UL 963

STANDARD FOR SAFETY

Sealing, Wrapping, and Marking Equipment

UL Standard for Safety for Sealing, Wrapping, and Marking Equipment, UL 963

Fourth Edition, Dated February 26, 2016

Summary of Topics

This new edition of UL 963 is being issued to add requirements for Electronic Circuits to Paragraphs 4.38, 22.2.1, 25.2, 32.15, and to Supplement SA.

The requirements are substantially in accordance with Proposal(s) on this subject dated December 9, 2015.

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UL 963

Standard for Sealing, Wrapping, and Marking Equipment

Prior to the first edition, the requirements for the products covered by this Standard were included in the Standard for Electric Heating Appliances, UL 499, and the Standard for Motor-Operated Appliances, UL 73.

First Edition – November, 1997
Second Edition – December, 2010
Third Edition September, 2011

Fourth Edition

March 3, 2016

This UL Standard for Safety consists of the Fourth Edition.

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

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

PROTECTION AGAINST INJURY TO PERSONS

PERFORMANCE

SUPPLEMENT SA - REQUIREMENTS FOR THE EVALUATION OF ELECTRONIC CIRCUITS

INTRODUCTION

CONSTRUCTION

PERFORMANCE

INTRODUCTION

1 Scope

1.1 These requirements cover household, industrial, and commercial sealing, wrapping, and marking equipment rated at 600 volts or less for use in unclassified locations in accordance with the National Electrical Code, NFPA 70, such as laminators, label makers/applicators, stamping machines, taping machines, wrapping machines, shrink tunnels, bag sealers, bag tying machines, heat sealing irons, and vacuum packaging machines.

1.2 These requirements also cover cord-connected units with an integral cigarette lighter connector assembly, or a direct current (DC) input jack for being powered from a separate Vehicle Battery Adapter.

1.3 These requirements do not cover appliances and equipment that are covered by individual requirements that are separate from this standard, such as soldering irons, ink-jet printers, or photographic film printers.

1.4 These requirements do not cover appliances and equipment that are intended for use in marine or aircraft.

2 Units of Measurement

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

2.2 Unless otherwise indicated, all voltage and current values mentioned in this standard are root-mean-square (rms), and all pressures are calculated in per square inch (psi).

3 Undated References

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

4 Glossary

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

4.2 APPLIANCE COUPLER – A single-outlet, female contact device for attachment to a flexible cord as part of a detachable power-supply cord to be connected to an appliance inlet (motor attachment plug).

4.3 APPLIANCE INLET (MOTOR ATTACHMENT PLUG) – A male contact device mounted on an end product appliance to provide an integral blade configuration for the connection of an appliance coupler or cord connector.

4.4 APPLIANCE (FLATIRON) PLUG – An appliance coupler type of device having a cord guard and a slot configuration specified for use with heating or cooking appliances.

4.5 AUTOMATICALLY CONTROLLED APPLIANCE – An appliance that complies with one or more of the following conditions:

a) The repeated starting of the appliance is independent of any manual control if, after one complete cycle of operation, a limit device or similar component opens the circuit;

b) During any single preset cycle of operation, the motor is caused to stop and restart;

c) When the appliance is energized, the initial starting of the motor may be intentionally delayed beyond intended, conventional starting; and

d) For an appliance using a motor with a separate starting winding, during any single predetermined cycle of operation, automatic changing of the mechanical load reduces the motor speed sufficiently to re-establish starting-winding connections to the supply circuit.

4.6 AUXILIARY CONTROL – A control that is intended primarily for time, temperature, or pressure regulation under conditions of intended operation, and not for protection against overload or excessive conditions resulting from abnormal operation.

4.7 BRANCH CIRCUIT – That portion of the building wiring system beyond the final overcurrent device on the power-distribution panel protecting the circuit to the field-wiring terminals in a permanently connected unit or to the receptacle outlet for cord-connected units.

4.8 CABINET – Refers to a housing of a unit that prevents access to a part that involves a risk of injury to persons as a result of hazardous moving parts or hot parts. The use of a cabinet to prevent access to a part that involves a risk of fire, electrical energy – high current levels, or electric shock is permitted.

4.9 CIGARETTE LIGHTER CONNECTOR – The male connector provided as part of a Vehicle Battery Adapter for insertion into a cigarette lighter receptacle.

4.10 CONTROL, AUTOMATIC ACTION – A control in which at least one aspect is non-manual.

4.11 CONTROL, AUXILIARY – A device or assembly of devices that provides a functional utility, is not relied upon as an operational or protective control, and therefore is not relied upon for safety. For example, an efficiency control not relied upon to reduce the risk of electric shock, fire, or injury to persons during normal or abnormal operation of the end product is considered an auxiliary control.

4.12 CONTROL, MANUAL – A device that requires direct human interaction to activate or rest the control.

4.13 CONTROL, OPERATING – A device or assembly of devices, the operation of which starts or regulates the end product during normal operation. For example, a thermostat, the failure of which, a thermal cutout/limiter or another layer of protection would reduce the risk of electric shock, fire, or injury to persons, is considered an operating control.

4.14 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during reasonably anticipated abnormal operation of the appliance.

4.15 CONTROL, TYPE 1 ACTION – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence has not been declared and tested under this standard.

4.16 CONTROL, TYPE 2 ACTION – The actuation of an automatic control for which the manufacturing deviation and the drift (tolerance before and after certain conditions) of its operating value, operating time, or operating sequence have been declared and tested under this standard.

4.17 CORD-CONNECTED UNIT – A unit intended for connection to the branch-circuit power line by means of a power-supply cord. By the nature of its construction, such a unit is intended to be removed for reasons of interchange or realignment of the unit of a system.

4.18 CORD CONNECTOR – A female contact device wired on flexible cord for use as an extension from an outlet to make a detachable electrical connection to an attachment plug or, as an appliance coupler, to an equipment inlet.

4.19 ENCLOSURE – Refers to a housing of a unit that prevents access to a part that involves a risk of fire, electrical energy at high current levels, or electric shock. The use of an enclosure to prevent access to a part that involves a risk of injury to persons which is present from hazardous moving parts or hot parts is permitted.

4.20 FIELD-WIRING TERMINAL – Any terminal to which a supply or other wire is to be connected by an installer in the field, unless the wire is provided as part of the unit and a connector, soldering lug, soldered loop, crimped eyelet, pressure terminal, or other means for making the connection is factory-assembled to the wire.

4.21 FIXED EQUIPMENT – Units that are:

a) Intended for permanent connection to the branch circuit,

b) Mechanically secured to the surface on which they are intended to be mounted, and

c) Neither intended by the manufacturer nor constructed for easy removal by service personnel from their intended location for maintenance and repair.

4.22 FLAMMABLE LIQUID – Any liquid having a flash point in accordance with the Standard for Tests for Comparative Flammability of Liquids, UL 340.

4.23 FLASH POINT – The minimum temperature, corrected to a pressure of 101.3 kPa (14.69 psi), at which a liquid gives off vapor within a test vessel in enough quantity to form an ignitable mixture with air above the surface of the liquid.

4.24 GUARD – Refers to a part inside or outside of the enclosure which prevents access to a component that involves a risk of injury to persons.

4.25 IGNITION TEMPERATURE – The minimum temperature to which any part of an air-vapor mixture must be raised by application of heat to produce self-sustained (autogenous) combustion, as indicated by the appearance of flame.

4.26 INTERNAL BARRIER – Refers to a part inside an enclosure which prevents access to a part that involves a risk of electric shock or injury to persons.

4.27 LINE-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage circuit. See 4.28.

4.28 LOW-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 30 volts (42.4 volts peak) and supplied by:

a) A battery,

b) A standard Class 2 transformer, or

c) A transformer with:

1) A fixed impedance,

2) A fuse,

3) A non-adjustable manual-reset circuit-protective device, or

4) A regulating network

which, as a unit, complies with all of the performance requirements of a Class 2 transformer. A circuit derived from a source of supply classified as a line-voltage circuit and a resistance in series with the supply circuit as a means of limiting the voltage and current is not determined to be a low-voltage circuit.

4.29 LOWER FLAMMABLE LIMIT – The minimum concentration of vapor in air below which propagation of flame does not occur on contact with a source of ignition. The lower flammable limit is expressed in terms of percentage by volume of gas or vapor in air based on atmospheric temperatures and pressures.

4.30 OPERATOR ACCESSIBLE AREA – All external surface areas, all internal areas that are capable of being entered without the use of tools, and all areas that the operator is instructed to enter regardless of whether or not tools are required to gain access.

4.31 OPERATOR SERVICING – Any form of servicing that is capable of being performed by personnel other than those who are trained to maintain the unit. Some examples of operator servicing are:

a) The installation of accessories by means of attachment plugs and receptacles or by means of other separable connectors.

b) Replacement of lamps and fuses and resetting of circuit breakers located in an operator-accessible area, unless the lamps, fuses, or circuit breakers are marked to indicate replacement or resetting only by qualified service personnel.

c) The making of routine operating adjustments required to adapt the unit for its different intended functions.

d) Routine cleaning or servicing.

4.32 PRESSURE-RELIEF DEVICE – A pressure-actuated valve or rupture member intended to relieve excessive pressures automatically.

4.33 PRIMARY CIRCUIT – Wiring and components that are electrically connected to a branch-circuit or an alternating-current or direct-current motor/generator set installed separately from or included as a part of a unit or system.

4.34 RISK OF ELECTRIC SHOCK – A risk of electric shock is determined to occur at any part when the potential between the part and earth ground or any other accessible part is more than 42.4 volts peak or the continuous current flow through a 1500-ohm resistor connected across the potential exceeds 5 milliamperes.

4.35 RISK OF FIRE – A risk of fire is determined to exist at all components and conductors unless the components and conductors are within a circuit which complies with the criteria for Class 2 circuits.

4.36 RISK OF INJURY TO PERSONS – A risk of injury to persons is determined to exist when one or more of the following conditions occur:

a) Moving parts such as gears and linkages are accessible during intended operation and are capable of resulting in a cut, crush, or laceration.

b) Sharp edges, burrs, or projections are present that are capable of resulting in injury during use or operator servicing.

c) The stability of a unit is such that it is capable of resulting in injury to persons.

d) Moving parts are present for which there is a risk that a part of the body becomes endangered or that clothing becomes entangled by the moving part, resulting in an injury.

e) Parts maintaining an elevated temperature that are subject to contact by persons by either intentional or casual fashion and capable of causing a burn.

4.37 SAFETY CIRCUIT – Any primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, injury to persons, or electrical energy at high current levels.

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

4.39 SAFETY INTERLOCK – A means relied upon to prevent access to an area that involves a risk of electric shock, electrical energy at high current levels, or injury to persons until the risk has been removed, or to remove automatically the risk when access is gained.

4.40 SECONDARY CIRCUIT – A circuit supplied from the secondary winding of an isolation transformer and that has no direct connection to the primary circuit (other than through the grounding means). Any circuit that has a direct connection to the line-connected circuit is evaluated as a primary circuit. A secondary circuit is capable of being a low-voltage circuit.

4.41 SUPPLY CORD – A separable cord set or a length of flexible cord, with one end connected to the primary-circuit wiring of the unit and the other end connected to the attachment plug for connection to branch-circuit power.

4.42 TEMPERATURE-LIMITING CONTROL – A control that functions only under conditions that produce abnormal temperatures. The malfunction of such a thermostat is capable of resulting in a risk of fire.

4.43 TEMPERATURE-REGULATING CONTROL – A control that functions only to regulate the temperature of the product under intended conditions of use, and whose malfunction does not result in a risk of fire.

4.44 TEMPERATURE-REGULATING AND -LIMITING CONTROL COMBINATION – A combination temperature-regulating and -limiting control that functions to regulate the temperature of the product under intended conditions of use, and also serves to reduce the risk of fire that results from conditions of abnormal operation.

4.45 THERMISTOR DEVICE – A thermally sensitive semiconductor resistor that is intended to be heated by an electric current and shows a sharp resistance increase over a small temperature range such as Positive Temperature Coefficients (PTC's) and Negative Temperature Coefficients (NTC's).

4.46 TOOL – A screwdriver, wrench, or any other object that is capable of being used to operate a screw, latch, bolt, or similar fastening means.

5 Safety Critical Functions

5.1 Any function involved in the control, protection, and monitoring of safety-related attributes of sealing, wrapping and marking equipment whereby a loss/malfunction of its functionality would represent an unacceptable risk of fire, electric shock, or casualty hazards would be considered a Safety Critical Function.

5.2 Electronic circuits that manage a Safety-Critical Function (SCF) shall be:

a) Reliable as defined as being able to maintain the SCF in the event of single defined component faults and

b) Not susceptible to electromagnetic environmental stresses encountered in the anticipated environments of the appliance.

5.3 Electronic circuits managing Safety Critical Functions shall comply with:

a) Requirements for the Evaluation of Electronic Circuits, Supplement SA or

b) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 and it's Part 2's as specified in this standard. The function shall be considered Class B.

5.4 Functions specified in Safety Critical Functions, Table 5.1 represent the common safety critical circuit functions of microwave ovens. It is not intended to represent all possible safety critical functions.

Table 5.1
Safety critical functions

Function (see 5.1)	Hazard	Location of parameters and tests
Motor running overload protection	Risk of fire or electric shock	Overload protection, 22.2
Motor locked rotor protection	Risk of fire or electric shock	Overload protection, 22.2
Motor short circuit protection	Risk of fire or electric shock	Overload protection, 22.2
Temperature control	Risk of fire or electric shock	25.2
Interlock function to de-energize a motor	Risk of personal injury	Electronic protective controls (limiting controls), 33.4
Loss of phase	Risk of electric shock	Electronic protective controls (limiting controls), 33.4

CONSTRUCTION

6 General

6.1 Only materials that have been evaluated for the particular use shall be used in these products. A product shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

6.2 When the operation of a product involves the generation and confining under pressure of steam or other gas, risk of explosion incident to such operation shall be evaluated. For example, a product having immersed electrodes, where the electrolysis of water results in the accumulation of oxygen and hydrogen. The product does not comply with the intent of this standard unless its strength has been investigated with regard to any risk of explosion that is capable of occurring.

7 Components

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

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

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

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

d) Additionally comply with the applicable requirements of this 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 of the National Electrical Code, ANSI/NFPA 70, where appropriate;

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

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

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

7.3 A component that is also intended to perform other functions, such as:

a) Overcurrent protection;

b) Ground-fault circuit-interruption;

c) Surge suppression;

d) Any other similar functions; or

e) Any combination thereof

shall comply additionally with the requirements of the applicable UL standard(s) that cover devices that provide those functions.

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

7.4 A component not anticipated by the requirements of this 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 7.1 (b) – (e).

7.5 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 standard.

8 Frame and Enclosure

8.1 General

8.1.1 The frame and enclosure of a product shall resist the abuses to be encountered during intended use. The degree of resistance shall reduce the possibility of a condition that results in an increase in the risk of fire, electric shock, or injury to persons.

8.1.2 The strength and rigidity of the frame and enclosure shall comply with the tests described in 67.1 – 67.4, as applicable.

8.1.3 A product shall be provided with an enclosure made of material that has been determined to be capable for use in this application. The enclosure shall house all electrical parts, except a supply cord and a recessed open-wire-element unit as specified in 19.5, that are capable of resulting in a risk of electric shock or injury to persons under any condition of use. When a product is constructed for permanent installation and connection to the power supply, the enclosure shall be provided with means for mounting in the intended manner and shall be furnished with any required fittings, such as brackets or hangers.

8.1.4 When ventilation openings are provided in the enclosure of a product, they shall be located so that they do not vent into concealed spaces of a building structure, such as a false-ceiling space or hollow spaces in the wall when the product is installed.

8.1.5 Among the factors to be determined when evaluating an enclosure are its:

a) Physical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Combustibility,

e) Resistance to corrosion, and

f) Resistance to distortion at temperatures to which the enclosure is capable of being subjected under conditions of use.

Except for (e), all of the preceding factors shall be used to determine the suitability of a nonmetallic enclosure. A sheet-metal enclosure shall be evaluated with regard to its size, shape, the thickness of metal, and the intended use of the product.

8.1.6 Cast and sheet-metal portions of the enclosure shall not have a thickness less than that indicated in Table 8.1 unless the enclosure complies with 8.1.5.

Table 8.1
Minimum thickness of metal enclosure

Metal	At small, flat, unreinforced surfaces, and at surfaces that are reinforced by curving, ribbing, and similar methods (or are otherwise of a shape and/or size to provide physical strength), inch	(mm)	At surfaces to which a wiring system is to be connected in the field, inch	(mm)	At large, unreinforced flat surfaces, inch	(mm)
Die-cast	3/64	(1.2)	–	–	5/64	(2)
Cast-malleable iron	1/16	(1.6)	–	–	3/32	(2.4)
Other cast metal	3/32	(2.4)	–	–	1/8	(3.2)
Uncoated sheet steel	0.026[a]	(0.66[a])	0.032	(0.81)	0.026	(0.66)
Galvanized sheet steel	0.029[a]	(0.74[a])	0.034	(0.86)	0.029	(0.74)
Nonferrous sheet metal	0.036[a]	(0.91[a])	0.045	(1.14)	0.036	(0.91)

[a] Thinner sheet metal is not prohibited from being used when it has been determined to be suitable for its intended use when the enclosure is evaluated under considerations such as those specified in 8.1.4.

8.1.7 Electrical parts of a product shall be located or enclosed so as to provide protection against unintentional contact with uninsulated live parts.

8.1.8 The enclosure shall be constructed such that molten metal, burning insulation, or flaming particles are not capable of falling on combustible materials, including the surface upon which the enclosure is supported. The product shall be provided with a barrier of metal, phenolic, urea, ceramic, or similar material located:

a) Under a motor unless:

1) The structural parts of either the motor or the product are determined to be the equivalent of such a barrier;

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

i) Open main winding,

ii) Open starting winding, and

iii) Short-circuited starting switch;

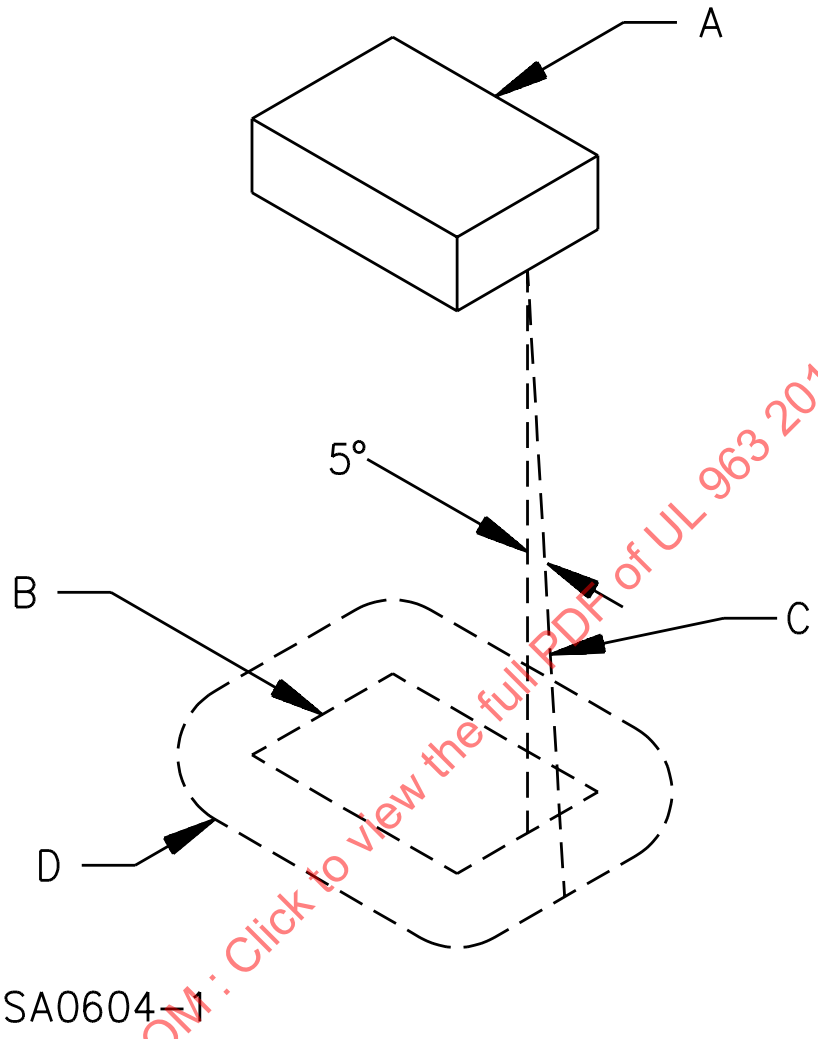
3) The motor is provided with a thermal motor protector that limits the motor winding temperature to maximum 125°C (257°F) under the maximum load under which the motor runs without causing the protector to cycle, and to maximum 150°C (302°F) with the rotor locked; and

4) The motor complies with the Standard for Thermally Protected Motors, UL 1004-3.

b) Under wiring, unless the wiring complies with the VW-1 flame test in the Standard for Thermoplastic-Insulated Wires and Cables, UL 83.

8.1.9 The barrier specified in 8.1.8 shall be horizontal and shall be located and sized as indicated in Figure 8.1. Openings for drainage or ventilation are not prohibited as long as molten metal, burning insulation, or flaming particles are not capable of falling through the opening onto combustible material.

Figure 8.1
Location and extent of barrier



A – Region to be shielded by barrier. This consists of the entire component when it is not otherwise shielded and is to consist of the unshielded portion of a component that is partially shielded by the component enclosure or part that has been determined to be equivalent.

B – Projection of outline of component on horizontal plane.

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

1) Tangent to the component,

2) Five (5) degrees from the vertical, and

3) Oriented so that the area traced out on a horizontal plane is maximum.

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

8.1.10 A component such as a switch, transformer, relay, solenoid, or similar components shall be individually and completely enclosed unless it is determined that malfunction of the component does not result in a fire, electric shock, or risk of injury to persons, or unless there are no openings in the bottom of the enclosure. An opening in the bottom of the enclosure does not comply with the intent of this requirement when it is located directly below field or factory-made splices or overload or overcurrent protective devices.

8.2 Accessibility

8.2.1 To reduce the risk of unintentional contact of uninsulated live parts or film-coated wire that is capable of involving a risk of electric shock or injury to persons, an opening in an enclosure shall comply with either of the following items:

a) For an opening that has a minor dimension less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the articulate probe illustrated in Figure 8.2 or

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 8.2.

See 8.2.3 for a definition of the minor dimension of an opening.

Figure 7.2
Articulate probe with web stop

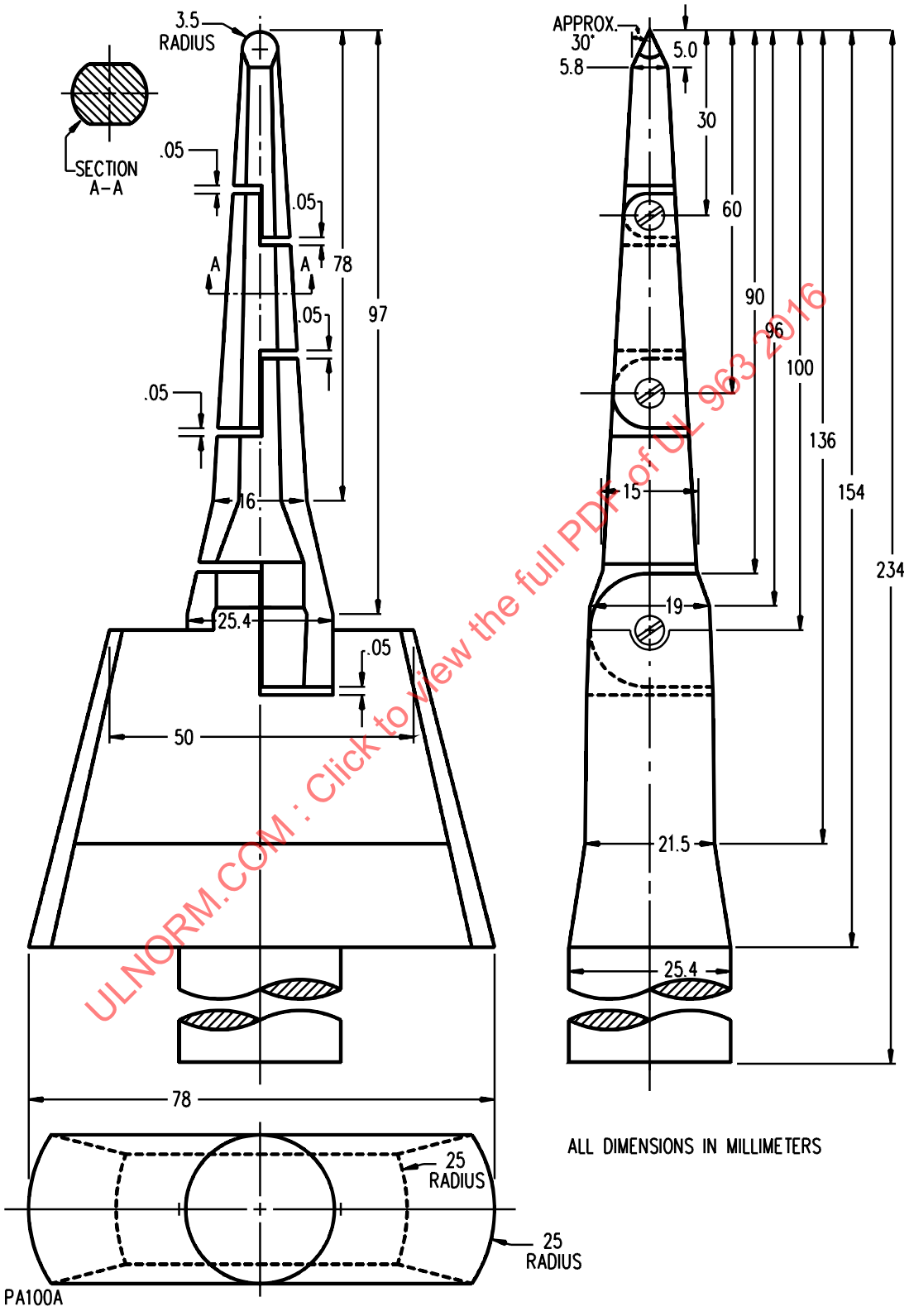


Table 7.2
Minimum distance from an opening to a part that involves a risk of electric shock or injury to persons

Minor dimension of opening,[a] inches[b]	(mm)[b]	Minimum distance from opening to part, inches	(mm)
1	(25.4)	6-1/2	(165)
1-1/4	(31.8)	7-1/2	(190)
1-1/2	(38.1)	12-1/2	(318)
1-7/8	(47.6)	15-1/2	(394)
2-1/8	(54.0)	17-1/2	(444)
6[c]	(152.0[c])	30	(762)

[a] See 8.2.3.
[b] Between 1 and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.
[c] More than 2-1/8 inches, but not more than 6 inches (152 mm).

8.2.2 Unless otherwise specified, the probe illustrated in Figure 8.2 shall be applied to any depth that the opening permits, and shall be rotated or angled before, during, and after insertion through the opening to any position that is required to examine the enclosure. The probe shall be applied in any possible configuration; and, when required, the configuration shall be changed after insertion through the opening.

8.2.3 The minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that is capable of being inserted through the opening.

8.2.4 The probe illustrated in Figure 8.2 shall be used as a measuring instrument to evaluate the accessibility provided by an opening, and not as an instrument to evaluate the strength of a material; it shall be applied with the minimum force required to determine accessibility.

8.2.5 During the examination of the product for compliance with the requirements in this section, a part of the outer enclosure that is capable of being removed by the user without the use of tools is to be disregarded, that is, it is not to be assumed that the part in question affords protection against the risk of electric shock. A warning marking, such as that specified in 75.2, is not determined to eliminate this risk of electric shock.

8.2.6 A marking shall not draw the user's attention to an opening in the enclosure for the adjustment of a component or control when a 1/16 inch (1.6 mm) diameter rod is capable of contacting insulation or uninsulated live parts.

8.2.7 Moving parts shall be enclosed or guarded to reduce the risk of injury to persons. The degree of protection required of the enclosure depends upon the general construction and intended use of the product. The factors to be taken into consideration in evaluating the acceptability of exposed moving parts are:

a) The degree of exposure;

b) The sharpness of the moving parts;

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

d) The speed of movement of those parts; and

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

8.2.8 The door or cover of an enclosure shall be provided with a means for securing it in place in the closed position. The door or cover of an enclosure shall be hinged or otherwise attached in a manner that has been determined to be equivalent when it gives access to any overload protective device whose functioning requires renewal, or when it is required to open the cover in connection with the operation of the protective device. Such a door or cover shall be provided with a latch or device that has been determined to be equivalent, and shall be tight-fitting or shall overlap the surface of the enclosure around the opening.

8.2.9 A component that requires inspection, replacement, cleaning, or other servicing shall be as accessible to the user as possible. The component shall be readily accessible without the use of special tools (those not available to other than service personnel) when it is intended to be manually operated or adjusted or periodically serviced.

8.2.10 When a product is intended primarily for use in public places, such as grocery stores or theaters:

a) The construction is such that special tools are required to gain access to components that require inspection, replacement, cleaning, adjustment, or other servicing and

b) A door or cover giving access to an overload protective device is not required to be provided with a hinge, latch, or part that has been determined to be equivalent when the cover must be in place to perform its function.

8.2.11 The bulb and capillary tube of a thermostat shall be protected from physical damage when such damage of the tube or bulb is capable of resulting in a risk of fire.

8.2.12 A cord-connected product that is provided with slots, notches, or holes for mounting the product on a wall shall be constructed in such a manner that the mounting means (screws, bolts, and similar parts) shall not be accessible without removing the product from the wall.

8.2.13 When determining compliance with 8.2.12, any part of the enclosure or barrier that is capable of being removed without the use of tools to gain access to the mounting means is to be removed prior to conducting an examination.

8.2.14 An opening in a product provided for mounting shall be located or guarded so that a nail or hook:

a) Does not displace a part that creates a risk of fire or electric shock and

b) Does not contact uninsulated live parts, magnet wire, internal wiring, moving parts, or other parts that create a risk of fire or electric shock.

8.2.15 A enclosure or 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.

8.3 External materials

8.3.1 Material such as steel, aluminum, glass, plastic, or other similar materials are not prohibited from being used for the enclosure, guard, or cabinet of a unit. Glass shall be heat-resistant, tempered, wired, or laminated.

8.3.2 Plastic materials used for part or all of an enclosure shall comply with the requirements in this section and with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. In applying the requirements in UL 746C, movable units having a mass less than 40 lbs (18.1 kg) shall be treated as portable equipment; other movable units shall be treated as stationary equipment.

8.3.3 Plastic materials used for a cabinet, a part of a cabinet, and for other external parts which do not serve as an enclosure, guard, or barrier shall have a minimum flame rating of HB. Small external parts that contribute a negligible amount of fuel to a fire are not required to be investigated.

8.3.4 An external surface of combustible material having an exposed area greater than 10 square feet (0.93 m^2) or a single dimension larger than 6 feet (1.83 m) shall have a flame spread rating of 200 or less when tested in accordance with one of the following:

a) The Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723, or

b) The requirements of the radiant panel flame spread test in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

8.3.5 The dimension limits specified in 8.3.4 refer to the exposed surface area of a single unbroken section. When two sides of a single unbroken section are exposed, only the larger side is to be evaluated in computing the area.

8.3.6 Conductive coatings applied to surfaces such as the inside surface of a cover or enclosure shall comply with the requirements for Metallized Parts described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, unless it is determined that flaking or peeling of the coating is not capable of resulting in the reduction of spacings or the bridging of live parts that is capable of presenting a risk of electric shock or fire.

8.4 Internal materials

8.4.1 All combustible materials used within an enclosure shall have a minimum flame rating of V-2 or HF-2.

Exception No. 1: The following materials may have a minimum flame rating of HB:

a) Electrical components within Class 2 circuits, other than printed-wiring boards employing only Class 2 circuits;

b) Tubing for air or fluid systems and containers for powders; and

c) The combustible material is completely enclosed within enclosure of portable attended household equipment.

Exception No. 2: Foamed plastics are not prohibited from having a minimum flame rating of HBF.

Exception No. 3: The following materials are not required to have an established flame rating:

a) Meter faces and cases (of the type required for mounting live parts) and indicator lamps and lenses;

b) Components within a unit that has a volume of not more than 2 cubic feet (0.57 m^3) when they are totally enclosed in metal and have no ventilation openings;

c) Components within a sealed unit containing an inert gas;

d) Integrated circuit packages, transistor packages, opto-isolator packages, capacitors, and other parts of similar size when the parts are mounted on a material rated minimum V-1;

e) Components isolated from uninsulated electrical parts that involve a risk of fire by either:

1) At least 0.5 inch (12.7 mm) of air, or

2) A solid partition of material rated minimum V-1;

f) Gears, cams, belts, bearings, strain-relief bushings, and other parts that contribute negligible fuel; and

g) Motors, relays, capacitors, transformers, switches, insulating tubing or tape, and other electrical components when they comply with the requirements applicable to the component.

8.4.2 Barriers used in an operator accessible area shall comply with the Tests for Guards, Enclosures, and Operator-Accessible Barriers, Section 67.

8.5 Handles

8.5.1 A handle or handles intended for lifting or carrying a unit shall comply with the Handle Strength Test, Section 65.

8.6 Mounting means

8.6.1 A support bracket or hanger of a wall-mounted product shall comply with the Strength of Mounting Test, Section 66.

8.7 Stability

8.7.1 A non-hand-held product shall comply with the Physical Stability Tests, Section 64.

9 Assembly

9.1 A product, such as a sealing iron, that is intended to be placed on combustible material, or against which combustible material is capable of being laid, shall be provided with a stand, guard, or both, of noncombustible material upon which it shall be placed when not in use.

Exception: A stand or guard is not required for a product that complies with the surface temperature requirements of 48.22.

9.2 Uninsulated live parts shall be secured so that they are prevented from turning or shifting in position when such motion is capable of resulting in a reduction of spacings below the minimum values specified in Table 17.2.

9.3 Friction alone between surfaces shall not be used as a means to prevent shifting or turning of live parts. A toothed lock washer or similar device is not prohibited from being used to prevent shifting or turning of live parts.

9.4 A product shall be assembled so that it is not adversely affected by the vibration of normal operation. Brush caps shall be tightly threaded or otherwise constructed to prevent loosening. A rotating part that by loosening presents a risk of fire, electric shock, or injury to persons shall be assembled so that the direction of rotation tends to tighten the means that hold the rotating part in place.

Exception: A keyed part, a press fit, a part locked in place with a pin, or a method that has been determined to be equivalent is not prohibited from being used to hold a rotating part in place.

9.5 A switch, fuseholder, pilot-light, receptacle, motor-attachment plug, or other similar component is not prohibited from rotating when all the following conditions are met:

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

b) The component mounting means is not subject to loosening as the result of operation,

c) The spacings are not reduced below the values specified in Table 17.2 when the component rotates, and

d) The operation of the component is by mechanical means rather than direct contact by persons.

10 Protection Against Corrosion

10.1 Except as noted in 10.2, iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other means, when the deterioration of such unprotected parts results in a risk of fire, electric shock, explosion, or injury to persons.

10.2 In equipment where the oxidation of steel is not accelerated due to the exposure of metal to air and moisture or other oxidizing influence (thickness of metal and temperature also being factors) surfaces of sheet steel within an enclosure are not be required to be protected against corrosion. A sheath used on a heating element operating in air and terminal parts attached directly to the heating element are not required to be protected against corrosion. Bearings, laminations, and minor parts of iron or steel, such as washers and screws, that are not relied upon for grounding are not required to be protected.

11 Supply Connections

11.1 Permanently-connected products

11.1.1 General

11.1.1.1 A product intended for permanent electrical connection to the power supply shall have provision for connection of one of the wiring systems that are intended for the product, in accordance with the National Electrical Code, ANSI/NFPA 70.

11.1.1.2 When supply connections are intended to be made directly to a motor provided with a product, the terminal compartment on the motor shall comply with the requirements for terminal compartments in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

11.1.1.3 A terminal box or compartment intended for permanent connection to the power supply shall be located such that the connections are capable of being readily inspected after the product is installed as intended.

11.1.1.4 A terminal compartment intended for the connection of a supply raceway shall be secured to the product so that it does not turn with regard to the product.

11.1.1.5 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 device (switch, pilot light, etc.) is not prohibited from being mounted on a wiring compartment cover as long as:

a) The component connecting leads are of such length that they are not capable of being moved aside and do not obstruct the making, and examination, of field-wiring connections;

b) None of the component connections are to be field wired;

c) Strain relief is provided to prevent stress of wire movement from being transmitted to the component wiring terminations, and it complies with the Strain Relief Test, Section 62;

d) The minimum size of the component leads is 18 AWG (0.82 mm^2);

e) Wiring terminations on the component are recessed or protected by barriers made from insulating material or material that has been determined to be equivalent that provides protection from either contact with wiring installed in the box or unintentional contact by persons during installation or inspection of field wiring; and

f) The component is located in a Class 2 circuit.

11.1.2 Wiring terminals

11.1.2.1 A product intended for permanent connection to the power supply shall be provided with wiring terminals or leads for the connection of conductors having an ampere rating of not less than 125 percent of the current rating of the product when the load is continuous (3 hours or more) and not less than the current rating of the product when the load is to be intermittent.

11.1.2.2 For the purpose of these requirements, wiring terminals are determined to be terminals to which power-supply or control connections are made in the field when the product is installed. It is assumed that 60°C (140°F) wire is to be used for connections to:

a) A continuous-load type of appliance rated at 80 amperes or less and

b) An intermittent-load type of appliance rated at 100 amperes or less.

Wire rated for 75°C (167°F) is assumed to be used with products rated in excess of these values.

Exception: When temperatures at the points described in 74.9 exceed 60°C when tested in accordance with the Normal Temperature Test, Section 48, the product shall be marked in accordance with 75.9 to indicate the wire size and temperature rating that shall be used for the supply connections.

11.1.2.3 A wiring terminal shall be provided with a soldering lug or with a pressure-wire connector securely fastened in place (i.e. bolted or held by a screw) except that a wire-binding screw is not prohibited from being employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor when upturned lugs or parts that have been determined to be equivalent are provided to hold the wire in position.

11.1.2.4 A wiring terminal shall not turn or shift in position. The use of two screws or rivets, by square shoulders, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or some other method that has been determined to be equivalent is not prohibited from being used to prevent a wiring terminal from turning or shifting. Friction between surfaces shall not be used as a means to prevent turning or shifting.

11.1.2.5 A wire-binding screw at a wiring terminal shall not be smaller than No. 10.

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

Exception No. 2: A No. 6 screw is not prohibited from being used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) control-circuit conductor.

11.1.2.6 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.3 mm) thick, except that a plate not less than 0.03 inch (0.8 mm) thick shall be used when the tapped threads have reliable mechanical strength. Terminal plates that are not less than 0.03 inch thick shall comply with the requirements of the Torque Test, Section 69. There shall be two or more full threads in the metal, which is not prohibited from being extruded when required to provide the threads.

11.1.2.7 Upturned lugs or a cupped washer shall be capable of retaining a conductor under the washer or the head of the screw.

11.1.2.8 A wire-binding screw shall not thread into surfaces other than metal.

11.1.2.9 A product intended for connection to a grounded power supply shall have one terminal or lead identified for connection of the grounded conductor of the supply circuit as follows:

a) The terminal shall be made of or plated with a metal white in color;

b) The terminal shall have the word ″white″ or ″neutral″ located adjacent to the terminal and shall be readily distinguishable from the other terminals; or

c) Proper identification of that terminal shall be clearly shown in some other manner, such as on a wiring diagram provided with the product.

A lead shall be finished to show a white or gray color and shall be distinguishable from the other leads.

11.1.2.10 The free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152 mm) or more when the lead is intended for field connection to an external circuit. However, a lead that is less than 6 inches in length is not prohibited when it is evident that the use of a longer lead results in a risk of fire or electric shock.

11.2 Cord-connected products

11.2.1 General

11.2.1.1 A cord-connected product shall be provided with a power-supply cord for connection to the supply circuit. The length of the power-supply cord shall be as specified in Table 11.1. The power-supply cord shall be of a type specified in Table 11.2 and shall comply with the Standard for Cord Sets and Power-Supply Cords, UL 817.

Table 11.1
Lengths of supply cord

Type of product	Minimum length,[a] feet	Minimum length,[a] (m)	Maximum length,[a] feet	Maximum length,[a] (m)
Counter-top, bench-top, or table-top products intended for household use	2.0[b]	(0.6[b])	7.0	(2.1)
All other products	6.0	(1.8)	–	–

[a] Measured external to the product and including the fittings and excluding the blades of the attachment plug.

[b] See 74.11 when cord length is less than 4.5 feet (1.4 m).

Table 11.2
Types of cord and applicable limitations on their use

Type of product	Cords where temperatures exceed 121°C (250°F) on any surface that the cord touches when the product is used as intended	Cords where temperatures are 121°C (250°F) or less on any surface that the cord touches when the product is used as intended
Household, indoor use only	HPD, HPN, HSJ, or HSJO	HPD, HPN, HSJ, HSJO, SP-2, SPE-2, SPT-2, SV, SVO, SVE, SVOO, SVT, SVTO, SJ, SJO, SJE, SJOO, SJT, SJTO, SVTOO, or SJTOO
Commercial or industrial, indoor-use only	HSJ or HSJO	HSJ, HSJO, SJ, SJE, SJOO, SJT, SJO, SJTO, SJTOO, S, SO, SE, SOO, ST, STO, or STOO
Heat-sealing irons	HPD, HPN, HSJ, or HSJO	HPD, HPN, HSJ, HSJO, SJ, SJE, SJO, SJOO, SJT, SJTO, or SJTOO

11.2.1.2 For a cord-connected appliance, the rating (both current and voltage) of the cord and the fittings shall be no less than that of the product. When the load is continuous (3 hours or more), the current rating of the attachment plug shall be no less than 125 percent of the current rating of the product.

Exception: The use of a 15-ampere attachment plug is acceptable for a product rated at not more than 1500 watts at 120 volts, or 3000 watts at 240 volts, and a 20-ampere attachment plug is acceptable for a heater rated at not more than 2000 watts at 120 volts or 4000 watts at 240 volts.

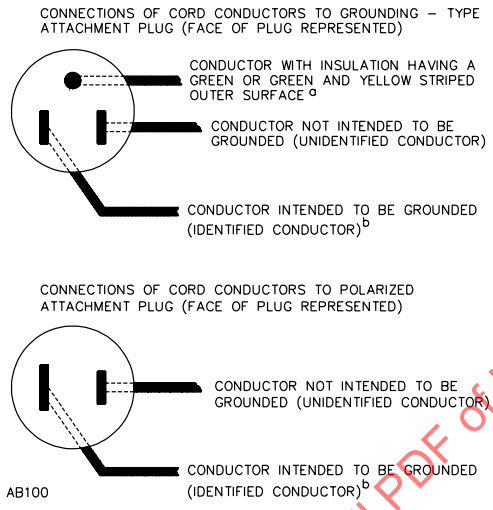
11.2.1.3 Additional insulation, when used on a flexible cord, shall not extend more than 1/2 inch (13 mm) outside the product, unless provided with additional mechanical protection, shall not fray or unravel, and shall not adversely affect the strain relief means.

11.2.1.4 When the power source for a product is electrically separable from the product, both the power source and the product shall be marked in accordance with 74.14. The power source shall comply with the applicable requirements for that power equipment.

11.2.1.5 The attachment plug of a product intended to be connected to a nominal 120-volt circuit, and employing devices required to be connected to a specific supply conductor as specified in 24.5, 26.1, 26.2, 30.2, 31.3, 32.2, and 32.3 shall be a polarized type (2-blade polarized or 3-wire grounding). The connections to the attachment plug shall be in accordance with Figure 11.1. The polarity identification of

the supply cord shall be in accordance with Table 11.3. When a two-blade plug is used, the instruction manual shall include the warning marking described in 76.3. When a three-wire grounding-type plug is used, the product shall be marked in accordance with 75.3.

Figure 10.1
Connections to attachment plugs



[a] In the above illustration, a U-shape instead of a circular cross-section for the blade to which the green conductor is connected is not prohibited.

[b] Signifies a conductor identified in accordance with Table 11.3.

Table 11.3
Polarity identification of flexible cords

Method of identification	Combinations	
	Wire intended to be grounded[a]	All other wires[a]
Color of braids on individual conductors	Solid white or gray, without tracer	Solid color other than white or gray, without tracer
	Color other than white or gray, with tracer	Solid color other than white or gray, without tracer
Color of insulation on individual conductors	Solid white or gray[b]	Solid color other than white or gray
	Light blue[c]	Solid color other than light blue, white, or gray
Color of separators	White or gray[c]	Color other than white or gray
Other means	Tin or other white metal on all strands of the conductors[d]	No tin or other white metal on the strands of the conductors
	A stripe, ridge, or groove on the exterior surface of the cord[d]	–

[a] A wire finished to show a green color with or without one or more yellow stripes or tracers is to be used only as an equipment-grounding conductor. See 18.8 and Figure 11.1.

[b] Only for cords, other than Types SP-2, SPT-2, or HPN, having no braid on any individual conductor.

[c] For jacketed cords.

Table 11.3 Continued on Next Page

Table 11.3 Continued

Method of identification	Combinations	
	Wire intended to be grounded[a]	All other wires[a]
[d] Only for Types SP-2, SPT-2, and HPN cords.		

11.2.1.6 A product that is capable of being adapted for use on two or more different voltage ratings by field alteration of internal connections shall be provided with an attachment plug that has been determined to be capable for use at the voltage for which the product is connected when shipped from the factory. The product shall be marked in accordance with 74.5.

11.2.1.7 Products that are mechanically connected to the surface on which they are mounted, and are neither intended by the manufacturer nor constructed for easy removal by service personnel for maintenance and repair, are not determined to be cord-connected products.

11.2.1.8 Attachment plugs, appliance couplers, appliance inlets (motor attachment plugs), and appliance (flatiron) plugs, shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. See 16.3.2 for single and multipole connectors for use in data, signal, control and power applications within and between electrical equipment.

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

11.2.1.9 Female devices (such as 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.

11.2.1.10 A cord reel shall comply with "special use cord reel" requirements of the Standard for Cord Reels, UL 355.

11.2.2 Strain relief

11.2.2.1 A strain relief means shall be provided to restrict the transmission of mechanical stress from a power-supply cord to terminals, splices, or internal wiring. The means shall comply with the Strain Relief Test, Section 62.

11.2.2.2 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, Section 62) may still need to be performed to confirm the combination of the insulating bushing and the supporting part are suitable.

11.2.2.3 When wood, pressboard, or other fibrous material is used to secure the strain-relief assembly, the fibrous material shall be secured to the product by a pin, set-screw, or other positive means.

11.2.2.4 Means shall be provided to restrict a power-supply cord from being pushed into a product enclosure through the cord-entry hole when such displacement subjects the cord:

a) To mechanical damage,

b) To a temperature higher than that for which it is rated, or

c) To a reduction in spacings, such as to a metal strain-relief clamp, below the minimum values described in Table 17.2.

11.2.2.5 When a knot in a supply cord serves as strain relief, any surface with which the knot is capable of coming into contact shall be free from projections, sharp edges, burrs, or fins that result in abrasion of the insulation on the conductors.

11.2.2.6 A metal strain-relief clamp or band used with Type SP-2, SPE-2, or lighter general-use rubber-insulated cord shall be provided with auxiliary insulation over the cord for mechanical protection. The auxiliary insulation is not required for Type SV, SVE, SVO, or SVOO cord.

11.2.2.7 A clamp made of any material (metal or otherwise) is not required to be used on Type SPT-2, SVT, SVTO, or SVTOO cord unless the combination has been investigated and found to be capable of being used for this application.

11.2.2.8 A clamp without an elastic wrap or similar type of auxiliary insulation is not required to be used on thermoplastic-insulated cord heavier than Type SPT-2, SVT, SVTO, or SVTOO, unless it is determined that the clamp is capable of damaging the cord insulation.

11.2.3 Bushings

11.2.3.1 A bushing, or part that has been determined to be equivalent, shall be provided at a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case. The bushing shall be secured in place, and shall have a smooth, well-rounded surface against which the cord is capable of bearing. The heat- and moisture-resistant properties of the bushing material shall be such that the bushing has been determined to be capable of being used for the particular application.

11.2.3.2 A bushing shall be an insulating bushing when Type SP-2, SPT-2, or other cord lighter than Type HSJ is employed, when the wall or barrier is of metal, and when the construction is such that the cord is capable of being subjected to strain or motion.

11.2.3.3 An insulated metal grommet is capable of being used in place of an insulating bushing 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 on which it is mounted.

11.2.3.4 An opening in porcelain, phenolic, or other nonconducting material has been determined to be equivalent to a bushing when it provides a smooth and well-rounded surface.

11.2.3.5 Ceramic materials and some molded compositions are permissible for use as insulating bushings. However, a separate bushing made of wood, hot-molded shellac and tar composition, or rubber material (other than in a motor) shall not be used. Vulcanized fiber is not prohibited from being employed when the bushing is not less than 3/64 inch (1.2 mm) thick, and when it is so formed and secured in place that it is not adversely affected by moist conditions.

11.2.3.6 A separate soft-rubber, neoprene, or polyvinyl chloride bushing is not prohibited from being employed in the frame of a motor or in the enclosure of a capacitor physically attached to a motor (and not elsewhere in an appliance, except as indicated in 11.2.3.7) as long as:

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

b) The bushing is located so that it is not exposed to oil, grease, oily vapor, or other substance that is capable of contributing to the deterioration of the material used for the bushing.

11.2.3.7 A bushing made of any of the materials specified in 11.2.3.6 is not prohibited from being used at any point in a product when used in conjunction with a type of cord for which an insulating bushing is not required, and when the edges of the hole in which the bushing is mounted are smooth and free from burrs and fins.

11.2.3.8 A bushing is not prohibited from being used at any point in a product as long as:

a) The bushing is made of the same material as the insulation of a Type SP-2 or harder-service supply cord,

b) The part is molded integrally with a Type SP-2 or harder-service supply cord, and

c) The built-up section of the bushing is no less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

11.2.3.9 Insulating bushings shall comply with the Standard for Insulating Bushings, UL 635.

11.3 DC input units

11.3.1 A Vehicle Battery Adapter connected to DC input jack of the equipment, shall comply with the Standard for Vehicle Battery Adapters, UL 2089.

11.3.2 A unit employing an integral cigarette lighter connector assembly shall also comply with the Standard for Vehicle Battery Adapters, UL 2089.

12 Separation of Circuits

12.1 General

12.1.1 Insulated and uninsulated conductors of circuits operating at different potentials shall be:

a) Provided with insulation that has been determined to be capable for use at the highest potential involved,

b) Separated by a required barrier, or

c) Segregated by clamping, routing, or other means that has been determined to be equivalent and permanent.

12.1.2 A barrier used to provide separation between the wiring of different circuits shall be of metal or of insulating material, of adequate mechanical strength when exposed or otherwise subjected to mechanical damage, and reliably held in place. Unclosed openings in a barrier intended for the passage of conductors shall be no larger than 1/4 inch (6.4 mm) in diameter and shall not exceed in number, on the basis of one opening per conductor, the number of wires that are required to pass through the barrier. The closure for any other opening shall present a smooth surface wherever an insulated wire is capable of coming into contact with it, and the area of any such opening, with the closure removed, shall not be larger than required for the passage of the required wires.

12.1.3 A metal barrier shall have a thickness at least as great as the minimum thickness of metal enclosures described in Table 8.1 unless it complies with the requirements of 8.1.5. A barrier made of insulating material shall be not less than 0.028 inch (0.71 mm) thick, and shall have a greater thickness when its deformation is capable of being readily accomplished so as to defeat its intended purpose.

12.2 Field wiring

12.2.1 When a compartment is intended for the field installation of conductors and contains provisions for the connection of Class 2 and Class 3 circuit conductors, and either Class 1, power, or lighting circuit conductors, the Class 2 or Class 3 conductors shall be separated from Class 1, power, or lighting conductors by a barrier or a minimum through-air or over-surface spacing of 1/4 inch (6.4 mm).

12.2.2 Field-installed conductors of any circuit shall be segregated by barriers from:

a) Field-installation and factory-installed conductors connected to any other circuit, unless the conductors of both circuits are or shall be insulated for the maximum voltage of either circuit and

b) Uninsulated live parts of any other circuit of the product, and from any uninsulated live parts whose short-circuiting results in a risk of fire or electric shock, except:

1) A construction in which field-installed conductors are capable of making contact with wiring terminals is not prohibited from being used, as long as Type T, TF, or conductors that have been determined to be equivalent are or shall be installed and

2) A construction in which field-installed conductors that do have or are capable of having insulation less than the types of wire specified in (b)(1) are capable of making contact with low-voltage wiring terminals (see 12.2.4) is not prohibited from being used, as long as the short-circuiting of such terminals does not result in a risk of fire or electric shock.

12.2.3 With regard to 12.2.2(a), when the intended uses of a product are such that in some applications a barrier is required, a removable barrier or one having opening for the passage of conductors is not prohibited from being employed, when instructions for the use of the barrier are a permanent part of the product. A complete set of instructions in conjunction with a wiring diagram, instead of a barrier, is not prohibited from being provided with the product when, upon investigation, the combination is found to comply with the requirements.

12.2.4 Segregation of field-installation conductors from other field-installation conductors and from uninsulated live parts of a product connected to different circuits is not prohibited from being accomplished by arranging the location of the openings in the enclosure for the various conductors (with regard to terminals or other uninsulated live parts) so that there is no risk of the intermingling of the conductors or parts of different circuits. When the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the product, and when each opening is located opposite a set of terminals, it is to be assumed (for the purpose of determining whether the product complies with the requirement in 12.2.2) that the conductors entering each opening are to be connected to the terminals opposite the opening. When more than the minimum number of openings are provided, the possibility of conductors entering at points other than opposite the terminals to which they are intended to be connected and contacting insulated conductors or uninsulated current-carrying parts connected to a different circuit is to be investigated.

12.2.5 To determine whether the product complies with the requirement in 12.2.2, the product is to be wired as intended during service. During this process, a reasonable amount of slack is to be left in each conductor within the enclosure, and no more than average care is to be exercised in stowing this slack in the wiring compartment.

13 Battery Circuits

13.1 The available power from a battery at the point where the battery circuit is interconnected with a secondary circuit shall not exceed the power available from the transformer supplying the secondary circuit. This shall be accomplished by:

a) Using batteries that are inherently limited in capability or

b) Using an overcurrent protective device in the battery circuit of the same rating as that of the transformer circuit.

Exception: The power available from the battery circuit is not prohibited from exceeding that available from the transformer circuit when this does not result in a risk of fire or electric shock.

13.2 When a battery circuit is provided with overcurrent protection to limit the power available as specified in 13.1, the portion of the battery circuit located on the supply side of the overcurrent protection shall comply with the requirements for primary circuit wire and spacings.

13.3 A compartment containing either:

a) Vented rechargeable batteries that emit explosive gases under normal charging conditions or

b) Completely sealed batteries which occasionally emit explosive gases under abnormal conditions

shall be ventilated to prevent the accumulation of an explosive atmosphere within the compartment.

13.4 A lithium ion (Li-On) single cell battery shall comply with the requirements for secondary lithium cells in the Standard for Lithium Batteries, UL 1642.

13.5 Rechargeable nickel cadmium (Ni-Cad) cells and battery packs shall comply with the applicable construction and performance requirements of this Standard.

13.6 Rechargeable nickel metal-hydride (Ni-MH) battery cells and packs shall comply with the applicable construction and performance requirements of this standard, or the applicable requirements for secondary cells or battery packs in the Standard for Household and Commercial Batteries, UL 2054.

13.7 Primary batteries (non-rechargeable) that comply with the relevant UL standards and 7.4 are considered to fulfill the requirements of this Standard.

13.8 A Class 2 battery charger shall comply with the Standard for Class 2 Power Units, UL 1310.

14 Secondary Circuits

14.1 Secondary circuits are not prohibited from being connected to the frame of a unit. When the frame is used as a current-carrying part, hinges or other movable parts shall not be relied upon as a current-carrying means.

14.2 A secondary circuit may be evaluated to the applicable requirements of the Standard for Solid-State Controls for Appliances, UL 244A, or the Standard for Industrial Control Equipment, UL 508 or 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 Temperature Sensing Controls, UL 60730-2-9.

14.3 A Class 2 power supply shall comply with the Standard for Class 2 Power Units, UL 1310.

14.4 A Class 2 transformer shall comply with 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.

14.5 A circuit with Class 2 performance characteristics (i.e. low-voltage circuit in 4.28) is not required to be investigated. However, printed-wiring boards and insulated wire used in such circuits shall be types that are required for the application, and isolation from circuitry that is capable of presenting a risk of electric shock shall be investigated when the circuit is accessible.

Exception No. 1: A component, the failure of which is capable of resulting in a risk of fire, shock, or injury to persons, shall be judged by the requirements for primary circuits.

Exception No. 2: All safety circuits shall be evaluated by the requirements for primary circuits.

14.6 With regard to 14.5, circuits supplied from a power supply that is limited to the available short-circuit current by either a fixed impedance, a fuse, a non-adjustable manual-reset circuit-protective device, or a regulating network, is not required to be investigated. A fuse or circuit-protective device used to limit current shall be rated or set at not more than the values specified in Table 14.1.

Table 14.1
Ratings for secondary fuse or circuit protector

Open-circuit volts (peak)	Amperes
0 – 21.2	5.0
21.3 – 42.4	3.2

14.7 With regard to 14.5, the measurements to determine the maximum output voltage and maximum output current of a Class 2 circuit are to be made in accordance with the requirements of the Standard for Class 2 Power Units, UL 1310, or the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1 and the Standard for Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers, UL 5085-3.

14.8 With reference to the requirements of this section, the complete transformer, the fuse or circuit protective device, or the regulating network, and all wiring up to the point at which the current and voltage are limited shall be evaluated under the requirements in this standard or other standards, as applicable.

14.9 General-purpose transformers shall comply with the Standard for Low Voltage Transformers – Part 1: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers – Part 2: General Purpose Transformers, UL 5085-2.

Exception: A transformer that complies with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411 and that is used in a circuit involving an audio or video component, meets the intent of this requirement.

15 Current-Carrying Parts

15.1 All current-carrying parts shall be made of metal that has been determined to be capable for use in the particular application. Current-carrying parts made of corrosion-resistant alloys (for example, stainless steel) are not prohibited from being used regardless of temperature. Current-carrying parts made of iron and steel shall not be used unless they are rendered corrosion-resistant by a coating and are used as:

a) Terminals and other parts of a motor and its controller (when applicable),

b) Parts whose normal operating temperature is higher than 100°C (212°F), or

c) Parts of a component that have been investigated and determined to be capable of being used with coated iron and steel parts.

16 Internal Wiring

16.1 General

16.1.1 The internal wiring of a product shall consist of wires of a size and type or types that have been investigated and determined to be capable of being used for the particular application with regard to:

a) The temperature and voltage to which the wiring is to be subjected;

b) Its exposure to oil or grease; and

c) Other conditions of service, such as flexing, to which it is to be subjected.

16.1.2 Thermoplastic-insulated wire used for the internal wiring of a product shall be standard building wire, fixture wire, or appliance-wiring material that has been investigated and determined to be capable of being used for the application. Type AF wire shall not be used in a product when the wire is exposed to moisture, including any condensation resulting from operation of the appliance unless the product includes a heating element, and the wire is subjected to a temperature exceeding 80°C (176°F).

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

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

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

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

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

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

16.2 Protection of wiring

16.2.1 The wiring and connection between parts of a product shall be protected or enclosed. A length of flexible cord is not prohibited from being used for external connections, or for internal connections that are capable of being exposed during servicing, when flexibility of the wiring is essential. A bare conductor shall not be used outside an enclosure.

16.2.2 Internal wiring which is exposed through an opening in the enclosure of a product is determined to be protected if, when evaluated as film-coated wire, the wiring complies with the requirements of Frame and Enclosure, Section 8. Even when it is capable of being touched with the applicable probe illustrated in Figure 8.2, internal wiring is not prohibited from being used within an enclosure when it is protected or guarded such that it is not capable of being grasped or hooked.

16.2.3 Wiring located in proximity to combustible material or that is capable of being subjected to mechanical damage shall be armored cable or in rigid metal conduit, electrical metallic tubing, metal raceway, or shall otherwise be protected.

16.2.4 All wiring shall be located or protected to prevent damage to the conductor insulation resulting from contact with any rough, sharp, or moving part.

16.2.5 An opening in a sheet-metal panel within the overall enclosure of a product, through which insulated wires pass, shall be provided with a smooth, well-rounded bushing or shall have smooth, well-rounded surfaces upon which the wires rest, so as not to abrade the insulation. A flexible cord used for external interconnection as specified in 16.2.1 shall be provided with a strain relief and bushings in accordance with the requirements for cord-connected products described in 11.2.1.1 – 11.2.3.8, unless the construction is such that the cord is protected from stress or motion.

16.3 Splices

16.3.1 All splices and connections shall be mechanically secure and shall provide reliable electrical contact. A soldered connection shall be made mechanically secure before being soldered when breaking or loosening of the connection is capable of resulting in a risk of fire or electric shock.

16.3.2 Wire-binding screws and nuts shall be prevented from becoming loosened due to excessive vibration within a product. The use of lock washers or similar parts are not prohibited from being used to prevent such loosening.

16.3.3 Insulated or uninsulated aluminum conductors used as internal wiring, such as for internal connection between current-carrying parts or as motor windings, shall be terminated by a method that has been determined to be reliable for the combination of metals involved at the point of connection.

16.3.4 With reference to 16.3.3, a wire-binding screw or a pressure-wire connector used as a terminating device shall be investigated and determined to be reliable for use with aluminum under conditions to which they are capable of being exposed, such as temperature, heat cycling, or vibration.

16.3.5 A splice shall be provided with insulation that has been determined to be equivalent to that of the wires involved when permanence of spacing between the splice and other metal parts of the product is not reliably maintained.

16.3.6 Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or one layer of friction tape on top of one layer of rubber tape, is not prohibited from being used on a splice when the voltage involved is not more than 250 volts. In determining whether splice insulation consisting of coated fabric, thermoplastic, or other type of tubing is capable of being used, consideration is to be given to such factors as its dielectric properties and heat-resistant and moisture-resistant characteristics. Thermoplastic tape wrapped over a sharp edge shall not be used.

16.3.7 Where stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall not contact any other uninsulated live part that is not always of the same polarity as the wire, and shall not contact any dead metal part. This shall be accomplished by the use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other reliable means.

16.3.8 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 be rated for the voltage and temperature of the intended use. They shall be applied per the installation instructions of the wire connector manufacturer.

16.3.9 Quick-connect terminals, both connectors and tabs, for use with one or two 22 – 10 AWG copper conductors, having nominal widths of 2.8, 3.2, 4.8, 5.2, and 6.3 mm (0.110, 0.125, 0.187, 0.205, and 0.250 inch), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

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

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

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

16.3.12 Single and multipole 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.

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

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

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

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:

a) Current-Carrying Parts, Section 15;

b) Spacings, Section 17; and

c) Electrical Insulation, Section 20.

This exception does not apply to protective conductor terminal blocks.

17 Spacings

17.1 Line-voltage circuits

17.1.1 General

17.1.1.1 The spacings in a product shall be in accordance with Tables 17.1 and 17.2. The spacings specified in Tables 17.1 and 17.2 do not apply to the inherent spacings of a component; such spacings are evaluated under the requirements for the component.

Table 17.1
Minimum spacings at field-wiring terminals

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

NOTES

1 These spacings do not apply to connecting straps or busses extending away from wiring terminals. Such spacings are to be evaluated using Table 17.2.

2 These spacings apply to the sum of the spacings involved where an isolated dead part is interposed.

[a] A spacing of not less than 3/8 inch (9.5 mm), through-air and over-surface, is capable of being used at wiring terminals in a wiring compartment or terminal box when the compartment or box is integral with a motor.

Table 17.2
Minimum spacings through-air or over-surface at other than field-wiring terminals or inside motors

Parts involved	Potential involved, volts	Inch	(mm)
Between uninsulated live metal parts of opposite polarity; and between a rigidly mounted uninsulated live metal part and a dead-metal part that is either exposed for persons to contact or is capable of being grounded	0 – 250	1/16[a,b]	(1.6[a,b])
	251 – 600	1/4	(6.4)

NOTE – When an uninsulated live part is not rigidly supported, or when a movable dead-metal part is in proximity to an uninsulated live part, the construction shall be such that at least the minimum spacing of 1/16 inch (1.6 mm) is maintained under all operating conditions and under all normal conditions of handling.

[a] Enamel-insulated wire is determined to be an uninsulated live part. However, a spacing of not less than 3/32 inch (2.4 mm) (over-surface and through-air) is not prohibited between a dead-metal part and enamel-insulated wire rigidly supported and held in place on a motor coil.

[b] A spacing of 1/16 inch (1.6 mm) is permissible at the heating element only, in a heater rated for 300 volts or less.

17.1.1.2 As an alternative to the spacing requirements of Tables 17.1 and 17.2, as appropriate, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are not prohibited from being used. The spacing requirements of UL 840 shall not be used for wiring terminals and spacings to dead-metal parts.

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

17.1.1.4 At closed-in points only, such as the screw-and-washer construction of an insulated terminal mounted in metal, a spacing of 3/64 inch (1.2 mm) is not prohibited from being provided in a product rated at 250 volts or less. Within a thermostat, except at contacts, the spacings between uninsulated live parts on opposite sides of the contacts shall be not less than 1/32 inch (0.8 mm) through-air and 3/64 inch over the surface of insulating material, and the construction is to be such that the spacings are maintained permanently.

17.1.1.5 On printed-wiring boards having a flammability classification of V-0 and constructed from a base material having a minimum Comparative Tracking Index (CTI) rating of 100 volts, spacings (other than spacings to ground, between primary and secondary circuits, or located in safety circuits) are not specified between traces of different potential connected in the same circuit when:

a) The spacing provided between traces withstands the appropriate Dielectric Voltage-Withstand Test, Section 49, or

b) No risk of fire or electric shock results from short-circuiting the spacings between traces as specified in the abnormal operation test for printed wiring boards described in 59.3.1.

17.1.1.6 A printed wiring board with spacings between opposite polarity circuits (other than a low-voltage circuit) less than those required in Table 17.2 is acceptable provided that the spacings:

a) Comply with the spacing requirements in the Standard for Solid-State Controls for Appliances, UL 244A. 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; or

b) Comply with the spacing requirements in Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840. The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure.

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

a) The applicable Overvoltage Category per Table 33.1;

b) The applicable Material Group per Table 33.2;

c) The pollution degree shall be Pollution Degree 2. See Table 33.3;

d) 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.

17.1.1.8 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product. This voltage limiting device or system shall comply with the requirements of the Standard for Surge Protective Devices, UL 1449.

17.1.2 Barriers

17.1.2.1 An insulating liner or a barrier made of fiber or similar material used where spacings do not comply with the intent of 17.1.1.1 shall be no less than 1/32 inch (0.8 mm) thick. The liner or barrier shall be located in a position within the product, or made of a material that is not capable of being affected by arcing, except that fiber not less than 1/64 inch (0.4 mm) thick is not prohibited from being used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone. However, an insulating material having a thickness less than specified is not prohibited from being used when it has been determined to be equivalent in appropriate properties.

17.1.2.2 A barrier of mica shall be minimum 0.010 inch (0.25 mm) thick unless it is protected from mechanical abuse during assembly and operation of the product.

17.2 Low-voltage circuits

17.2.1 In a circuit determined to be a low-voltage circuit, the spacing between uninsulated live parts of opposite polarity and between such parts and dead metal that is capable of being grounded in service is not specified.

Exception: The spacings in any safety circuit shall comply with the requirements for line-voltage circuits.

18 Grounding

18.1 A permanently-connected product shall have provision for grounding. A cord-connected product that is rated over 150 volts or that is stationary shall have provision for grounding.

Exception: Products that comply with the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, shall not be provided with additional grounding means. Also see 74.17.

18.2 The grounding conductor of a power-supply cord shall be secured to the frame or enclosure of the product by means of a screw that is not to be removed during any servicing operation not involving the power-supply cord, or by other methods that have been determined to be equivalent. Solder alone shall not be used for securing the grounding conductor. Servicing as specified in this paragraph includes repair of the product by qualified service personnel.

18.3 The grounding conductor of a cord-connected product shall be connected to the grounding terminal of an attachment plug. The grounding terminal shall be fixed.

18.4 A separable connection, such as that provided by an attachment plug and a mating connector or receptacle, shall be such that the equipment-grounding connection is made before connection to and broken after disconnection from the supply conductors.

Exception: This requirement does not apply to interlocked plugs, receptacles, and connectors that are not energized when the equipment-grounding connection is made or broken.

18.5 When a product is provided with means for separate connection to more than one power supply, each separate connection shall be provided with a means for grounding.

18.6 A terminal provided solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the application. A connection device that depends on solder alone shall not be provided for connecting the equipment-grounding conductor.

18.7 A wire-binding screw or pressure-wire connector intended for the connection of an equipment-grounding conductor shall be located so that it is not capable of being removed during normal servicing of the product.

18.8 The surface of the insulation of a grounding conductor shall be green and provided with or without one or more yellow stripes. No other lead shall be so identified.

18.9 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, such as by being marked ″G,″ ″GR,″ ″Ground,″ or ″Grounding,″ or by a marking on a wiring diagram provided on the product. The wire-binding screw or pressure wire connector shall be located so that it is not capable of being removed during the servicing of the product.

18.10 Permanently-connected products shall be provided with instructions in accordance with 76.5.

18.11 A terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the particular product, in accordance with the National Electrical Code, ANSI/NFPA 70.

19 Heating Elements

19.1 The voltage rating of a heating element used in an appliance shall be no less than that specified in Table 19.1.

Table 19.1
Heating element ratings

Nominal voltage of circuit	Minimum rating of heating elements, volts
120	110
208	208
240	220
277	277
480	430
Greater than 480	Rating of circuit

19.2 A heating element shall be supported in a manner that has been investigated and complies with the requirements in 19.3.

19.3 In determining whether a heating element is supported as described in 19.2, consideration is to be given to sagging, loosening, and other adverse conditions of the element resulting from continuous heating.

19.4 A heating element shall be protected against mechanical damage and contact with outside objects.

19.5 A product in which the heating element is constructed for use only in an air blast shall be wired or controlled so that the element is capable of being operated only while under the cooling effect of the blast. A product in which the cooling effect of the motion of a part is required to limit temperatures shall be wired or controlled so that the element is not capable of being operated without such motion.

19.6 Sheathed type heating elements shall comply with the Standard for Sheathed Heating Elements, UL 1030 or the Standard for Electric Heating Appliances, UL 499.

19.7 Thermistor-type heaters (e.g. PTC heaters) shall comply with the Standard for Thermistor-Type Devices, UL 1434.

19.8 Insulated heating wire shall comply with the requirements of the Standard for Appliance Wiring Material, UL 758.

19.9 A flexible heating device shall comply with applicable requirements in the Standard for Electric Heating Pads, UL 130.

20 Electrical Insulation

20.1 General

20.1.1 Insulating washers and bushings that are integral parts of a product and bases or supports for the mounting of current-carrying parts shall be of a moisture-resistant material that is not capable of being damaged by the temperatures to which they are intended to be subjected under conditions of actual use. Molded parts shall be constructed so that they have the mechanical strength and rigidity required to withstand the stresses of actual service.

20.1.2 Insulating material used in a product is to be evaluated with regard to its acceptability for its particular application. Material for mounting an uninsulated live part shall be porcelain, phenolic composition, or other material that has been determined to be equivalent. Vulcanized fiber is not prohibited from being used for insulating bushings, washers, separators, and barriers. However, vulcanized fiber shall not be used as the sole support for uninsulated live parts. Materials, such as mica, some molded compounds, and certain refractory materials have been investigated and found to be capable of being used as the sole support of live parts. Some other materials that have not been determined to be capable for general use, such as magnesium oxide, are not prohibited from being used when employed in conjunction with other less hygroscopic insulating materials, or when located and protected so that they are not subject to mechanical damage and are resistant to the absorption of moisture.

20.1.3 When it is required to investigate a material to determine whether it is capable of being used in its intended application, consideration is to be given to its mechanical strength, dielectric properties, insulation resistance, heat-resistant qualities, the degree to which it is enclosed or protected, and any other features having a bearing on the risk of fire or electric shock involved, in conjunction with conditions of actual service. All of these factors are evaluated with regard to thermal aging.

20.1.4 Thermoplastic material is not usually determined to be capable of being used for the sole support of uninsulated live parts. However, such material is not prohibited from being employed when determined to have the required mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric-voltage withstand, and other appropriate properties as indicated in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

20.1.5 In the mounting or supporting of small, fragile insulating parts, screws or other fastenings shall not be so tight as to result in cracking or breaking of these parts with expansion and contraction. Such parts shall be slightly loose.

20.1.6 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill the requirements of Protection of wiring, Section 16.2 or a performance requirement of this standard. In such cases:

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

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

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

20.2 Film-coated wire (magnet wire)

20.2.1 The component requirements for film-coated wire and Class 105 (A) insulation systems are not specified.

20.2.2 Film coated wire in intimate combination with one or more insulators, incorporated with 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 and shall have a suitable temperature class.

21 Thermal Insulation

21.1 Thermal insulation shall be constructed and be located and mounted or supported within the product such that it is not capable of being adversely affected by any intended operation of the product.

21.2 Thermal insulation that is not rigid shall be mounted or supported so that it does not sag. Adhesive material used for mounting thermal insulation shall be investigated and determined to be capable of being used for the temperature to which it is capable of being subjected.

21.3 Adhesive is not required to be evaluated as specified in 21.2 when the thermal insulation is mechanically supported by a least one rivet, or a part that has been determined to be equivalent, per square foot of material (at least 11 rivets, or a part that has been determined to be equivalent, per square meter).

21.4 Unless it has been investigated and determined to be capable of being used for the purpose, flammable thermal insulation or other flammable material shall not be used when it is located in the heated air stream of a product.

21.5 Flammable or electrically conductive thermal insulation shall not make contact with uninsulated live parts of a product.

21.6 Some types of mineral-wool thermal insulation contain conductive impurities in the form of slag. Such material shall not be used as thermal insulation when it is in contact with uninsulated live parts. See the Humidity Conditioning Test, Section 52.

22 Motors

22.1 Construction

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

Exception: Motors located in a low voltage circuit (See 4.28) are evaluated for the risk of fire and personal injury in accordance with the applicable requirements of this Standard.

22.1.2 A motor shall be investigated and found to be capable of being used for the particular application. The motor shall be capable of handling its maximum intended load without risk of fire, electric shock, or injury to persons.

22.1.3 A motor winding shall resist the absorption of moisture and shall be formed and assembled in a workmanlike manner. However, film-coated wire is not required to be additionally treated to resist absorption of moisture. Fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials are to be provided with impregnation or otherwise treated to resist moisture absorption.

22.1.4 A brush-holder assembly shall be constructed so that when a brush is worn out (no longer capable of performing its function), the brush, spring, and other parts of the assembly will be retained to the degree necessary to reduce the likelihood of:

a) Accessible dead-metal parts becoming energized and

b) Live parts becoming accessible.

22.1.5 With reference to the requirement in 22.1.4, the parts of a brush holder assembly are considered to be acceptably retained if:

a) The motor is enclosed, independently of the appliance enclosure, to the degree that the brush, spring, or other parts of the assembly will be contained within the motor enclosure, and no conductive parts of the motor enclosure are accessible.

b) The appliance has spacings such that parts of the brush holder assembly which can become free to move will not become live and accessible, nor bridge live parts to accessible metal parts, and the motor enclosure is not accessible; or

c) Other constructions equivalent to (a) or (b).

22.2 Overload protection

22.2.1 Except as noted in 22.2.2 – 22.2.8, a motor shall be provided with overload protection that complies with one of the following:

a) Thermal protection (both running-overload and locked-rotor) complying with the requirements in the Standard for Overheating Protection for Motors, UL 2111 or with the Standard for Thermally Protected Motors, UL 1004-3.

b) Impedance protection complying with the Standard for Impedance Protected Motors, UL 1004-2, when tested as used in the application.

c) A sensing circuit that serves to disconnect power from the motor to protect it against overheating using the temperature criteria in UL 2111 or with the Standard for Thermally Protected Motors, UL 1004-3. This sensing circuit shall be the one used to shut down the motor when it does not perform its intended function. The sensing circuit is to be evaluated as a safety circuit and shall be investigated with motor combination complying with the Standard for Electronically Protected Motors, UL 1004-7, or the requirements in the Requirements for the Evaluation of Electronic Circuits, Supplement SA.

d) Secondary circuit motors rated less than 100 volts or less than 200 volt-amperes and tested in accordance with Secondary circuit motors, 59.2.

22.2.2 Motors indicated below are not required to comply with the overload protection requirement in 22.2.1:

a) Motors that are supplied by Class 2 circuits.

b) Motors rated less than 1 horsepower and:

1) Which are manually started,

2) Where the operator is in attendance during the entire operating cycle, and

3) Where malfunction of the motor is evident.

c) Motors which, by their intrinsic operation, normally operate under locked-rotor conditions, such as stepper motors.

22.2.3 Running overload protection is not required for the following constructions:

a) A motor that is used for air-handling only when the blower or fan impeller is coupled directly to the motor shaft or

b) A shaded-pole motor with a 2:1 or smaller ratio between locked-rotor and no-load currents and a 1 ampere or smaller difference between no-load and locked-rotor currents.

22.2.4 An overload-protective device that complies with the National Electrical Code (NEC), ANSI/NFPA 70, is determined to comply with 22.2.1. This overload-protective device shall be responsive to motor current and rated or set as specified in Column A of Table 430-72(b) of the NEC. When the rating of the motor-running overload protection determined in accordance with the foregoing does notcorrespond to a standard size or rating of a fuse, nonadjustable circuit breaker, thermal cutout, thermal relay, or heating element of a thermal-trip motor switch, the next higher size, rating, or setting is not prohibited from being used, and shall not be more than that specified in Column B of Table 430-72(b) of the NEC. For a multi-speed motor, each winding connection is to be evaluated separately.

22.2.5 The functioning of an overload protective device, whether or not such a device is required, shall not result in a risk of fire, electric shock, or injury to persons. Overload devices used for running overload protection, other than those that are inherent in a motor, shall be located in each ungrounded conductor of a supply system.

22.2.6 Motor-overload protection in which contacts control a relay coil in a motor starter shall comply with the requirements of 22.2.1.

22.2.7 Fuses used in motor-overload-protective devices shall be configured so that the motor is investigated with the largest size of fuse that is capable of being inserted in the fuseholder unless the product is marked in accordance with 75.6.

22.2.8 When a motor is constructed so that only a portion of its winding is energized during any portion of the start or run cycle, the overcurrent (overload) protection for the motor shall also be effective during those parts of the cycle.

22.3 Insulation systems

22.3.1 Class A insulation systems shall consist of a combination of magnet wire and major component insulation materials evaluated and found to operate as intended in its end use. Thermoset materials and materials in Table 22.1 at the thicknesses specified are permitted to be used without further evaluation.

Table 22.1
Primary Class A insulating materials and minimum thicknesses

Material	Minimum thickness	
	Inch	(mm)
Vulcanized fiber	0.028	(0.71)
Polyethylene terephthalate film	0.007	(0.018)
Cambric	0.028	(0.71)
Treated cloth	0.028	(0.71)
Electrical grade paper	0.028	(0.71)
Mica	0.006	(0.15)
Aramid paper	0.010	(0.25)

22.3.2 For Class A insulation systems employing other materials or thinner materials than those indicated in Table 22.1 or a combination of materials, the materials, whether polymeric or not polymeric (treated cloth, for example), shall comply with the requirements in 22.3.3.

22.3.3 A polymeric material employed in a Class 105 (A) insulation system that isolates the windings from dead metal parts shall be:

a) Unfilled or glass-reinforced nylon;

b) Polycarbonate;

c) Polybutylene terephthalate;

d) Polyethylene terephthalate;

e) Phenolic; or

f) Acetal

and shall have a relative or generic thermal index for electrical properties of 105°C (221°F) minimum. Leads shall be rated 90°C (194°F) minimum.

Exception: Other polymeric materials used in a Class 105 (A) insulation system shall comply with the requirements for thermal aging in Section 70.4.

22.3.4 Materials used in an insulation system that operates above Class 105 (A) temperatures shall comply with the Standard for Systems of Insulating Materials – General, UL 1446.

22.3.5 All insulation systems employing integral ground insulation shall comply with the requirements specified in the Standard for Systems of Insulating Materials – General, UL 1446.

23 Capacitors

23.1 A motor or power-factor correction capacitor shall comply with the Standard for Capacitors, UL 810. An electromagnetic interference filter with an integral enclosure complying with the Standard for Electromagnetic Interference Filters, UL 1283.

23.2 When a capacitor that is not a part of a capacitor motor or a capacitor-start motor is connected in an appliance that is intended to be automatically or remotely controlled so that malfunction or breakdown of the capacitor results in a risk of fire, electric shock, or injury to persons, thermal or overcurrent protection shall be provided in the appliance to prevent such a condition.

23.3 Capacitors, connected line-to-line or line-to-ground, shall comply with the 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. A capacitor connected from one side of the line to the frame or enclosure of an appliance shall have a capacitance rating of not more than 0.10 µF.

23.4 A product that is intended to be controlled by or operated in conjunction with a capacitor or a capacitor/transformer unit shall be supplied with such a capacitor or capacitor/transformer capacitor unit.

23.5 Under both normal and abnormal conditions of use, a capacitor using a dielectric medium more combustible than askarel shall not result in a risk of electric shock or fire and shall be protected against expulsion of the dielectric medium.

24 Overcurrent Protection

24.1 Each bus bar and insulated wire, including those in heater, motor, and control circuits, in a product rated at more than 40 amperes shall be protected by an overcurrent protective device provided as a part of the product. When the product is intended for connection to more than one branch circuit, each section of the product intended for connection to a different branch circuit is to be evaluated individually in applying the foregoing requirement. The rating of the overcurrent protective device shall be in accordance with Table 24.1.

Table 24.1
Maximum protective device ratings

Type of conductor	Conductor protected within the product, AWG		Current rating of largest acceptable overcurrent protective device, amperes
	Copper	Aluminum	
Wires	18 – 14	12	50
	12	–	60
	–	10	80
	10	8	90
	8	6	125
	6	4	175
	4	3	200
Busbars, solid	Copper		Low enough to limit the current density in the busbar to 3000 A/inch^2 (4.650 A/mm^2) of busbar cross-section
	Electrical-conductor (EC) grade of aluminum (conductivity is 61 percent)		Low enough to limit the current density in the busbar to 2000 A/inch^2 (3.100 A/mm^2) of busbar cross-section
	Aluminum having a conductivity of 55 percent of International Annealed Copper Standard (IACS)		Low enough to limit the current density in the busbar to 1776 A/inch^2 (2.753 A/mm^2) of busbar cross-section

24.2 The requirement in 24.1 does not apply to a conductor that:

a) Is not longer than 10 feet (3.05 m),

b) Is completely within the enclosure of the product,

c) Terminates at its load end in one or more overcurrent protective devices, and

d) Has an ampere rating according to the 60°C (140°F) tables in the National Electrical Code, ANSI/NFPA 70, not less than 80 percent of the combined ratings of the one or more overcurrent protective devices supplied by the conductor.

24.3 The rating of the branch-circuit overcurrent protective device shall be 150 percent of the rating of the product unless the product is marked to specify the use of a protective device having a lower rating. Standard ampere ratings for overcurrent protective devices are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70,80, 90, 100, 110, 125, 150, 175, and 200 amps. When 150 percent of the rating of the product does not equal one of the standard overcurrent-protective-device ratings specified above, the next lower rating or setting of overcurrent protective device shall be employed.

24.4 The overcurrent protection shall be of a type intended for branch-circuit protection such as a Class CC, G, H, J, K, R, or T cartridge fuse or a Type S plug fuse. A plug-fuseholder shall be of Type S construction or shall be of the Edison-base type with a factory-installed nonremovable adapter of Type S construction.

24.5 In a product rated 125 or 125/250 volts (3-wire) or less, an overcurrent-protective device, other than an auxiliary control, shall be electrically connected to a terminal or lead intended for connection to an ungrounded conductor of the supply circuit.

24.6 A product rated more than 48 amperes and that uses resistance-type heating elements shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected by an overcurrent protective device rated no greater than 60 amps.

Exception No. 1: Open coil or exposed sheathed-coil types of surface elements in commercial-type appliances shall be protected by overcurrent protective devices rated no greater than 50 amps.

Exception No. 2: Infrared lamp commercial and industrial appliances shall have overcurrent protection not exceeding 50 amps.

24.7 With reference to 24.6, the overcurrent protective devices shall be provided either as an integral part of the product or shall be provided by the manufacturer as a separate assembly for independent mounting for use with the product and marked in accordance with 74.15.

24.8 An overload or thermal-protective device shall have a current and voltage rating not less than the load it controls.

24.9 When the current rating of a product is more than 40 amps, and there are subdivided circuits within the product feeding two or more power-consuming components, such as motors, motor-control circuits, or electric heating elements, connected in parallel with each other across any pair of main-supply terminals or leads, the conductors of each terminal circuit of the product shall be provided with overcurrent protection.

Exception: Additional overcurrent protection is not required as a part of the product for the conductors of the subdivided circuits described below:

a) For each separate motor or heating-element circuit supplied by insulated conductors having an ampere rating at least one-third that of the protective device in the branch circuit to which the appliance is to be connected.

b) For each separate motor-control circuit supplied by insulated conductors having an ampere rating at least one-fifth that of the protective device in the branch circuit to which the appliance is to be connected.

24.10 A protective device that requires resetting or replacement after it opens shall be readily accessible.

Exception: The protective device is not required to be readily accessible when:

a) The product, with the protective device shunted out of the circuit, complies with all applicable requirements in this standard and

b) The presence of the protective device is unknown to the user of the product because of its location and the omission of reference to the device in the operating instructions or circuit diagrams for the appliance.

24.11 A protective device shall be wholly inaccessible from outside the product without opening a door or cover.

Exception: The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts are not prohibited from protruding outside of the product enclosure.

24.12 A fuseholder shall be constructed and installed so that an uninsulated live part other than the screw shell or clips is not exposed to contact by persons removing or replacing fuses.

Exception: This requirement does not apply when the presence of the protective device is unknown to the user of the appliance because of its location and the omission of reference to the device in the operating instructions or circuit diagrams for the appliance.

24.13 The screw shell of a plug-type fuseholder shall be connected toward the load. A removable end cap of a fuseholder in a household product shall not be accessible from the outside of the product.

24.14 A motor or transformer in a product rated at more than 16 amperes shall be protected against short circuits and grounding by an overcurrent protective device having a maximum ampere rating in accordance with the National Electrical Code, ANSI/NFPA 70. Such overcurrent protection shall be provided as a part of the product unless it is determined that equivalent overcurrent protection is incorporated as the branch-circuit protective device. The overcurrent protection shall be of a type that has been investigated and determined to be capable of being used for branch-circuit protection.

24.15 Overcurrent protection for a product rated 20 amperes or less shall be provided by means of a circuit breaker or fuse as a part of a product for each general-use receptacle circuit, and each lampholder circuit independent of a heating element included in the product, unless the product is properly connected to a branch circuit rated at 20 amperes or less. The overcurrent protection shall be of a type that has been investigated and determined to be capable of being used for branch-circuit protection.

24.16 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part 2 (e.g. 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 appropriate UL standard for the fuse are considered to comply with this requirement.

24.17 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and the applicable Part 2 (e.g. the Standard for Fuseholders – Part 9: Class K, UL 4248-9).

24.18 When provided, 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.

24.19 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.

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

25 Temperature Controls

25.1 A temperature-regulating control used to regulate the temperature of a heater during normal operation shall comply with:

a) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873; or

b) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1; and

c) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

See 32.8.

Exception: This requirement does not apply to products that do not attain temperatures in excess of the limits of the Normal Temperature Test, Section 48, when the control is short-circuited during the Abnormal Operation Test, Section 59.

25.2 A temperature-limiting control used to limit the temperature of a heater during abnormal operation shall comply with:

a) The Standard for Temperature-Indicating and -Regulating Equipment, UL 873;

b) The Standard for Limit Controls, UL 353;

c) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1; and

d) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

e) The circuits requirements in the Requirements for the Evaluation of Electronic Circuits, Supplement SA.

See 32.11.

Exception: This requirement does not apply to products that do not result in a fire when the control is defeated during the Abnormal Operation Test, Section 59.

25.3 Thermal cutoffs shall comply with the requirements in the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

25.4 A thermal cutoff shall be reliably secured in place. A field-replaceable thermal cutoff shall be used only in a commercial or industrial product. The thermal cutoff shall be located so that it is accessible for replacement without damaging other connections or internal wiring. The product shall be marked in accordance with 75.2.

25.5 A temperature sensing positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control shall comply with:

a) 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 Temperature Sensing Controls, UL 60730-2-9 with Annex J; or

b) The Standard for Thermistor-Type Devices, UL 1434.

25.6 Temperature-regulating control and temperature-limiting control shall comply with the requirements of the Overload test described in 60.1 and the Endurance test described in 60.2.

26 Receptacles

26.1 A 15-amp or 20-amp general-use receptacle in a product provided with a means for grounding (a permanently wired product or a cord-connected product with a grounding conductor in the cord) shall be of the grounding type. The grounding contact of the receptacle shall be electrically connected to dead metal that is to be grounded when the product is in use.

26.2 A general-use receptacle rated for use on a nominal 120-volt circuit shall be of a polarized type. The grounded supply conductor shall be connected to the terminal that is substantially white in color or otherwise marked to indicate that it is intended for connection to the grounded supply conductor.

26.3 Each circuit having a receptacle intended for general use shall have overcurrent protection rated no more than 20 amperes provided as a part of the product when the overcurrent protection of the branch circuit to which the product is to be connected exceeds the current rating for the receptacles. The overcurrent protection provided shall be of the time-delay type.

26.4 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.

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

27 Adhesives

27.1 An adhesive that is relied upon to reduce a risk of fire, electric shock, or injury to persons shall comply with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

27.2 An adhesive that is relied upon to secure a conductive part shall comply with the requirements for adhesives in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, so that, when loosened or dislodged, it is capable of:

a) Energizing an accessible dead metal part,

b) Making a live part accessible,

c) Reducing spacings below the minimum values described in Table 17.2, or

d) Short-circuiting live parts.

The possibility of these occurrences is to be evaluated with regard to both a part inside the device, and a part on the outside of the device that is capable of affecting equipment in which the device is to be installed.

28 Air Filters

28.1 Air filters for use in cooling systems shall comply with the requirements in the Standard for Air Filter Units, UL 900, or shall be constructed of materials with a minimum flame rating of V-2 or HF-2.

Exception: This requirement does not apply to air filters in closed systems and to air filters located external to the enclosure and constructed of materials with a minimum flame rating of HB or HBF. A closed system is defined as that which, although not required to be air-tight, is not intended to be vented outside the enclosure.

29 Printed-Wiring Boards

29.1 A printed-wiring board used in a primary circuit, in a non-low-voltage secondary circuit, and in a secondary circuit where separation of the bond between the conductor and the base material results in contact with uninsulated parts that represent a risk of electric shock or a risk of fire, shall comply with the Standard for Printed-Wiring Boards, UL 796 with a flammability rating of V-1 or better.

Exception: A printed-wiring board in a Class 2 non-safety circuit is not required to comply with the bonding requirements in the Standard for Printed-Wiring Boards, UL 796 if the board is separated from parts of other circuits such that loosening of the bond between the foil conductor and the base material will not result in the foil conductors or components coming in contact with parts of other circuits of the control or of the end-use product.

29.2 With reference to 29.1, the printed-wiring board shall be capable of being used for its intended application with regard to flammability rating, operating temperatures, direct support of live parts, and soldering times.

29.3 Circuit components mounted on a printed-wiring board to form a printed-wiring assembly shall be secured so that the assembly is not capable of being displaced by any force exerted on it which is capable of resulting in a risk of fire, electric shock, injury to persons, or electrical energy at high current levels during assembly of the unit, during intended operation, or during operator or other servicing.

29.4 Consideration is to be given to the mechanical protection and electrical insulation provided to the printed-wiring board by a partition.

29.5 A printed-wiring board containing circuitry in a line-connected circuit or a safety circuit shall comply with the direct-support requirements for insulating materials in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C.

29.6 Unless otherwise specified, the flammability class and temperature rating shall be that specified for insulating materials in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C.

30 Lampholders

30.1 A lampholder for a low-voltage lamp, such as a 6-volt lamp, shall not be tapped across a part of a winding of a motor when the motor is rated for more than 230 volts.

30.2 The screw-shell of an Edison-base lampholder in a permanently-connected product or in a product equipped with a polarized attachment plug shall be connected to the terminal or lead that is intended to be connected to the grounded conductor of the power-supply circuit.

30.3 A lampholder shall be constructed and installed so that uninsulated live parts other than the screw-shell are not exposed to contact by persons removing or replacing lamps. Live parts are not prohibited from being exposed to contact when, in order to remove or replace a lamp, it is required to dismantle the product by means of tools. In this case, the product shall also be marked in accordance with 75.2.

30.4 A medium-base lampholder or screw-shell receptacle shall not be used as a holder for a heating element rated at more than 6 amperes or 660 watts, except that a screw-shell with a left-handed thread is not prohibited from being used with a heating element rated at not more than 10 amps.

30.5 A female screw-shell used as a holder for a heating element shall be of copper or of a copper-base alloy and shall be plated with nickel or oxidation-resistant metal that has been determined to be equivalent.

30.6 Lampholders and indicating lamps integral with lampholders shall comply with the Standard for Lampholders, UL 496.

31 Switches

31.1 A switch or other control device provided as a part of a product shall be of a type intended for the particular application and shall have a current and voltage rating not less than that of the circuit (load) that it controls. All switches shall be of an indicating type. A switch shall be located or protected so that it is not capable of being subjected to mechanical damage during use.

31.2 With reference to the requirement in 31.1, the current rating of a switch that controls an inductive load other than a motor, such as a transformer or an electric-discharge-lamp ballast, shall be not less than twice the rated full-load current of the transformer or ballast, unless the switch has been investigated and found to be capable of being used for the application.

31.3 In a product rated 125 or 125/250 volts (3-wire) or less, single pole switches with a marked ″off″ position shall be electrically connected to a terminal or lead intended for connection to an ungrounded conductor of the supply circuit.

31.4 A manual motor-control switch or motor control shall be provided in a cord-connected product that uses a motor rated more than 1/3 horsepower (250 watts output).

Exception: When the switch is not accessible and the product is marked in accordance with 74.19, the manual motor-control switch or motor control is not required to be provided.

31.5 A switch on a cord-connected product incorporating a heating element construction shall be of such a type and connected so that it disconnects the element or elements that it controls from all conductors of the supply circuit. This requirement applies to a switch in the off position or any other setting in which the element is not heated.

Exception: The switch need not disconnect the open-wire heating element from all conductors if:

a) The construction is such that the open-wire element cannot be made to contact user accessible metal under normal conditions;

b) In the event of a breakage of the element, no part of the open-wire element is able to contact user accessible metal parts; and

c) The open-wire element is secured in place by reliable means.

31.6 A switch or other device controlling one or more elements of a product intended for permanent connection to the power supply shall be arranged so that the opening of the switch disconnects all of the ungrounded conductors of the supply circuit, unless there are no live parts exposed to unintentional contact when the switch is open or unless the fact that such parts are live is definitely apparent.

31.7 A switch or other means of control intended to provide for the use of a limited number of elements at one time shall be so located or of such a type that the user is not capable of changing the connections to energize more elements than intended.

31.8 A switch controlling a lampholder is to have been previously evaluated for use with tungsten-filament lamps.

31.9 A switch shall not be incorporated in a handle made of wood or other combustible material unless the device is enclosed in metal or insulating material.

31.10 Manually operated snap-switches shall comply with one of the following, as applicable:

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

b) Standard for General-Use Snap Switches, UL 20; or

c) Standard for Nonindustrial Photoelectric Switches for Lighting Control, UL 773A.

Exception: Switching devices that comply with the appropriate 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 with this requirement.

31.11 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 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 Timers and Time Switches, UL 60730-2-7 or

b) The Standard for Clock-Operated Switches, UL 917.

31.12 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, shall comply with the requirements for an operating control with Type 1 action for 6000 cycles of operation, or as a manual control for 5000 cycles of operation, in accordance with the following:

a) 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 Timers and Time Switches, UL 60730-2-7; or

b) The Standard for Solid-State Controls for Appliances, UL 244A.

32 Controls and Control Circuits

32.1 A control circuit shall comply with the requirements in Separation of Circuits, Section 12.

32.2 The operation of an auxiliary control device in a product shall disconnect the element or elements that it controls from all ungrounded conductors of the supply circuit, unless it is determined that live parts are not exposed to unintentional contact when the device is open, or unless it is readily apparent that such parts are live.

32.3 A device intended to reduce the risk of fire or electric shock shall be operative whenever the product is connected to its power supply. Except for the inherent thermal protector of a motor, the control of a product intended to be permanently connected electrically and that is provided with exposed live parts shall disconnect the element or elements it controls from all ungrounded conductors of the supply circuit. The operation of such a control shall comply with the requirements in 32.2. A controlled contactor shall comply with the endurance requirement for a limiting control when it is a part of the limiting-control circuit.

32.4 The terminals of a device specified in 32.3 shall either be further enclosed or located within the product in such a manner as to prevent unintentional short-circuiting and damage.

32.5 A control device shall not be constructed to deliberately overload the branch-circuit protective device as a means of disconnecting the product from the supply.

32.6 A contactor or similar device required for use with a limit control shall be provided by the manufacturer of the product. However, the device is not required to be mounted on the product. In addition, the product shall be marked in accordance with 74.15.

32.7 Auxiliary controls shall be evaluated in accordance with the applicable requirements of this standard and the parameters in Controls – End Product Test Parameters, Section 33 unless otherwise specified in this standard. See 32.14.

32.8 Operating (regulating) controls shall be evaluated in accordance with the applicable component standard requirements specified in 25.1 and 25.2, if applicable, and the parameters in Controls – End Product Test Parameters, Section 33, unless otherwise specified in this standard. See 32.14.

32.9 Electronic operating controls that rely upon software for the normal operation of the end product where deviation or drift of the control may result in a risk of fire, electric shock, or injury to persons, such as loss of an OFF control or a speed control unexpectedly changing its output, etc., shall comply with one of the following:

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

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

See 33.4.

32.10 If a single malfunction or breakdown of an electronic component, located in electronic operating control, results in increased risk of injury to persons, such as a loss of OFF control or unexpected operation, this control shall comply with one of the following:

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

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

See 33.4.

32.11 Protective (limiting) controls shall be evaluated in accordance with the applicable component standard requirements specified in 25.1 and 25.2 and if applicable, the parameters in Controls – End Product Test Parameters, Section 33, unless otherwise specified in this standard.

32.12 Electronic protective controls that do not rely upon software as a protective component shall comply with one of the following:

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

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1, except the Controls Using Software requirements, Clause H11.12.

See 33.4.

32.13 Electronic protective controls that rely upon software as a protective component shall comply with one of the following:

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

b) The Standard for Automatic Electrical Controls for Household and Similar Use; Part 1: General Requirements, UL 60730-1.

See 33.4.

32.14 An electronic auxiliary or operating control (e.g. a non-protective control), the failure of which would not increase the risk of fire, electric shock, or injury to persons, need only be subjected to the applicable requirements of this standard.

32.15 Any control or circuit function whereby a loss/malfunction of its functionality would represent an unacceptable risk of fire, electric shock, or casualty hazards would be considered a Safety Critical Function. See Safety Critical Functions, Section 5 for the most common Safety Critical Functions anticipated by this standard. An electronic circuit that complies with the Requirements for the Evaluation of Electronic Circuits, Supplement SA is considered to fulfill the requirements of a control.

33 Controls – End Product Test Parameters

33.1 General

33.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in Spacings, Section 17.

33.1.2 Where reference is made to declared deviation and drift, this indicates the manufacturer's declaration of the control's tolerance before and after certain conditioning tests.

33.2 Auxiliary controls

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

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

Exception: An auxiliary control that complies with a component standard(s) specified in 25.1 and 25.2 is considered to fulfill this requirement.

33.3 Electronic operating controls (regulating controls)

33.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1:

a) Control action Types 1 or 2;

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

c) Installation Class 2 per the Standard for Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test, IEC 61000-4-5;

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

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

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

33.3.2 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using other than the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1:

a) Control action Types 1 or 2;

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

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

d) For the applicable Material Group, see Table 33.2;

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

Table 33.1
Overvoltage categories

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

Table 33.2
Material group

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

Table 33.3
Pollution degrees

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

33.4 Electronic protective controls (limiting controls)

33.4.1 An electronic control that performs a protective function shall comply with the applicable requirements in Temperature Controls, Section 25 and Controls and Control Circuits, Section 32, while tested using the parameters in this Section. Examples of protective controls are:

a) A control used to sense abnormal temperatures of components within the appliance;

b) A safety interlock function to de-energize a motor etc.;

c) Temperature protection of the motor due to locked rotor, running overload, loss of phase; or

d) Other safety or link function intended to reduce the risk of electric shock, fire, or injury to persons.

Exception: An electronic protective control, the failure of which would not increase the risk of fire, electric shock, or injury to persons, is not required to comply the requirements in this Section.

33.4.2 The following test parameters shall be among the items considered when determining the acceptability of an electronic protective control investigated using the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1:

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

b) Power Supply Voltage Dips, Variation and Interruptions within a temperature range of 10°C (18°F) and the maximum ambient temperature determined by conducting the Normal Temperature Test, Section 48;

c) Surge Immunity Test – Installation Class 3 shall be used;

d) Electrical Fast Transient/Burst Test, a test level 3 shall be used;

e) Electrostatic Discharge Test;

f) Radio-Frequency Electromagnetic Field Immunity:

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

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

g) Thermal Cycling test shall be conducted at ambient temperatures of 10.0+2°C (50.0 ±3°F) and the maximum ambient temperature determined by conducting the Normal Temperature Test, Section 48. The test shall be conducted for 14 days;

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Normal Temperature Test, Section 48; and

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

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

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

b) A field strength of 3 V/m is to be used for the Radiated EMI Test;

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

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

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

f) The Computational Investigation is not applicable to equipment covered by this standard;

g) For the Demonstrated Method Test, the multiplier for the test acceleration factor is to be 576.30 for intermittent use appliances, or 5,763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 25°C (77°F) use ambient;

h) The Endurance Test is to be conducted concurrently with the Operational Test. The control shall perform its intended function while being conditioned for 14 days in an ambient air temperature of 60°C (140°F), or 10°C (18°F) greater than the operating temperature of the control, whichever is higher. During the test, the control is to be operated in a manner representing normal use;

i) For the Electrical Fast Transient Burst Test, test level 1 is to be used; and

j) Conduct a Failure-Mode and Effect Analysis (FMEA).

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

33.4.4 Unless otherwise specified in this standard, protective controls shall be evaluated for 100,000 cycles for Type 2 devices and 6,000 cycles for Type 1 devices with rated current. Also see Table 60.1.

34 Lasers

34.1 A product employing a laser shall comply with the Code of Federal Regulations, Performance Standards for Light-Emitting Products, Title 21 CFR 1040.

34.2 With reference to 34.1, compliance of laser products with the Code of Federal Regulations (CFR), Title 21 Part 1040, shall be determined by:

a) Determining the Class of laser (as defined in the CFR) from the manufacturer's required documentation, such as the Center for Devices and Radiological Health (CDRH) report, markings and labels, or similar documentation;

b) Verifying that the manufacturer's markings and labels, having the information specified in the CFR, are affixed on the laser product (as defined in the CFR);

c) Determining that the corresponding construction features, such as protective housing, interlocks, and similar features, are provided in accordance with CFR; and

d) Determining that the resulting construction complies with the construction requirements of this standard.

35 Liquid Handling Systems

35.1 Containers such as reservoirs, hoses, and storage chambers that are used to store liquids shall not leak due to warpage of the vessel or otherwise be adversely affected by the liquids that are intended to be used in these containers.

Exception: This requirement does not apply to liquid containers and hoses that comply with the requirements in the leakage test described in 56.2.1.

35.2 Seals, boots, diaphragms, and gaskets in contact with a liquid shall not be adversely affected by the liquid, as determined by compliance with the Standard for Gaskets and Seals, UL 157.

Exception No. 1: Parts that flex during normal operation shall comply with the component malfunction test described in 56.4.1.

Exception No. 2: Parts that do not flex during normal operation are not prohibited from being evaluated in accordance with the component malfunction test described in 56.4.1.

35.3 The spillage from containers described in 35.1 of any liquid, powder, or other material that must be replenished, removed, or replaced shall not result in risk of fire, electric shock, or injury to persons as determined by the overflow test described in 56.3.1.

Exception: A reservoir or liquid storage chamber that must be removed for filling is not required to comply with 35.3.

35.4 Liquid-handling systems such as reservoirs and hoses shall:

a) Be routed and positioned so there is no possibility of mechanical damage,

b) Not transfer more liquid than a reservoir or container is capable of containing, and

c) Incorporate (for a manual-fill system) a visual or audible means of indicating when the reservoir or container is full.

35.5 A reservoir or liquid storage chamber shall be marked to indicate the intended liquid.

36 Flammable Liquids

36.1 Equipment using a flammable liquid shall be marked as indicated in 75.4 and shall comply with the requirements in this section. The flammable liquid shall comply with the requirements in the Standard for Tests for Comparative Flammability of Liquids, UL 340.

Exception: The requirement does not apply to bearing and gear lubricants, to hydraulic oils, or to printing inks with a total volume less than 4 fluid ounces (118 ml).

36.2 Fluids intended for use in a unit for cooling purposes or for use in a hydraulic system shall have a flash point of 148.9°C (300°F) or higher, and the container in which the fluid is located shall be constructed so it is completely sealed. The liquid-handling system shall have provision for expansion of the fluid and shall incorporate means for automatic pressure relief.

36.3 Flammable liquids intended for use within the equipment shall be contained only in a closed storage container.

36.4 The maximum capacities of a separate storage container and a liquid handling system for flammable liquids within the equipment shall comply with Table 36.1.

Table 36.1
Maximum capacity of a flammable liquid in equipment

Liquid		Closed storage container			Liquid handling system, including processing container and reservoir	
Flash point, °F (°C)	Boiling point, °F (°C)	Material	Size, gallon	(L)	Size, quart	(L)
Below 73 (22.8)	Below 100 (37.8)	Shall not be used			Shall not be used	
Below 73 (22.8)	Above 100 (37.8)	Glass	0.25	(0.95)	1.25	(1.18)
		Metal or plastic	5.0	(18.9)	1.25	(1.18)
At or above 73 (22.8) and below 140 (60)	– –	Glass	1.0	(3.79)	5.0	(4.69)
		Metal or plastic	5.0	(18.9)	5.0	(4.69)
At or above 140 (60)	– –	Glass	5.0	(18.9)	5.0	(4.69)

Table 36.1 Continued on Next Page

Table 36.1 Continued

Liquid		Closed storage container			Liquid handling system, including processing container and reservoir	
Flash point, °F (°C)	Boiling point, °F (°C)	Material	Size, gallon	(L)	Size, quart	(L)
		Metal or plastic	5.0	(18.9)	5.0	(4.69)
NOTE – The maximum total quantity of flammable liquid stored in a unit shall not be greater than 10 gallons (37.8 L) or the amount required for one 8-hour operation, whichever is greater.						

36.5 Under intended operating conditions, equipment using a flammable liquid shall not generate a vapor-air mixture that exceeds:

a) Twenty-five percent of the lower flammable limit in air when in proximity to an ignition source and

b) Eighty percent of the lower flammable limit in air when in areas not in proximity to an ignition source.

Exception: This requirement does not apply to liquids having a flash point of 60°C (140°F) or higher and not under enough pressure to result in the atomization of the liquid.

36.6 With reference to 36.5, an ignition source is determined to be:

a) Any surface which, under intended operating conditions, has a temperature that exceeds the ignition temperature of the vapor-air mixture.

b) Any area where an ignition-capable electric arc is capable of occurring due to switching devices, commutators, and similar parts.

36.7 Compliance with 36.6 is not prohibited from being determined by measuring the vapor concentration in the affected areas with the equipment operating under the conditions described for the Normal Temperature Test, Section 48. Measurements are to be taken using an instrument or methods that provide a 5 percent or better accuracy.

36.8 When operation of the equipment is possible with any of its fans not functioning, the test described in 36.7 shall be repeated with one or all of its fans disconnected.

PROTECTION AGAINST INJURY TO PERSONS

37 General

37.1 When the operation and maintenance of a product by the user involves the risk of injury to persons, such as fire or electric shock, protection shall be provided to reduce the risk. When evaluating a product consideration shall be given to foreseeable misuse.

37.2 A functional attachment that is provided with the basic product or specified by the manufacturer for use with the basic product shall be included in the investigation of the product. Unless the manufacturer specifies the use of two or more attachments at the same time, only one attachment at a time is to be investigated with the product.

37.3 Whether a guard, release, or interlock is required and whether such a device serves the intended purpose shall be determined from an investigation of the complete product, its operating characteristics, and the risk of injury to persons resulting from a result other than gross negligence. The investigation shall include consideration of the results of breakdown or malfunction of any one component, and not more than one component at a time, unless one event contributes to another. When the investigation shows that breakdown or malfunction of a particular component is capable of resulting in a risk of injury to persons, that component shall be investigated for reliability.

37.4 Specific constructions, tests, markings, and guards are detailed for some common constructions. Specific features and products not covered herein are to be given appropriate consideration.

38 Pressure Vessels and Parts Subject to Pressure

38.1 A pressure vessel having an inside diameter of more than 6 inches (152 mm) and subject to a pressure of more than 15 lbf/inches^2 (103 kN/m^2) shall be certified by the National Board of Boiler and Pressure-Vessel Inspectors, and marked in accordance with the appropriate boiler and pressure vessel code symbol (″H,″ ″M,″ ″S,″ or ″U″) of the American Society of Mechanical Engineers (ASME) for a working pressure not less than that to which it is subject to during normal or abnormal operation.

38.2 Pressure vessels that do not comply with 38.1 shall comply with Hydrostatic Pressure Test, Section 68.

Exception No. 1: This requirement does not apply to a section of a pressure system constructed of continuous tubing or of lengths of tubing connected by hard-soldered, brazed, or welded joints, when the wall thickness of tubing is not less than the value specified in Table 38.1.

Exception No. 2: This requirement does not apply when study and analysis of the material used to make the pressure vessel and of its dimensions concludes that the part has the strength intended for the application (for example, copper or steel pipe of standard size and provided with standard fittings is determined to have the strength for the application).

Table 38.1
Wall thickness for copper and steel tubing

Outside diameter,		Minimum wall thickness,		Maximum pressure to which tubing is subjected					
				Seamless copper,		Butt-welded steel,		Seamless steel,	
inch	(mm)	inch	(mm)	Psi	(MPa)	Psi	(MPa)	Psi	(MPa)
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	(18.0)	0.021	(0.53)	360	(2.48)	432	(2.98)	720	(4.97)
3/4	(18.0)	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)

38.3 A part supported or actuated hydraulically that results in a risk of injury to persons due to pressure loss shall comply with the requirements in 38.1 or 38.2 with regard to a pressure equal to five times the maximum pressure capable of being developed in the system.

38.4 Pressure-relief devices provided with the features described in 38.9, such as fusible plugs, soldered joints, nonmetallic tubing, and other pressure-relief means that have been determined to be equivalent, are not prohibited from being used to comply with the requirements in 38.3.

38.5 A means for relieving pressure shall be provided for all parts in which pressure is capable of being generated by an external source of heat, including fire.

38.6 There shall be no shut-off valve between the pressure-relief means and the parts that they are intended to protect.

38.7 A vessel having an inside diameter of more than 3 inches (76.2 mm) and subject to air or steam pressure generated or stored within the product, shall be protected by a pressure-relief device.

38.8 The start-to-discharge pressure setting of the pressure-relief device shall be no higher than the working pressure marked on the vessel. The discharge rate of the device shall be capable of relieving the pressure.

38.9 A pressure-relief device shall:

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 is not capable of being readily rendered inoperative,

c) Have its discharge opening located and directed so that the risk of scalding is reduced to a minimum, and

d) Have its discharge opening located and directed so that operation of the device does not deposit moisture on bare live parts or on insulation or components affected by moisture.

38.10 A pressure-relief device having an adjustable setting is to be evaluated on the basis of its maximum setting unless the adjusting means is sealed at a lower setting. A pressure-relief device shall be certified by the American Society of Mechanical Engineers (ASME) or otherwise investigated for suitability.

38.11 A pressure-relief device is determined to be a pressure-actuated valve or rupture member constructed to relieve excessive pressures automatically.

38.12 Where a pressure relief device is required, the control responsible for limiting the pressure in the vessel shall be capable of performing under rated load for 100,000 cycles of operation and the control shall limit the pressure so that it does not exceed 90 percent of the relief device setting under any condition of intended operation.

39 Sharp Edges

39.1 An enclosure, frame, guard, or handle shall not be so sharp as to constitute a risk of injury to persons in normal maintenance and use unless the part or portion of a part is required to perform a working function within the product.

39.2 A product, or any item furnished with the product, shall not have any sharp edges, burrs, points, or spikes inside or outside the product that are capable of presenting a risk of injury to persons during its intended use, servicing, and cleaning operations.

40 Enclosures and Guards

40.1 The rotor of a motor, pulley, belt, gear, fan, or other moving part that is capable of resulting in an injury to persons shall be enclosed or provided with other means to reduce the risk of unintentional contact. The moving part shall not be contacted by the probe illustrated in Figure 8.2.

Exception No. 1: An opening in the integral enclosure of a motor that is not used in either a hand-held product or a hand-supported portion of a product complies with the intent of this requirement when a moving part is not capable of being contacted by the probe illustrated in Figure 8.2.

Exception No. 2: A part or portion of a part that is necessarily exposed to perform its intended function is not required to be enclosed. However, when required, guarding shall be provided for the part.

40.2 A part of the enclosure that is capable of being removed without the use of a tool to attach an accessory, to make an operating adjustment, or for other reasons is to be opened or removed unless the product is marked in accordance with 75.2.

40.3 Among the factors to be evaluated in determining the acceptability of an exposed moving part are:

a) The degree of exposure required to perform the intended function,

b) The sharpness of the moving part,

c) The risk of unintentional contact therewith,

d) The speed of the moving part, and

e) The risk that a part of the body becomes endangered or that clothing becomes entangled by the moving part, resulting in a risk of injury to persons.

These factors are to be evaluated with regard to both the intended operation of the product and any foreseeable misuse.

40.4 Features of guards that are to be evaluated include:

a) Removal without the use of a tool;

b) Servicing;

c) Strength and rigidity;

d) Completeness;

e) The creation of a risk of injury to persons such as a pinch point, and the necessity for additional handling because of the increased requirement for servicing, such as for cleaning or removing obstructions;

f) Usage of the product (household or commercial); and

g) Self-restoring.

40.5 An enclosure or guard over a rotating part shall be constructed so it retains a part that, because of breakage or other reasons, is capable of loosening or is capable of separating from a rotating part, and retains a foreign object that is capable of being struck and propelled by the rotating part.

40.6 When complete guarding of a moving part that obviously results in injury to persons defeats the utility of a product:

a) A control, such as a momentary contact switch, shall be provided with the product and

b) An appropriate marking shall be provided in the instruction manual warning the user of the risk.

40.7 A feeding mechanism, either manual or automatic, shall be constructed or guarded to reduce the risk of or the necessity of the operator's fingers being in an area that is capable of resulting in injury to persons. A hopper or tubular feed opening for manual feeding with an average inside throat diameter (one-half the sum of the maximum and minimum dimensions) of not more than 2-1/2 inches (64 mm) complies with the intent of this requirement when the cutters are recessed below the plane of the opening.

40.8 A cutting or slicing mechanism shall be guarded unless the exposure of the blade or part that has been determined to be equivalent is required for proper operation of the product.

41 Materials

41.1 The material used for a part, such as an enclosure, frame, or guard, shall have such properties as to meet the demands of expected loading conditions when the breakage or deterioration of the part is capable of resulting in a risk of injury to persons. The properties for which these parts shall be evaluated include mechanical, thermal, and flammability.

41.2 The requirement in 41.1 applies to those portions of a part adjacent to a moving part determined to involve a risk of injury to persons.

41.3 Materials used in the construction of the product that reduces the risk of injury to persons shall be investigated and determined to be capable of being used for the particular use.

42 Rotating or Moving Members

42.1 A rotating or moving part that, when it becomes disengaged, is capable of creating a risk of injury to persons, shall be provided with a means to retain the part in place under conditions of use.

42.2 A rotating member, the breakage of which is capable of creating a risk of injury to persons, shall be constructed to reduce the risk of its breakage, or the release or loosening of a part that becomes a risk of injury to persons. To determine whether a product using a series or universal motor complies with the requirement, it shall be tested as described in the Overvoltage Test, Section 51.

43 Switches, Controls, and Interlocks

43.1 A product shall be constructed so as to reduce the risk of unexpected operation of any part capable of causing injury to persons. Each function of a multiple-function product is to be taken into consideration in determining compliance with these requirements.

43.2 In situations where a product has a moving part that is capable of resulting in injury to persons, a motor control switch other than a momentary-contact switch shall be provided on the product. See 74.12.

43.3 The actuator of a switch shall be located or guarded so that unintentional operation does not occur when such operation is capable of resulting in a risk of injury to persons. Guarding shall be accomplished by recessing, ribs, barriers, or similar means.

43.4 The actuator of an interlock switch shall be located so that unintentional operation does not occur.

43.5 Operation of an interlock during its intended use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock. An interlock shall not be capable of being defeated by materials such as wood or metal chips that accumulate during its intended use. An interlock shall be such that it is not capable of being readily defeated:

a) Without damaging the product,

b) Without making wiring connections or alterations, or

c) By using materials that are readily available.

43.6 When an interlock is energized by movement of a guard, the arrangement shall be such that the guard is in place when the interlock is in the position that enables operation of the parts being guarded. With the guard removed, the interlock shall comply with the requirements in 43.4.

43.7 A floor or ground-supported product that is capable of traveling or rotating to an extent that results in injury to persons when left unattended shall be provided with a momentary contact switch that is not capable of being locked in the ″on″ position.

43.8 A device that automatically starts a product, such as a timer or automatically reset overload-protective device, shall not be used unless it is demonstrated that automatic starting does not result in a risk of injury to persons.

43.9 An interlock provided for the purpose of protecting personnel against risk of electric shock or electrical energy at high current levels, shall open all current-carrying conductors of cord-connected units and all ungrounded conductors of permanently-connected units.

Exception: An interlock switch that opens all current-carrying conductors in the area in which the interlock is intended to provide protection is not prohibited from being used, even though conductors outside the protected area are still capable of carrying current.

43.10 A safety interlock system that uses solid state devices shall comply with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. Solid state control(s) of a system fulfill this requirement if they comply with 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 Temperature Sensing Controls, UL 60730-2-9.

43.11 Additional requirements for a safety interlock system are not specified and are to be determined from a study of the entire unit, its construction, operating characteristics, intended function, and possible misuse. An investigation of the system is to include the frequency of operation and the nature of the risks involved. This investigation shall include an endurance test based on these factors. In general, the endurance test for interlocks involving only service personnel is 6000 operations and the test for interlocks involving an operator is 100,000 operations.

PERFORMANCE

44 General

44.1 The performance of a product shall be investigated by subjecting the requisite number of representative products to all of the following applicable tests. Insofar as practicable, the tests shall be conducted in the order in which they are presented here. Products employed for leakage-current tests shall be tested for leakage prior to using the products for other tests.

44.2 Cheesecloth required for use during any of the following tests is to be bleached, weighing 14 – 15 yds/lb (28 – 30 m/kg) and having a count of 32 x 28, that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for the square centimeter, 13 threads in one direction and 11 threads in the other direction).

44.3 Equipment with one frequency rating is to be tested at that frequency. Equipment with a dual frequency rating or frequency range is to be tested at the frequency which is determined to represent the worst case (i.e. highest current input, highest temperatures, etc.).

44.4 Unless otherwise specified, the voltage of the test circuit is to be the highest voltage of the applicable range of voltages when the marked voltage is within one of the voltage ranges indicated: 100 – 120, 220 – 240, 254 – 277, 440 – 480, 550 – 600. At any other voltage rating, the equipment is to be tested at its marked voltage rating. When agreeable with all parties concerned, a different voltage is not prohibited from being used. Equipment that is rated for use at more than one voltage or for a range of voltages, and contains a means of being adapted to different supply voltages, is to be tested while connected in accordance with the manufacturer's instructions.

44.5 Unless otherwise specified, the source of supply used during each test shall be protected by a branch-circuit protective device with a rating corresponding to that of the branch-circuit to which the product is intended to be connected.

44.6 For products with DC input unit described in DC input units, Section 11.3, all tests are to be conducted at the marked DC voltage. The test supply of rated voltage shall have a minimum capacity of 30 A.

45 Starting Current Test

45.1 A product shall start and operate normally on a circuit protected by a non-time-delay fuse having a current rating corresponding to that of the branch circuit to which the product is to be connected. The fuse shall not open, and an overload protector provided as part of the product shall not trip.

Exception: A time-delay fuse is not prohibited from being used when:

a) The construction of the product or the nature of its usage is such that it is to be used continually on the same branch circuit after installation,

b) The product is intended to start and operate normally on a circuit protected by a time-delay fuse, and

c) The product is marked in accordance with 74.23.

45.2 The product is to be started three times at room temperature at the beginning of the test. Each start is to be made under conditions representing the beginning of normal operation, or the beginning of the normal operating cycle, in the case of an automatic product. A motor is to be allowed to come to rest between successive starts.

46 Input Test

46.1 The normal measured input current, power, or both of a product shall be not more than 105 percent of its marked current or power rating.

46.2 The input current, power, or both, is to be measured with the product at normal operating temperature under full-load conditions, and while connected to a supply circuit as specified in Performance, General, Section 44. When a product uses a nonmetallic heating element, such as carbon, the input rating is to be determined with a new element.

47 Leakage Current Test

47.1 Cord-connected products

47.1.1 The leakage current of a cord-connected product rated for a nominal 120-, 208-, or 240-volt supply shall not be more than:

a) 0.5 milliamp for an ungrounded (2-wire) product,

b) 0.5 milliamp for a grounded (3-wire) portable product, and

c) 0.75 milliamp for a grounded (3-wire) product intended to be fastened in place or located in a dedicated space and using a standard attachment plug rated 20 amperes or less.

Exception: During heat-up and cool-down, as defined in Table 1 of the Standard for Leakage Current Appliances, ANSI C101.1, the leakage current of a product using a sheath-type heating element is not prohibited from exceeding 0.5 milliamp or 0.75 milliamp, as applicable, and shall not exceed 2.5 milliamp during a period of 5 minutes beginning with the moment the leakage current exceeds 0.5 milliamp or 0.75 milliamp, as applicable. At the end of the 5-minute period, the leakage current shall not be more than 0.5 milliamp or 0.75 milliamp, as applicable.

47.1.2 Leakage current refers to all currents, including capacitively coupled currents, that are capable of being conveyed between exposed conductive surfaces of a product and ground or other exposed conductive surfaces of a product.

47.1.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively where simultaneously accessible, and from one surface to another where simultaneously accessible. Parts are determined to be exposed surfaces unless guarded by an enclosure that has been found to be capable of serving as protection against a risk of electric shock. Surfaces are determined to be simultaneously accessible when they are capable of being contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltage levels that do not involve a risk of electric shock.

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

47.1.5 The leakage current test is to be conducted without interruption for other tests. However, with the concurrence of those concerned, the leakage-current tests is not prohibited from being interrupted for the purpose of conducting other nondestructive tests.

47.1.6 A heated surface of insulating material is to be investigated with regard to the leakage current available from the use of metal utensils.

47.1.7 The measurement circuit for leakage current is to be as shown in Figure 47.1. The ideal measurement instrument is defined in (a) – (d). The meter which is actually used for a measurement is only required to indicate the same numerical value for a particular measurement in the same manner as the ideal instrument. The meter used is not required to have all the attributes of the ideal instrument.

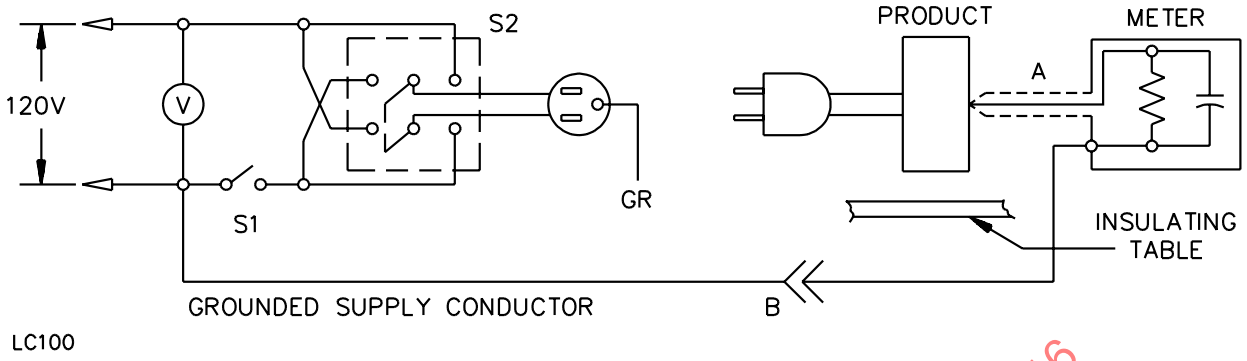
a) The meter is to have an input impedance of a 1500-ohm resistor shunted by the capacitance of a 0.15µF capacitor.

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

c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response (ratio indicated to actual value of current) that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15 µF capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milliamp, the measurement is to have an error of not more than 5 percent at 60 hertz.

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

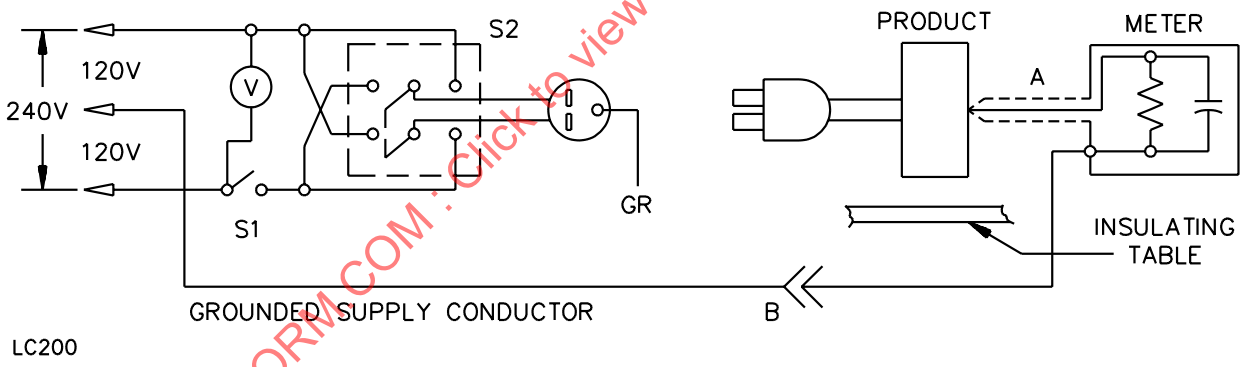
Figure 47.1
Leakage-current measurement circuit



LC100

Product intended for connection to a 120-volt power supply.

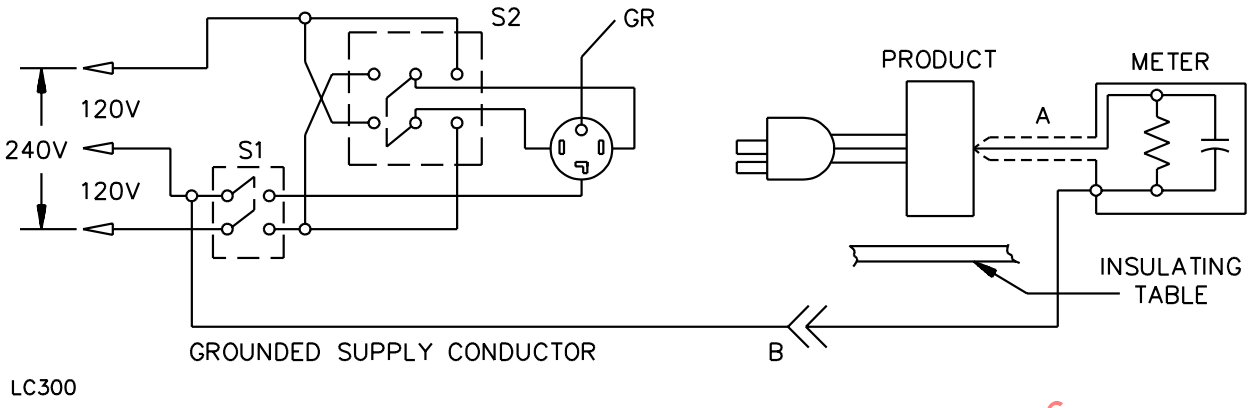
(Continued)



LC200

2-wire product intended for connection to a 3-wire, grounded neutral power supply, as illustrated above.

(Continued)



LC300

3-wire product intended for connection to a 4-wire, grounded neutral power supply, as illustrated above.

A – Probe with shielded lead.

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

47.1.8 A representative product is to be tested for leakage current starting in an as-received condition with all its switches and thermostats closed, and with its grounding conductor, when provided, open at the attachment plug. The supply voltage is to be 120, 208, or 240 volts, as applicable. The test sequence, with reference to the measuring circuit, Figure 47.1, is to be as follows:

a) With switch S1 open, the product is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2.

b) Switch S1 is then to be closed, energizing the product, and within a period of 5 seconds, the leakage current is to be measured using both positions of switch S2, and with the product operated at the maximum speed and heat setting of controls.

c) Leakage current is to be monitored from the time the product is energized until the product reaches thermal stabilization. Both positions of switch S2 are to be used. Thermal stabilization is determined to be achieved when obtained in the same manner as that described in 48.6. When a thermostat does not cycle at the maximum heat setting, it is to be adjusted until it cycles before the final measurements are taken. Measurements are to be made with the thermostat, when provided, open and closed. Upon evidence of stabilizing readings, intervals between measurements are not prohibited from being increased.

d) Leakage current is to be monitored until the leakage current stabilizes or decreases after the product is turned off.

47.2 Permanently-connected products

47.2.1 A permanently-connected liquid-product of the electrode type, and the type in which live parts of the heating element are in contact with the liquid, shall not have a leakage current to ground in excess of 0.5 ampere with current flowing through the element or with one side of the line open as described in 47.2.2.

47.2.2 To determine whether a liquid-protection complies with the requirement in 47.2.1, the product is to be connected to a grounded supply circuit having full rated voltage between the ungrounded side of the line and ground. The case is to be mounted so that it is insulated from ground, and the liquid is to be supplied by means of a rubber tube. A hard-water solution of 0.018 ounces (0.5 g) of calcium sulfate ($CaSO_4 \cdot 2H_2O$) per liter of distilled water is to be used for the testing of a water heater constructed for general use. An ammeter is to be placed between the pipe connections on the heater and the water pipe or other ground, and leakage readings are to be observed under all conditions representing an open fuse or fuses, except that in the case of a heater constructed and marked for use with a solid (not fused) and grounded neutral, the grounded conductor is not required to be disconnected.

47.2.3 The maximum leakage current is usually noted with the maximum water temperature that is capable of being obtained by reducing the flow of water to a minimum.

48 Normal Temperature Test

48.1 A product, when tested under the conditions described in this section, shall comply with all of the following conditions:

a) The product shall not attain a temperature at any point that constitutes a risk of fire or damage to any materials used in the product.

b) At any time during the test, other than as indicated in 48.2, temperature rises at specific points shall not be greater than indicated in Table 48.1.

c) The product shall comply with the enclosure requirements in 8.1.1 – 8.1.10.

d) The product shall comply with the surface temperature requirements in 48.23. See Table 48.2.

e) A thermal or overload-protective device shall not operate.

Table 48.1
Maximum temperature rises

Materials and component parts	°C	(°F)
1. Any point within a terminal box or wiring compartment of a permanently-connected product in which field-installed conductors are to be connected (including such conductors themselves) unless the product is marked in accordance with 74.9	35	(63)
2. Capacitor:		
Electrolytic[a]	40	(72)
Other types[b]	65	(117)
3. Any point on a surface adjacent to a product that is permanently-connected electrically or cord-connected and intended to be fastened in place or located in a dedicated space (including the surface in which the product is mounted, and specified points on test surfaces and enclosures at designated clearances from the product).	65	(117)
4. Fuses	65	(117)
5. Fiber used as electrical insulation or as cord bushings	65	(117)
6. Wood or other combustible material which is part of a product.	65	(117)
7. Cotton or rayon braid of a flexible cord	65	(117)
8. Class A insulation systems on winding of relays or solenoids, and similar components:		
Thermocouple method	65	(117)
Resistance method	85	(153)
9. Class A insulation systems on coil windings of AC motors having a frame diameter of more than 7 inches (178 mm) and of DC and universal motors[c,d]		
a) In open motors:		
Thermocouple method	65	(117)
Resistance method	75	(135)
b) In totally enclosed motors:		
Thermocouple method	70	(126)
Resistance method	80	(144)
10. Class A insulation systems on coil windings of AC motors (not including universal motors) having a frame diameter of 7 inches (178 mm) or less and on vibrator coils (thermocouple or resistance method[c,d])		
a) In open motors and on vibrator coils	75	(135)
b) In totally enclosed motors	80	(144)
11. Class B insulation systems on winding of relays, solenoids, and similar components:		
Thermocouple method[c]	85	(153)
Resistance method	105	(189)
12. Class B insulation systems on coil windings of AC motors having a frame diameter of more than 7 inches (178 mm) and of DC and universal motors[c,d]		
a) In open motors:		
Thermocouple method	85	(153)
Resistance method	95	(171)
b) In totally enclosed motors:		
Thermocouple method	90	(162)
Resistance method	100	(180)
13. Class B insulation systems on coil windings of AC motors (not including universal motors) having a frame diameter of 7 inches (178 mm) or less and in vibrator coils (thermocouple or resistance method[c,d])		

Table 48.1 Continued on Next Page

Table 48.1 Continued

Materials and component parts	°C	(°F)
a) In open motors and on vibrator coils	95	(171)
b) In totally enclosed motors	100	(180)
14. Class F insulation systems on coil windings of AC motors (not including universal motors) having a frame diameter of 7 inches (178 mm) or less and in vibrator coils (thermocouple or resistance method[c,d])		
a) In open motors and on vibrator coils	120	(216)
b) In totally enclosed motors	125	(225)
15. Flatiron or product plug	175	(315)
16. Insulated wire or cord	25°C (77°F) less than its temperature rating[e]	
17. Sealing compound	f	f
18. Copper conductors, bare or insulated, without nickel coating or other protection	125	(225)
19. Termination of copper conductor and pressure terminal connector without being nickel-coated or otherwise protected	125	(225)
20. Varnished-cloth insulation	60	(108)
21. Phenolic composition used as electrical insulation or where deterioration results in risk of fire, electric shock, or injury to persons[g]	125	(225)
22. Points on surface supporting a cord-connected heater	125	(225)
23. Class A insulation systems on transformers:		
Thermocouple method	65	(117)
Resistance method	75	(135)

[a] The temperature rise on insulating material integral with the enclosure of an electrolytic capacitor that is physically integral with or attached to a motor is to be not more than 65°C (117°F).

[b] A capacitor that operates at a temperature rise of more than 65°C is not prohibited from being evaluated on the basis of its marked temperature limit.

[c] See 48.9.

[d] The frame diameter is the diameter measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, boxes, and similar parts used solely for motor mounting, assembly, or connection.

[e] Inside a product, the temperature rise on a wire or cord that is greater than the specified maximum rise complies with the intent of this requirement when the insulation on each individual conductor is protected by supplementary insulation (such as braid, wrap, tape, or close-fitting tubing) which is appropriate for the temperature and the type of insulation involved.

[f] Unless a thermosetting material, the maximum sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature, is 15°C (27°F) less than the softening point of the compound as determined by the Standard for Ball and Ring Apparatus, ASTM E28-67.

[g] The limitation on phenolic composition does not apply to a compound which has been investigated and determined to have special heat-resistant properties.

Table 48.2
Maximum surface temperatures

Location	Composition of surface[a]	
	Metal	Nonmetallic
Handles or knobs that are grasped for lifting, carrying, or holding	55°C (131°F)	75°C (167°F)
Handles or knobs that are contacted and do not involve lifting, carrying, or holding; and other surfaces subject to contact and user maintenance	60°C (140°F)	85°C (185°F)
Surfaces other than a heating function surface and known to be hot due to proximity to the heating function surface	70°C (158°F)	95°C (203°F)

NOTE – When the test is conducted at a room temperature of other than 25°C (77°F), the results are to be corrected to that temperature.

[a] A handle, knob, or similar item made of material other than metal, that is plated or clad with metal having a thickness of 0.005 inch (0.127 mm) or less is determined to be, and is evaluated as, a nonmetallic part.

48.2 Initial temperature transients are not prohibited from being in excess of the value shown in Table 48.1, when the duration and extent of the excursion do not result in a risk of fire or electric shock and do not unduly shorten the life of the product.

48.3 All values in Table 48.1 are based on an assumed room ambient temperature of 25°C (77°F), however, a test is not prohibited from being conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F). However, when the operation of an automatic thermal control during the test limits the temperatures under observation, a temperature higher than 25°C plus the specified maximum rise does not comply with the intent of this requirement.

48.4 A product shall not subject a stored or vaporized chemical to temperatures that result in ignition.

48.5 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2), except that a coil temperature is not prohibited from being determined by the change-of-resistance method when the coil is inaccessible for mounting thermocouples. When thermocouples are used in determining temperatures in electrical equipment, it is standard practice to use thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument, and such equipment is to be used whenever referee temperature measurements by thermocouples are required. The thermocouple wire is to comply with the requirements specified in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M. The thermocouples and related instruments are to be accurate and calibrated in accordance with established laboratory practice.

48.6 Thermal equilibrium is determined to exist when three successive readings, taken after three consecutive equal intervals of time, indicate no change. The duration of each interval shall either be five minutes or ten percent of the total test time elapsed prior to the start of the first interval, whichever is longer.

48.7 A thermocouple junction and adjacent thermocouple lead wire are to be securely held in reliable thermal contact with the surface of the material whose temperature is being measured. In most cases, reliable thermal contact results from securely taping or cementing the thermocouple in place. However, when a metal surface is involved, alternate methods of securing the thermocouple to the surface, such as brazing or soldering, are not prohibited from being used.

48.8 The temperature of a coil or winding is to be measured by means of thermocouples mounted on the outside of the coil wrap. When the coil is inaccessible for mounting thermocouples (i.e. a coil immersed in sealing compound) or when the coil wrap includes thermal insulation of more than 1/32 inch (0.8 mm) of cotton, paper, rayon, or similar material, the change-of-resistance method is to be used. 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, the thermocouple is to be mounted on the integrally applied insulation of the conductor.

48.9 The temperature rise at a point on the surface of a coil that is affected by an external source of heat is not prohibited from exceeding the maximum value indicated in Table 48.1 by the amount listed in Table 48.3, when the temperature rise measured by the change-of-resistance method does not exceed the values indicated in Table 48.1. When the temperature rise on the coil wrap does not exceed its temperature limitation by radiation from an external source, the temperature of the coil is not prohibited from being measured by means of a thermocouple on the integral insulation of the coil conductors.

Table 48.3
Additional temperature rises

Item in Table 48.1	Additional temperature rise, °C	(°F)
Item 8 and part a of item 9	15	(27)
Part a of item 10	5	(9)
Part a of item 12	20	(36)
Part a of item 13	10	(18)

48.10 Except for the products noted in 48.11, to determine whether a product complies with the requirements in 48.1, the product is to be operated continuously at maximum normal load at the voltage specified in 44.4 until thermal equilibrium has been reached. See 48.6.

48.11 Cord connected vacuum sealers intended only for household use shall be operated for 30 cycles. Each cycle is to consist of vacuuming and sealing a 1-gallon preformed bag or the maximum size preformed bag recommended in the instruction manual, whichever is less. For 1-gallon preformed bags, each bag shall be loaded with a solid block of any material measuring approximately 2.4 inch (60 mm) by 2.4 inch (60 mm) by 2.4 inches (60 mm). For preformed bags less than one gallon, each bag shall be loaded with a solid block of any material measuring approximately 1.2 inch (30 mm) by 1.2 inch (30 mm) by 1.2 inches (30 mm). Replacement of bags between each cycle should be within 10 seconds.

Exception No. 1: If the product is provided with options to make the bag or to use perfumed bags, each cycle is to consist of preparing and loading, vacuuming and sealing bag, whichever combination of recommended operations results in highest temperatures.

Exception No. 2: Replacement of bags between each cycle is allowed to be more than 10 seconds, when the product is provided with one of the following features:

a) An operating control as described in 4.13 with a built-in duty cycle that prevents the duty cycle for bag replacement to be preformed in less that 10 seconds or

b) Permanently and prominently marked with a duty cycle with a minimum letter height of 3/32 inch (2.4 mm) with or without visual indicator.

48.12 When a product uses a motor in addition to a heating element, the voltage applied to an integrally connected motor is to be the same test voltage as described in 44.4. A motor supplied from a separate circuit is to be connected to the test voltage derived from its marked rated voltage.

48.13 In conducting a test to determine whether a product complies with the temperature requirements, it is to be mounted or supported as in service and tested under conditions approximating those of normal operation, except as otherwise noted. Temperatures are to be observed on nearby surfaces, on the supporting surface, at points of support, on attachment plugs, and at other points as required, including building wiring that is located adjacent to or behind a permanently installed product.

48.14 A product intended to be permanently-connected to the power supply or a product that is cord-connected and that is intended to be fastened in place or located in a dedicated space is to be supported in the intended manner on black-painted wood not less than 3/8 inch (9.5 mm) thick and is to be located in a corner, with vertical walls meeting at a right angle, formed by two black-painted vertical sheets of 3/8 inch plywood having such width and height that they extend not less than 2 feet (61 cm) beyond the physical limits of the product. The product is to be located as close to both walls of the corner as its construction tolerates, and it is to be so placed relative to the walls that maximum heating of the walls occurs, except that it is not prohibited from being spaced away from the walls to limit the wall temperatures from rising more than 65°C (117°F) when the product is marked as described in 74.10.

48.15 Unless otherwise indicated, a cord-connected product is to be supported on two layers of white tissue paper on a softwood surface.

48.16 An automatic temperature-regulating control, temperature-limiting control, or other protective device is to be shunted out of the circuit, unless the control has been shown, in accordance with Table 60.1, to be rugged, reliable, and not capable of being defeated by the user. The control is determined to be not capable of being defeated when tools are required to gain access to the control, or a positive stop is incorporated in the control.

48.17 When the heating of a liquid is a determining factor in the temperatures attained, the intended duty of a product is to be evaluated. Regular operating conditions cannot be obtained, however, when certain types of products are operated continuously and in a dry condition. Accordingly, in determining whether a product complies with the requirements in 48.1, actual service conditions or an approximation thereof are to be used. Unless otherwise specifically indicated below:

a) When the product is controlled by an adjustable thermostat, the thermostat is to be set to give maximum temperatures and

b) When the product is controlled by a nonadjustable thermostat, it is to operate at whatever temperature the thermostat permits.

In each case, operation is to be continued until temperatures are stabilized.

48.18 A product that is capable of being either open or closed in actual service, such as a heat transfer press, is to be tested both open and closed to determine which condition produces the higher operating temperatures. In the case of an open-front tabletop product, where some heating operation is capable of being performed without a tray in place, temperatures are to be measured on the horizontal supporting surface in front of the open face of the product.

48.19 External thermal insulation, such as woven glass fiber or mineral wool, is to be removed before a product is installed in the test enclosure unless the material is bonded or permanently attached to the product. Rubber or other material similarly subject to deterioration is to be removed from feet or other supports when the removal of the material results in higher temperatures being attained on the product.

48.20 When a product incorporates a reel for the power-supply cord, one-third of the length of the cord is to be left unreeled.

48.21 Maximum normal load is determined to be the load that simulates as closely as possible the most severe conditions of intended use as defined by the manufacturer. It is not a deliberate overload except as the conditions of actual use are somewhat more severe than the maximum load conditions that are specified by the manufacturer of the product.

48.22 A product shall not attain a temperature of more than 125°C (257°F) on any exterior surface on which combustible material is capable of being laid, or against which combustible material is capable of being laid. There shall be no emission of smoke or molten material.

Exception: This requirement does not apply to a product that is provided with a non-combustible stand, guard, or both as indicated in 9.1.

48.23 The temperature of a surface that is intended to be contacted by the user shall not exceed the value specified in Table 48.2. However, accessible surfaces, other than handles or knobs, are not prohibited from having temperatures that exceed those shown in Table 48.2 when marked in accordance with 75.9.

49 Dielectric Voltage-Withstand Test

49.1 Primary circuits

49.1.1 Except as noted in this section, a product or system shall withstand without breakdown the application of a primarily sinusoidal potential at a frequency of 40 – 70 hertz for 1 minute. During this test, the product shall be in a well-heated condition. The potential is to be applied between:

a) Each different type of primary circuit and earth ground (dead-metal parts), with all other primary circuits connected to the earth ground;

b) Any live or current-carrying part of the primary circuit of an isolating-type transformer and each secondary circuit of that transformer; and

c) Terminals of opposite polarity on capacitors that are connected across-the-line.

49.1.2 The test potential is to be:

a) 1000 volts for a product employing a motor rated 1/2 horsepower (373 watts output) or less and 250 volts or less or

b) 1000 volts plus twice the rated voltage for a product employing a motor rated more than 1/2 horsepower or more than 250 volts.

49.1.3 When an auto-transformer is in the circuit, a potential of 1250 volts plus twice the rated voltage is to be applied directly to all wiring involving more than 250 volts while the primary of the auto-transformer is disconnected.

49.1.4 The test potential specified in 49.1.2 is to be obtained from any convenient source having a capacity of at least 500 volt-amperes. The capacity is not prohibited from being lower when the meter is located in the output circuit in order to maintain the potential at the required level except in case of breakdown. The voltage of the source is to be continuously adjustable.

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

49.1.6 In the case of a product in which wiring passes through a hinged member or spring, the cover is to be raised and lowered three or more times while the test potential is being applied in order to determine whether a breakdown is capable of occurring as a result from damaged insulation on the conductors while the cover is in various positions.

49.1.7 An immersion-type heater in which the electrodes make contact with a liquid shall be capable of withstanding a potential of 150 percent of the maximum rated voltage of the product across the supply connections under any condition of intended operation of the product.

49.2 Secondary circuits

49.2.1 A product or system shall withstand without breakdown the application of a primarily sinusoidal potential at a frequency of 40 – 70 hertz for 1 minute. The product is to be in a well-heated condition during the test. The potential is to be applied between:

a) Primary and secondary circuits,

b) Secondary circuits and grounded metal with any grounding connections disconnected,

c) Secondary circuit current-carrying parts that are isolated from each other after all common ground connections are disconnected, and

d) Isolated secondary windings of transformers.

49.2.2 The test potential is to be as indicated in Table 49.1. The maximum voltage used to determine the test voltage for the dielectric voltage-withstand potentials specified in Table 49.1 is to be determined in accordance with 49.2.3 – 49.2.8.

Table 49.1
Magnitude of test potential for secondary circuits

Maximum voltage (rms) in the circuit[a]	Test potential
30 or less (42.2 peak)	500 volts
More than 30 (42.4 peak) and not more than 333.3 (471.3 peak)	Ten times the maximum voltage in circuit (maximum of 1000 volts rms)
More than 333.3 (471.3 peak) and not more than 1000 (1414 peak)	Three times the maximum voltage in circuit
More than 1000 (1414 peak)	1750 volts plus 1.25 times voltage in circuit

[a] Where the peak voltage is greater than 120 percent of 1.414 times the rms voltage, the circuit is to be tested as though the voltage were peak voltage divided by 1.414.

49.2.3 The test potential is to be obtained from any convenient source having a capacity to maintain the voltage indicated in Table 49.1, except in case of breakdown. The output voltage of the test apparatus is to be monitored. Starting at zero, the applied potential is to be increased at a rate of 200 volts per second until the required test value is reached and is to be held at that value for 1 minute. A DC source or an AC source with a peak value equal to the DC value is not prohibited from being used for testing a DC circuit.

49.2.4 Voltages are to be measured with and without any accessories provided with the product. In each case, all operating controls and all user-servicing controls are to be adjusted to produce the maximum voltage.

49.2.5 An automatic voltage-regulating device is to be rendered inoperative unless, upon investigation, it is determined that it is capable of being relied upon to prevent an increase in voltage. The investigation is to take into consideration any likely malfunctions or breakdown of either the regulating device or the product and the possibility of the device being disconnected when it is not permanently connected in the circuit.

49.2.6 A connector or comparable part that is capable of being disconnected during intended operation or operator servicing is to be both connected and disconnected during the test so the maximum voltage is capable of being obtained.

49.2.7 When a complex voltage is present, the peak value of the voltage is to be measured.

49.2.8 When required, the frequency of the source is to be varied up to 1000 hertz to prevent saturation of the transformer core.

50 Insulation Resistance Test

50.1 A permanently-connected product or a cord-connected product, other than as described in 47.1.1, shall have an insulation resistance of not less than 50,000 ohms between live parts and interconnected dead-metal parts.

50.2 The insulation resistance is to be measured by one of the following methods:

a) A magnetic megohmmeter that has an open circuit output of 500 volts,

b) A voltmeter having an internal resistance of at least 30,000 ohms and using a 250-volt DC circuit, or

c) Equipment that has been determined to be equivalent.

51 Overvoltage Test

51.1 For the test required by 42.2, a product using a motor is to be operated for 1 minute at the no-load speed resulting from application of 1.3 times the rated voltage. A product in which the rotating load is capable of being varied is to be tested for each condition of loading that is capable of occurring. A part that is capable of presenting a risk of injury to persons shall not work loose at the conclusion of this test.

52 Humidity Conditioning Test

52.1 A product using insulation material that is expected to be adversely affected by moisture under conditions of intended use shall be conditioned for 48 hours in moist air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F).

52.2 Following the conditioning described in 52.1, the product is to be subjected to a repeated Dielectric Voltage-Withstand Test, Section 49, and Leakage Current Test, Section 47, or Insulation Resistance Test, Section 50, as applicable.

52.3 Regarding the Leakage Current Test noted in 52.2, the test is to be discontinued when the leakage current of the product stabilizes.

53 Immersion Test

53.1 A product that is capable of being immersed in water for cleaning shall be conditioned as described in this section.

Exception: The test does not apply to a product marked in accordance with 75.5.

53.2 Following the conditioning described in 53.3 – 53.6, the product is to be subjected to a repeated Dielectric Voltage-Withstand Test, Section 49, at a test value of 1000 volts and Leakage Current Test, Section 47, with a maximum leakage current of 0.5 milliamp. Also, there shall be no entrance of water into the interior of the product.

53.3 Three samples of the product are to be heated while dry, with the thermostat at the highest setting, until the thermostat automatically switches to the low or ″off″ position.

53.4 The samples are then to be immediately immersed in water at a temperature of 10 – 25°C (50–77°F). The immersion is to be complete unless the product is marked to indicate that it is intended for partial immersion only (see 75.5), in which case each product is to be immersed only to the extent indicated. After 1 hour of immersion, the samples are to be removed from the water, dried with a soft cloth to remove all surface moisture, and tested for leakage current as indicated in 53.2.

53.5 The entire procedure of immersion and leakage-current measurement is to be performed a total of five times. Immediately following the fifth leakage current measurement, each sample is to be tested for dielectric breakdown as indicated in 53.2. Afterwards, the samples are to be inspected for any entrance of water.

53.6 When the samples rely on a gasket to prevent the entrance of water into the enclosure, each sample is to be operated dry for 240 hours. After cooling to room temperature, each sample is to be heated according to 53.3, immersed according to 53.4, and then tested for leakage current and dielectric breakdown and examined for any sign of water in the interior of the product. These samples are to be subjected to only one immersion cycle.

53.7 As a result of the accelerated thermal aging described in 53.6, the gasket shall not become hard or brittle, shall not crack, and shall show no other signs of deterioration.

54 Grounding Continuity Test

54.1 A product shall have a maximum resistance of 0.1 ohm between any part required to be grounded and:

a) For permanently-connected products, the point on the product at which the power-supply system is to be connected and

b) For cord-connected products, the point to which the grounding conductor of the power-supply cord is connected.

54.2 The resistance is to be measured using a typical ohmmeter.

54.3 When an ohmmeter yields results that do not comply with the intent of 54.1, the resistance is to be re-measured by passing an AC or DC current between the two points at which the measurement was recorded. The current is to be equal to the maximum-current-rated branch-circuit overcurrent-protective device that is capable of being employed with the product. The resistance is to be calculated by dividing the voltage drop between the two points by the current.

55 Mechanical Endurance Test

55.1 When the intended operation of a product results in movement of the internal wiring, the product shall be capable of operating for 6000 cycles in the intended manner while connected to a supply source as indicated in Performance, General, Section 44. When the normal cleaning of a product results in movement of the internal wiring, the movable part shall be capable of operating for 6000 cycles, not connected to a power source, in the intended manner. At the conclusion of the test, there shall be no electrical or mechanical malfunction, and the product shall comply with Dielectric Voltage-Withstand Test, Section 49.

55.2 Any mechanical arrangement shall be used to operate the movable part at a rate of 12 cycles per minute. That part is to be operated in a manner that results in the part reaching the maximum limits of travel in both directions during each cycle. In the case of a product that has two different stop positions for a hinged cover, 1000 cycles out of the total of 6000 cycles are to be made with the cover moved to the wide-open position.

56 Flooding Tests

56.1 General

56.1.1 As a result of each of the tests described in this section:

a) There shall be no wetting of live parts, film-coated wire, or insulation that is expected to be adversely affected by the liquid involved;

b) No liquid shall enter a compartment housing field-installed wiring;

c) The product shall comply with a repeated Dielectric Voltage-Withstand Test, Section 49; and

d) The product shall comply with either the Leakage Current Test, Section 47, or the Insulation Resistance Test, Section 50.

56.1.2 For each test, the liquid provided with the product is to be used, unless the liquid poses a hazard, such as ignition, flammability, or hazardous vapors. In that case, a substitute liquid is to be used.

56.2 Leakage test

56.2.1 A reservoir or tank assembly, including attached tubing, is to be drilled with a 1/4 inch (6.4 mm) diameter hole in the most adverse location. The hole is to be plugged and the tank or reservoir filled to 50 percent of its capacity. The plug is then to be removed so the entire contents flow from the container. During this test, the reservoir is to be in its intended position in the product and the product is to be in the most adverse position that is capable of occurring during normal operation.

Exception: When a hole is to be drilled in tubing that is less than 1/4 inch inside diameter, the hole size is to be equal to the inside diameter of the tubing.

56.3 Overflow test

56.3.1 A reservoir or tank assembly that is expected to be overfilled during its intended use is to be filled to the level specified by the manufacturer, when such a level is plainly marked; otherwise, the reservoir is to be filled to its maximum capacity. Additional liquid equal to 10 percent of the capacity, and not more than 1 qt. (940 ml), is then to be poured into the reservoir through an orifice 3/8 inch (9.5 mm) in diameter. During this test, the product is to be in the normal position for filling the reservoir.

Exception: This test does not apply to a reservoir that must be removed from the product for filling.

56.4 Component malfunction test

56.4.1 A product is to be operated through one complete cycle of normal operation under the following conditions, one malfunction at a time:

a) A timer switch or float- or pressure-operated switch is to be operated with the switch defeated in the most adverse position and

b) A boot, diaphragm, liquid seal, or gasket used in a liquid handling product is to be removed.

Exception: A boot, diaphragm, liquid seal, or gasket that does not flex shall instead comply with the requirements in the Standard for Gaskets and Seals, UL 157. Infrequent motion of small amplitude, such as that experienced during normal operation by a diaphragm covering a pressure-sensitive switch, is not determined to constitute flexing.

57 Continuous Operation Test

57.1 A product that is not provided with a momentary contact switch is to be tested as described in this section. At the conclusion of the test, neither the cheesecloth nor the tissue paper shall ignite, and the 3-amp ground fuse shall not open.

57.2 The product is to be placed on a softwood surface covered with white tissue paper and completely draped with a double layer of cheesecloth. The cheesecloth is to be located within 1/8 inch (3.2 mm) of each opening in the enclosure. The product is to be connected to the supply source indicated in Performance, General, Section 44, in series with a 20-amp time-delay plug fuse. Thermocouples are to be attached to the product in the same manner as that required in the Normal Temperature Test, Section 48. The exposed dead-metal parts are to be connected to earth ground by a 3-amp non-time-delay plug fuse.

57.3 The product is to be operated continuously at no load until temperatures stabilize or burnout occurs.

58 Operational Test

58.1 The operation of a product intended for household use shall not result in a risk of fire, electric shock, or injury to persons.

58.2 An as-received sample of the product is to be set up or installed in accordance with the manufacturer's instructions. The sample is to be operated in accordance with the manufacturer's instructions, including maintenance and cleaning as specified by the manufacturer and lack of such maintenance and cleaning; and with all accessories specified by the manufacturer for use with the product. The product is to be operated as intended, including manipulation of all controls and operation under the various loading conditions that is to be expected. The product is to be operated for a suitable length of time or through a suitable number of cycles to determine that all logically foreseeable complications are revealed.

59 Abnormal Operation Test

59.1 General

59.1.1 A unit or system is to be operated continuously under abnormal conditions until ultimate results described in 59.1.2 have been observed. Only one abnormal condition is to be simulated at a time.

59.1.2 Unless otherwise stated in this section, following each abnormal condition:

a) The product shall comply with a repeated Dielectric Voltage-Withstand Test, Section 49;

b) The current between accessible parts and ground through a 500-ohm resistor shall not exceed 5 milliamperes;

c) There shall be no emission of flame or molten metal, other than drops of melted solder, from the product; and

d) There shall be no glowing or flaming of combustible material upon which the product is capable of being placed or, in the case of a permanently-installed product, is capable of being in proximity to the product as installed.

59.1.3 Unless otherwise indicated, the product is to be placed in the same position as described in the Normal Temperature Test, Section 48. A single layer of cheesecloth is to be loosely draped over the entire unit and a 3-amp non-time-delay fuse is to be connected between dead metal parts and earth ground. A counter-supported product is to be placed on a softwood surface covered with a layer of white tissue paper.

59.1.4 Unless ultimate results, such as a open circuit, are obtained in less time, the tests are to be continued for at least 1 hour, or for the maximum setting of any timer or control, whichever is longer. When, during that time period, there is an indication of a possible impending condition of fire or electric shock, such as smoke or deterioration of insulation, the test is to be continued until ultimate results are achieved, and no longer than 7 or 8 hours. In most cases, continuous operation for 7 to 8 hours is required to determine the ultimate result.

59.1.5 Examples of component malfunctions and probable misuses of the equipment that are capable of presenting conditions that do not comply with the intent of 59.1.2 are as follows:

a) An obstruction that stalls or overloads a drive motor;

b) A blocked solenoid or motor;

c) Unintended connection or internal adjustment of equipment that is rated for use at more than one voltage or for a range of voltages and contains a tapped transformer or other means of being adapted to different supply voltages;

Exception: This test is not required to be conducted when internal adjustments are intended to be made only by qualified service personnel, or when all of the following conditions are met:

a) A clear, permanent marking located adjacent to the cord or supply compartment shall warn the user that internal adjustments are required to be made when the equipment is installed or moved;

b) Detailed instructions, clearly showing the adjustments that are required to be made for various voltages, are to be permanently attached to the equipment. These instructions shall be on the outside or inside of the overall enclosure of a unit where visible at the point at which adjustments for supply voltages are to be made; and

c) The means provided for adjusting for different voltages are to comply with the requirements for wiring terminals described in Section 11.1.2.

d) When supplied with an operator-accessible selecting means, the unit is not prohibited from being tested at the worst case(s) of voltage applied and voltage setting means combination(s);

e) Malfunction of a fan or a blower relied upon to remove heat produced by heaters. The fan or blower motors are to be disconnected rather than stalled for this test;

f) Malfunction of a timer switch or a temperature-regulating thermostat which is capable of energizing a heating element continuously;

g) A jam or malfunction of a drive system that holds the load under a heat source for an excessive length of time;

h) Overloading of power supplies through operator-accessible connectors or unused printed-wiring board receptacles in operator-accessible card cages, or both;

i) For a motor connected across a portion of a resistance element, the portion of the element that is in parallel with the motor is to be open-circuited; and

j) Malfunction of a temperature control device.

59.1.6 The tests specified in Sections 59.1 – 59.3, are to be repeated under the following conditions for equipment with DC input unit described in DC input units, Section 11.3, as applicable:

a) Reverse polarity for Vehicle Battery Adapter; and

b) Simultaneous AC and DC operation.

59.1.7 A component that has been subjected to a 100,000-cycle endurance test under load is capable of being used in its intended application. As such, the malfunction of the component is not to be simulated during the abnormal operation tests. The 100,000-cycle endurance test represents the mechanical parts that actuate the switch as well as the electrical parts.

59.1.8 When overloading low-voltage connectors, printed-wiring board receptacles, or both, these parts are to be connected to a resistive load which draws the maximum available output current. The maximum available output current is to be determined to be the lower of:

a) The short-circuit current,

b) That current that is just below the trip point of any overcurrent or over-temperature protective device, or

c) That current that is just below the point at which the power supply circuitry limits the output current.

The trip point of overcurrent-protective devices is to be determined to be 110 percent of their current rating.

59.1.9 Circuit diagrams and component specifications are to be examined to determine which electronic component fault conditions are capable of occurring. Examples are short circuits and open circuits of transistors, rectifiers, diodes, and capacitors, particularly electrolytic capacitors, faults causing continuous dissipation in resistors designed for intermittent dissipation, and internal faults in integrated circuits causing excessive dissipation.

59.1.10 With regard to the power supply section of the product, the malfunction of bridge rectifiers, rectifying diodes, and electrolytic capacitors connected across a secondary supply circuit is to be evaluated. The malfunction of other electronic components is also to be evaluated when it is determined that such malfunction is capable of resulting in the risk of a fire or electric shock.

59.1.11 The tests specified in 59.1.9 and 59.1.10 are to be applied one at a time. Short circuits are to be applied only between two terminals of a multi-terminal device at one time. Simulated circuits are not prohibited from being used for secondary circuit abnormal tests. Simulated circuits are also not prohibited from being used for primary circuit abnormal tests. However, when the tests performed on simulated circuits indicate damage to other parts of the equipment to the extent that the safety of the equipment is capable of being affected, the tests are to be repeated in the equipment. The abnormal condition is to be introduced while the equipment is operating under intended conditions. This is not prohibited from being accomplished by jumper leads and remote switches with consideration given to the effect these devices are capable of having on the test.

59.1.12 When the circuit is interrupted by the opening of a component, the test is to be repeated twice, using new components as required.

59.2 Secondary circuit motors

59.2.1 Motors rated less than 100 volts or less than 200 volt-amperes in secondary circuits shall comply with the test in 59.2.2 unless they are used as follows:

a) Motors that are supplied by Class 2 circuits,

b) Motors that are rated less than 1 horsepower and

1) Are manually started,

2) Where the operator is in attendance during the entire operating cycle, and

3) Where malfunction of the motor is evident.

c) Motors which, by their intrinsic operation, normally operate under locked-rotor conditions such as stepper motors.

59.2.2 The motor, or the unit in which the motor is installed, is to be placed on a wooden board that is covered with a single layer of tissue paper. The motor, or the unit in which the motor is installed, is to be covered with a single layer of bleached cotton cheesecloth of 40 g/cm^2. The motor is to be operated at its working voltage with the rotor locked for 7 hours, or until steady-state conditions are established, whichever is longer. At the conclusion of the test, there shall be no ignition of the tissue paper or cheesecloth.

59.3 Printed-wiring boards

59.3.1 When spacings on printed-wiring boards are investigated in accordance with 17.1.1.5, printed-wiring board traces of different potentials are to be short-circuited. The overcurrent protection provided with the branch circuit to which the unit is connected shall not open as a result of these tests. Additionally, a wire or a printed-wiring board trace shall not open during these tests.

59.4 Products with breakable surfaces

59.4.1 A product that has an exterior surface of glass, ceramic, or comparably brittle material in or on which a heating element is mounted, or that is an essential part of the enclosure of live parts, shall be capable of withstanding the stresses that are expected to be encountered in actual service.

59.4.2 With the product in a fully heated condition, the surface under consideration shall withstand, without cracking or breaking, the application of a cloth that is fully saturated with the hard-water solution described in 47.2.2 at room temperature. The quantity of water involved shall completely wet the surface.

59.4.3 The surface under consideration shall withstand, without cracking or breaking, the impact of a 2-inch (50.8-mm) diameter, 1.18-lb (0.535-kg) steel ball, dropped from a height of 40.5 inches (1.03 m). Four impacts are to be made at different places on the surface.

59.5 Liquid heaters

59.5.1 A liquid heater is to be operated in a dry condition and with all automatic temperature controls or protective devices shunted out of the circuit.

59.6 Products with a heated chamber

59.6.1 The product is to be operated without any temperature regulation.

59.7 Capacitors

59.7.1 The short-circuiting of either the rectifier or the capacitor of a combination consisting of a rectifier and an electrolytic capacitor shall not result in a risk of fire, electric shock, or injury to persons.

59.8 Thermal cutoffs

59.8.1 When the product is connected to a supply source as specified in Performance, General, Section 44, and is placed in its intended operating position and energized in a manner that results in abnormal heating, a thermal cutoff shall be capable of opening the circuit in the intended manner without causing the short-circuiting of live parts and without causing live parts to become grounded to the enclosure.

59.8.2 Any other thermally operated control devices in the product are to be short-circuited. Each cutoff shall perform as described in 59.8.1. During the test, the enclosure is to be connected through a 3-amp fuse to a supply conductor not containing the thermal cutoff.

60 Switches and Control Devices Tests

60.1 Overload

60.1.1 Switches and control devices shall perform as intended by the manufacturer when subjected to an overload test consisting of 50 cycles of operation under the conditions specified in 60.1.2 – 60.1.6. The rate of operation is to be no greater than 10 cycles per minute, except that a faster rate of operation is not prohibited from being used when agreeable to those concerned. At the conclusion of this test, there shall be no electrical or mechanical malfunction or breakdown of the device, no undue burning or pitting of the contacts, and the fuse in the grounding connection shall not open.

Exception: This requirement does not apply to a device that has been successfully evaluated for use in this application, or to a device interlocked so that it does not break the motor locked-rotor current.

60.1.2 Exposed dead-metal parts of the product are to be connected to ground through a 3-amp plug fuse. The connection is to be such that any single-pole, current-interrupting device is to be located in the ungrounded conductor of the supply circuit. When the product is intended to operate on direct current, or on both direct current and alternating current, the exposed dead-metal parts of the product are to be connected so as to be positive with regard to a single-pole, current-interrupting control device.

60.1.3 When testing a switch or other device that controls a solenoid or relay coil, the product is to be connected to a supply circuit at rated frequency and 110 percent of maximum rated voltage. The load on the device is to be the same as that which it is intended to control in normal service.

60.1.4 When testing a switch or other device that controls a motor, the rotor of the motor is to be locked and the product is to be connected to a supply circuit of maximum rated voltage.

60.1.5 When testing an automatic control for temperature-regulating or temperature-limiting functions, the product is to be connected to a supply circuit having a potential of 120 percent of the voltage specified in 44.4.

60.1.6 Additionally, a DC-rated automatic control constructed such that the starting handle does not stay latched with the timing knob in all of its position settings, thereby resulting in a slow break of the switch contacts upon release of the handle, is to be operated for 50 additional cycles at normal load by releasing the handle slowly. The 3-amp fuse shall not open as a result of the test. This test is to be conducted after the overload test and preceding the endurance test on the control device.

60.2 Endurance

60.2.1 A thermostat is to be operated for the number of cycles indicated in Table 60.1. Unless specified that the test be conducted without load, the thermostat shall make and break the rated current of the product while connected to a circuit of rated voltage. At the conclusion of this test, there shall be no electrical or mechanical malfunction of the thermostat, or undue burning, pitting, or welding of the contacts.

Table 60.1
Number of cycles of operation for endurance test

Type of thermostat	Automatically reset thermostat	Manually reset thermostat
Temperature regulating	A number of cycles equivalent to 1000 hours of normal operation of the heater, and not less than 6000 cycles when it is a household heating product, or 30,000 cycles when it is a commercial product. However, the test is not required when, with the thermostat short-circuited, no temperatures higher than the limits given in Table 48.1 are attained during the Normal Temperature Test, Section 48	To be made the subject of special consideration[a].
Temperature-limiting	A number of cycles equivalent to 100 hours of operation of the product under any condition which causes the thermostat to function, or 100,000 cycles, whichever is greater. However, the test is not required when, with the thermostat short-circuited, there is of no evidence of risk of fire during the Abnormal Operation Test, Section 59	1000 cycles under load and 5000 cycles without load. However, this test is not required when, with the thermostat short-circuited, there is no evidence of risk of fire during the Abnormal Operation Test, Section 59.
Combination temperature-regulating and -limiting	Following Abnormal Operation Test: 1. When a risk of fire exists, test as a temperature-limiting thermostat. 2. When no risk of fire exists, test as a temperature-regulating thermostat.	To be made the subject of special consideration[a].

[a] When the operation of the thermostat controls the physical movement of a part of the product, the test is to be arranged so that each cycle involves the complete normal operation of the product.

60.3 Limited short circuit

60.3.1 Motor thermal protectors, such as automatic reset, manual reset, or thermal cutoffs, shall comply with the limited short circuit test in the Standard for Overheating Protection for Motors, UL 2111.

61 Resistance to Impact Test

61.1 A unit shall comply with the applicable resistance to impact test in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. Following the test, each product:

a) Shall comply with Dielectric Voltage-Withstand Test, Section 49;

b) Shall not experience circuit interruption by component burnout other than operation of a one-time protective device;

c) Shall comply with the accessibility requirements of Frame and Enclosure, Section 8; and

d) Shall be constructed so that when, for a heating element in a hand-supported product, the live part or wire is broken at any point there is no reduction of spacings below the minimum values described in Spacings, Section 17.

61.2 When, at the conclusion of the test described in 61.1, it is not determined that the sample is in compliance with 61.1, each sample is to be energized for 1 hour, or until ultimate results are noted, whichever occurs first. After the test, each sample shall comply with 61.1 (a) – (d).

62 Strain Relief Test

62.1 The strain-relief means provided on a non-detachable flexible cord shall withstand for 1 minute, without displacement, a 35 lbf (156 N) applied to the cord with connections within the product disconnected.

Exception: The cord of a hand-held product weighing less than 1/2 lb (0.227 kg), exclusive of the cord, shall withstand the application of a force of 20 lbs (89 N).

62.2 The strain-relief means provided on leads as specified in item (c) of the Exception to 11.1.1.5 shall withstand for 1 minute, without displacement, a 5 lbf (22 N) applied to the leads with connections at the termination disconnected.

62.3 With regard to 62.1 and 62.2, the force is to be applied to the cord or leads with the product supported such that the strain-relief means is stressed from any angle that the construction of the product tolerates. The strain relief does not comply with the intent of 62.1 and 62.2 when, at the point of disconnection of the conductors, there is enough movement of the cord or leads to constitute evidence of stress on the connections.

63 Printed-Wiring Board Ground Continuity Test

63.1 The ground trace of a printed-wiring board shall not open when carrying a current equal to twice the current rating of the overcurrent device which the board is relied upon for 2 minutes. Any primary circuit overcurrent protection is not prohibited from being relied upon during this test. Secondary circuit overcurrent protection is not prohibited from being relied upon when it is the first component in the secondary circuit.

64 Physical Stability Tests

64.1 General

64.1.1 A fully assembled unit shall not become physically unstable to the degree that presents a risk of injury to operators or service personnel under all conditions of servicing and intended use after installation.

64.1.2 In conducting the stability tests described in this section, all casters and jacks are to be placed in their most unfavorable position, and wheels are to be locked or blocked. However, when casters are being used only to transport the unit and jacks are lowered after installation, the jacks, and not the casters, are to be used in the most unfavorable position for the test, consistent with reasonable leveling of the unit.

64.1.3 A free-standing unit is defined as one that is placed on the floor and is not intended to be secured to other units, to the floor, or to other parts of the building.

64.1.4 A stabilizing means is not prohibited from being used to improve stability when doors, gates, or drawers are opened. The stabilizing means shall either be automatic in operation or interlocked when associated with operator use. For service personnel, where it is not automatic in operation, a conspicuous marking shall be provided to caution the personnel on its use. See 75.7.

64.2 Tip-over test

64.2.1 A unit shall not tip over when tilted 10 degrees from its intended upright position while all doors, covers, gates, and drawers are in place and closed.

64.3 Horizontal surface loading test

64.3.1 A free-standing unit that has an external surface, such as a work top or ledge, at a height not exceeding 39-3/8 inches (1 m) from the floor and that is expected to be stepped on or sat upon shall not tip over when a continuous downward force of 180 lbf (800 N) is applied to that surface at the point of maximum moment. For this test all doors, covers, gates, drawers, and similar parts are to be in place and closed. It has been determined that delicate parts such as keyboards or control panels are not expected to be stepped on or sat upon.

64.4 Push-over test

64.4.1 A free-standing unit more than 39-3/8 inches (1 m) high and weighing more than 55.1 lbs (25 kg) shall not tip over when a force equal to one-fifth the weight of the unit, and not more than 56.2 lbf (250 N), is applied to the product in any direction, except upward, at a height not exceeding 78-3/4 inches (2 m) from the floor. For this test all doors, drawers, and frames that are capable of being opened for operator or service personnel servicing are to be opened and in the most unfavorable position. Separate tests are not prohibited from being performed when operator and service extensions are different or when stabilizers are used.

65 Handle Strength Test

65.1 A handle intended for lifting or carrying a product shall withstand a force equal to four times the weight of the unit. The handle, its securing means, or the part of the unit to which the handle is attached shall not weaken, crack, or break.

65.2 The force is to be applied uniformly in the intended carrying direction over a 2-5/16-inch (75-mm) length at the center of the handle. Starting at zero, the force is to be gradually increased within 5 to 10 seconds to the required test value and then maintained for 1 minute.

65.3 When more than one handle is provided, the test force is to be determined by the percentage of the unit weight sustained by each handle with the unit in the intended carrying position. When a unit weighing less than 55 lbs (25 kg) is provided with more than one handle and is capable of being carried by using only one of the handles, each handle is to be capable of withstanding a force based on the total weight of the unit.

66 Strength of Mounting Test

66.1 The mounting means of a product intended for mounting to a wall shall withstand a force equal to four times the weight of the unit. The mounting means, its securing means, or the part of the unit to which the means are attached shall not weaken, crack, or break.

66.2 The complete product is to be mounted to a smooth vertical surface in accordance with the manufacturer's instructions using the brackets or hangers that are shipped with the unit.

66.3 The force is to be applied to the center of the unit so as to result in the greatest moment. Starting at zero, the force is to be gradually increased within 5 to 10 seconds to the required test value and then maintained for 1 minute.

66.4 When no wall construction is specified in the installation instructions, or when the construction described does not represent expected wall constructions, the test is to be conducted with each of the following wall constraints:

a) 3/8-inch thick trade size gypsum dry wall fastened to trade size 2- by 4-inch wood studs spaced 16-inch (40.6-cm) centers are to be used as the support surface. The hardware is to be applied as specified in the installation instructions, and the mounting screws (or other fasteners) are to be positioned between the studs and secured into the gypsum dry wall. An adjustable product is to be adjusted to the position that maximizes the projection from the wall. When the installation instructions indicate that the mounting screws are to be secured into wood studs:

1) A product less than 32 inches (81.3 cm) wide is to be mounted on one side to a wood stud and on the other side to the dry wall, even when the instructions specify securement to two studs.

2) A product at least 32 inches (81.3 cm) wide is to be mounted to a wood stud on each side.

b) 1/2-inch thick trade size gypsum dry wall fastened to trade size 2- by 4-inch wood studs spaced 24-inch (61.0-cm) centers are to be used as the support surface. The hardware is to be applied as specified in the instruction, and the mounting screws (or other fasteners) are to be positioned between the studs and secured into the gypsum dry wall. An adjustable product is to be adjusted to the position that maximizes the projection from the wall. When the installation instructions indicate the mounting screws are to be secured into wood studs, the unit is to be mounted on the lightest side to a wood stud and on the other side to the dry wall even when the instructions specify securement to two studs.

67 Tests for Guards, Enclosures, and Operator-Accessible Barriers

67.1 A polymeric part, such as an enclosure or barrier, shall comply, as required, with the applicable resistance to impact tests in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

67.2 A metal enclosure or guard shall withstand a static force of 25 lbs (111 N) for 1 minute. A metal enclosure or guard shall also withstand an impact of 5 ft-lbs (6.8 J) for 1 minute. At the conclusion of each test, there shall be:

a) No reduction of spacings below the minimum values described in Spacings, Section 17;

b) No development of openings that do not comply with the accessibility requirements in Frame and Enclosure, Section 8; or

c) No transient distortion that results in contact with live parts.

67.3 With regard to 67.2, the 25-lbf (111-N) is to be applied by means of a hemisphere 1/2 inch (12.7 mm) in diameter. The 5 ft-lbf (6.8 J) impact is to be applied by means of a smooth, solid, steel sphere 2 inches (50.8 mm) in diameter and having 1.18-lb (0.54-kg) mass. The sphere is to fall freely from rest through a vertical distance of 51 inches (1.30 m). Each test is not prohibited from being conducted on separate products.

67.4 A nonmetallic enclosure or guard and all operator-accessible barriers shall withstand a push force of 6.75 lbf (30 N) applied by means of a hemisphere 1/2 inch (12.7 mm) in diameter. At the conclusion of this test, there shall be:

a) No reduction of spacings below the minimum values described in Spacings, Section 17;

b) No development of openings that do not comply with the accessibility requirements in Frame and Enclosure, Section 8; or

c) No transient distortion that results in contact with live parts.