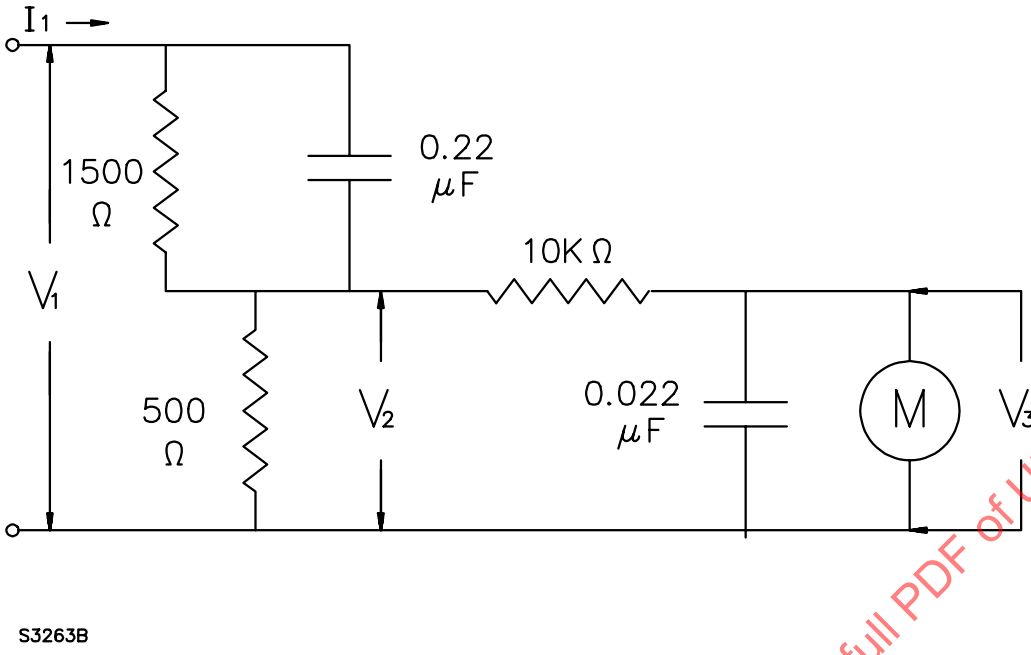
B – Separated and used as clip when measuring currents from one part of equipment to another.

C – Equipment intended for connection to a 2–wire 240–volt power supply is to be tested assuming that the product will be connected to an end–grounded supply (top circuit, above), unless the product is marked in accordance with paragraph 86.11 of UL 197, in which case it is to be tested for connection to a grounded–neutral supply (middle circuit, above).

LC100T

Figure 46.2

Measurement instrument for reaction (leakage) current



Note – Detailed specifications and guidance for the calibration of this instrument are given in the American National Standard for Leakage Current for Appliances, ANSI C101.

47 Power Input Test

47.1 The power or current input to an appliance 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 83.8.

47.2 To determine whether an appliance complies with the requirement in 47.1, 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.

47.3 In addition to the test required by 47.1 and 47.2, 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 16.3.2, 17.1.4, and 28.1.4.

a) When the marked voltage rating of an appliance falls within a voltage range mentioned in 83.3, 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.

47.4 The power input to an appliance that employs a nonmetallic heating element, such as carbon, is to be determined when the element is new – that is, when it is first subjected to heat.

47.5 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 47.1 – 47.4.

Exception: When the receptacle is marked for a specific load in accordance with 86.15, the marked load is to be used in calculating the total power or current input.

48 Input Averaging Test

48.1 This test is to be conducted when required by 28.1.4 or the Exception to 17.1.4. When tested as indicated in (a) and (b) for a minimum of 3 hours, the time weighted average input shall not exceed 80 percent of the anticipated branch circuit protected device in accordance with 28.1.3 and 28.1.5. The supply voltage shall be as specified in 47.3. General use receptacles shall be loaded as described in 47.5. The appliance is to be operated in a no-load condition or with the intended food load, whichever results in the maximum average current draw. When a food load is used, the food is to be replaced and the cooking cycle repeated as intended throughout the test period.

a) When the appliance is designed for a specific operation which requires the appliance to be energized and deenergized, and this operation has an inherent human limitation of cycle time, that cycle time shall be used for this test.

b) When the appliance is limited to a duty cycle by a controller, the test is to be conducted with the controller adjusted to the most severe operating conditions available using user adjustable controls.

49 Short-Circuit Tests

49.1 Devices and conductors referenced in Exception No. 2 to 28.5.3.2 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.

49.2 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.

49.3 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 49.1. 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 49.1
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

49.4 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.

50 Normal Temperature Test

50.1 General

50.1.1 When an appliance is tested in accordance with 50.4 and 50.5, the temperature at any point shall not adversely affect any materials employed in the appliance, and temperature rises shall not exceed those specified in Table 50.1 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.

50.1.2 When evaluating components and wiring in secondary circuits, the requirements in 34.2 shall apply. When any component exceeds 121°C (250°F), see 34.1.5.

Table 50.1
Maximum acceptable temperature rises

Materials and components		Degrees	
		°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 64.3.	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 resistence 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 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 resistence 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])
	Resistance method	105	(189)
12.	Class 130(B) insulation systems on a vibrator coil – themocouple 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)

Table 50.1 Continued on Next Page

Table 50.1 Continued

	Materials and components	Degrees °C	Degrees (°F)
14.	Class 130(B) insulation systems on coil windings of an a-c motor – not including 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])
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 88.10, 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 88.12. 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 88.11.

[c] A fuse that has been investigated and found acceptable for use at a higher temperature may be used at that temperature.

Table 50.1 Continued on Next Page

Table 50.1 Continued

Materials and components	Degrees	
	°C	(°F)
[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] 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.		
[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 85.5 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.		

50.1.3 All values in the table 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.

50.1.4 When an appliance is intended for use with more than a thin film of oil or grease (for example, a tilting frying pan or a popcorn machine), the maximum temperature on the cooking surface at thermal equilibrium shall not exceed 315°C (599°F).

50.1.5 During the tests described in 50.5, a temperature limiting control shall not function.

50.1.6 A thermal- or overcurrent-protective device for a motor shall not open the circuit during the tests described in 50.5.6 – 50.5.10.

50.2 Surface temperatures

50.2.1 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 50.2. 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.

Exception No. 1: The temperature of a surface marked in accordance with 85.2 is not prohibited from exceeding the values specified in Table 50.2.

Exception No. 2: This requirement does not apply to a surface that, because of its location, is known to be hot. Examples of such surfaces are a handle of a deep-fat fryer kettle, a handle of a broiler drawer, and the horizontal surface of a cooktop containing surface-cooking units.

Table 50.2
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.

50.3 Test equipment

50.3.1 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, 47.3, and shall have a temperature rating in accordance with the temperature marking on the appliance. See 16.3.4, and 88.3 – 88.5.

50.3.2 Temperatures are to be measured by thermocouples except as indicated in 50.3.7. 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 with the requirements specified in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

50.3.3 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.

50.3.4 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.

50.3.5 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.

50.3.6 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 50.1, the thermocouple is to be mounted on the integrally applied insulation of the conductor.

50.3.7 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.

50.3.8 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.

50.3.9 When measuring the temperature of a surface exposed to a radiant heat source, such as a heat lamp or infrared food warmer, the thermocouple bead is to be shielded from direct exposure to the radiant heat source. When a coil wrap is exposed to a radiant heat source, the temperature of the coil is to be measured by means of a thermocouple on the integral insulation of the coil conductors.

50.4 Procedure

50.4.1 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.

50.4.2 Except as specified in 50.4.4, 50.4.6 and 50.4.8, 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 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. An appliance of pass through construction, the intended function of which requires access to two sides (such as a conveyor pizza oven or slanted sandwich chute), is to be installed between two walls, one along each closed side of the appliance. An appliance that may be accessed from one or two sides (such as horizontal warming shelves or Display cases) without defeating the intended operation of the appliance is to be tested in an alcove or two wall construction, which ever is worse case.

50.4.3 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 50.4.2.

Exception: A permanently connected appliance that weighs, with all accessories that are removable without the use of tools removed, 80 pounds (36 kg) or more; is not provided with casters; and is marked in accordance with 86.5 or 86.6 is to be spaced away from the test corner in accordance with the marking.

50.4.4 An appliance intended to be built-in and an appliance intended to be mounted to a wall or under a cabinet or shelf (see Section 43, Surface Mounted Units) 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 (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 86.5 or 86.6, is to be mounted in the test enclosure with clearances as specified in the marking.

50.4.5 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 50.4.6 and 50.4.8, surfaces surrounding the equipment are to be constructed of a minimum trade size 3/8-inch thick black-painted plywood. See 91.2.

50.4.6 Except as specified in 50.4.7, a stationary or fixed appliance marked for installation only in noncombustible surroundings, see 88.12, or marked with different clearances to combustible and noncombustible surfaces, see 86.5 and 86.6, is to be tested as specified in 50.4.2 – 50.4.5, 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 the Exception to 50.4.3 or 50.4.4, in which case the clearances specified for noncombustible surrounding surfaces are to be used.

Exception: When all involved parties agree, plywood is to be used instead of the gypsum wallboard.

50.4.7 An appliance that heats food external to the appliance using radiant heat and is marked for installation only in noncombustible surroundings, see 88.12, or is marked with different clearances to combustible and noncombustible surroundings, see 86.5 and 86.6, is to be tested as specified in 50.4.6 except that the test corner or test enclosure is to be constructed of commercial grade stainless steel with a 100 grit or smoother finish. The appliance shall be marked in accordance with 86.6.

Exception: An adjustable radiant-heat food warmer marked for installation only over a noncombustible surface, see 88.12, is to be tested in accordance with 50.5.23 over a stainless steel surface, as noted above, and marked in accordance with 85.4 rather than 86.6.

50.4.8 A stationary or fixed appliance marked with lesser clearances to noncombustible surroundings than to combustible surroundings is to be tested as described in 50.4.2 – 50.4.5 at the combustible clearances, and as specified in 50.4.6 at the noncombustible clearances.

50.4.9 An automatic temperature-regulating or -limiting control or other protective device is to be shunted out of the circuit, unless the control has been shown, in accordance with 27.1 – 27.3, to be reliable, rugged, and unlikely to be defeated by the user. The control is determined unlikely to be defeated when a tool is required to gain access to the control, or a positive stop is incorporated in the control.

50.4.10 Unless otherwise specified in 50.5.6 – 50.5.10, temperature-regulating controls that are adjustable are to be set for maximum temperatures.

50.4.11 An adjustable temperature limiting control is to be set for the minimum trip temperature. See 50.1.5.

50.4.12 When an operating temperature is specified in 50.5, the temperature is the mean of the maximum and minimum readings at thermal equilibrium.

50.4.13 To determine whether an appliance complies with the requirements in 50.1.1, it is to be operated continuously until constant temperatures have been reached.

Exception: When an appliance is restricted to a duty cycle as specified in 48.1, that duty cycle is to be used for this test.

50.4.14 Unless a particular test voltage is specified in 50.5.6 – 50.5.10, the test voltage is to be the highest of the following:

a) The marked voltage rating;

b) The highest voltage of the applicable range of voltages specified in 83.3 when the marked voltage is within one of the voltage ranges included in 83.3; or

c) The voltage necessary to cause the wattage input to the appliance to be equal to the wattage rating marked on the appliance.

Exception: The voltage applied to the motor of an appliance that employs a motor in addition to a heating element is not to be more than 120 volts for an appliance rated 100 to 120 volts, and not more than 240 volts for an appliance rated 220 to 240 volts.

50.4.15 An appliance employing a power supply cord having a plug configuration for a specific voltage supply but rated for a different voltage (for example, an appliance rated 208 volts but employing a 240 volt power supply cord/plug) shall be subjected to the Abnormal Heating Test, outlined in 56.2.1, at both voltages.

50.4.16 An attachment plug receptacle that serves as a general-use outlet, see 21.2, shall be loaded in accordance with the anticipated load. See 83.6. The accessory or accessories that provide the heaviest load are to be connected to a receptacle marked for use with an accessory or accessories.

50.4.17 Feet, or any parts thereof, that are made of a material not capable of withstanding the temperature attained during the test are to be removed for the temperature test. Metal studs or other means used to retain the material are not to be removed.

50.4.18 An appliance that is capable of being either open or closed in actual service, such as a sandwich toaster or grill, is to be tested both open and closed to determine which condition produces the higher operating temperatures.

50.4.19 Unless otherwise specified, an appliance with a multiple speed conveyor is to be tested at both low and high speeds.

50.5 Normal test conditions

50.5.1 In determining whether an appliance complies with the requirements in 50.1.1, actual service conditions or an approximation thereof are to be employed as described in 50.5.6 – 50.5.37. Any type of appliance not covered in the specified test conditions is to be tested in any condition of actual normal use as specified in the manufacturer's literature.

50.5.2 Appliances specified in test conditions 50.5.8 – 50.5.10 is to be operated in a no-load condition or with the intended food load, whichever results in the maximum temperature. When food load is used, the food is replaced and the cooking cycle repeated as intended throughout the test period.

50.5.3 With reference to those tests outlined in 50.5.1 and 50.5.2, the tests are to be continued until constant temperatures are attained, thermal equilibrium is determined to exist when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test indicate no change. No interval is to be less than 5 minutes.

50.5.4 When the design of an appliance is such that cooking or heating of a liquid is the determining factor in the temperature obtained – for example, a coffee maker – the intended duty of the device is to be taken into consideration. Normal operating conditions will not be obtained, however, when certain types of appliances are operated continuously and in a dry condition.

50.5.5 Conditions for the performance of normal temperature tests for appliances of the common types are specified in 50.5.6 – 50.5.10. All applicable test conditions are to be performed.

50.5.6 APPLIANCES WITH ADJUSTABLE PUMPS – An appliance with an adjustable pump is to be operated with the pump set for maximum.

Exception: The pump is not prohibited from being operated at less than the maximum setting when:

a) The pump is not intended for user servicing as noted in the Exception to 10.1.6 and is marked in accordance with 86.13; and

b) The pump is marked to indicate the proper setting for normal operation.

50.5.7 APPLIANCES EMPLOYING LIQUID RESERVOIRS – An appliance which employs a liquid, other than cooking oil, reservoir is to be tested with the reservoir filled. Additional liquid is to be added when the liquid level becomes lower than the half-full mark. The test is then to be repeated with the reservoir empty (dry).

Exception No. 1: Dry operation is not required as a normal temperature test condition if a unit employs a level sensing device which deenergizes the heating element(s) when the water falls below the normal operating level. The unit is to be tested while filled with water until the level sensing device de-energizes the heating elements. The level sensing device shall be suitable for 30,000 cycles of operation.

Exception No. 2: Dry operation is not required as a normal temperature test condition if a unit employs a level sensing device which automatically fills the reservoir when the water level falls below the normal operating level. The level sensing device shall be suitable for 30,000 cycles of operation.

50.5.8 BROILERS, CONVEYOR – The conveyor broiler is to be operated continuously with all controls set for maximum temperature. Ground beef with a 30 percent fat content is to be used. The patties are to be 4 inches (102 mm) in diameter and 1/2 inch (12.7 mm) thick, and are to be spaced such that there are 4 patties per square foot. Permanently marked instructions (see 84.1) for adding water to a fat receptacle are to be followed when provided. The conveyor is to be set at the belt speed that results in the highest temperatures, while cooking food in an edible fashion.

Exception: When agreeable to all parties involved, metal disks measuring 4 inches (102 mm) in diameter and weighing 1/2 pound (0.23 kg) are able to be used in lieu of the ground beef patties.

50.5.9 BROILERS, CLOSED – The closed broiler is to be operated continuously with all controls set for maximum temperature.

50.5.10 BROILERS, OPEN – The open broiler is to be operated continuously with all controls set for maximum temperature. Ground beef with a 30 percent fat content is to be used. The patties are to be 4 inches (102 mm) in diameter and 1/2 inch (12.7 mm) thick, and are to be spaced such that there are 4 patties per square foot. Permanently marked instructions (see 84.1) for adding water to a fat receptacle are to be followed when provided.

Exception: When agreeable to all parties involved, metal disks measuring 4 inches (102 mm) in diameter and 1/2 inch (12.7 mm) thick are able to be used in lieu of the ground beef patties.

50.5.11 COFFEE MAKERS, AUTOMATIC – When an adjustable thermostat is provided, the thermostat is to be set for the maximum temperature that does not result in dispensing boiling water. The appliance is to be operated as described by the following until temperatures stabilize:

a) A percolator is to be filled with the intended amount of cold water and operated until the thermostat automatically switches to the "low" or "off" position, at which time the percolator is to be emptied and refilled with the intended amount of water and the cycle repeated.

b) An automatic coffee maker is to be operated under standby conditions until temperatures are constant, after which water is to be dispensed in the intended manner. Each cycle is not to proceed until the water is at the ready temperature and the thermostat has deenergized the heater. Decanters, or similar utensils, that are filled in the process are to be used, and when filled, replaced with empty decanters.

50.5.12 COFFEE MAKERS, NONAUTOMATIC – The appliance is to be filled with the intended amount of water and operated until temperatures become stabilized. Additional water is to be added during the test when the water level becomes lower than the half-full mark.

50.5.13 COFFEE MAKER STOVES – The stove is to be operated continuously warming water in the intended decanters. As the water in a decanter reaches the temperature at which it is forced into the upper section of the coffee maker, it is to be replaced by a fresh decanter of water at a temperature of 10 – 15°C (50 – 59°F).

50.5.14 DRINK DISPENSERS – The dispenser is to be operated under standby conditions (if applicable) until temperatures become constant. A second test is to be conducted dispensing product, as follows:

a) Automatic fill batch-type dispensers – The appliance is to be operated until the water is at the "ready" temperature (when the thermostat de-energizes the heater). The maximum recommended amount of liquid (per batch) is then to be dispensed. The serving cycle is to be repeated, with a 2 second delay between cycles, until the heating element is deenergized by the thermostat. At the end of the serving cycle during which the thermostat energizes the heater, the water is to be allowed to reach the "ready" temperature again, at which time the cycling is to be repeated. This cycling is to continue until the maximum measured temperatures have stabilized.

b) Continuous-flow and Pour-Over (Instantaneous-type) dispensers – The flow or serving rate is to be adjusted to a rate that maintains a maximum water temperature at a point just below the opening temperature of the temperature regulating control. When this condition is restricted by design, the unit shall be operated as close to this temperature as possible.

c) Non-automatic fill dispensers with reservoirs – The appliance is to be operated as specified in (a) or (b) above, based upon the dispensing method, except that room-temperature water is to be added when the water level reaches the minimum level recommended by the manufacturer.

50.5.15 ESPRESSO MACHINES – All user-adjustable controls are to be set for maximum temperatures and pressures. Controls intended for adjustment only by service personnel (not user servicing, see 2.32) are to be set for the maximum temperatures and pressures specified in the installation manual. The machine is to be operated continuously until temperatures stabilize. The users manual is to be used as a guide for operation. All outputs of the machine are to be used in such a manner as to create the maximum normal operating temperatures. The following sequence is an example:

a) All groups simultaneously: 20 seconds or longest pre-programmed cycle;

b) Steam: 10 – 20 seconds or longest pre-programmed cycle;

c) Repeat steps (a) and (b) five times;

d) Tea water: 20 seconds or longest pre-programmed cycle;

e) Repeat steps (a) through (d).

The above operating sequence is to be adjusted when required. For example, a "wait" cycle is to be added when necessary so that the water temperature and pressure values do not fall below the normal operational values. Each group is to be tested with the recommended amount of ground coffee. The coffee is to be changed at any convenient interval, but not used for more than 10 cycles.

50.5.16 HOT FOOD RECEPTACLES FOR STEAM TABLES – The appliance is to be operated continuously with switches or thermostats set for maximum temperature. When a preheat position above a mechanically definite maximum temperature position is provided on the control, the appliance is to be operated at the preheat setting for 15 minutes or for a marked preheat period, whichever is greater. It is then to be operated at the mechanically definite next lower setting until temperatures are constant. See 50.5.7.

50.5.17 HOT FOOD STORAGE CABINETS – The cabinet is to be operated continuously with each switch and each temperature regulating control set for maximum temperature. When a preheat position above a mechanically definite maximum temperature position is provided on the control, the appliance is to be operated at the preheat setting for 15 minutes or for a marked preheat period, whichever is greater. It is then to be operated at the mechanically definite next lower setting until temperatures are constant. See 50.5.7.

50.5.18 LIQUID HEATERS – The heater is to be operated continuously warming water.

50.5.19 OVENS – The oven is to be operated continuously with the temperature regulating control set for the maximum temperature.

50.5.20 POPCORN MACHINES – The test is to consist of continuous operation with switches and thermostat set for maximum temperature while popping corn in the intended manner.

50.5.21 RADIANT-HEAT FOOD WARMERS The food warmer is to be operated continuously until temperatures are constant. A food warmer using reflector lamps is to be tested with both clear and colored lamps. Food containers detachable without tools are to be removed for the test. See 50.3.9.

50.5.22 Adjustable radiant-heat food warmers are to be operated continuously with the heater(s)/lamp(s) positioned as close to the carving/supporting surface as the construction permits. The heater(s)/lamp(s) are to be centered above the warming surface. When two adjustable lamps are provided, the lamps are to be positioned such that they have one common focal point at the center of the warming surface.

Exception: When the heater(s)/lamp(s) is adjustable and capable of being moved closer than 9 inches from the carving/supporting surface, the heater(s)/lamp(s) may be tested at 9 inches when marked in accordance with 85.4. The measurement is to be taken from the bulb surface or physical barrier that prevents the bulb from contacting the carving or supporting surface.

50.5.23 RANGES AND TABLE STOVES – A stove plate as specified in 50.5.26 is to be placed on one surface unit when there are not more than four surface units, and on two units when there are more than four surface units. Each remaining surface unit is to be covered with a pan of water. The unit or units to be covered with a plate is to be in accordance with the following order of precedence:

a) Front unit;

b) Units having highest wattage rating;

c) Units farthest from the wall of the test booth;

d) Units having largest diameter.

50.5.24 Ranges and table stoves provided with only one surface unit are to be tested with a stove plate and retested with a pan of water.

50.5.25 With reference to 50.5.24, the front of a counter-mounted surface assembly is defined as the long side adjacent to the highest-wattage unit unless the manufacturer's installation instructions or some other feature indicates otherwise.

50.5.26 The stove plates are to be circular cast-iron or steel plates. The plate used with a 6-inch (152-mm) or smaller surface unit is to be 7-1/2 inches (190 mm) in diameter and is to weigh approximately 3 pounds (1.4 kg). The plate used with a surface unit larger than 6 inches is to be 10-1/2 inches (267 mm) in diameter and is to weigh approximately 7 pounds (3.2 kg). The plates are to be flat on one side and are not prohibited from being ribbed on the other side to reduce the likelihood of warping. The plates are to be kept free from rust and other foreign material by the use of steel wool or a wire brush.

50.5.27 The pans are to have vertical sides. The diameter of the bottom plane surface of the pan is to be no less than the maximum diameter of the active part of the surface unit on which the pan is used, and is to be not more than 1 inch (25.4 mm) larger than that diameter. The pans are to be of aluminum.

50.5.28 Surface units are to be operated as indicated in 50.5.30 and 50.5.31.

50.5.29 The control for each surface unit covered with a stove plate is to be adjusted to result in a temperature of 275°C (527°F) at the center of the top surface of the stove plate. An automatic or cycling type – intermittent input – control is to be set so that the average temperature at the center of the top surface of the stove plate will be 275°C. When a control having a definite number of settings cannot be set to result in this temperature, the next higher setting is to be used.

Exception: When setting the surface unit control in the position that provides maximum heat results in a temperature less than 275°C at the center of the top surface of the stove plate, or when the control has only one setting, the test is to be conducted with the control set in this position.

50.5.30 The control for each surface unit not covered with a stove plate, is to be set at its maximum setting.

50.5.31 SANDWICH TOASTERS, GRILLS, AND GRIDDLES – A toaster, grill, or griddle is to be operated continuously with the heat control switch adjusted to give a surface cooking temperature of 275°C (527°F). When a surface cooking temperature of 275°C cannot be attained, the heat control switch is to be set the maximum temperature position. This applies also to combination grills and waffle irons in which reversible grids are used.

50.5.32 STEAM COOKERS, EXTERNAL STEAM SUPPLY – The cooker is to be connected to a steam supply of rated pressure and is to be operated continuously until temperatures become constant. When timers, electric valves, or similar components operate intermittently, the appliance is to be operated with the shortest and longest cooking cycles recommended in the operating instructions as required to result in maximum heating of components. One minute is to be allowed between cycles for unloading and reloading the cooking chamber.

50.5.33 STEAM COOKERS, SELF-CONTAINED STEAM GENERATOR – The cooker is to be operated as described in 50.5.32. When a fitting is provided to supply other appliances, steam is to be drawn off at the maximum rate possible such that the highest operator-adjustable steam pressure is maintained.

50.5.34 TILTING FRYING PANS – The frying pan is to be operated continuously with all controls set for maximum temperature until temperatures become constant. See 50.1.4.

50.5.35 TOASTERS – The toaster is to be operated continuously toasting slices of bread to a dark brown color. Immediately preceding the toasting, a nonautomatic toaster is to be preheated for 15 minutes.

Exception: This test is not required for a nonautomatic toaster when the results of the abnormal or burnout test comply with the requirements with respect to normal operation.

50.5.36 WAFFLE IRONS – A waffle iron is to be operated continuously with the temperature regulating control at the maximum heat position for the automatic type. For a non-automatic type, the switch is to be set to a temperature closest to, but not less than 210°C (410°F) on the grids, unless a temperature less than 210°C (410°F) is obtained with the switch in the maximum position.

50.5.37 WATER HEATERS FOR COOKING APPLIANCES – The water heater is to be operated continuously with temperature regulating control set at a temperature 98°C (208°F) or, for an appliance provided with a thermostat at the maximum temperature setting of the thermostat when it is less than the boiling point of the water in the appliance or as dispensed from the appliance.

51 Dielectric Voltage-Withstand Test

51.1 General

51.1.1 To determine whether an appliance complies with the requirements in 51.2 – 51.4, 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.

51.1.2 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) is not prohibited from being tested using a DC potential of 1.414 times the appropriate AC voltage.

51.1.3 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.

51.1.4 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.

51.1.5 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 is not prohibited from being repeated according to 51.1.6. However, when the test in 51.1.6 is used, the same test sample shall be subjected to the Leakage Current Test, Section 46, or the Insulation Resistance Test, Section 53, as applicable.

51.1.6 When a referee test is necessary in accordance with 51.1.5, 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.

51.1.7 For the dielectric voltage-withstand test of an appliance in which electrical wiring passes through a hinged member or spring, the cover or other movable member is to be raised and lowered not less than three times while the test potential is being applied in order to determine whether a breakdown results from damaged insulation on the conductors with the cover in other than the closed position.

51.1.8 An appliance which employs water or other liquid is to be tested with the solution described in 46.4. Where a reservoir is provided, it is to be filled to the normal operating level.

51.2 Primary circuits

51.2.1 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 30.4); and

d) Between terminals of a capacitor connected between the line and the enclosure (see 30.4)

51.2.2 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.

51.3 Secondary Circuits

51.3.1 Secondary circuits shall withstand for 1 minute the application of a test potential as specified in Table 51.1:

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 34.3)

2) Limited voltage/current circuits (see 34.4)

3) Limited voltage circuits (see 34.5)

4) Limiting impedance circuits (see 34.7)

5) Safety extra-low voltage circuits (see 34.8).

Table 51.1
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

51.3.2 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.

51.4 Transformers

51.4.1 While at its maximum intended operating temperature, each power transformer shall operate without breakdown while the potential specified in Table 49.1 is induced for 1 minute in each secondary winding that normally operates at a higher potential than the primary winding.

51.4.2 Transformers evaluated in accordance with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1, the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2, or the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3, need not be subjected to this test.

51.4.3 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.

51.4.4 Primary- and secondary-circuit wiring connected to a transformer is to be disconnected for the test required by 51.4.1.

52 Resistance to Moisture Test

52.1 Immediately after being operated as described in 52.2, an appliance having an electrical part that is exposed to moisture produced by the appliance, such as a proofing cabinet, coffeemaker, or steam table, shall comply with the following:

a) The appliance shall withstand without breakdown for 1 minute the application of the potential specified in Section 51, Dielectric-Voltage-Withstand Test.

b) A cord-connected appliance constructed according to 46.1 (a) or (b), shall comply with the requirement in 46.1 in a repeated leakage current test, except that the test is to be discontinued when leakage current stabilizes.

c) An appliance, other than that constructed according to 46.1 (a) or (b), shall comply with the Insulation Resistance Test, Section 53.

52.2 The appliance is to be connected to the water line, or water is to be added as intended, and the appliance is to be operated continuously under standby conditions – heated, but not dispensing water – for 24 hours immediately after which the insulation resistance or leakage current is to be measured and the test potential is to be applied.

52.3 An appliance, such as a hot cup, that is immersed in water for cleaning shall have a leakage current of not more than 0.5 MIU and shall withstand a potential of 1000 volts when tested in accordance with 52.4

and 52.5. There shall be no entrance of water into the appliance that might come into contact with uninsulated live parts as a result of the test.

52.4 Three samples of the appliance are to be filled with cold water and are to be heated as described in 50.4.13. When the water boils, each appliance is to be emptied and is to be completely immersed for 3 – 10 seconds in a detergent solution maintained at a maximum temperature of 40°C (104°F).

52.5 The entire procedure of heating and immersion is to be repeated until 1000 hours have elapsed, immediately after which each appliance is to be subjected to the dielectric voltage withstand test, followed by the leakage current. The heating element terminals and insulators are to be wiped with a towel to remove surface moisture. Each sample is then to be disassembled and the internal parts are to be visually examined for the presence of water to determine whether the appliance complies with the requirement in 52.3.

53 Insulation Resistance Test

53.1 An appliance constructed other than as described in 46.1 (a) or (b), shall have an insulation resistance of not less than 50,000 ohms when tested in accordance with 53.2.

53.2 Insulation resistance is to be determined as follows (see Figure 53.1) 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:

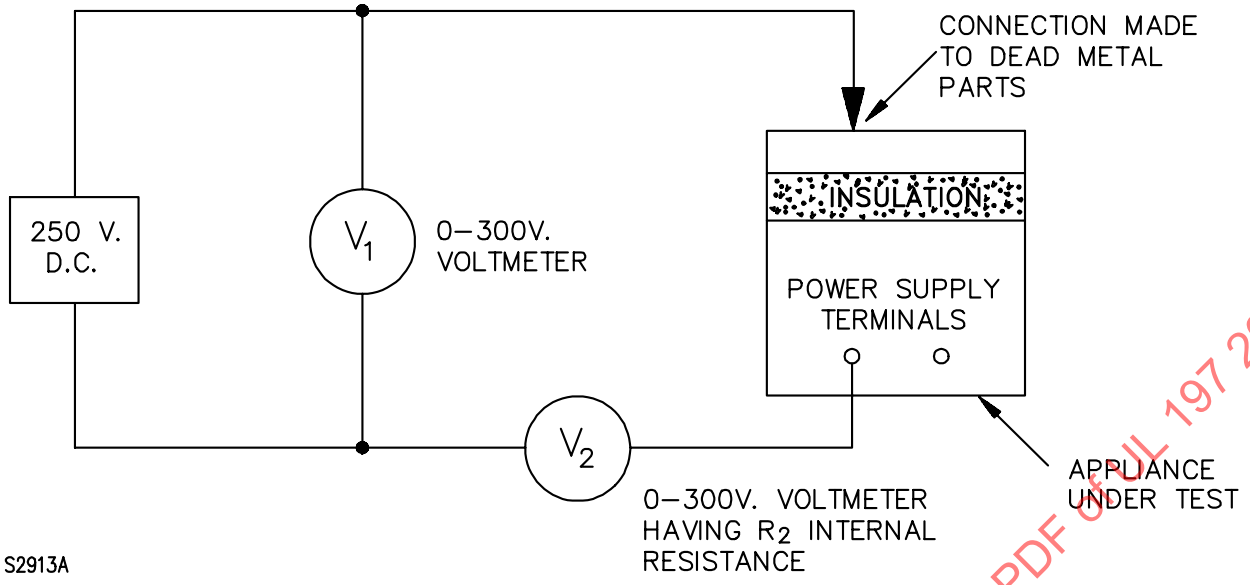
V_1 is the measured supply line voltage, in volts.

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 53.1

Insulation resistance test



54 Grounding and Bonding Test

54.1 Grounding

54.1.1 The grounding blade of the attachment plug and the exposed dead metal parts mentioned in 18.1 shall be conductively connected as determined by the grounding test in 54.1.3 – 54.1.4.

54.1.2 Any indicating device, such as an ohmmeter, is to be employed during testing.

54.1.3 When tested, the resistance between any point required to be grounded, as noted in 54.1.1 and 18.1, 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 54.1.2, except that when unacceptable results are obtained, a reference measurement is to be taken in accordance with 54.1.4.

54.1.4 When a reference measurement is required by 54.1.3, either a direct or alternating current equal to the anticipated current rating of the branch-circuit overcurrent-protective device for the appliance – see 28.1.3 and 28.1.4 – 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.

54.2 Bonding

54.2.1 When required by Exception No. 2 of 18.8, a bonding connection is to be subjected to the test in 54.2.2. The bonding connection shall not open during the test.

54.2.2 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 28.1.3 and 28.1.4 – for the period specified by Table 54.1.

Exception: When overcurrent protection complying with 28.1.1 or 28.2.1 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 54.1
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

55 Stability

55.1 A freestanding appliance shall not overturn when tipped through an angle of 10 degrees from the horizontal as described in 55.2.

55.2 The appliance is not to be energized during the stability test. An appliance equipped with wheels, casters, or the like shall be tested with the wheels, casters, or the like locked or blocked to prevent the appliance from moving. 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, casters, and other movable or adjustable parts, including that of a supply cord, if any, resting on the surface supporting the appliance;

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.

Exception No. 1: The door of a cord-connected appliance is not required to be placed in the most unfavorable position for this test if, with the appliance placed on a horizontal surface and with the door in any position, the appliance does not tip when a 35 pound (156 N) force is applied to that part of the door edge that is most likely to cause the appliance to tip.

Exception No. 2: The door of a cord-connected appliance that is on casters and weighs 250 pounds (113 kg) or less is not required to be placed in the most unfavorable position for this test if, with the appliance placed on a horizontal surface and the door in any position, the appliance does not tip when a 15 pound (67 N) force is applied to that part of the door edge that is most likely to cause the appliance to tip.

Exception No. 3: The drawer of a cord-connected appliance is not required to be placed in the most unfavorable position for this test if, with the appliance on a horizontal surface the appliance does not tip when a 35 pound (156 N) force is applied to that part of the outer edge of a fully open drawer that is most likely to cause the appliance to tip.

55.3 A permanently-connected appliance is to be tested when installed in accordance with the manufacturer's instructions.

55.4 An appliance intended for use with gelled or liquid fuel shall comply with the requirements in 55.1 and 55.2 with full gelled or liquid fuel container(s) located as intended. As a result of the test, the containers shall not be displaced from their intended location on the appliance. In addition, gelled or liquid fuel shall not be expelled from their container(s).

56 Abnormal Heating Test

56.1 General

56.1.1 When the conditions of normal operation are not representative of abnormal conditions that can occur in actual service, an appliance shall not present a risk of fire or electric shock when operated continuously under such abnormal conditions.

56.1.2 The functioning of an overload protector or overcurrent-protective device provided for a motor, whether or not such a device is required, shall not result in a risk of fire, electric shock, or injury to persons. See 31.4.9.

56.1.3 When operated under the conditions described in 56.2.1, an appliance is considered to involve a risk of fire when there is any emission of flame or molten metal, or when operation of the appliance results in the charring, glowing, or flaming of combustible material upon which the appliance is placed or on adjacent wall surfaces.

56.1.4 An appliance is considered to involve a risk of electric shock when the fuse in the grounding connection opens.

Exception: The fuse in the grounding connection is not prohibited from opening when the appliance:

a) Is provided with a grounding conductor;

b) Is cord connected;

c) Is rated 120 volts, 20 amperes or less;

d) Is not normally hand held by persons and any gripping areas, such as a handle, dispensing tap, and the like are made of a material other than metal;

e) Has dead metal parts that will not normally be in contact with other metal surfaces when used; and

f) Complies with 56.1.5 and 56.1.6.

56.1.5 With reference to the Exception to 56.1.4, the fuse mentioned is not prohibited from opening if the appliance complies with (a) – (e) when subjected to the procedures in 56.1.6.

a) The leakage current measured in accordance with the Leakage Current Test, Section 46, shall not exceed 0.5 MIU immediately following the grounded condition and until the product returns to ambient conditions.

b) The dielectric voltage-withstand test, conducted in accordance with the Dielectric Voltage-Withstand Test, Section 51, shall show acceptable results when tested for 1 minute within 15 minutes of the grounded condition.

c) The voltage across the 1.0 ohm resistor and the 500 ohm resistor in the tests described in 56.1.6 (a) and (b) shall not exceed 30 volts rms for the duration of the short circuit condition.

d) The duration of the ground fault shall not exceed 10 seconds; and if the line fuse opens, the ground fault shall not exist after the line fuse opens.

e) There shall be no emission of flame or molten metal, or glowing or flaming of the combustible material upon which the appliance is placed or on adjacent wall surfaces.

56.1.6 With regard to 56.1.5, the two test procedures are as follows:

a) The test described in 56.2.1 is to be repeated, except exposed dead metal parts are to be connected to ground without a fuse. The duration of the ground fault condition is to be indicated by a low impedance current indicator through a 1.0 ohm resistance and the voltage across the resistance is to be monitored. Nontime delay line fuses rated 20 amperes are to be placed in the supply circuit, unless the product is marked for time delay fuses, in which case time delay fuses are to be used.

b) The test described in 56.2.1 is to be repeated, except exposed dead metal parts are to be connected to ground through a 500 ohm resistance. The duration and magnitude of the ground fault condition is to be indicated by a high impedance voltage indicator. Nontime delay line fuses rated 20 amperes are to be placed in the supply circuit, unless the product is marked for time delay fuses, in which case time delay fuses are to be used.

56.1.7 When an appliance employs oil or grease in its normal cooking operation, or when oil or grease can accumulate as a result of intended use of the appliance, neither normal nor abnormal conditions of use shall result in sparks, flareups, and the like that will ignite the reservoir of oil or grease.

56.1.8 When an appliance is intended for use with more than a thin film of oil or grease, the recommended amount of vegetable oil shall be placed on or in the appliance in the location specified by the manufacturers instructions before each test.

Exception: When the manufacturers instructions recommend the use of a specific type(s) of oil or grease, the tests shall be conducted using the type(s) of oil or grease specified.

56.1.9 A thermal cutoff shall not open during the abnormal heating tests.

Exception No. 1: A thermal cutoff is not prohibited from opening in a coffee maker or similar appliance during operation without water.

Exception No. 2: A thermal cutoff, the opening of which requires replacement of a subassembly such as a heating element, is not prohibited from opening during the abnormal heating test.

56.2 Procedure

56.2.1 To determine whether a risk of fire or electric shock exists, a separate burnout or abnormal heating test is to be conducted for each abnormal condition with the appliance operating continuously until the ultimate result has been determined. Unless otherwise indicated, the test is to be conducted with the applied voltage, method of mounting, and thermostat setting in accordance with 50.4 and 50.5, except that:

a) All grounding connections are to be disconnected and the appliance is to be isolated from ground (for example, water pipes disconnected, appliance mounted on a nonconductive surface);

b) Exposed dead metal parts are to be connected to ground through a 3-ampere fuse; and

c) Adjustable temperature limiting controls are to be set to the maximum temperature.

In most cases, continuous operation for 7 or 8 hours is required to make sure that the ultimate result has been observed.

56.3 Test conditions – disabled thermostat

56.3.1 The temperature-regulating control (see 2.30) is to be defeated by short-circuiting the control at its output(s), removing the temperature sensor from the heated area, or other equivalent means. When more than one temperature-regulating control is provided to separately control different elements, a separate test is to be conducted for each element or group of elements by defeating the temperature regulating control(s) for that element or group. In such cases, all other independent temperature-regulating control(s) are to be set to their maximum user-adjustable setting and are to function as intended. Where multiple temperature-regulating controls control the same element or group of elements, the controls are to be defeated together; however, temperature-limiting controls, see 2.29, are not to be defeated.

56.3.2 A temperature-regulating control that is provided with multiple sets of switching contacts or outputs is to have all such sets of contacts or outputs short-circuited or otherwise defeated simultaneously prior to starting the test.

Exception: When disabling all sets of contacts does not represent the worst overheating condition, the test is to be conducted with those contacts defeated that will present the worst overheating condition. More than one test may be required to determine the worst condition.

56.3.3 A single-pole double-throw temperature regulating control is to be short-circuited by connecting the common contact terminal to either the control's normally-open contact terminal or the normally-closed contact terminal, whichever results in maximum heating conditions.

56.4 Test conditions – locked rotor

56.4.1 An appliance having a motor in which the lack of motion of that motor causes overheating of the appliance or of the motor (from a heat source external to the motor) is to be operated with the rotor of the motor locked. Examples include but are not limited to a motor controlling a fan or belt. An appliance having multiple motors is to be tested with one motor locked at a time.

56.4.2 In addition to the criteria specified in 56.2.1, an impedance-protected motor shall comply with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111, with the rotor locked. See 56.4.3.

Exception: If a temperature control external to the motor (including a thermal cutoff) in the appliance operates when the rotor is locked, the applicable temperature limits in the Standard for Overheating Protection for Motors, UL 2111 may be applied. Such temperature controls and thermal cutoffs shall comply with the requirements in UL 2111 with respect to the number of samples to be tested and the test time

56.4.3 With reference to 56.4.2, when a motor has been previously tested in accordance with the Standard for Overheating Protection for Motors, UL 2111, testing is to be discontinued when the stabilized winding temperature is no higher than the previous test results.

56.5 Stalled fan test – control compartment fan

56.5.1 Except as noted in 56.5.2, when tested as described in 56.5.3 and 56.5.4, an appliance provided with a control compartment cooling fan or fans shall not exceed the temperature rises specified in Table 50.1 by more than 10°C (18°F).

56.5.2 With reference to 56.5.1, when an appliance exceeds any of the temperature rises specified in Table 50.1 by more than 10°C (18°F), a means such as an indicator light or audible signal shall be provided to alert the user that the appliance is not operating normally. The means to alert the user shall comply with 56.5.5 and 56.5.6.

Exception: An alert means is not required when it is shown that malfunction of the fan results in the operation of a temperature-limiting control to open ungrounded conductors to the heating elements and to render the appliance inoperable until the appliance is serviced by a qualified serviceperson.

56.5.3 The test is to be conducted as described in the Normal Temperature Test, Section 50, except that the cooling fan, or any combination of cooling fans as described in 56.5.1, is to be stalled or de-energized when stabilized temperatures are obtained. The test is to be continued after the fan has been stalled or de-energized, and the maximum temperatures are to be recorded.

56.5.4 If, after the fan has been stalled or de-energized, the operation is interrupted by a temperature-limiting device, the maximum temperatures are to be recorded at that time. When required, the test is to be restarted from ambient temperature with the fan stalled or de-energized to determine whether the temperature limits are exceeded before the temperature-limiting device operates.

56.5.5 With regard to 56.5.2, when an indicator light is provided to alert the user that the appliance is not operating normally, the following conditions apply:

a) The light shall have a minimum rated life of 20,000 continuous hours at the operating voltage and shall be connected in a circuit in which the increased voltage incident to switching or any other operational characteristic of the appliance does not exceed 120 percent of the voltage recommended to provide the required life.

b) The light shall be readily visible to the user during normal operations of the appliance.

c) The marking and instructions described in 85.8 and 91.9 shall be provided.

56.5.6 With regard to 56.5.2, when an audible signal is provided to alert the user that the appliance is not operating normally, the following conditions apply:

a) The signal shall withstand, without malfunction or breakdown, an endurance test consisting of 6000 cycles of 1 minute on and 30 seconds off.

b) The signal shall withstand, without malfunction or breakdown, a durability test consisting of 72 hours of continuous energization while in an ambient 10°C (18°F) higher than the maximum operating temperature of the device under normal operating conditions, but not less than 70°C (158°F).

c) The marking and instructions described in 85.9 and 91.9 shall be provided.

56.6 Abnormal dry operation test

56.6.1 An appliance which employs water or other liquid in its normal cooking operation and is not subjected to dry operation under the Normal Temperature Test per Exceptions No. 1 and No. 2 to 50.5.7 shall be subjected to the tests in 56.6.3 – 56.6.5.

Exception: This requirement does not apply when the level sensing device specified in the Exceptions to 50.5.7 has been evaluated to the Standard for Limit Controls, UL 353, and the sensing means is suitably protected from physical abuse and corrosion, and is unlikely to be defeated by an accumulation of food.

56.6.2 In addition to the requirements of 50.1:

a) There shall be no wetting of live parts;

b) The appliance shall comply with the Leakage Current Test, Section 46, and the Dielectric Voltage-Withstand Test, Section 51.

56.6.3 The appliance is to be filled with water and operated continuously with the level sensing device bypassed and the thermostat set to give maximum temperature. The unit is to be allowed to boil dry and then to operate dry until the ultimate result has been observed. See 56.2.1.

56.6.4 Starting from room temperature, the appliance is to be operated continuously without water with the level sensing device bypassed and the thermostat set to give maximum temperature.

56.6.5 Upon completion of the conditioning, the appliance is to be filled with water in the normal manner.

56.7 Test conditions – specific appliances

56.7.1 The variety of appliances is such that it is impractical to detail the test conditions representing abnormal operation of every type of appliance. However, some specific examples of such test conditions are given in 56.7.2 – 56.7.11.

56.7.2 COFFEE MAKERS – The coffee maker is to be operated continuously without water with the thermostat set to give maximum temperature.

56.7.3 HOT FOOD RECEPTACLES FOR STEAM TABLES – The appliance is to be operated continuously without water and with the switch or thermostat set to give maximum temperature.

56.7.4 OPEN BROILERS – The broiler is to be operated continuously with the controls set for maximum temperature. The grease pan is to be one-half full of lard at the start of the test. When temperatures have stabilized, commercial ground beef patties with a 50 percent fat content, 4 inches (100 mm) in diameter by 1/2 inch (13 mm) thick, are to be broiled. A sufficient number of patties are to be broiled, two or three at a time, to determine that ignition of the lard is unlikely. The beef patties are not to be pressed or mashed deliberately while cooking on the grill. Any instructions for adding water or similar materials to the grease pan or fat receptacles are to be disregarded. Flare-ups from the griddle surface or meat during broiling or manipulation of the beef patties are to be disregarded, but ignition of the grease in the grease pan is not acceptable.

56.7.5 RANGES – The range is to be operated continuously as described in 50.5.23 except that the heat controls or switches are to be set to give the highest temperature.

56.7.6 GRIDDLES – When the temperature control permits a surface temperature higher than 275°C (527°F), the griddle is to be operated continuously under the same conditions described in 50.5.32 but with the heat controls or switches set to give the highest temperature on each griddle plate.

56.7.7 SANDWICH TOASTERS AND GRILLS – The toaster or grill is to be operated dry and with the cover – if any – closed.

56.7.8 TABLE STOVES – The stove is to be operated continuously with each heating unit covered with a circular stove plate as described in 50.5.27.

56.7.9 TOASTERS – The toaster is to be operated without toast and with doors or the equivalent closed.

56.7.10 RADIANT HEATING TYPE WARMING APPLIANCES – The warmer(s) are to be placed in any position the construction permits to result in maximum heating of the alcove walls or the supporting surface. When the position of maximum heating is not obvious, testing is to be repeated to evaluate multiple positions of the heating lamps. Each test is to be conducted for 7 hours.

56.7.11 APPLIANCES WITH ADJUSTABLE PUMPS – An appliance with an adjustable pump which is operated at less than the maximum setting in accordance with the Exception to 50.5.6 shall be operated with the pump adjusted to its maximum setting.

56.7.12 APPLIANCES WITH MULTIPLE HEATING ELEMENTS – Where necessary to determine compliance with 27.13, an appliance is to be operated with any one heating element disabled.

57 Breakdown of Components Test

57.1 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 34.3);

c) For components in Limited Voltage/Current Secondary Circuits (see 34.4), Limited Energy Secondary Circuits involving open circuit potentials less than or equal to 30 V ac or 42.4 V peak (see 34.6), and Limiting Impedance Secondary Circuits (see 34.7);

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.

57.2 During and after the test of 57.1, 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.

57.3 For the purposes of the test, the series resistor of a gaseous discharge lamp is to be left in the circuit.

58 Wiring Endurance Test

58.1 An appliance in which the normal cooking or cleaning function results in movement of electrical wiring or other insulated live parts shall withstand an endurance test as described in 58.3 and 58.4. 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 51.

58.2 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.

58.3 The endurance test required by 58.1 is to consist of:

a) 30,000 cycles of operation for an appliance such as a waffle iron, in which the movement of electrical parts occurs during the intended cooking operation; or

b) 6000 cycles of operation for an appliance in which the movement occurs only during a cleaning operation.

58.4 For the endurance test described in 58.3, 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.

Exception: For an appliance, such as a sandwich toaster, that has two different stop positions for the hinged cover, 5000 operations of the 30,000 total are to be with the cover moved to the wide open position.

59 Cord Endurance Test – Hand-held Appliances

59.1 To determine whether the cord mentioned in 17.1.8 is acceptable, the tests described in 59.2 and 59.3 are to be conducted. Additionally, for appliances employing a thermoplastic cord guard, the tests of 59.4 and 59.5 are to be conducted. During the test, the cord shall not develop an open circuit, and there shall be no exposure of an uninsulated conductor strand.

59.2 To conduct the flexing test referred to in 59.1, three assemblies of the cord or cord and cord guard combination are to be assembled to the appliances, simulated mounting surfaces, or test-fixtures, so as to not interfere with the test procedure. Each assembly is to be mounted so that rotation is centered at the point where the guard enters the unit. See Figure 59.1. For the start of the test, the axis of the cord guard is to be positioned vertically with the cord end down. The cord is to be passed through a horizontal bushing having a smoothly rounded 1-inch (25-mm) diameter opening, located 2 feet (610 mm) below the cord guard entry to the appliance. The free end of the cord is to be attached to a 1/2-pound (220-gram) unsupported weight. The supply end of each cord is to be connected to a circuit of rated voltage, protected

by a time-delay fuse suitable for the attachment plug cap on the appliance, but rated not less than 20 A. A mechanism shall be provided to shut down the machine if a conductor opens. Half of the maximum rated load is to be passed through the conductors of the power supply cord. The three assemblies are to be flexed for 30,000 cycles through an angle of approximately 180 degrees, as illustrated in Figure 59.1, by a machine at a rate of approximately 20 cycles per minute, unless faster cycling is agreeable to those concerned.

59.3 With reference to 59.2, one cycle consists of 90-degree rotation of the test assembly in one direction, 180-degree rotation in the opposite direction and then return to the starting point. Flexing through an angle of 90 degrees in one direction only and return to the starting point is acceptable if the number of cycles is doubled and the flexing is changed to the opposite direction after each 10,000 cycles.

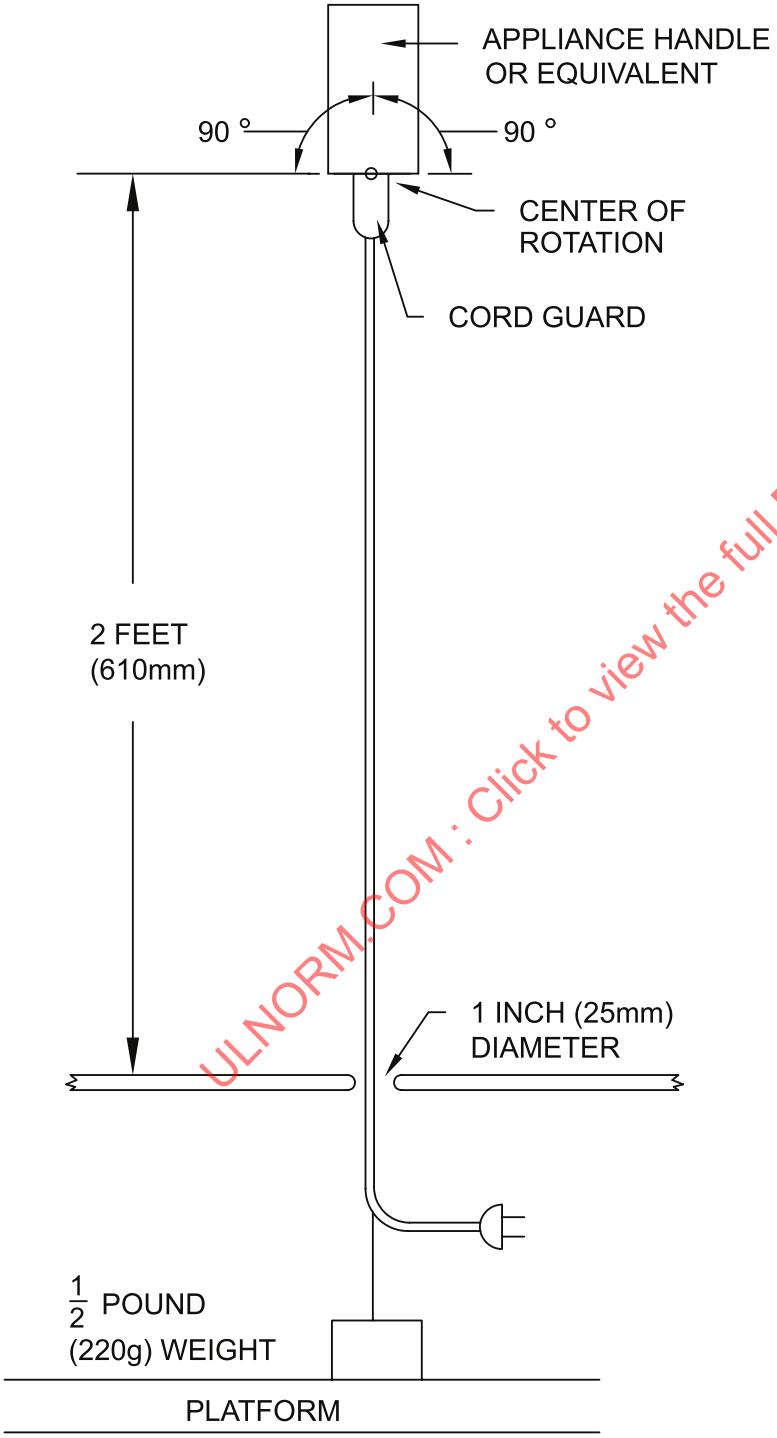
59.4 For appliances employing a thermoplastic cord guard, three additional samples are to be assembled to the appliances, simulated mounting surfaces, or test-fixtures so as to not interfere with the test procedure and subjected to the conditioning and flexing test described in 59.5. During the test, the cord shall not develop an open circuit, and there shall be no exposure of an uninsulated conductor strand. Following the test there shall be no visible cracks in the cord or cord guard.

59.5 To conduct the test required by 59.4, the samples are to be conditioned for 96 hours in an oven maintained at a temperature of 20°C (36°F) more than the maximum temperature observed on the cord or cord guard during the temperature test, but not less than 100°C (212°F). Following the conditioning, the assemblies are to be flexed for 5000 cycles in the manner described in 59.3.

Figure 59.1

Cord endurance test

TYPICAL MECHANICAL SET UP



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60 Strain Relief Test

60.1 When tested in accordance with 60.2, 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.

60.2 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.

61 Push-Back Relief

61.1 When required by reference to 17.2.3, a cord-connected appliance shall be tested in accordance with 61.2 without occurrence of any of the conditions specified in 17.2.3.

61.2 The supply 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 supply cord or lead within the product is to be manipulated to determine compliance with 61.1.

62 Thermal Shock Test – Glass/Ceramic Cooking Surfaces

62.1 The cooking surface of a glass/ceramic-top appliance shall not crack or break when tested as described in 62.2.

62.2 The largest surface unit is to be operated for 1/2 hour at its maximum heat setting. Then, 1/2 liter (0.13 gallons) of tap water at room temperature is to be poured over the hottest area of the cooking surface over a period of 15 seconds.

63 Strength of Enclosures, Frames, and Guards Test

63.1 General

63.1.1 An external enclosure or frame shall comply with 63.2 – 63.5 without permanent distortion, reducing spacings below the values specified in 37.1.9, or transient distortion that results in contact with live parts. Except as noted in 63.4, 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 10.1.3 – 10.1.6.

63.1.2 A guard required by 10.3 or 11.1 shall comply with 63.3 – 63.5 to the extent that:

a) A moving part involving a risk of injury to persons cannot be contacted by the probe illustrated in Figure 10.3; and

b) The appliance complies with Section 51, 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.

63.2 Static force test

63.2.1 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.

63.2.2 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 10.3 contacts a portion of a moving part when inserted through any opening in the guard.

63.3 Impact test – frames, guards, and metal enclosures

63.3.1 A frame, guard, or external enclosure of live parts shall withstand an impact applied by means of a solid, smooth, steel sphere 2 inches (51 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 No. 1: This test is not required for a polymeric enclosure that has been evaluated in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

63.4 Impact test – glass/ceramic-cooking surfaces

63.4.1 Each glass/ceramic panel of a glass/ceramic-top appliance that constitutes a part of the electrical enclosure shall withstand the tests described in 63.4.2 and 63.4.3 without cracking or exposing live parts.

Exception: Breakage or cracking of the glass/ceramic panel as a result of this test is acceptable provided uninsulated live parts do not become wet when tested in accordance with 63.4.4 – 63.4.6.

63.4.2 With reference to 63.4.1, each glass/ceramic panel is to be subjected to the impact produced by dropping a steel sphere, 2 inches (50.8-mm) in diameter and weighing 1.18 pounds (535 g), through a distance of 20-1/4 inches (514 mm). The test is to be conducted with the panel at room temperature.

63.4.3 Following the test described in 63.4.2, each glass/ceramic panel is to be subjected to ten impacts produced by dropping a 3.96 pound (1.8 kg) weight through a distance of 6 inches (152 mm). The weight is to be shaped as a cooking utensil, is to have a flat bottom of copper or aluminum, and is to have a diameter of 4-1/4 to 5-1/8 inches (108 to 130 mm) with a corner radius of 3/8 inches (9.5 mm). Each panel is to be subjected to ten impacts, and the impacts are to be equally distributed over the panel. The weight is to be dropped so that it strikes the panel as flatly as possible. The test is to be conducted with the panel at room temperature.

Exception: Concave glass/ceramic cooking surfaces are to be tested with a weight having the same curvature as the surface to be tested. The diameter of the weight shall be the minimum diameter of cooking pan (wok) intended to be used with the appliance.

63.4.4 With reference to the Exception to 63.4.1, to determine whether a broken or cracked panel is acceptable, a solution of 1/2 liter (0.13 gallon) of distilled water containing 1/4 gram (0.009 ounce) of calcium sulphate ($CaSO_4$) is to be spilled over the broken or cracked area of the panel.

63.4.5 Determination of whether uninsulated live parts have become wet as a result of testing is to be done by visual inspection and the following means:

a) The appliance shall withstand without breakdown for 1 minute the application of the potential specified in Section 51, Dielectric Voltage-Withstand test;

b) A cord-connected appliance constructed according to 46.1 (a) or (b) shall comply with the requirement in 46.1 in a repeated leakage current test, except that the test is to be discontinued when leakage current stabilizes; and

c) An appliance, other than that constructed according to 46.1 (a) or (b), shall comply with the Insulation Resistance Test, Section 53.

These tests are to be conducted as soon after the water-salt solution has been poured on the ceramic/glass panel as is possible.

63.4.6 The tests noted in 63.4.5 are to be conducted between the following locations;

a) Between live parts and the enclosure; and

b) Between live parts and a layer of metallic foil that is placed over the glass/ceramic panel. The foil is to be covered with a 1-inch (25-mm) thick layer of 1 pound-per-cubic-foot (16 kg-per m^3) glass fiber insulation. A 10 inch (254 mm) diameter pan filled with sufficient water to make it weigh 10 pounds (4.54 kg) is to be placed on the insulation directly over the broken or cracked area.

63.5 Impact – exposed glass parts other than glass/ceramic cooking surfaces

63.5.1 An exposed glass part, including a guard, shall comply with one of the following:

a) The glass shall be a nonshattering or tempered type that, when broken, complies with the performance specifications in the Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings, ANSI Z97.1; or

b) The glass shall withstand an impact from a 2-inch (51-mm) diameter, smooth steel sphere, weighing 1.18 pounds (535 g) falling through a distance of 25-1/2 inches (646 mm) without cracking or breaking to the extent that a piece is released or dropped from its normal position. See 63.1.1.

Exception: The requirement does not apply to glass that does not enclose uninsulated live parts and is not less than 0.115 inch (2.92 mm) thick, when no dimension of the glass is greater than 12 inches (305 mm).

64 Mounting Means Test

64.1 When required by Condition F in Table 43.1, a surface mounted appliance shall be tested as described in 64.2 and 64.3. The test result is not acceptable when:

a) The appliance, separable mounting bracket, or screws are pulled from the mounting surface;

b) The appliance becomes detached from the separable mounting bracket; or

c) The appliance is damaged to the extent that internal wiring, splices, a switch or uninsulated live parts are exposed. Wireways or decorative parts are not prohibited from being bent.

64.2 Each test is to be conducted using the hardware provided by the manufacturer and with the appliance mounted in accordance with the instructions provided. An adjustable appliance is to be adjusted to the position that results in the most severe test.

Exception: When the instructions do not specify a minimum mounting surface, the tests shall be conducted using 3/8 inch (9.5 mm) trade size plaster board securely attached to studs on 16 inch (406 mm) centers.

64.3 A weight equal to three times the maximum normal weight of the appliance (including food or liquid load, if applicable), but not exceeding 400 pounds, is to be gradually applied at the point of the maximum projection of the appliance and maintained for 1 hour.

64.4 When an appliance is intended to be mounted to more than one surface, each combination shall be tested.

65 Reservoir Tests

65.1 General

65.1.1 An automatic fill or manual fill appliance which incorporates a reservoir or liquid storage chamber shall be investigated by subjecting at least one sample to all applicable tests described in this Section.

65.1.2 As a result of testing, liquid overflowing from the reservoir or chamber shall not wet uninsulated live parts or film-coated wires, and shall not wet electrical insulation that is likely to be adversely affected by the liquid used in the reservoir or chamber.

65.1.3 The test water for the test specified in 65.2 is to be tap water. The test water for the tests specified in 65.3 and 65.4 is to be a hard water solution of 1/2 gram of calcium sulphate ($CaSO_4$) per liter of distilled water (0.07 ounces $CaSo_4$ per gallon of distilled water).

65.1.4 Determination of whether uninsulated live parts have become wet as a result of testing is to be done by the following means:

a) Visual inspection;

b) The appliance shall withstand without breakdown for 1 minute the application of the potential specified in Section 51, Dielectric Voltage-Withstand Test;

c) A cord-connected appliance constructed according to 46.1 (a) or (b), shall comply with the requirement in 46.1 in a repeated leakage current test, except that the test is to be discontinued when leakage current stabilizes; and

d) An appliance, other than that constructed according to 46.1 (a) or (b), shall comply with the Insulation Resistance Test, Section 53.

65.2 Overflow test for automatic fill appliances

65.2.1 With the level sensing device bypassed, water is to be allowed to overflow the reservoir for one minute.

Exception No. 1: The duration of the test is to be extended when uninsulated live parts, film-coated wire, or electrical insulation are likely to be adversely affected by the liquid when flooding is allowed to continue.

Exception No. 2: This test is not required when the level sensing device has been evaluated to the Standard for Limit Controls, UL 353, and the sensing means is suitably protected from physical abuse and corrosion and is unlikely to be defeated by an accumulation of food.

Exception No. 3: This test is not required when an appliance employs a plumbed overflow drain of sufficient capacity to carry the maximum anticipated overflow rate of fill water of the appliance.

65.3 Overflow test for manual fill appliances

65.3.1 The test water is to be poured into the reservoir through an orifice 3/8 inch (9.5 mm) in diameter. The reservoir is to be filled until the reservoir begins to overflow. Then an additional amount of water, equal to 50 percent of the volume required to reach overflow or 16 fluid ounces (0.47 liters) whichever is less, is to be poured into the reservoir.

65.4 Removable container test

65.4.1 An appliance that incorporates a removable container shall be tested as specified in 65.4.2.

Exception: An appliance that is marked in accordance with 85.6 is not required to be subjected to the removable container test.

65.4.2 With the cooking container removed, 16 fluid ounces (0.47 liters) of test water solution is to be poured into the appliance through a 3/8-inch (9.5-mm) diameter orifice in the locations likely to cause wetting of live parts and wiring.

65A Door Latch Release Test

65A.1 An interior latch release device of a walk-in appliance, or door panel assembly door (see 5A.9.1) shall release with a force of 15 pounds (66.7 N) or less, applied at the rate of 3 to 4 pounds (13.4 to 17.8 N) per second.

65A.2 When the force required to release the door latch is intended to be applied to an interior bar, lever, or similar actuator, the force is to be applied to this actuator.

65A.3 Components of a latch release mechanism that permit the door to open as a result of a force applied to an actuator shall not break, crack, or permanently deform from the application of 50 successive 20 pounds (88.9 N) pushing operations followed by 50 successive 20 pound pulling operations (when either or both are applicable, depending on the component construction).

65B Door Opening Test

65B.1 The door of a walk-in appliance, or door panel assembly (see 5A.9.1) shall open when a force of 50 pounds (220 N) is applied.

65B.2 The force is to be applied at a rate of 3 – 4 lbs (13.4 – 17.8 N) per second until the door opens.

65B.3 When a door latch release mechanism is employed, the force is to be applied to the door within 12 inches (30 cm) of the interior latch release mechanism. The door opening test is conducted after the Door Latch Release Test, 65A.

65B.4 When a door latch release mechanism is not employed, the release force measurements are to be made by means of a force gauge at each of three points on the inside of the door or door liner edge on the side opposite the hinges. One point is to be near the top of the door, one point near the bottom of the door, and one point midway between these two points. The force measurements may be made at points on the outer door surface corresponding to the three internal points.

65B.5 When the test in 65B.1 is applied to a door with an adjustable spring closing or counterbalancing mechanism, the mechanism is to be adjusted to the position requiring maximum opening force.

PERFORMANCE – COMPONENTS

66 General

66.1 The tests in Sections 67 – 79 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 28.3.3, 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 50.4.14 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 Temperature-Regulating Controls

68.1 A temperature-regulating control shall be subjected to an endurance test consisting of the number of cycles specified in Table 27.1. At the completion of the test, the temperature control shall remain mechanically and electrically operable.

68.2 The temperature-regulating control or switching device is to be cycled while operating at the maximum rated load of the controlled circuit.

69 Endurance Test for Interlock Switches

69.1 An interlock system as specified in 14.1.5 shall function as intended after 100,000 cycles of operation controlling a load not less than that controlled in the appliance.

70 Motor Switch Overload Test

70.1 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.

70.2 To determine whether a switch complies with the requirement in 70.1, 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.

71 Components Containing Liquid Metal Test

71.1 Liquid metal escaping due to the deliberate rupture by overpressure or deliberate puncture of a bellows, diaphragm, or other liquid-metal-containing part shall not enter an oven or food handling compartment, or contact food handling hardware. Mercury, sodium, and potassium shall be contained in the switch body or control enclosure. There shall be no resulting risk of fire.

Exception: A temperature-regulating or -limiting control is not required to be evaluated according to 71.1 when it has previously been evaluated to the applicable requirements in the Standard for Temperature-Indicating and -Regulating Equipment, UL 873. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

72 Printed-Wiring Board Abnormal Operation Test

72.1 Where required by Exception No. 2 of 37.1.1, printed-wiring boards are to be tested as described in 72.3 – 72.8. 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.

72.2 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 89.11 shall be provided.

72.3 With respect to the limiting impedance circuit requirements in 34.7, 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 50.

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.

72.4 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 37.1, they are to be short-circuited one at a time.

72.5 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.

72.6 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.

72.7 The test is to be continued for 1 hour or until one of the conditions described in 72.1 occurs. However, if at the end of 1 hour none of the conditions described in 72.1 have occurred, and indications are such that a condition will eventually occur, the test is to be continued until ultimate results are obtained.

72.8 When the circuit is interrupted by the opening of a component, the test is to be repeated twice using new components.

73 Secondary Circuits Tests

73.1 General

73.1.1 The following tests are to be conducted as specified in Section 34, 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.

73.2 Maximum voltage

73.2.1 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 40, Separation of Circuits.

73.2.2 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.

73.2.3 Voltage measurements are to be made using a voltmeter having an internal impedance of not less than 3,000 ohms per volt.

73.2.4 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 34.1.9 and 34.1.10.

73.3 Maximum current test for inherently limited circuits

73.3.1 The maximum available current in a secondary circuit intended to be inherently current limited shall be tested as described in 73.3.2 – 73.3.7. 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 40, Separation of Circuits.

73.3.2 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.

73.3.3 The results are in compliance when the measured current does not exceed 8 amps for a limited voltage/current circuit.

73.3.4 The impedance of the short circuit measuring circuit in the secondary is to be limited to 0.03 ohm.

73.3.5 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.

73.3.6 When the current is interrupted by a resettable or replaceable protective device, the test is to be repeated with the protective device shorted.

73.3.7 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 73.3.3 for two minutes. The results are acceptable when the circuit is not able to maintain the current given in 73.3.3 for two minutes or when the current is interrupted.

73.4 Limited power point determination test

73.4.1 With reference to 34.7.1(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 73.4.2.

73.4.2 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 50.

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.

73.4.3 With reference to 73.4.1, 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. See 89.11.

73.5 Component failure

73.5.1 A power supply or other source that is required to limit current or power to a secondary circuit under single-fault conditions (see 34.4.7 and 34.7.2), 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.

73.5.2 With respect to 34.4.7 and 34.7.2, the tests mentioned in 73.5.1 shall be used to modify the determination of the first point of the limited voltage/current circuit or the limiting impedance circuit, when required.

73.5.3 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.

73.6 Maximum power test

73.6.1 The maximum obtainable output power is not to exceed 200 VA for limited energy circuits (see 34.6) or limited voltage/current circuits (see 34.4). 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 73.2, the internal resistance (R_I) of the transformer is to be calculated using the formula:

$$R_I = (V_{OC} - V_{FL}) / I_{FL}$$

c) The load resistance (R_L) required in (d), (f), and (g) is to be calculated using the formula:

$$R_L = R_I \frac{\%}{1.0 - \%}$$

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:

$$VA_O = V_O \times I_O$$

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 73.6.1(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.

73.7 Power dissipation test

73.7.1 With respect to 34.7.1(a), the power dissipated by the limiting impedance shall not exceed the power rating of the impedance when tested in accordance with 73.7.2.

73.7.2 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.

74 Parts Subject to Contact with Oil or Other Liquids

74.1 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.

74.2 To determine whether a part made of elastomers, flexible cellular, or thermoplastic material complies with the requirement in 74.1, 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 74.1.

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 50. 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.

74.3 To determine whether a composite gasket complies with the requirement in 74.1, 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 50. 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 74.1
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	(197)	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

74.4 To determine whether a strain relief bushing or other strain relief means complies with the requirement in 74.1, an investigation is to be conducted in accordance with 74.2. However, instead of performing tensile strength, elongation, and hardness tests, the Strain Relief Test, Section 60, is to be repeated after the aging of part.

74.5 To determine whether a part constructed of a thermoset material (such as phenolic) complies with the requirement in 74.1, an investigation is to be conducted in accordance with 74.2 for tensile strength only. The tensile strength test is to be conducted as described in the Standard for Gaskets and Seals, UL 157, except the rate of travel of the power actuated tip is to be 1/10 inch (2.54 mm) per minute.

75 Hydrostatic Pressure Test

75.1 When required by 41.1.7, two samples of each part subject to pressure are to be filled with any nonhazardous liquid, such as water, so as to exclude air, and are to be connected to a hydraulic pump. The pressure is to be raised gradually to the required test value and is to be held at that value for 1 minute, during which time the sample shall not burst or leak. Leakage is to be determined visually by examination of the sample for release of the test medium or as evidenced by a decreasing hydrostatic gauge pressure.

Exception: Leakage at a gasket or seal meets the intent of the requirement when it does not occur at a pressure lower than 40 percent of the required test value. The component is to be capable of withstanding the required test pressure even though leakage occurs at the gasket or seal.

76 Start-To-Discharge Test

76.1 When required by 41.1.8 or 41.3.3, the setting of a pressure-relief device, determined in accordance with 76.2, shall not exceed the value marked on the device. See 89.15.

76.2 Two samples of the device are to be tested. Each sample is to be connected to a gas source, such as air, carbon dioxide, or nitrogen. Oxygen or any flammable gas is not to be used. The sample is to be immersed in water, and the pressure is to be gradually increased until the device starts to discharge as evidenced by the occurrence of bubbles in the water. The test is to be repeated for a total of three operations of each sample. The highest value obtained in tests of the two samples is determined to be the setting of the device.

77 Relief Device Maximum Pressure Test

77.1 When required by 41.3.4(d), two samples are to be subjected to the test described in 77.2 and 77.3.

77.2 The appliance is to be operated continuously at rated input, with all controls that limit the pressure in the system bypassed or disabled. Operation is to be continued until ultimate results have occurred. The pressure in the system shall not exceed the pressure setting of the pressure relief device.

77.3 When agreed upon by all involved parties, the pressure vessel/pressure relief device combination is not prohibited from being tested separately, using an external pressure source of sufficient pressure and capacity to simulate the appliance.

78 Pressure Controls Endurance Test

78.1 Where required by 41.4.1, a pressure control shall be subjected to an endurance test consisting of the number of cycles indicated in Table 78.1. At the completion of the test:

a) Both pressure controls shall remain operable; and

b) When reinstalled in the appliance, both pressure controls shall prevent the pressure from exceeding 90 percent of the relief-device setting when the appliance is operated as specified in the Normal Temperature test, Section 50.

78.2 Two samples of the device, including the sensing means, are to be tested. Each sample is to be connected to a gas source, such as air, carbon dioxide, or nitrogen. Oxygen or any flammable gas is not to be used. A pressure measuring device is to be placed in the source line as close to the device as possible. The sample is to be immersed in water, and the pressure is to be gradually increased until the device operates to open the control circuit.

Table 78.1
Cycling for pressure controls

Type of control	Number of cycles				
	Total	First	Maximum cycles per minute	Last	Maximum cycles per minute
An automatically reset control	100,000	75,000	6	25,000	1[a]
[a] The test is to be conducted with 50 ±20 percent on time. The control is to be tested using a slow rate of change					

79 Permanence of Marking Test

79.1 Labels

79.1.1 When required by 84.2 or the Exception of 84.1, three sample labels applied to test surfaces as in the intended application are to be conditioned for 24 hours in a controlled atmosphere maintained at 23

±2°C (73 ±4°F) and at a 50 ±5 percent relative humidity, followed by immersion in corn oil at a temperature of 200 ±2°C (392 ±4°F) for 48 hours. After the conditioning, the labels shall comply with 79.1.3.

Exception: The oil temperature is to be 23 ±2°C (73.4 ±3.6°F) when the label is:

a) Used on an appliance that does not employ oil or grease in the cooking operation; or

b) Located inside the enclosure or otherwise shielded from spillage of hot oil.

79.1.2 When required by 84.3, three sample labels applied to test surfaces as in the intended application are to be conditioned for 24 hours in a controlled atmosphere maintained at 23 ±2°C (73 ±4°F) and at a 50 ±5 percent relative humidity. The labels are to then be immersed for 48 hours in a liquid representative of service use, maintained at the temperature the liquid attains in service, and no less than 23 ±2°C. After the conditioning, the labels shall comply with 79.1.3.

79.1.3 After being immersed as specified in 79.1.1 and 79.1.2, the samples are to be evaluated in accordance with the tests described in the table titled Permanence and Legibility in the Standard for Marking and Labeling Systems, UL 969. The evaluation is to be made while the samples are wet after removal from the test liquid. However, the Adhesion Test specified in UL 969 is to be conducted after the samples are dried for at least 24 hours at a temperature of 23 ±2°C (73.4 ±3.6°F) and a relative humidity of 50 ±5 percent.

79.2 Cord tags

79.2.1 A tag used for a marking as described in 84.9 shall comply with the requirements in 79.2.2 – 79.2.5, the requirements for permanence and legibility in the Standard for Marking and Labeling Systems, UL 969, and with 79.1, when applicable.

79.2.2 Three as-received samples of the tag/cord assembly and six samples of the tag/cord assembly that have been subjected to the conditioning specified in 79.2.4, three for each condition, are to be subjected to the test described in 79.2.5. After testing, the samples shall comply with the following requirements:

a) The tag shall not tear for more than 1/16 inch (1.6 mm) at any point;

b) The tag shall not separate from the power-supply cord;

c) The tag shall not slip or move along the length of the power-supply cord more than 1/2 inch (12.7 mm);

Exception: The tag is not prohibited from slipping when no cautionary markings are provided on the tag.

d) There shall be no permanent shrinkage, deformation, cracking, or any other condition that will render the marking on the tag illegible; and

e) Overlamination shall remain in place and not be torn or otherwise damaged. The printing shall remain legible.

79.2.3 Each sample is to consist of a length of power-supply cord. The tag is to be affixed to the power-supply cord in the intended manner. If tags are applied by an adhesive, tests are to be conducted no sooner than 24 hours after application of the tag.

79.2.4 The conditioning required by 79.2.2 is to consist of the following:

a) The samples are to be conditioned for 24 hours in an air-circulating oven maintained at a uniform temperature of 87.0 ±1.0°C (188.6 ±1.8°F). Following removal from the oven, the samples are to remain at a temperature of 23.0 ±2.0°C (73.4 ±3.6°F) and a relative humidity of 50 ±5 percent for 30 minutes before testing.

b) The samples are to be conditioned for 72 hours in a humidity of 85 ±5 percent at 32.0 ±2.0°C (89.6 ±3.6°F). The samples are to be tested within 1 minute after the conditioning.

79.2.5 The power-supply cord, with the attachment plug pointing up, is to be held tautly in a vertical plane. A force of 5 pounds (22.3 N) is to be applied to the uppermost corner of the tag farthest from the power-supply cord, within 1/4 inch (6.4 mm) of the vertical edge of the tag. The force is to be applied vertically downward in a direction parallel to the major axis of the cord and maintained for 1 minute. In determining compliance with 79.2.2(d), manipulation is possible, such as straightening of the tag by hand.

MANUFACTURING AND PRODUCTION TESTS

80 Dielectric Voltage-Withstand

80.1 Each appliance shall withstand without electrical breakdown, as a routine production-line test, the application of a potential at a frequency within the range of 40 – 70 hertz, or a dc potential:

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

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

80.2 The production-line test shall be in accordance with either Condition A or Condition B of Table 80.1.

Table 80.1
Production-line test conditions

Appliance rating	Condition A			Condition B		
	Potential, volts		Time, seconds	Potential, volts		Time, seconds
	ac	dc		ac	dc	
250 volts or less	1000	1414	60	1200	2500	1
Rated more than 250 volts	1000 + 2V[a]	1414 + 2√2V[a]	60	1200 + 2.4V[a]	–	2

[a] Maximum rated voltage.

80.3 For equipment employing secondary circuits, the test is to be conducted with the low-voltage circuit connected to the cabinet, chassis, or other dead metal part so that the potential applied between the high voltage live parts and dead metal parts will simultaneously be applied between high-voltage live parts and low voltage circuits.

80.4 The test is to be conducted when the appliance is fully assembled. The appliance is not to be unwired, modified, or disassembled for the test.

Exception No. 1: The test is not required on a part, such as a snap cover or friction-fit knob, that interferes with performance of the test is not required to be in place.

Exception No. 2: The test need not be performed with the appliance fully assembled when the test represents that for the complete product. Any component not included shall not affect the results with

respect to determination of the risk of electric shock resulting from mis-wiring, defective component, insufficient spacings, and the like.

80.5 Solid-state and similar components that have the potential to be damaged by a secondary effect of the test (such as an induced voltage surge or excessive heating) are to be short-circuited by means of a temporary electrical jumper or the test is to be conducted without the component electrically connected. The wiring and terminal spacings are to be maintained. Additionally, components providing a direct current path in parallel with the insulation to be tested (primary to dead-metal) are not prohibited from being disconnected during the test. Examples of such components are discharge resistors for filter capacitors and voltage limiting devices such as transient voltage suppressors (other than capacitors).

80.6 Where an appliance contains multiple heating elements, such that a false indication of breakdown is possible due to cumulative leakage currents and/or capacitive effects, the elements are not prohibited from being tested individually or in smaller groups.

80.7 The test equipment shall have a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic reject feature for any unacceptable appliance. When an ac test potential is applied, the test equipment shall include a transformer having an essentially sinusoidal output.

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

80.9 When the output of the test-equipment transformer is 500 volt-amperes or more, the test potential shall be indicated:

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

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

c) For equipment having a single test-potential output, by a marking in a readily visible location to indicate the test potential. When a marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

80.10 Test equipment other than that described in 80.7 – 80.9 is not prohibited from being used when found to accomplish the intended factory control.

80.11 During the test, the primary switch is to be in the "on" position, both sides of the primary circuit of the appliance are to be connected together and to one terminal of the test equipment, and the second test-equipment terminal is to be connected to the accessible dead metal.

Exception: An appliance having circuitry – resistive, high-impedance winding, or the like – not subject to excessive secondary-voltage build-up in the case of electrical breakdown during the test may be tested:

a) With a single-pole primary switch, if used, in the "off" position; or

b) With only one side of the primary circuit connected to the test equipment when the primary switch is in the "on" position, or when a primary switch is not used.

81 Grounding Continuity

81.1 Each cord-connected appliance shall be tested as a routine production-line test to determine that continuity exists between the grounding blade of the attachment plug and the exposed dead metal parts described in 18.1.

81.2 Any indicating device such as an ohmmeter or a low-voltage battery-and-buzzer combination, is to be employed to determine compliance with the grounding continuity requirement in 81.1.

82 Pressure Vessels and Parts Subject to Pressure

82.1 Unless it is certified by the American Society of Mechanical Engineers (ASME) and eligible to be covered by the National Board of Boiler and Pressure Vessel Inspectors, each pressure vessel and pressure-relief device shall be examined and tested as specified in 82.2 – 82.4 to determine that it is acceptable.

82.2 Each pressure vessel shall be visually examined to determine that the welds, pipe connection fittings, and general assembly details are acceptable. Each weld shall be continuous, smooth, uniform, and with penetration and fusion for its entire length. The weld shall be free of scale or slag, and without voids or impurities, undercuts, overlaps, abrupt ridges, or valleys.

82.3 Each pressure vessel shall withstand a pressure of 1-1/2 times the maximum marked pressure of the vessel. The pressure is to be gradually increased to the specified test value. The vessel is not acceptable when it ruptures or leaks during the test.

82.4 Each automatically reset pressure-relief device shall be tested at its marked setting to determine that it functions as intended. The device is to be tested with air or a similar pneumatic source.

APPLIANCE RATINGS

83 Electrical Ratings

83.1 An appliance shall be rated in volts, amperes or watts, and frequency. The rating shall include the number of phases when the appliance is designed for use on a polyphase circuit, and an appliance intended for a 3-phase 4 wire "Y" connection shall include "Y" in the voltage rating (such as 208Y, 480Y). The rating shall include the number of current-carrying power supply conductors (including both ungrounded and grounded supply conductors, but not including the equipment grounding conductor) when the appliance is designed for use on a circuit with more than two current-carrying conductors.

Exception: In place of a frequency rating, an appliance is not prohibited from being rated ac, when it does not contain a component such as a motor, relay coil, or other control device for which a specific frequency rating is required.

83.2 When the input currents of different ungrounded supply conductors vary sufficiently to require overcurrent protection or supply wiring different from that which would be calculated assuming a balanced load, see 28.1.3, the current rating of each individual ungrounded supply conductor shall be stated separately (for example, L1: ___ amperes, L2: ___ amperes).

Exception: The current ratings of the individual ungrounded supply conductors are not required to be stated separately when:

a) The appliance is rated in watts and the maximum ampere rating (the maximum current drawn from any individual ungrounded supply conductor) is specified; and

b) One of the following is true:

1) The requirements of this Standard (for instance, the short-circuit and ground-fault protection requirements in Section 28) would be met if all ungrounded supply conductors were protected by protective devices rated in accordance with the maximum ampere rating given (see 28.1.3); or

2) The appliance is marked to specify the use of a protective device with a specific rating, in accordance with the Exception to 28.1.3, and the requirements of this Standard are met when the appliance is protected at that rating. See also 28.1.4.

83.3 The voltage rating shall be in accordance with any appropriate single voltage or range of voltages such as 110 – 120, 120/208Y, 220 – 240, 120/240, 277/480Y, 254 – 277, 416, 440 – 480, 550, 575, and 600.

83.4 A nominal 120/208Y, 120/240, 120/208Y, 208 volt single or three phase, or a 120/240 appliance is considered to involve a potential to ground of less than 150 volts. A two-wire, single-phase, or a three-wire, three-phase appliance with a rating in the range from 220 – 240 volts is assumed to involve a potential to ground of more than 150 volts.

Exception: A two-wire, single-phase or a three-wire, three-phase appliance with a rating in the range from 220 – 240 volts is assumed to involve a potential to ground of 150 volts or less if the appliance is marked in accordance with 86.11, 86.12, 88.8, or 88.9.

83.5 An appliance intended for alternating current only or direct current only shall be rated accordingly.

83.6 The added load that may be imposed on an appliance and its supply connections by an attachment-plug receptacle that serves as a general use outlet – 80 percent of the current rating of a single or 100 percent of the current rating of a duplex receptacle, unless the receptacle is marked for a specific load (see 86.15) – is to be taken into consideration when determining the electrical rating of the appliance.

83.7 The added load that may be imposed on an appliance and its supply connections by an accessory or accessories, see Section 6, is to be taken into consideration when determining the electrical rating of the appliance.

83.8 The rated power of an appliance shall not be less than the sum of the rated power of any resistive heating elements that operate simultaneously during any condition of normal use. The rated current of an appliance shall not be less than the sum of the calculated currents (rated power divided by rated voltage) of any resistive heating elements that operate simultaneously during any condition of normal use.

Exception: When, under normal conditions of use, a heating element is operated at a voltage different from its rated voltage, the power or current rating of that element is to be adjusted in accordance with the following formulas:

$$W_a = V^2{}_a / V^2{}_r \times W_r$$

$$I_a = V_a / V_r \times I_r$$

Where:

W_r is the rated power of the element, in watts

W_a is the actual power of the element, in watts

I_r is the rated current of the element, in amperes

I_a is the actual current of the element, in amperes

V_r is the rated voltage of the element

V_a is the voltage applied to the element in normal use

83.9 When two power supply cords are provided, the electrical rating for each cord shall be considered separately. When the two cords are connected to the same branch circuit in accordance with 17.5.1(d), the total electrical rating shall also be calculated. See 86.19.

MARKING

84 General

84.1 A marking required to be permanent shall be molded, die-stamped, paint-stenciled, stamped or etched on metal, or indelibly stamped on pressure-sensitive labels secured by adhesive. Pressure-sensitive labels secured by adhesive shall comply with the requirements in the Standard for Marking and Labeling Systems, UL 969. Pressure-sensitive labels shall be rated for the maximum temperature and type of surface to which the label is applied and shall be suitable for occasional exposure to cooking oil.

Exception: A pressure-sensitive label is not required to be rated for exposure to cooking oil in accordance with UL 969 when it complies with 79.1.1.

84.2 A pressure-sensitive label which is:

a) Used on an appliance that employs oil or grease in its normal cooking operation;

b) Required to be permanent; and

c) Not located inside the enclosure or otherwise shielded from spillage of hot oil

is to be tested in accordance with 79.1.1.

Exception: This test is not required for a label that has been evaluated for exposure to cooking oil at 200°C in accordance with UL 969.

84.3 Pressure-sensitive labels exposed to unusual service conditions shall be tested in accordance with 79.1.2.

Exception: This test is not required for a label that has been evaluated for the intended service conditions in accordance with UL 969.

84.4 A marking that is required to be permanent shall be located on a part that is not removable without the use of tools or on a part that cannot be removed without impairing the operation of the filter.

84.5 A warning marking shall be permanent and legible, shall contrast with its background, and shall be located on a part that cannot be removed without impairing the operation or appearance of the appliance.

Exception: A marking is not required to be of contrasting colors when it complies with 84.8.

84.6 A warning marking shall be visible from the operator's position or from the position in which a specific risk of injury to persons exists.

84.7 In a warning marking, the words "CAUTION," "WARNING," or "DANGER" shall be in letters not less than 3/32 inch (2.4 mm) high and displayed in all capital letters.

84.8 When a warning marking, that is not colored in a manner contrasting with the background, is stamped or molded into a surface the signal word – "CAUTION", "WARNING", or "DANGER" – shall be at least 1/2 inches (12.7 mm) high. The remaining words in the marking shall be at least 7/64 inches (2.8 mm) high. The lettering shall be either raised or have a depth of at least 0.02 inches (0.51 mm).

84.9 When necessary due to the limited space on the appliance, the markings for a cord connected hand held appliance are not prohibited from being provided on a cord tag. See 84.10.

84.10 The tag specified in 84.9 shall:

a) Be permanently affixed to the power-supply cord;

b) Be located not more than 6 inches (152.4 mm) from the attachment plug;

c) Be made of substantial material such as cloth, plastic, or the equivalent that provides the necessary mechanical strength and prevents easy removal;

d) Comply with the requirements in Subsection 79.2;

e) Be sized so that the required markings are legible; and

f) Be a flag-type tag having:

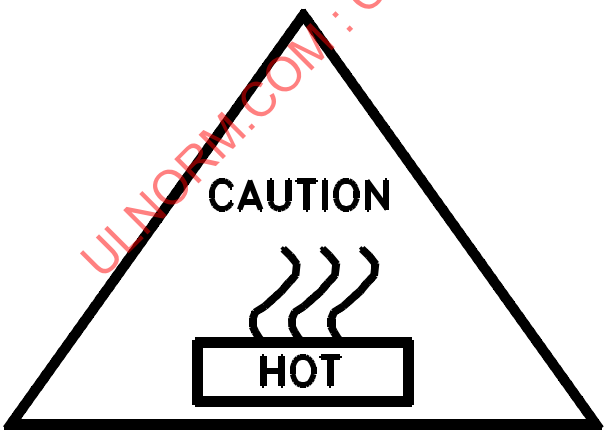
1) A hole to permit securement to the power-supply cord by a plastic strap or equivalent means which shall no be removable without cutting; or

2) An adhesive back. The tag shall be wrapped tightly once around and is to adhere to the power-supply cord. The ends of the tag are to adhere to each other and project as a flag. The required markings shall be positioned on the projecting flag portion of the tag.

85 Visible to Operator

85.1 The marking required by 85.2 – 85.9 shall be permanent and shall be plain, legible, and readily visible from the operator's position.

85.2 When the temperature of the surface exceeds the limits specified in Table 50.2, the appliance shall be marked with the words "CAUTION – HOT" , "CAUTION – HOT SURFACE" or equivalent wording. The following symbol may be used in lieu of the above wording:



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See 50.2.1. The marking shall be located on or adjacent to the surface in question and shall be readily visible and legible from any anticipated user or observer locations within 3 feet from the surface. When the symbol is used, the equilateral triangle shall have a height not less than 1-1/2 inches (38 mm). The symbol

and words contained within the triangle shall be scaled proportionately to the height of the equilateral triangle.

Exception No. 1: When a surface is marked in accordance with 85.5, the marking in 85.2 is not required.

Exception No. 2: The wording "Warning" is not prohibited from being substituted for the wording "Caution" when the risk associated with a product is such that the use of the word "Warning" is appropriate.

85.3 When required by 11.1.6, the following marking or equivalent shall be provided: "WARNING – Burn Hazard – Do Not Handle The Lever Without First Inserting The Filter Holder With Ground Coffee." The marking shall be located in front of each handle.

85.4 When required by the Exception to 50.5.23, the warmer(s) are to be marked "WARNING" and the following or equivalent: "Risk of Fire – Do Not Position Closer Than 12 Inches To the Carving (or supporting) Surface". When the appliance is accessible from more than one direction, the marking shall be visible from all anticipated operator locations.

85.5 In accordance with footnote j of Table 50.1, a storage cabinet or drawer shall not exceed a temperature rise of 65°C (117°F) during the normal temperature test, unless it is marked as follows, "CAUTION: Risk of Fire or Burn Hazard. Do Not Store Combustible Material In This Area." This marking shall be visible to a user while accessing the storage area.

85.6 When required by the Exception to 65.4.1, an appliance with a removable cooking container shall be marked with the word "CAUTION" and the following or equivalent on the internal surface of the basic appliance: "To Reduce the Risk of Electric Shock, Cook Only In Removable Container."

85.7 With regard to the Exception to 45.5, the following marking, or the equivalent, shall be provided: "CAUTION – Risk of Fire or Electric Shock. Only Operate This Appliance With the (name of removable part) In Place". The marking shall be directly adjacent to or behind the removable part, and be located on a part that is permanently attached or requires a tool for removal, and be visible by the user when removing the part.

85.8 An appliance that employs an indicator light in accordance with 56.5.5 shall be provided with a permanent marking, located adjacent to the light, that identifies the function of the light. The marking shall consist of the word "WARNING" and the following or equivalent: "Appliance Is Malfunctioning, Turn Off or Disconnect From Power Supply. See instruction manual before operating."

85.9 An appliance that employs an audible signal in accordance with 56.5.6 shall be provided with a permanent marking, located in an area readily visible to the user during the operation of the appliance. The marking shall consist of the word "WARNING" and the following or equivalent: "If alarm signal (for example, a bell or buzzer) sounds, appliance is malfunctioning. Turn off or disconnect from power supply and see instruction manual before operating."

86 Visible After Installation

86.1 The marking required by 86.2 – 86.23 shall be permanent and shall be plain, legible, and readily visible after the appliance is installed in the intended manner.

86.2 An appliance shall be marked with:

a) The manufacturer's name, trade name, trademark, or other descriptive marking by which the organization responsible for the product is capable of being identified – hereafter referred to as the manufacturer's name;

b) A distinctive catalog number or the equivalent;

c) The electrical rating; and

d) The date or other dating period of manufacture not exceeding any three consecutive months.

Exception No. 1: The manufacturer's identification is not prohibited from being in a traceable code when the appliance is identified by the brand or trademark owned by a private labeler.

Exception No. 2: The date of manufacture is not prohibited from being abbreviated or in a nationally accepted conventional code or in a code affirmed by the manufacturer, when:

a) The date code does not repeat in less than 20 years.

b) The date code does not require reference to the manufacturer's records to determine when the product was manufactured.

86.3 A permanently-connected appliance having one motor and other loads, or more than one motor with or without other loads, shall be marked with:

a) The minimum supply-circuit conductor ampacity based on the maximum input in accordance with 47.2; and, the maximum rating and type – for example, nontime-delay fuse, dual-element time-delay fuse, and the like – of supply-circuit overcurrent-protective device in accordance with 28.1.3; or

Exception: This requirement does not apply to an appliance in which both the minimum circuit size and maximum rating of the circuit overcurrent-protective device are not more than 15 amperes.

b) The rating of the largest motor in volts and amperes, and the additional load in volts and amperes, or volts and watts.

Exception: The ampere rating of a motor rated 1/8 horsepower (94 W output) or less or a nonmotor load of 1 ampere or less may be omitted unless such loads constitute the principal load.

86.4 When a manufacturer produces or assembles appliances at more than one factory, each finished appliance shall have a distinctive marking, which is not prohibited from being in code, by which it is capable of being identified as the product of a particular factory.

86.5 When required by 16.2.4, or the Exception to 50.4.3 or 50.4.7, the appliance shall be marked, "WARNING – Risk of Fire – Do Not Install Closer Than ____ Inches To a Back Wall (side wall, warming surface, or other surface)". When the appliance has been tested at different clearances from combustible and noncombustible surfaces, both clearances shall be marked.

86.6 Where required by 50.4.3 or 50.4.7, a non-adjustable radiant heat food warmer shall be marked "WARNING" and the following or the equivalent: "Risk of Fire install not closer than ____ inches above the food support surface." When the warmer has been tested at different clearances from combustible and non-combustible surfaces, both clearances shall be marked. See 85.4 for adjustable radiant-heat food warmers.

86.7 An appliance having provision for permanent connection to multiple power supplies shall be marked with the word: "CAUTION" and the following or the equivalent: "This appliance has more than one power supply connection point. Disconnect all power supplies before servicing," or the appliance shall be marked as specified in 89.13.

86.8 An appliance that incorporates a part or parts subject to pressure other than municipal water line pressure shall be marked to specify the normal operating pressure(s). See 41.4.1.

86.9 Where required by the Exception to 17.1.4, the appliance shall be marked: "For use on individual branch circuit only" or the equivalent.

86.10 Where required by the Exceptions to 16.3.2 or 28.1.3, the appliance shall be marked to indicate the maximum branch circuit overcurrent protective device current rating. When the marked overcurrent protective device current rating is 20 amperes or less, the marking shall also indicate that the appliance is to be connected to a dedicated branch circuit.

86.11 A two-wire, 220 – 240 volt cord-connected appliance intended for connection to a circuit operating at 150 volts or less to ground shall be marked: "Do not connect to a circuit operating at more than 150 volts to ground" or with equivalent wording. See 83.4.

86.12 A three-wire, three-phase, 220 – 240 volt cord-connected appliance intended for connection to branch-circuit conductors operating at 150 volts or less to ground shall be marked: "Do not connect to a circuit operating at more than 150 volts to ground" or with equivalent wording. The marking shall identify the plug pins that are to be supplied by circuit conductors of 150 volts or less to ground. See 83.4.

86.13 When required by 2.32(b), 10.4.1, 140.2, or the Exception to 10.1.6, the cover of the compartment shall be marked "WARNING" and the following or the equivalent: "To reduce the risk of electric shock, do not remove or open cover. No user-serviceable parts inside. Refer servicing to qualified personnel." The marking shall be located on or adjacent to the cover of the compartment.

86.14 An electrical accessory intended for field installation in or on an appliance shall be marked with the name or identifying symbol of the manufacturer or private labeler, with a catalog number or equivalent with which it is intended to be used. The appliance shall be marked to indicate the catalog number or equivalent designation of such an accessory and the name of the manufacturer or private labeler of that accessory. See 6.12.

86.15 When required by 21.1, 83.6, or the Exception to 47.5, an attachment plug receptacle shall be marked with the load, in amperes or watts, on or adjacent to the receptacle where it is clearly visible to the user when plugging in an attachment plug to the receptacle.

86.16 A receptacle intended only for the connection of a part of the appliance or a specific accessory or accessories, see 21.2, shall be marked to specify the part, accessory or accessories to be connected. The marking shall include the model number(s) of the accessory or accessories, or the maximum electrical ratings.

86.17 When required by 17.5.1(h), the following permanent markings shall be provided on a product that contains two power supply cords:

a) "CAUTION – This unit has two power supply cords. Unplug both cords before moving or servicing this appliance."

b) The appliance nameplate electrical rating shall be as shown in 86.19.

86.18 When required by Exception No. 1 of 17.5.1(d), the appliance shall be marked, "CAUTION – This Product has Two Power Supply Cords. Connect Each Plug to a Receptacle that is Connected to an Individual Branch Circuit."

86.19 When two power supply cords are provided, an electrical rating for each cord shall be provided on the appliance. When the appliance does not meet the requirements for Exception No. 1 or Exception No. 2 of 17.5.1(d), the total electrical rating shall also be marked on the appliance as follows:

(Example)

	ELECTRICAL RATING
Warmer	120 V, 10 A, 1200 W*, 60 Hz
Refrigerator	120 V, 7 A, 60 Hz
Total	120 V, 17 A, 60 Hz

* Wattage rating is not required

86.20 The markings in 86.17 and 86.18 are not prohibited from being combined into the following:

"CAUTION – This product has two power supply cords. Connect each plug to a receptacle that is connected to an individual branch circuit. Unplug both cords before moving or servicing this appliance."

86.21 When required by 17.5.2, the following permanent markings shall be provided on a bank or stack of appliance:

a) "Caution – This group of appliances has multiple power supply cords. Disconnect all power supply cords before moving or servicing this appliance."

b) Each appliance shall be provided with a separate, individual nameplate in accordance with 86.2.

86.22 In accordance with the Exception to 17.5.1(f), the following marking shall be provided adjacent to each disconnect switch or control: "CAUTION – This unit has more than one disconnect switch", or an equivalent wording.

86.23 Where required by 10.4.7(d), the appliance shall be marked: "CAUTION – Risk of electric shock. Do Not Obstruct Access to this Panelboard. No Storage in this Area." The marking shall be located on or adjacent to the panelboard where visible from the direction of access.

87 Graphical Symbols and Supplemental Markings

87.1 No user-serviceable parts compartment warning

87.1.1 The combination of the two graphical symbols (a lightning flash with arrow point within an equilateral triangle, and an exclamation point within an equilateral triangle) and the supplemental marking – "WARNING – RISK OF FIRE OR ELECTRIC SHOCK – DO NOT OPEN" depicted in Figure 87.1 may be provided on the surface of the appliance enclosure through which the user might gain access to the interior, as an alternative to the marking required by 86.13.