UL 756

STANDARD FOR SAFETY

Coin and Currency Changers and Actuators

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Coin and Currency Changers and Actuators, UL 756

Eighth Edition, Dated August 25, 2016

Summary Of Topics

This revision of UL 756, dated October 2, 2018, was issued to include the following changes in requirements:

Revisions To Update Requirements For Controls

Addition Of And Revisions To Requirements To Address Switch Mode Power Supply Units Increasingly Used In Coin And Currency Changers and Actuators

Addition Of Requirements To Clarify Requirements Applicable To Accessories

Additions Of Requirements To Clarify Requirements Applicable To Products Used In Protected Locations

Revisions To Marking Requirements To Clarify Application Of UL 969 Requirements

Revisions To EMI Filter Requirements To Specify An Alternate Compliance Option

Revisions To Leakage Current Test Requirements To Allow Higher Leakage Current For Products That Require Electromagnetic Interference Suppression

Revisions To Incorporate Editorial Corrections

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated June 29, 2018.

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UL 756

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

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INTRODUCTION

1 Scope

1.1 These requirements cover self-contained coin, credit card, debit card, currency, and token changers and actuators rated not more than 600 volts for use in accordance with ANSI/NFPA 70.

1.2 These requirements cover open-type appliances intended to be factory or field installed in vending machines and other appliances.

1.3 These requirements cover open-type controls for use with coin, credit card, debit card, currency, and token-operated devices intended to be factory installed within vending machines and other appliances.

1.4 These requirements do not cover the effectiveness of antitheft protection features.

1.5 Battery operated coin and currency changers and actuators are covered by these requirements.

2 Glossary

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

2.1.1 ACCESSORY – A device or component intended for installation in or connection to a product for the purpose of modifying or supplementing the functions of the product. It is intended for installation by the serviceman or another equally qualified person in the field. An accessory relies upon the product for electrical power, signaling, switching, or the like.

2.2 ADJUSTABLE SPEED DRIVE – A combination of power converter, inverter, motor, and motor-mounted auxiliary devices such as encoders, tachometers, thermal switches and detectors, air blowers, heaters, and vibration sensors.

2.3 ADJUSTABLE SPEED DRIVE SYSTEM – An interconnected combination of equipment that provides a means of adjusting the speed of a mechanical load coupled to a motor. A drive system typically consists of an adjustable speed drive and auxiliary electrical apparatus.

2.4 APPLIANCE – Denotes all coin, credit card, debit card, currency, and token changers and actuators included in the scope of this standard. A requirement that applies only to specific equipment is identified by a specific reference in that requirement to the equipment involved.

2.5 BARRIER – A partition for isolating high-voltage electrical components, separating ignition sources from flammable materials, isolating moving parts and protection of wiring.

2.6 CABINET – The part of the equipment that provides physical protection to insulated wiring, enclosures, moving parts, motors, enclosed electrical parts, tubing or other parts that may cause injury to persons.

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

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2.7 CIRCUITS, ELECTRICAL –

a) High-Voltage (Class 1) – A circuit involving a potential of not more than 600 volts and having circuit characteristics in excess of those of a low-voltage power-limited circuit.

b) Low-Voltage – A circuit involving a potential of not more than 30 volts AC rms, 42.4 volts DC or AC peak.

c) Power-Limited – A circuit whose output is limited as specified in Power-Limited Circuits, Section 62.

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d) Class 2 – A circuit in which the voltage and power limitations are in accordance with the Class 2 requirements of Table 62.1 for AC circuits and Table 62.2 for DC circuits.

e) Class 3 – A circuit in which the voltage and power limitations are in accordance with the Class 3 requirements of Table 62.1 for AC circuits and Table 62.2 for DC circuits.

2.8 COMPONENT – A device or fabricated part of the appliance covered by the scope of a safety standard dedicated to that purpose. If incorporated in an appliance, a product that is otherwise typically field installed (e.g. luminaire) is considered to be a component. Unless otherwise specified, materials that compose a device or fabricated part, such as aluminum or copper, are not considered components. Generally, components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under specific, limited conditions, such as certain temperatures not exceeding specified limits.

2.9 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 mitigate the risk of electric shock, is considered an operating control. Operating controls are also referred to as ″regulating controls″. Appendix A, Operating and Protective (Safety Critical) Control Functions, specifies control functions that are not considered to result in a risk of fire, electric shock, or injury to persons.

2.10 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of fire, electric shock, or injury to persons during normal and reasonably anticipated abnormal operation of the appliance. For example, a thermal cutout/limiter, or any other control/circuit relied upon for normal and abnormal conditions, is considered a protective control. Protective controls are also referred to as ″limiting controls″ or ″safety controls″ and are investigated under normal and single-fault conditions. Appendix A specifies control functions that are considered to result in a risk of fire, electric shock, or injury to persons.

2.11 ELECTRONIC COMPONENT – A part in which electrical conduction is achieved principally by electrons moving through a vacuum, gas or semiconductor. A metal oxide varistor (MOV) is considered to be an electronic component, but neon indicators are not.

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2.12 ELECTRONIC DISCONNECTION – The de-energizing of a load within an appliance by an electronic device of a circuit. No electro-mechanical component having an air gap, such as a switch, contactor or relay is used to de-energize the load.

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2.13 ENCLOSURE – The part of the appliance that does one or more of the following:

a) Isolates ignition sources;

b) Renders inaccessible all or any part(s) of the equipment that may otherwise present a risk of electric shock;

c) Retards propagation of flame initiated by electrical disturbances occurring within.

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2.14 FUNCTIONAL PART – A part other than an enclosure or cabinet used to maintain the intended relative physical position of fixed or moving parts, or maintain the integrity of the structure.

2.15 GROUNDING, FUNCTIONAL – Grounding of a point in an appliance which is necessary for a purpose other than safety.

2.16 IGNITION SOURCE – Any high-voltage electrical component not located within an enclosure.

2.17 MAXIMUM OPERATING CURRENT (MOC) – The current resulting when an electric motor and adjustable speed drive or drive system are operated under any conditions such as maximum speed/maximum load, maximum speed/minimum load, minimum speed/minimum load, minimum speed/maximum load, including locked-rotor such that current to the motor/adjustable speed drive or drive system is at a maximum.

2.18 MOTOR CONTROLLER – Any device normally used to start and stop a motor, such as a switch, thermostat, pressure limiting control, or the like.

2.19 MOTOR, DIRECTLY ACCESSIBLE – A motor that can be contacted without opening or removing any part, or that is located so as to be accessible to contact.

2.20 MOTOR, INDIRECTLY ACCESSIBLE – A motor that is accessible only by opening or removing a part of the cabinet, such as a guard or panel that can be opened or removed without using a tool, or that is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

2.21 NONFUNCTIONAL PART – A part of the equipment that does not perform a specific function.

2.22 NONFUNCTIONAL PART, SMALL – A nonfunctional part having an area of less than 1 ft^2(0.093 m^2) located so it cannot propagate flame from one area to another, and does not connect a possible source of ignition to the other ignitable parts.

2.23 OPEN-TYPE CONTROL – Controls and devices that are incomplete in certain construction features and need to be installed within another appliance.

2.24 OPERATOR OR USER SERVICING – Any form of servicing that might be performed by personnel other than qualified service personnel. Some examples are:

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

b) Resetting or replacement of circuit breakers, tubes, fuses, and lamps that are accessible without the use of tools.

c) Making routine operating adjustments necessary to adapt the appliance for its different intended functions.

d) Routine cleaning, removal of coins, price changing, replenishing the product supply, making minor adjustments, and other services performed by the route man who regularly opens an appliance for such purposes.

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2.24.1 OUTDOOR LOCATION – In the open and subjected to the full effects of weathering.

2.24.2 PROTECTED LOCATION – In an area that is partially protected from the effects of weathering through the use of a roof, canopy, marquee, or the like.

2.25 PROTECTIVE ELECTRONIC CIRCUIT (PEC) – An electronic circuit that prevents a risk of fire, electric shock or injury to persons under abnormal operating conditions.

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2.26 ROUTE PERSON – A person who regularly opens an appliance for such purposes as cleaning, removing coins, making minor adjustments and replenishing the product supply.

2.27 SELF-CONTAINED APPLIANCE – Coin, credit card, debit card, currency, and token changers and actuators that are complete in their construction.

2.28 SERVICE PERSON – A person who may periodically open an appliance to repair or maintain electrical or mechanical components.

2.28.1 SWITCH MODE POWER SUPPLY UNIT – Electronic device incorporating transformer(s) and electronic circuitry(ies), that converts electrical power into single or multiple power outputs by rapidly switching a solid-state device on and off. It may also isolate the input circuit from the output circuit and regulate and/or convert the output voltage and current. The device may consist of one or more individual units with identical or different waveforms and frequencies including dc output.

2.29 THERMISTOR – A thermally sensitive semiconductor resistor, which shows over at least part of its resistance/temperature characteristic a significant non-linear change in its electrical resistance with a change in temperature. A thermistor may be either of the positive temperature coefficient (PTC) type or of the negative temperature coefficient (NTC) type.

2.30 VOLTAGE FOLDBACK – A circuit design feature intended to protect the power supply output transistors. When overcurrent is drawn by the load, the supply reduces the output voltage and current to within the safe power dissipation limit of the output transistors.

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3 Units Of Measurement

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

4 References

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

ANSI Standards

ANSI Z97.1, *Safety Glazing Materials Used In Buildings – Safety Performance Specifications And Methods Of Test*

ASTM Standards

ASTM D412, *Standard Test Methods for Vulcanized Rubber, and Thermoplastic Rubber and Thermoplastic Elastomers – Tension*

ASTM A90/A90M, *Test Method of the Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*

ASTM A90/A90M-95a, *Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*

ASTM A653/A653M, *Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM E28, *Standard Test Methods for Softening Point of Resins Derived from Pine Chemicals and Hydrocarbons, by Ring-and-Ball Apparatus*

ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*

ASTM E230/E230M, *Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples*

IEC Standards

IEC 60127-1, *Miniature Fuses: Part 1, Definitions for Miniature Fuses and General Requirements for Miniature Fuse-Links*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and Measurement Techniques – Radiated, Radio-Frequency, Electromagnetic Field Immunity Test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and Measurement Techniques – Electrical Fast Transient/Burst Immunity Test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and Measurement Techniques – Surge Immunity Test*

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IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and Measurement Techniques – Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields*

IEC 61000-4-11, *Electromagnetic Compatibility (EMC) – Part 4-11: Testing and Measurement Techniques – Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests*

IEC 61000-4-13, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and Measurement Techniques – Harmonics and Interharmonics Including Mains Signalling at a.c. Power Port, Low Frequency Immunity Tests*

IEC 61000-4-34, *Electromagnetic Compatibility (EMC) – Part 4-34: Testing and Measurement Techniques – Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests for Equipment with Input Current More Than 16 A Per Phase*

NEMA Standards

NEMA WD6, *Wiring Devices – Dimensional Requirements*

NFPA Standards

ANSI/NFPA 70, *National Electrical Code*

UL Standards

UL 1, *Flexible Metal Conduit*

UL 4, *Armored Cable*

UL 6, *Rigid Metal Conduit – Steel*

UL 20, *General-Use Snap Switches*

UL 44, *Thermoset-Insulated Wires and Cables*

UL 62, *Flexible Cords and Cables*

UL 83, *Thermoplastic-Insulated Wires and Cables*

UL 94, *Tests for Flammability of Plastic Materials for Parts in Devices and Appliances*

UL 157, *Gasket and Seals*

UL 224, *Extruded Insulating Tubing*

UL 244A, *Solid-State Controls for Appliances*

UL 248-1, *Standard for Low-Voltage Fuses – Part 1: General Requirements*

UL 248-4, *Low-Voltage Fuses – Part 4: Class CC Fuses*

UL 248-5, *Low-Voltage Fuses – Part 5: Class CC Fuses*

UL 248-8, *Low-Voltage Fuses – Part 8: Class J Fuses*

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UL 248-9, *Low-Voltage Fuses – Part 9: Class K Fuses*

UL 248-10, *Low-Voltage Fuses – Part 10: Class L Fuses*

UL 248-11, *Low-Voltage Fuses – Part 11: Plug Fuses*

UL 248-12, *Low-Voltage Fuses – Part 12: Class R Fuses*

UL 248-14, *Low-Voltage Fuses – Part 14: Supplemental Fuses*

UL 248-15, *Low-Voltage Fuses – Part 15: Class T Fuses*

UL 310, *Electrical Quick-Connect Terminals*

UL 486A-486B, *Wire Connectors*

UL 486C, *Splicing Wire Connectors*

UL 486E, *Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors*

UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures*

UL 489A, *Circuit Breakers For Use in Communications Equipment*

UL 496, *Lampholders*

UL 498, *Attachment Plugs and Receptacles*

UL 499, *Electric Heating Appliances*

UL 508, *Industrial Control Equipment*

UL 508C, *Power Conversion Equipment*

UL 510, *Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape*

UL 514A, *Metallic Outlet Boxes*

UL 514B, *Conduit, Tubing, and Cable Fittings*

UL 514C, *Nonmetallic Outlet Boxes, Flush Device Boxes, and Covers*

UL 514D, *Cover Plates for Flush-Mounted Wiring Devices*

UL 542, *Fluorescent Lamp Starters*

UL 635, *Insulating Bushings*

UL 719, *Nonmetallic Sheathed Cables*

UL 723, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*

UL 746A, *Polymeric Materials – Short Term Property Evaluations*

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UL 746B, *Polymeric Materials – Long Term Property Evaluations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 746E, *Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards*

UL 758, *Appliance Wiring Material*

UL 796, *Printed-Wiring Boards*

UL 797, *Electrical Metallic Tubing – Steel*

UL 810, *Capacitors*

UL 817, *Cord Sets and Power Supply Cords*

UL 840, *Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment*

UL 870, *Wireways, Auxiliary Gutters and Associated Fittings*

UL 917, *Clock-Operated Switches*

UL 935, *Fluorescent-Lamp Ballasts*

UL 969, *Marking and Labeling Systems*

UL 1004-2, *Impedance Protected Motors*

UL 1004-3, *Thermally Protected Motors*

UL 1004-7, *Electronically Protected Motors*

UL 1012, *Power Units Other Than Class 2*

UL 1029, *High-Intensity-Discharge Lamp Ballasts*

UL 1030, *Sheathed Heating Elements*

UL 1059, *Terminal Blocks*

UL 1077, *Supplementary Protectors for Use in Electrical Equipment*

UL 1283, *Electromagnetic Interference Filters*

UL 1310, *Class 2 Power Units*

UL 1412, *Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances*

UL 1434, *Thermistor-Type Devices*

UL 1439, *Test for Sharpness of Edges on Equipment*

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UL 1441, *Coated Electrical Sleeving*

UL 1446, *Insulating Materials – General*

UL 1449, *Surge Protective Devices*

UL 1565, *Positioning Devices*

UL 1577, *Optical Isolators*

UL 1642, *Lithium Batteries*

UL 1977, *Component Connectors for Data, Signal, Control and Power Applications*

UL 2054, *Household and Commercial Batteries*

UL 4248-1, *Fuseholders – Part 1: General Requirements*

UL 4248-4, *Fuseholders – Part 4: Class CC*

UL 4248-5, *Fuseholders – Part 5: Class G*

UL 4248-8, *Fuseholders – Part 8: Class J*

UL 4248-9, *Fuseholders – Part 9: Class K*

UL 4248-11, *Fuseholders – Part 11: Type C (Edison Base) and Type S Plug Fuse*

UL 4248-12, *Fuseholders – Part 12: Class R*

UL 4248-15, *Fuseholders – Part 15: Class T*

UL 5085-1, *Low Voltage Transformers – Part 1: General Requirements*

UL 5085-2, *Low Voltage Transformers – Part 2: General Purpose Transformers*

UL 5058-3, *Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers*

UL 60065, *Audio, Video and Similar Electronic Apparatus – Safety Requirements*

UL 8750, *Light Emitting Diode (LED) Equipment For Use in Lighting Products*

UL 60335-1, *Household and Similar Electrical Appliances, Part 1: General Requirements*

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

UL 60691, *Thermal-Links – Requirements and Application Guide*

UL 60730-1, *Automatic Electrical Controls – Part 1: General Requirements*

UL 60730-2-6, *Automatic Electrical Controls – Part 2-6: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements*

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UL 60730-2-9, *Automatic Electrical Controls – Part 2-9: Particular Requirements for Temperature Sensing Controls*

UL 60939-3, *Passive Filter Units for Electromagnetic Interference Suppression – Part 3: Passive Filter Units for Which Safety Tests are Appropriate*

UL 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

UL 61058-1, *Switches for Appliances – Part 1 General Requirements*

CONSTRUCTION

5 General

5.1 An appliance shall employ materials found by investigation to be acceptable for the use, and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

5.2 A component shall:

a) Comply with the safety standard 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; and

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

Exception: 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.

5.3 A component that is also required to perform other necessary functions, such as overcurrent protection, ground-fault circuit interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable standard(s) covering products that provide those functions.

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6 Barriers

6.1 A barrier shall be formed from one or more of the following:

a) Metal, minimum 0.005 inch (0.13 mm) thick;

b) Fiberglass, minimum 0.5 inch (12.7 mm) thick;

c) A nonmetallic material rated 5 volt-ampere;

d) A nonmetallic material evaluated to the 127 mm (5 inch) End Product Flame Test as described in UL 746C;

e) Vulcanized fiber, varnished cloth, mica or phenolic composition, minimum 0.028 inch (0.71 mm) thick; or

f) Any other material or construction determined to be equivalent to items (a) to (e).

6.2 A barrier shall be secured to the mounting surface such that tools are required for its removal.

6.3 Except as specified in 6.5 and 13.2, a nonmetallic barrier that isolates ignition source(s) shall comply with the enclosure requirements of Table 67.1.

6.4 A nonmetallic barrier providing mechanical protection shall comply with the cabinet requirements of Table 67.1.

6.5 If a barrier made of the materials specified 6.1(e) but less than 0.028 inch (0.71 mm) thick is used, the:

a) Air spacing between the parts being insulated by the barrier shall be not less than one-half of the required through-air spacing; and

b) Barrier shall be not less than 0.013 inch (0.3 mm) thick.

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7 Frame And Enclosure

7.1 General

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

7.1.2 Electrical parts of an appliance, other than a supply cord or low-voltage terminals – see 18.1 – shall be located or enclosed so that protection against unintentional contact with uninsulated live parts will be provided. See 11.1.

Exception: An enclosure is not required for an appliance designed for assembly as part of another appliance.

7.1.3 The frame or chassis of an appliance shall not be relied upon to carry current during normal operation.

Exception: As provided in 13.5.

7.1.4 A part such as a dial or nameplate that is, in effect, a part of the enclosure shall comply with the requirements in 7.3.1, 7.4.1, or 7.6.1.

7.2 Doors and covers

7.2.1 An enclosure cover shall be hinged if it gives access to a fuse, thermal cutout, or any other overload-protective device, the intended functioning of which requires renewal, or if it is necessary to open the cover in connection with the normal operation of the device.

Exception: A hinged cover and the construction described in 7.2.2 – 7.2.4 are not required for an appliance in which the only fuses enclosed are an extractor-type fuse with its own enclosure, or fuses in low-voltage circuits. See 18.1.

7.2.2 A door or cover giving access to a fuse or thermal cutout in other than a low-voltage circuit – see 18.1 – shall shut closely against a 1/4-inch (6.3-mm) rabbet or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the walls of the box proper and shall overlap the edges of the box not less than 1/2 inch (12.7 mm). A construction that affords equivalent protection, or a combination of flange and rabbet that has been investigated and found to be acceptable, may be used.

7.2.3 Strips used to provide rabbets, or angle strips fastened to the edges of a door shall be secured at not less than two points, not more than 1-1/2 inches (38.1 mm) from each end of each strip and at points between these end fastenings not more than 6 inches (152 mm) apart.

7.2.4 A hinged cover shall be provided with a spring latch or catch.

Exception: For a hinged cover that is provided, although not required, a hasp, sliding latch, or other means for holding the cover closed may be employed.

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7.2.5 An enclosure and a part of an enclosure such as a door, a cover, or a tank, shall be provided with means for firmly securing it in place.

7.2.6 Sheet-metal screws threading directly into metal shall not be used to attach a cover, a door, or other part that is removed to install field wiring or for operation of the equipment. Sheet-metal screws may thread into sheet-metal nuts that are permanently mounted and protected against corrosion, and machine screws and self-tapping machine screws may thread directly into sheet-metal walls.

7.2.7 Sheet-metal screws mounting internal components that are not removed for installation or operation may thread directly into metal.

7.3 Cast metal

7.3.1 Cast metal for an enclosure shall not be less than 1/8 inch (3.2 mm) thick at every point, of greater thickness at reinforcing ribs and door edges, and not less than 1/4 inch (6.3 mm) thick at tapped holes for conduit, except that, other than at plain or threaded conduit holes, die-cast metal shall not be less than 3/32 inch (2.4 mm) thick for an area greater than 24 square inches (155 cm^2) or having any dimension greater than 6 inches (152 mm), and shall not be less than 1/16 inch (1.6 mm) thick for an area of 24 square inches or less and having no dimension greater than 6 inches. The area limitation for metal 1/16 inch thick may be obtained by the provision of reinforcing ribs subdividing a larger area.

Exception No. 1: Die-cast metal not less than 0.035 inch (0.89 mm) thick may be employed if the enclosure will not be used as a splice box and if the voltage rating of the complete appliance is such that the voltage between any two conductors is 250 volts or less and is limited to direct current or single-phase alternating current.

Exception No. 2: Die-cast metal not less than 0.028 inch (0.71 mm) thick may be employed for an enclosure housing only low-voltage circuits as defined in 18.1.

7.4 Sheet metal

7.4.1 Unless investigated and found acceptable for the application, the thickness of a sheet-metal enclosure shall not be less than that specified in Tables 7.1 and 7.2.

Exception: Uncoated steel shall not be less than 0.032 inch (0.81 mm) thick, zinc-coated steel shall not be less than 0.034 inch (0.86 mm) thick, and nonferrous metal shall not be less than 0.045 inch (1.14 mm) thick at points at which a wiring system is to be connected.

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

7.4.3 With reference to Tables 7.1 and 7.2, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and that has the torsional rigidity to resist the bending moments that may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels.

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7.4.4 With reference to 7.4.3 and Tables 7.1 and 7.2, a construction is not considered to have a supporting frame if it is:

a) A single sheet with single formed flanges – formed edges;

b) A single sheet that is corrugated or ribbed;

c) An enclosure formed or fabricated from sheet metal; or

d) An enclosure surface loosely attached to a frame, for example, by spring clips.

Table 7.1
Thickness of sheet metal for enclosures, carbon steel or stainless steel

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b] inches	(cm)	Maximum length,[c] inches	(cm)	Maximum width,[b] inches	(cm)	Maximum length, inches	(cm)	Uncoated, inch	(mm)	Metal coated, inch	(mm)
4.0	(10.2)	Not limited		6.25	(15.9)	Not limited				0.023[d]	(0.58)
4.75	(12.10)	5.75	(14.6)	6.75	(17.1)	8.25	(21.0)	0.020[d]	(0.51)		
6.0	(15.2)	Not limited		9.5	(24.1)	Not limited				0.029[d]	(0.74)
7.0	(17.8)	8.75	(22.2)	10.0	(25.4)	12.5	(31.8)	0.026[d]	(0.66)		
8.0	(20.3)	Not limited		12.0	(30.5)	Not limited				0.034	(0.86)
9.0	(22.9)	11.5	(29.2)	13.0	(33.0)	16.0	(40.6)	0.032	(0.81)		
12.5	(31.8)	Not limited		19.5	(49.5)	Not limited				0.045	(1.14)
14.0	(35.6)	18.0	(45.7)	21.0	(53.3)	25.0	(63.5)	0.042	(1.07)		
18.0	(45.7)	Not limited		27.0	(68.6)	Not limited				0.056	(1.42)
20.0	(50.8)	25.0	(63.5)	29.0	(73.7)	36.0	(91.4)	0.053	(1.35)		
22.0	(55.9)	Not limited		33.0	(83.8)	Not limited				0.063	(1.60)
25.0	(63.5)	31.0	(78.7)	35.0	(88.9)	43.0	(109.2)	0.060	(1.52)		
25.0	(63.5)	Not limited		39.0	(99.2)	Not limited				0.070	(1.78)
29.0	(73.7)	36.0	(91.4)	41.0	(104.1)	51.0	(129.5)	0.067	(1.70)		
33.0	(83.8)	Not limited		51.0	(129.5)	Not limited				0.084	(2.13)
38.0	(103.4)	47.0	(119.4)	54.0	(137.2)	66.0	(167.6)	0.080	(2.03)		
42.0	(106.7)	Not limited		64.0	(162.6)	Not limited				0.097	(2.46)
47.0	(119.4)	59.0	(149.9)	68.0	(172.7)	84.0	(213.4)	0.093	(2.36)		
52.0	(132.1)	Not limited		80.0	(203.2)	Not limited				0.111	(2.82)
60.0	(152.4)	74.0	(188.0)	84.0	(213.4)	103.0	(261.6)	0.108	(2.74)		
63.0	(160.0)	Not limited		97.0	(246.4)	Not limited				0.126	(3.20)
73.0	(185.4)	90.0	(228.6)	103.0	(261.6)	127.0	(322.6)	0.123	(3.12)		

[a] See 7.4.3 and 7.4.4.
[b] The width is the smaller dimension of a rectangular sheet-metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

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Table 7.1 Continued on Next Page

Table 7.1 Continued

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]				Minimum thickness			
Maximum width,[b] inches	(cm)	Maximum length,[c] inches	(cm)	Maximum width,[b] inches	(cm)	Maximum length, inches	(cm)	Uncoated, inch	(mm)	Metal coated, inch	(mm)

[c] For panels that are not supported along one side; for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified.

[d] Sheet steel for an enclosure intended for outdoor use shall not be less than 0.034 inch (0.86 mm) thick if metal coated and not less than 0.032 inch (0.81 mm) thick if uncoated.

Table 7.2
Thickness of sheet metal for enclosures, aluminum, copper, or brass

Without supporting frame[a]				With supporting frame or equivalent reinforcing[a]					
Maximum width,[b] inches	(cm)	Maximum length,[c] inches	(cm)	Maximum width,[b] inches	(cm)	Maximum length, inches	(cm)	Minimum thickness, inch	(mm)
3.0	(7.6)	Not limited		7.0	(17.8)	Not limited		0.023[d]	(0.58)
3.5	(8.9)	4.0	(10.2)	8.5	(21.6)	9.5	(24.1)		
4.0	(10.2)	Not limited		10.0	(25.4)	Not limited		0.029	(0.74)
5.0	(12.7)	6.0	(15.2)	10.5	(26.7)	13.5	(34.3)		
6.0	(15.2)	Not limited		14.0	(35.6)	Not limited		0.036	(0.91)
6.5	(16.5)	8.0	(20.3)	15.0	(38.1)	18.0	(45.7)		
8.0	(20.3)	Not limited		19.0	(48.3)	Not limited		0.045	(1.14)
9.5	(24.1)	11.5	(29.2)	21.0	(53.3)	25.0	(63.5)		
12.0	(30.5)	Not limited		28.0	(71.1)	Not limited		0.058	(1.47)
14.0	(35.6)	16.0	(40.6)	30.0	(76.2)	37.0	(94.0)		
18.0	(45.7)	Not limited		42.0	(106.7)	Not limited		0.075	(1.91)
20.0	(50.8)	25.0	(63.4)	45.0	(114.3)	55.0	(139.7)		
25.0	(63.5)	Not limited		60.0	(152.4)	Not limited		0.095	(2.41)
29.0	(73.7)	36.0	(91.4)	64.0	(162.6)	78.0	(198.1)		
37.0	(94.0)	Not limited		87.0	(221.0)	Not limited		0.122	(3.10)
42.0	(106.7)	53.0	(134.6)	93.0	(236.2)	114.0	(289.6)		
52.0	(132.1)	Not limited		123.0	(312.4)	Not limited		0.153	(3.89)
60.0	(152.4)	74.0	(188.0)	130.0	(330.2)	160.0	(406.4)		

[a] See 7.4.3 and 7.4.4.

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

[c] For panels that are not supported along one side; for example, side panels of boxes, the length of the unsupported side shall be limited to the dimensions specified.

[d] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use shall not be less than 0.029 inch (0.74 mm) thick.

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7.5 Gaskets and adhesives

7.5.1 Each gasket required to seal electrical enclosures against the entrance of rain and condensate shall comply with 66.1 – 66.5 or with UL 157 if the gasket physical properties are equivalent to those specified in 66.1 – 66.5. In addition, each gasket shall:

a) Be neoprene, rubber, thermoplastic or other materials with equivalent properties that comply with the requirements in 66.1 – 66.5; and

b) Be held in place by mechanical fasteners or adhesives except as specified in 7.5.2.

7.5.2 In reference to 7.5.1, gaskets which are not held in place by mechanical fasteners or adhesives but are intended to be retained in the correct position by some other means shall be prevented from displacement either:

a) Due to their location within the equipment; or

b) By the placement of other components in the enclosure so that if the equipment cover is removed, the gasket will be reengaged in the intended manner when the cover is replaced.

7.5.3 An adhesive required to secure gaskets shall comply with the requirements in 66.7.

7.5.4 Sealing compounds required to seal enclosures shall comply with 66.6.

7.6 Nonmetallic Parts

7.6.1 All nonmetallic parts, except for small nonfunctional parts shall comply with Sections 7.7 – 7.9 and Table 67.1.

7.6.2 In addition to the requirement in 7.6.1, nonmetallic materials that serve as electrical insulation or that directly support live parts shall comply with the requirements for electric insulation in UL 746C.

7.7 Nonmetallic Materials

7.7.1 Materials shall be classified with respect to flammability characteristics that are established by the tests specified in UL 94.

7.7.2 Materials shall be assigned flammability ratings based on greatest to least resistance to flame and are identified as: 5VA, 5VB, V-0, V-1, V-2, HF-1, HF-2, HB, and HBF.

7.7.3 In reference to 7.7.2, the assigned flammability rating shall be appropriate for the material-use application in accordance with Section 7.8 and Table 67.1.

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7.8 Nonmetallic Material Ignition Sources Separation

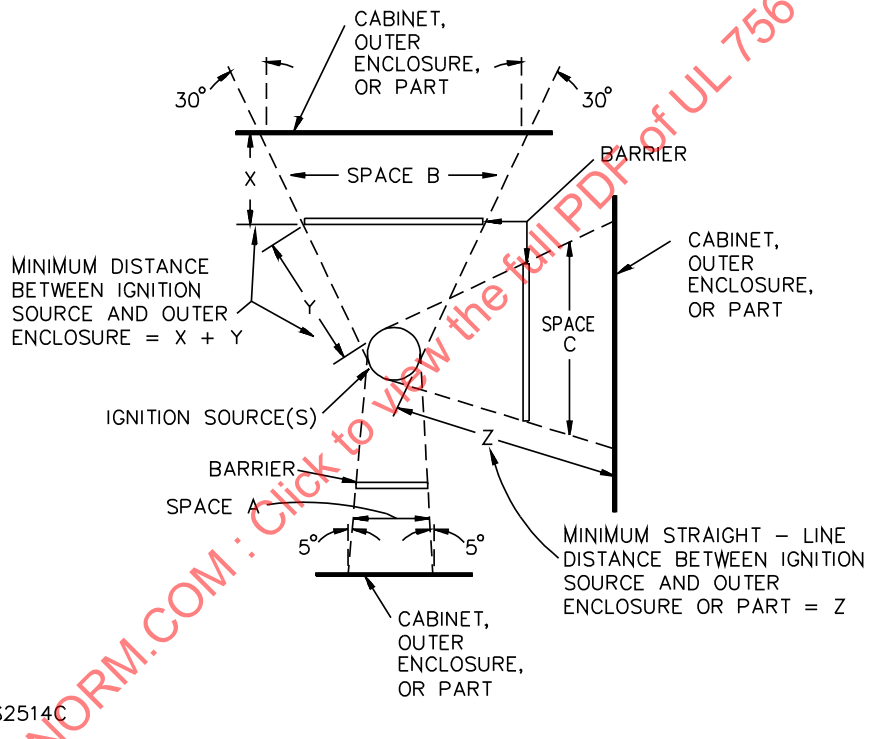
7.8.1 Parts formed from nonmetallic materials that are rated HB or HBF and positioned as shown in Figure 7.1 shall be separated from ignition sources by means of a barrier, extending at least to the boundary surface of the space if such parts are located:

a) Below an ignition source and within Space A;

b) Above an ignition source and within Space B; and

c) In the vertical plane relative to an ignition source and within Space C.

Figure 7.1
Separation of ignition sources from nonmetallic materials



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7.8.2 The HB or HBF materials referenced by 7.8.1 shall be located such that the distance between:

a) High-voltage wiring not employing VW-1 insulation and the HB or HBF materials shall be a minimum of 2 inches (51 mm); and

b) Any other ignition source and the HB or HBF materials shall be a minimum of 4 inches (102 mm).

7.8.3 In reference to 7.8.2 and Figure 7.1, the minimum distance for HB or HBF materials located:

a) Above the ignition source shall be as shown in Distance X + Y; and

b) In the vertical plane relative to the ignition source shall be as shown in straight-line Distance Z.

7.9 Nonmetallic Material Application and Location

7.9.1 Nonmetallic materials shall comply with the applicable tests as described in Table 67.1.

7.9.2 Nonmetallic fasteners used as a part of the enclosure shall comply with the Fastener Strength Test, Section 68.

7.10 Glass-covered openings

7.10.1 Glass covering an opening shall be secured in place so that it cannot be readily displaced in service, and shall provide mechanical protection for the enclosed parts. Glass for an opening not more than 4 inches (102 mm) in any dimension shall not be less than 1/16 inch (1.6 mm) thick. Glass for a larger opening, but not more than 144 square inches (929 cm^2) in area and having no dimension greater than 12 inches (305 mm), shall not be less than 1/8 inch (3.2 mm) thick. Glass used to cover a larger area shall not be less than 1/8 inch thick and:

a) Shall be of a nonshattering or tempered type that, when broken, complies with the performance specifications in ANSI Z97.1; or

b) Shall withstand a 2-1/2 foot-pound (3.38 joules) impact from a 2-inch (50.8-mm) diameter, 1.18-pound (535-gram) steel sphere without cracking or breaking to the extent that a piece is released or dropped from its normal position.

7.11 Wiring openings

7.11.1 If threads for the connection of conduit are tapped all the way through a hole in an enclosure wall, or if an equivalent construction is employed, there shall not be less than three nor more than five threads in the metal, and the construction of the device shall be such that a conduit bushing can be properly attached. If threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors that shall afford protection to the conductors equivalent to that provided by a standard conduit bushing and that shall have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

7.11.2 An enclosure threaded for support by rigid conduit shall provide at least five full threads for engaging the conduit.

7.11.3 Clamps, fittings and fasteners for the attachment of conduit, electrical metallic tubing, armored cable, nonmetallic flexible tubing, nonmetallic-sheathed cable, service cable, and the like, that are supplied as a part of an enclosure shall comply with UL 514B.

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

7.11.5 A knockout shall be provided with a flat surrounding surface adequate for proper seating of a conduit bushing or locknut and shall be located so that installation of a bushing or locknut at any knockout likely to be used during installation will not result in spacing between uninsulated live parts and the bushing or locknut of less than the requirements in this standard.

7.11.6 A plate or plug for an unused conduit opening or other hole in the enclosure shall have a thickness not less than:

a) 0.014 inch (0.36 mm) for steel or 0.019 inch (0.48 mm) for nonferrous metal for a hole having a 1/4-inch (6.4-mm) maximum dimension; and

b) 0.027-inch (0.69-mm) for steel or 0.032-inch (8.1-mm) for nonferrous metal for a hole having a 1-3/8-inch (34.9-mm) maximum dimension.

A closure for a larger hole shall have a thickness equal to that required for the enclosure of the device or a standard knockout seal shall be used. Such plates or plugs shall be securely mounted.

7.11.7 In measuring a spacing between an uninsulated live part and a bushing installed in a knockout as mentioned in 7.11.5, it is to be assumed that a bushing having the dimensions specified in Table 7.3 is in place, in conjunction with a single locknut installed on the outside of the enclosure.

7.12 Enclosures for outdoor use

7.12.1 An enclosure shall be constructed so as to reduce the risk of wetting of live parts, and protect the appliance against a risk of electric shock due to exposure to weather as determined by the tests specified in the Resistance to Moisture Test, Section 67.

7.12.2 A hole for conduit shall be threaded unless it is located wholly below the lowest terminal lug or other live part within the enclosure, and there shall be provision for drainage of the enclosure if knockouts or unthreaded holes are provided.

7.12.3 An enclosure of sheet steel shall be protected against corrosion as specified in Protection Against Corrosion, Section 10.

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Table 7.3
Knockout or hole sizes and dimensions of bushings

Trade size of conduit, inches	Knockout or hole diameter, inches	(mm)	Bushing dimensions			
			Overall diameter, inches	(mm)	Height, inches	(mm)
1/2	7/8	(22.2)	1	(25.4)	3/8	(9.5)
3/4	1-3/32	(27.8)	1-15/64	(31.4)	27/64	(10.7)
1	1-23/64	(34.5)	1-19/32	(40.5)	33/64	(13.1)
1-1/4	1-23/32	(43.7)	1-15/16	(49.2)	9/16	(14.3)
1-1/2	1-31/32	(50.0)	2-13/64	(56.0)	19/32	(15.1)
2	2-15/32	(62.7)	2-45/64	(68.7)	5/8	(15.9)
2-1/2	3	(76.2)	3-7/32	(81.8)	3/4	(19.1)
3	3-5/8	(92.1)	3-7/8	(98.4)	13/16	(20.6)
3-1/2	4-1/8	(104.8)	4-7/16	(112.7)	15/16	(23.8)
4	4-5/8	(117.5)	4-31/32	(126.2)	1	(25.4)
4-1/2	5-1/8	(130.2)	5-35/64	(140.9)	1-1/16	(27.0)
5	5-5/8	(142.9)	6-7/32	(158.0)	1-3/16	(30.2)
6	6-3/4	(171.5)	7-7/32	(183.4)	1-1/4	(31.8)

8 Mounting

8.1 Provision shall be made for securely mounting an appliance in position. A bolt, a screw, or another part used for mounting an appliance shall be independent of those used for securing a component to the frame, base, or panel. Provision for drilling a mounting hole by the installer is acceptable provided that the area for locating the mounting hole is specified by a marking on the appliance or in the installation instructions. See Stability, Section 51.

Exception: A freestanding appliance need not be provided with means for being securely mounted in position.

9 Mechanical Assembly

9.1 The assembly of an appliance shall provide for easy and safe servicing as defined in 2.24 by the route person. The servicing performed shall not result in damage to wiring, electrical components, or refrigerant-containing parts.

9.2 An appliance shall be assembled so that it will not be adversely affected by the vibration of normal operation.

9.3 A switch, a fuseholder, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or other component that is handled by the user shall be mounted or assembled securely, and shall be prevented from turning or shifting in its mounting panel.

Exception: The requirement that a switch be prevented from turning or shifting may be waived provided all four of the following conditions are met:

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

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

c) Spacings are not reduced below the minimum acceptable values if the switch rotates.

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

9.4 With reference to the requirements in 9.3, friction between surfaces is not acceptable as the sole means to prevent shifting or turning of live parts for a device having a single-hole mounting means, but a properly applied lock washer is acceptable.

10 Protection Against Corrosion

10.1 General

10.1.1 Ferrous metal parts shall be protected against corrosion by enameling, coating, plating, or other equivalent means.

Exception: Bearings, thermal elements, and the like where such protection is impracticable.

10.1.2 Metals used in combination shall be galvanically compatible.

10.1.3 Hinges and other attachments shall be resistant to corrosion.

10.1.4 These requirements do not contemplate corrosion that might be caused by exposure to the earth or other corrosive agents.

10.2 Outdoor use

10.2.1 A metallic enclosure shall be protected against corrosion as specified in 10.2.2 – 10.2.9.

Exception No. 1: A motor enclosure if the motor is contained within the appliance enclosure.

Exception No. 2: A decorative grill that does not form a required part of an enclosure.

10.2.2 Copper, bronze, brass containing not less than 80 percent copper, or stainless steel may be used without additional protection against corrosion. Aluminum – sheet, extrusion, or casting, die-cast zinc, or another metal shall be of a grade or alloy known to be resistant to atmospheric corrosion, or shall be subjected to appropriate tests, or shall be additionally protected against corrosion.

10.2.3 An enclosure of cast iron or malleable iron at least 1/8 inch (3.2 mm) thick shall be protected against corrosion by:

a) A 0.00015-inch (0.004 mm) thick coating of zinc, cadmium, or the equivalent on the outside surface and a visible coating of such metal on the inside surface; or

b) One coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. Unless suitability of the paint can be determined by consideration of its composition, corrosion tests are required.

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10.2.4 An enclosure of sheet steel having a thickness less than 0.126 inch (3.20 mm) zinc-coated or 0.123 inch (3.12 mm) thick if uncoated shall be protected against corrosion by one of the following means or by other metallic or nonmetallic coatings that have been found to provide equivalent protection as described in 10.2.7:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating Designation G90 in Table 1 of ASTM A653/A653M, with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any suitable method; however, in case of question, the weight of coating shall be established in accordance with ASTM A90/A90M-95a.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.015 mm) on each surface with a minimum thickness of 0.00054 inch (0.014 mm). The thickness of the coating shall be established by the Metallic-Coating-Thickness Test, Section 71. An annealed coating shall also comply with 10.2.9.

c) A zinc coating conforming with 10.2.5 (a) and (b) with one coat of an organic finish of the epoxy or alkyd-resin type or other outdoor paint applied after forming on each surface. The suitability of the paint may be determined by consideration of its composition or by corrosion tests.

d) A cadmium coating not less than 0.001 inch (0.025 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic-Coating-Thickness Test, Section 71.

e) A cadmium coating not less than 0.00075 inch (0.019 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.00051 inch (0.013 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established in accordance with the Metallic-Coating-Thickness Test, Section 71, and the paint shall be as specified in (c).

10.2.5 An enclosure of sheet steel, 0.126 inch (3.20 mm) thick if zinc-coated, or 0.123 inch (3.12 mm) thick if uncoated or heavier, shall be protected against corrosion by one of the following means or by other metallic or nonmetallic coatings that have been shown to give equivalent protection as described in 10.2.7:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating Designation G60 or A60 in Table 1 of ASTM A653/A653M with not less than 40 percent of the zinc on any side, based on the minimum single-spot test requirement in this ASTM designation. The weight of zinc coating may be determined by any suitable method; however, in case of question, the weight of coating shall be established in accordance with ASTM A90/A90M-95a.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.010 mm) on each surface with a minimum thickness of 0.00034 inch (0.009 mm). The thickness of the coating shall be established by the Metallic-Coating-Thickness Test, Section 71.

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

d) Any one of the means specified in 10.2.4.

10.2.6 The requirements of 10.2.5 also apply to sheet steel 0.056 inch (1.42 mm) thick if zinc-coated, or 0.053 inch (1.35 mm) thick if uncoated or heavier, for an enclosure to be mounted within and protected from direct exposure to weather by the enclosure of other equipment. Such an enclosure shall not be marked rainproof or raintight.

10.2.7 With reference to 10.2.4 – 10.2.6, other finishes, including paints, metallic finishes, and combinations of the two may be accepted when comparative tests with galvanized sheet steel – without annealing, wiping, or other surface treatment – conforming with 10.2.4(a) or 10.2.5(a), as applicable, indicate they provide equivalent protection. Among the factors that are taken into consideration when judging the suitability of such coating systems are exposure to salt spray, moist carbon-dioxide sulphur-dioxide air mixtures, moist hydrogen-sulphide air mixtures, ultraviolet light, and water.

10.2.8 Test specimens of a finish as described in 10.2.3, or 10.2.4(c), or 10.2.5(c), if the paint is tested, are to be consistent with the finish that is to be used in production with respect to the base metal, cleaning or pretreatment method, application method, number of coats, curing method, thickness, and the like.

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

11 Accessibility Of Uninsulated Live Parts, Film-Coated Wire, And Moving Parts

11.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part or film-coated wire, or injury to persons from a moving part, an opening in an enclosure shall comply with either (a) or (b). This requirement applies to the cabinet with and without the parts specified in 11.8, and also applies to parts located behind a locked door.

a) For an opening that has a minor dimension (see 11.6) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 11.2.

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 11.1.

Exception No. 1: A motor need not comply with these requirements if it complies with the requirements in 11.2.

Exception No. 2: A moving part capable of causing injury to persons on an appliance that is provided with an on-off control that is readily accessible from the normal operating position need not comply with this requirement if complete guarding of the part would defeat the utility of the appliance.

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Table 11.1
Distance from an opening to a part that may involve a risk of electric shock or injury to persons

Minor dimension[a] of opening, inches[b]	(mm)[b]	Minimum acceptable distance from opening to part, inches[b]	(mm)[b]
3/4[c]	(19.1)	4-1/2	(114)
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)
d	d	30	(762)

[a] See 11.6.
[b] Between 3/4 inch (19.1 mm) and 2-1/8 inches (54.0 mm), interpolation is to be used to determine a value between values specified in the table.
[c] Any dimension less than 1 inch applies to a motor only.
[d] More than 2-1/8 inches, but not more than 6 inches (152 mm).

11.2 In an integral enclosure of a motor as specified in Exception No. 1 to 11.1

a) An opening that has a minor dimension (see 11.6) less than 3/4 inch (19.1 mm) is acceptable if:

1) A moving part cannot be contacted by the probe illustrated in Figure 11.3;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 11.1;

3) In a directly accessible motor, an uninsulated live part cannot be contacted by the probe illustrated in Figure 11.4; and

4) In an indirectly accessible motor, an uninsulated live part cannot be contacted by the probe illustrated in Figure 11.3.

b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 11.1.

The requirement in (a)(2) and (b) applies before and after opening a locked door or doors.

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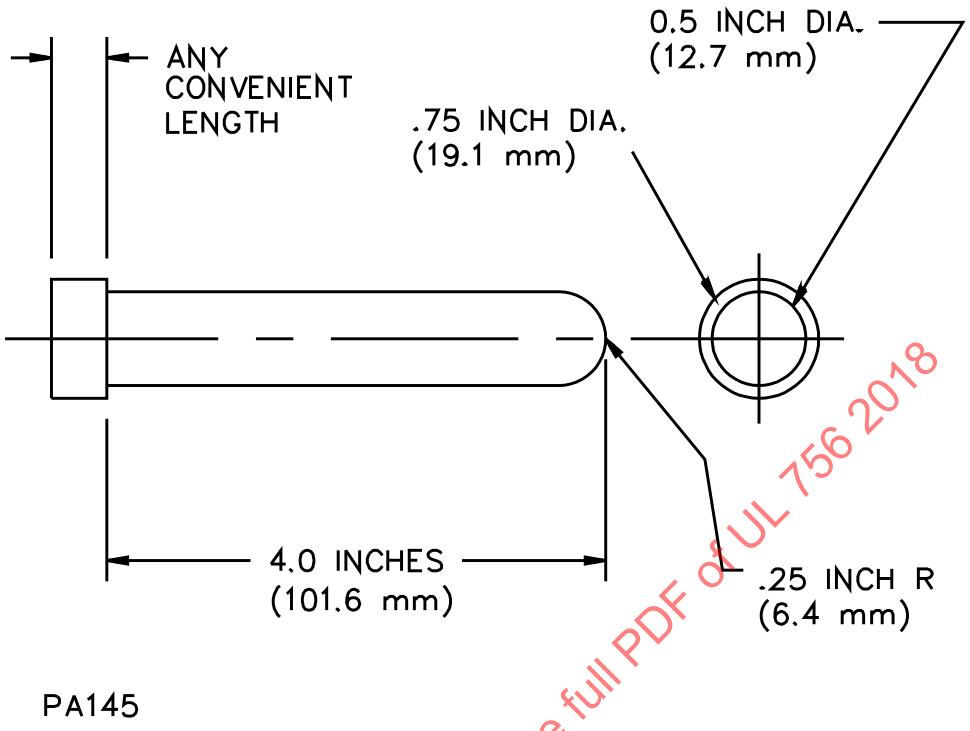
Figure 11.1
Probe for film-coated wire



11.3 An uninsulated live part or film-coated wire is not considered to involve a risk of electric shock if the voltage is 42.4 volts peak or less or if the available current measured through a 1500-ohm noninductive resistor is 0.5 milliamperes or less.

11.4 The probes specified in 11.1 and 11.2 and illustrated in Figures 11.1 – Figure 11.4 are to be applied to any depth that the opening will permit; and are to be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figure 11.2 and Figure 11.4 are to be applied in any possible configuration; and, if necessary, the configuration is to be changed after insertion through the opening.

11.5 The probes specified in 11.4 and 11.6 are to be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material; they are to be applied with the minimum force necessary to determine accessibility.

11.6 With reference to the requirements in 11.1 and 11.2, the minor dimension of an opening is the diameter of the largest cylindrical probe having a hemispherical tip that can be inserted through the opening.

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Figure 11.2
Articulate probe with web stop

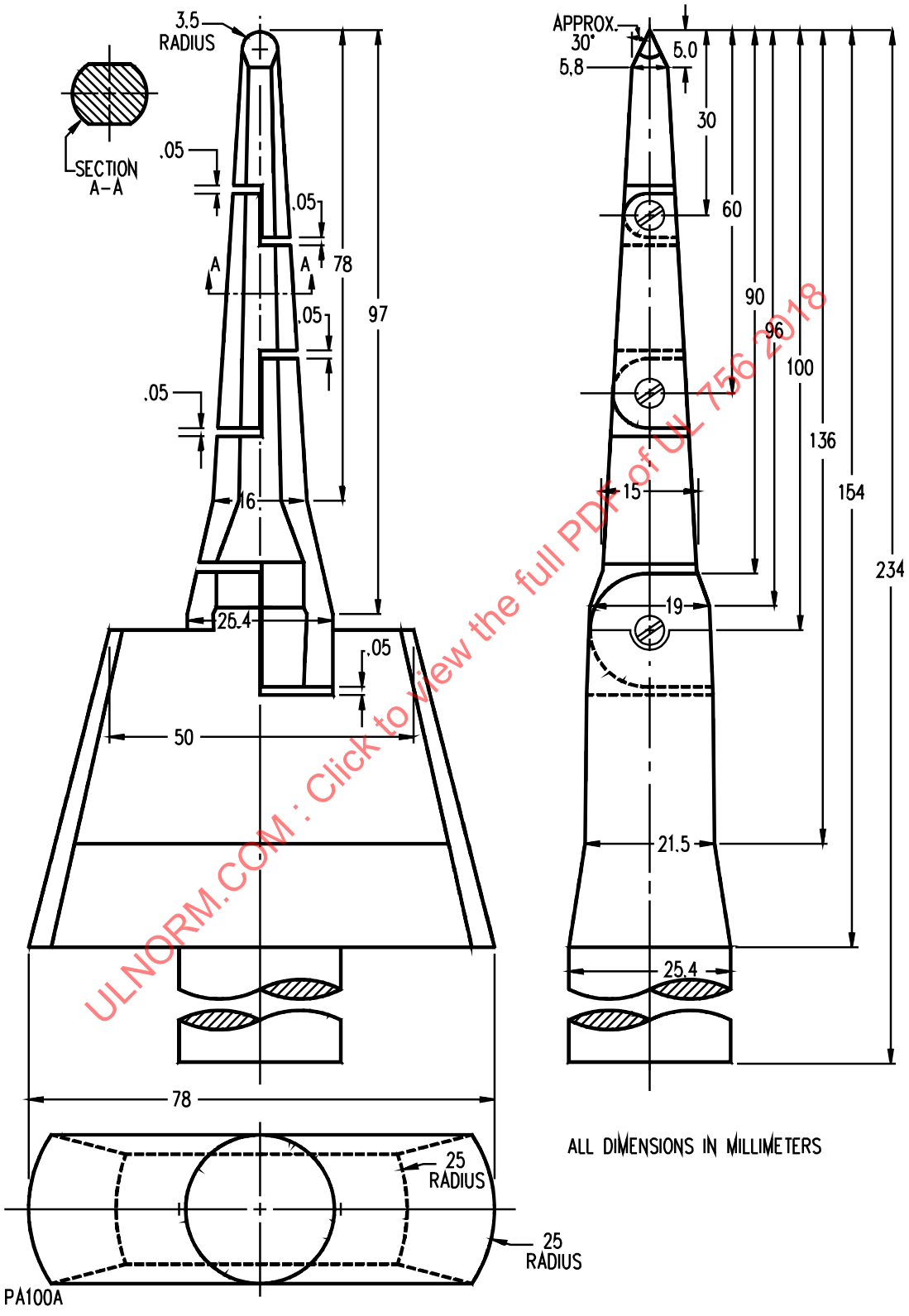

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Figure 11.3
Probe for moving parts and uninsulated live parts

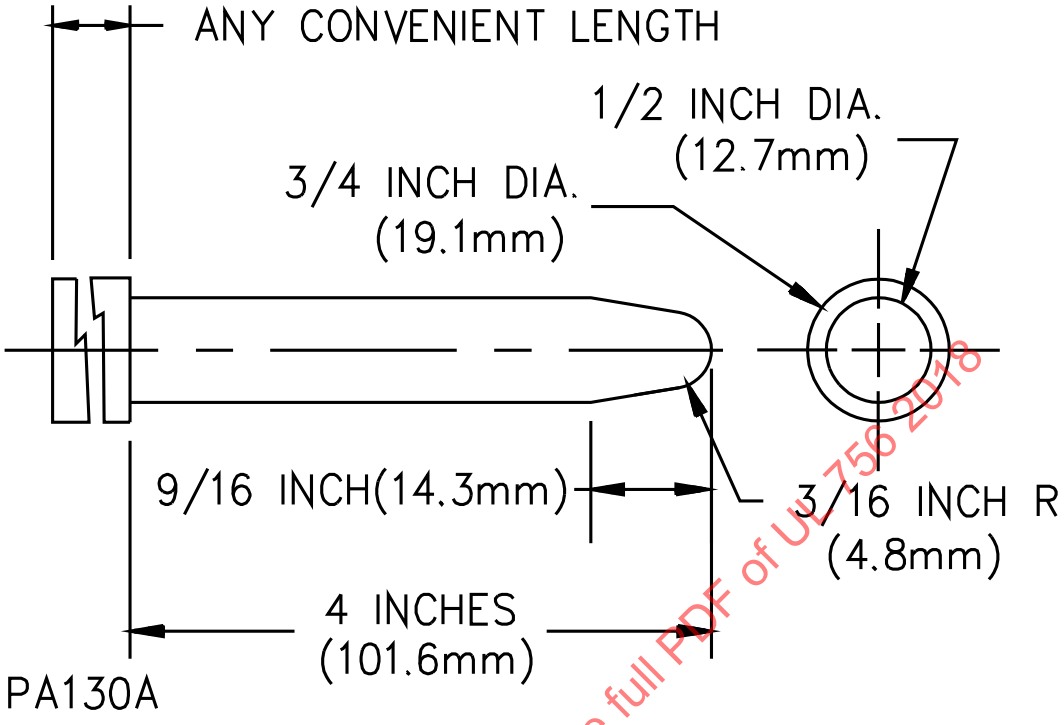

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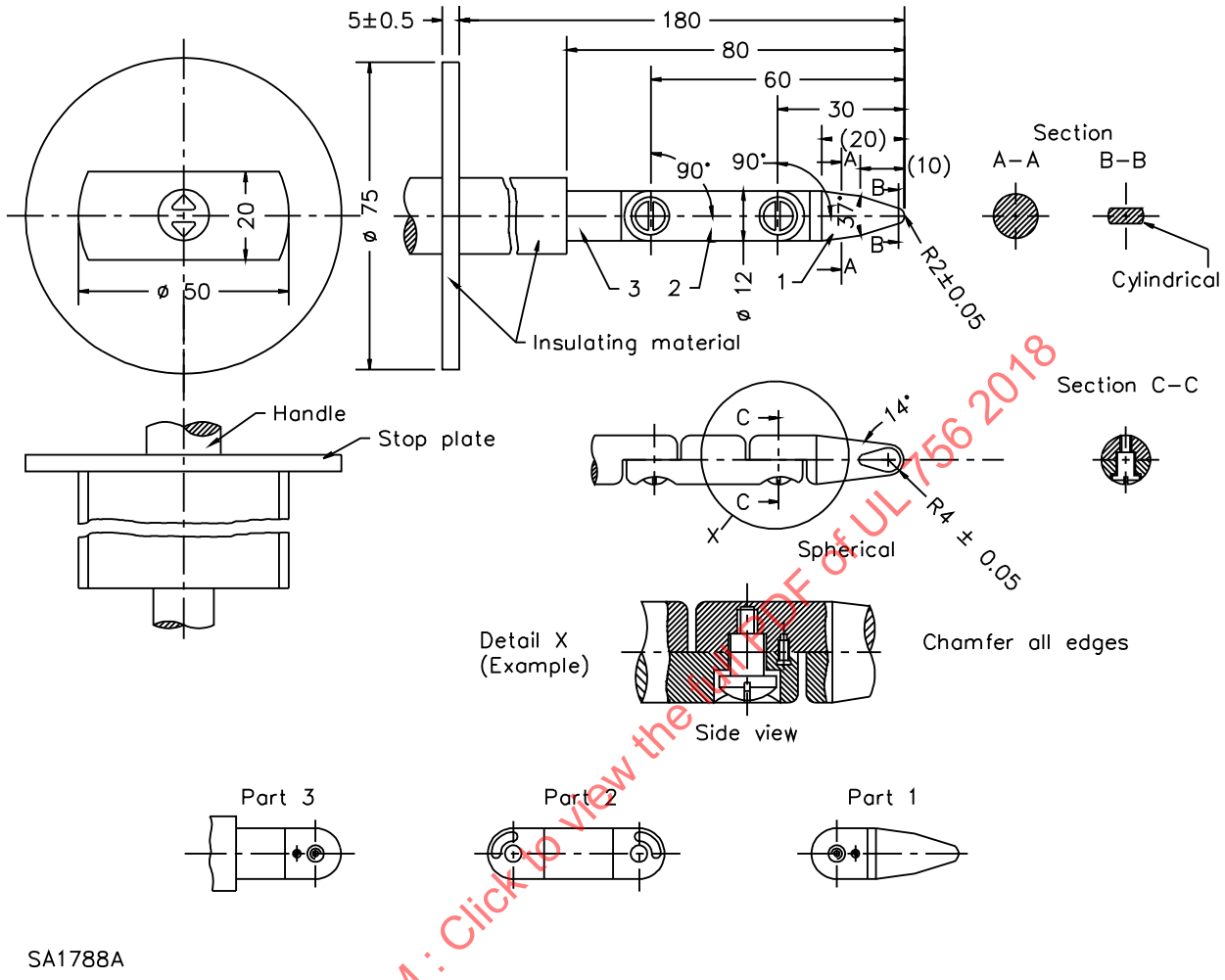
Figure 11.4
Articulate probe



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11.7 The requirements in this section also apply to a component coin and currency mechanism that is intended to be installed within the enclosure of another appliance. The coin sorter – rejector or acceptor – contained in the coin mechanism is to be left in place during this evaluation.

11.8 During the examination of a product to determine whether it complies with the requirements in 11.1 or 11.2, a part of the cabinet that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

11.9 Except as noted in 11.1, an uninsulated live part in a compartment that is normally opened by a route person for refilling, coin or currency collecting, relamping, lubricating, control adjusting, or other such routine, periodic service operation shall be located or guarded so as to prevent unintentional contact with such part by the attendant while performing that operation. The coin sorter – rejector or acceptor – contained in a coin-changer or actuator is to be left in place during this evaluation unless price selection switches are located behind the coin sorter in which case it is to be removed.

11.10 With reference to 11.1 concerning uninsulated live parts, it is to be assumed that cord-connected coin, currency, or credit mechanisms for use in vending machines and appliances are energized when price settings are changed.

11.11 The requirement in 11.9 will necessitate the use of an enclosure, a cover, or a barrier over an uninsulated live part that the route person may inadvertently touch while servicing or adjusting the appliance. A cover or a barrier that must be removed to perform a servicing function, as mentioned in 11.9, is not considered to provide the protection required.

11.12 Insulating tubing having a wall thickness not less than 0.028 inch (0.71 mm) may be used to provide protection against contact with live parts.

11.13 The smaller dimension – width – of an opening in an enclosure around a dial, adjusting knob, lever, handle, pointer, or the like shall not be more than 1/8 inch (3.2 mm) for any setting or position of the dial, knob, or the like.

11.14 With reference to the requirements in 11.1 and 11.2, insulated brush caps are not required to be additionally enclosed.

12 Supply Connections

12.1 General

12.1.1 An appliance intended to be permanently connected to the electrical source of supply shall comply with 12.2, 12.3 and 12.4. An appliance intended for cord-connection shall comply with 12.5, Cord Connected.

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12.2 Permanently connected

12.2.1 An appliance intended to be permanently connected electrically shall have provision for permanent connection to the source of supply in accordance with ANSI/NFPA 70.

12.2.2 The field-wiring outlet box or compartment to which power-supply connections are made shall be accessible for inspection after the appliance is installed as intended.

12.2.3 The connections shall be accessible without removing parts other than a service cover or panel and the cover of the outlet box or compartment in which the connections are made.

12.2.4 The appliance shall be provided with field-wiring terminals or leads for connection of supply-circuit conductors. The terminals or leads shall not be less than the size required by ANSI/NFPA 70, having an ampacity acceptable for the marked rating of the appliance.

12.2.5 As used in Section 12.3, Terminals, and Section 12.4, Leads, a field-wiring terminal is considered to be a terminal to which power supply, control, or equipment grounding connections will be made in the field when the appliance is installed.

12.2.6 The wiring of a permanently connected appliance shall terminate in an outlet box or similar compartment with provision for the connection of metal-clad cable or conduit, or shall have provisions for the connection of a nonmetallic wiring system which, in accordance with ANSI/NFPA 70, would be acceptable for connection to the appliance.

12.2.7 Space shall be provided in the field-wiring compartment or outlet box for installation of conductors of the number and size required by 12.2.4 using Type TW or THW wire when at least a 6 inch (150 mm) length of each conductor is brought into the wiring compartment.

Exception: Conductors other than Type TW or THW may be used if specified in the installation instructions.

12.3 Terminals

12.3.1 Pressure wire connectors shall be used for field-wiring terminals except that for field-wiring terminals intended for 8 AWG (8.4 mm^2) and smaller conductors, the parts to which wiring connections are made may consist of clamps or wire binding screws with cupped washers, terminal plates, or the equivalent to hold the wire in position.

12.3.2 Size 14 AWG (2.1 mm^2) wire shall be considered as being the smallest wire that can be used for branch circuit wiring and at a terminal intended for the connection of the power supply leads.

12.3.3 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size mentioned in 12.2.4, but no smaller than 14 AWG (2.1 mm^2), under the head of the screw or the washer.

12.3.4 Wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with 12.3.5 – 12.3.10 or with UL 486E.

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12.3.5 If a wire-binding screw is employed at a wiring terminal for the connection of supply circuit conductors, it shall not be:

a) Smaller than 8 (4.2 mm diameter) for 14 AWG (2.1 mm^2) supply circuit conductors; or

b) Smaller than 10 (4.8 mm diameter) for 12, 10, or 8 AWG (3.3, 5.3, or 8.3 mm^2) supply circuit conductors.

12.3.6 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick. There shall be at least two full threads in the metal of the plate.

Exception: A plate not less than 0.030 inch (0.76 mm) thick is acceptable for 14 AWG (2.1 mm^2) conductors.

12.3.7 A terminal plate formed from stock having the thickness specified in 12.3.6, may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

12.3.8 A wire-binding screw shall thread into metal.

12.3.9 A field-wiring terminal shall be prevented from turning or shifting in position by means other than friction between surfaces. This may be accomplished by such means as two screws or rivets; by square shoulders or mortises; by a dowel pin, lug, or offset; or by a connecting strap or clip fitted into an adjacent part.

12.3.10 A field-wiring terminal for the connection of a grounded conductor shall be identified by means of a metallic-plated coating, substantially white in color, and shall be distinguishable from the other terminals; or identification of the terminal for the connection of the grounded conductor shall be shown in some other manner, such as on an attached wiring diagram.

12.3.11 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,″ ″GROUNDING,″ or the like, or by a marking on a wiring diagram provided on the appliance. The wire-binding screw or pressure wire connector shall be secured to the frame or enclosure of the appliance and shall be located so that it is unlikely to be removed during normal servicing of the appliance.

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12.4 Leads

12.4.1 Leads intended for connection to any external high-voltage circuit or to an external low-voltage circuit that contain one or more of the components specified in 18.4 shall comply with all of the following:

a) Be one of the types of wiring specified in 14.1 and sized not smaller than 18 AWG (0.82 mm^2);

b) Be 6 inches (152 mm) or more in length, as measured from the lead end to the strain relief means, unless the use of a shorter lead is required to prevent damage to the lead insulation;

c) Be provided with strain relief if stress on the lead may be transmitted to terminals, splices, or internal wiring. Leads shall comply with 65.1 when subjected to a direct pull of 20 pounds-force (89 N);

d) Not be connected to wire binding screws or pressure wire connectors located in the same compartment as the lead ends (that are intended for spliced connections to the field-wiring) unless the screws or connectors are rendered unusable for field-wiring connections or the lead ends are insulated; and

e) Be insulated at the free end, if the lead will not be used in every installation and if the end can reduce spacings below the minimum acceptable values specified in High-Voltage Circuits, Section 17, for high-voltage circuits or Low-Voltage Circuits, Section 18, for low-voltage circuits.

12.4.2 A lead intended for the connection of a grounded conductor shall be finished to show a white or gray color, shall be distinguishable from other leads, and no other lead shall be so identified.

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

12.5 Cord-connected

12.5.1 An appliance intended for cord connection shall employ a flexible power-supply cord having an equipment grounding conductor and a grounding-type attachment plug.

12.5.2 In reference to 12.5.1, a power supply cord and plug shall comply with UL 817.

12.5.3 Except as indicated in 12.5.4, a cord-connected appliance shall be constructed so that the cord can be removed to adapt the appliance for connection to a permanent wiring system. The construction shall comply with Permanently Connected, Section, 12.2, Terminals, Section 12.3, and Leads, Section 12.4. Instructions for making the conversion shall be provided with the appliance and they are to be reviewed to determine that they are complete and correct. These instructions shall be located adjacent to the compartment containing the cord connections.

12.5.4 A coin, currency, credit or other similar mechanism that does not comply with 12.5.3 shall be intended for use on or within a vending machine or other appliance.

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12.5.5 An appliance that is intended to be fastened in place or located in a dedicated space and that requires a form of supply connection that will facilitate the interchange of the appliance to maintain continuous service or otherwise meet special conditions of use shall be provided with not more than 8 feet (2.4 m) of power-supply cord.

12.5.6 For an appliance other than the types specified in 12.5.5, the length of the power supply cord shall be not more than 10 feet (3.0 m) nor less than 6 feet (1.83 m).

12.5.7 In reference to 12.5.5 and 12.5.6, the power supply cord length shall be measured between the attachment plug and any point at which the cord exits the appliance cabinet or the last strain relief, whichever is shorter.

12.5.8 The power supply cord shall have a voltage rating not less than the rated voltage of the appliance, and shall have an ampacity not less than required by the input as specified in the Input Test, Section 56.

12.5.9 The power supply cord shall be Type S, SE, SEO, SJ, SJE, SJEO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, or STOO as specified in ANSI/NFPA 70.

12.5.10 A power-supply cord for an appliance intended for use in a protected or outdoor location shall be marked on the jacket with the designation of ″W″ following the cord type designation.

12.5.11 The power-supply cord shall be provided with strain relief so that a stress on the cord will not be transmitted to terminals, splices, or internal wiring. The strain relief means shall comply with 65.1 when subjected to a direct pull of 35 pounds-force (156 N).

12.5.12 If a flexible cord is capable of being pushed into the appliance through the cord-entry hole, any such displacement shall not result in:

a)Mechanical damage to the cord;

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

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

d) Damaging internal connections or components.

12.5.13 Except as indicated in 12.5.14, the grounding-type attachment-plug shall comply with the ANSI designation as specified in Table 12.1 based on the appliance voltage and ampere rating.

12.5.14 In reference to 12.5.13, if the grounding-type attachment plug does not comply with the ANSI designation specified in Table 12.1, then the equipment shall be rated 250 V or less and shall be intended for connection to circuits rated for other than:

a) 60 Hz; and/or

b) The voltages specified in 55.4.

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Table 12.1
ANSI designations for attachment plugs

Attachment plug rating	ANSI designation[a]
15 amperes, 125 volts	5-15
20 amperes, 125 volts	5-20
15 amperes, 250 volts	6-15
20 amperes, 250 volts	6-20

[a] Designations in accordance with NEMA WD6

12.5.15 The power supply cord equipment grounding conductor shall be:

a) Finished with a continuous green color or with a continuous green color with one or more yellow stripes, and no other conductor shall be so identified;

b) Secured to the frame or enclosure of the appliance by a positive means that is not likely to be removed during any servicing operation not involving the power supply cord. A sheet metal screw or quick-connect terminal shall not be used; and

c) Connected to the grounding blade of the attachment plug.

13 Grounding

13.1 An appliance shall have provision for the grounding of all exposed or accessible noncurrent-carrying metal parts that may be contacted by the user or by route and service personnel during service operations that are likely to be performed when an appliance is energized.

13.2 Uninsulated metal parts of cabinets, electrical enclosures, motor frames and mounting brackets, controller mounting brackets, capacitors, and other electrical components shall be bonded for grounding if they may be contacted by the user, route person, or service person.

Exception: Metal parts as described in the following (a) – (d) need not be bonded for grounding:

a) An adhesive attached metal foil marking, a screw, a handle, or the like that is located on the outside of an enclosure or cabinet and isolated from electrical components or wiring by grounded metal parts so that they are not likely to become energized.

b) An isolated metal part, such as a magnet frame and an armature, a small assembly screw, or the like that is positively separated from wiring and uninsulated live parts.

c) A panel or cover that does not enclose uninsulated live parts if wiring is positively separated from the panel or cover so that it is not likely to become energized.

d) A panel or cover that is insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick and reliably secured in place.

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13.3 Metal-to-metal hinge bearing members may be considered as a means for bonding the door for grounding.

13.4 If the continuity of the grounding system relies on the dimensional integrity of a nonmetallic material, the material shall be acceptable for the purpose when investigated for dimensional stability.

13.5 Other than as noted in 13.6, the circuitry shall be arranged so that the equipment grounding connection or conductor, the enclosure, the frame, the component mounting panel, and the earth ground do not carry current except during an electrical fault.

13.6 A single point reference ground may be employed in a low-voltage or isolated-limited-secondary circuit. The enclosure, frame, or panel, including bolted joints may carry the current of a low-voltage circuit. In neither of these instances is such current to be carried through the field-equipment grounding means, the metallic raceway or other power-supply grounding means, or the earth ground. See 18.1 and 19.1.

13.7 A separate component bonding conductor shall be of copper, a copper alloy, or other material acceptable for use as an electrical conductor. A separate bonding conductor or strap shall:

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

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

13.8 The bonding shall be by a positive means, such as by clamping, riveting, bolted or screwed connection, or by welding, soldering, or brazing with materials having a softening or melting point greater than 455°C (850°F). The bonding connection shall penetrate nonconductive coatings such as paint or vitreous enamel. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material, other than as indicated in 13.9.

13.9 A connection that depends upon the clamping action exerted by rubber or similar material may be acceptable if it complies with the requirements in the Bonding Conductor Test, Section 72, under any normal degree of compression permitted by a variable clamping device and if the results are still acceptable after exposure to the effects of oil, grease, moisture, and thermal degradation that are likely to occur in service. Also, the effect of assembling and disassembling, for maintenance purposes, such a clamping device is to be considered with particular emphasis on the likelihood of the clamping device being reassembled in its intended position.

13.10 On a permanently connected or cord-connected appliance, the size of a conductor or a strap employed to bond an electrical enclosure or motor frame shall be based on the rating of the branch-circuit overcurrent device to which the appliance will be connected. The size of the conductor or strap shall be in accordance with Table 13.1.

Exception: A smaller conductor or strap may be used if it complies with the requirements in the Bonding Conductor Test, Section 72.

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Table 13.1
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor[a]			
	Copper wire,		Aluminum wire,	
	AWG	(mm^2)	AWG	(mm^2)
15	14	(2.1)	12	(3.3)
20	12	(3.3)	10	(5.3)
30	10	(5.3)	8	(8.3)
40	10	(5.3)	8	(8.3)
60	10	(5.3)	8	(8.3)
100	8	(8.3)	6	(13.3)

[a] Or equivalent cross-sectional area.

13.11 The resistance between two parts connected by a bonding conductor shall not be more than 0.1 ohm.

13.12 A bonding conductor to a component, device, or electrical enclosure is not required to be larger than the size of the conductors supplying power to the component or components within the enclosure.

13.13 If more than one size branch-circuit overcurrent device is involved, the size of the bonding conductor is to be based on the rating of the overcurrent device intended to provide ground-fault protection for the component bonded by the conductor. For example, if a motor is individually protected by a branch-circuit overcurrent device smaller than other overcurrent devices used with the equipment, a bonding conductor for that motor is sized on the basis of the overcurrent device intended for ground-fault protection of the motor.

13.14 The following are considered to constitute means for grounding:

a) An appliance intended to be permanently connected by a metal enclosed wiring system – a knockout or equivalent opening in the metal enclosure of the appliance.

b) An appliance intended to be permanently connected by a nonmetal-enclosed wiring system, for example, nonmetallic-sheathed cable – an equipment-grounding terminal or lead.

c) A cord-connected appliance – an equipment-grounding conductor in the cord.

13.15 Open-type coin, currency, or credit mechanisms for installation on or within other appliances shall have provisions for grounding by:

a) An arrangement wherein it is accomplished automatically by normal mounting of the mechanism; or

b)A separate bonding conductor in the receptacle and plug-in connector. The AWG size of the bonding conductor shall be at least as large as the largest sized power-supply conductor to the mechanism.

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13.16 The grounding contact in a grounding receptacle shall be located and formed so that the path of electrical continuity to the grounding pin or blade of a mating plug is completed before such continuity is established between any other contact and its respective pin or blade on the plug. This grounding path shall be substantial and reliable when the plug is properly seated in the receptacle.

13.17 Functional grounding shall not be relied upon for equipment grounding or bonding.

14 Internal Wiring

14.1 The internal wiring of an appliance shall comply with UL 44, UL 62, UL 83, or UL 758.

14.2 The internal wiring of an appliance shall have insulation rated for the potential involved and the temperatures to which it may be subjected. Compliance shall be determined in accordance with any of the following:

a) Wiring temperatures shall be evaluated on the basis of the temperatures measured during the applicable temperature test specified in Normal Temperature Test, Section 58.

b) Other than motor wiring, all wiring shall:

1) Have an ampacity of the conductors in accordance with Table 14.1; and

2) Not be exposed to heat from radiating sources or heated components.

c) Motor wiring shall have an ampacity not less than 125% of the motor full load or maximum operating current rating in addition to complying with (b).

14.3 With reference to 14.2, high voltage circuit conductors supplying more than one motor or a motor together with other loads shall have an ampacity not less than 125 percent of the full load or maximum operating current rating of the largest motor plus the full load or maximum operating current rating of any other motors or other loads supplied.

14.4 Except as specified in 14.5, 14.6 and 14.7, wiring material shall have an insulation thickness not less than 1/16 inch (1.6 mm) thick for 16 AWG (1.3 mm^2) and smaller conductors, and 5/64 inch (1.98 mm) thick for 14, 12 or 10 AWG (2.1, 3.3 or 5.3 mm^2) conductors.

14.5 Wiring with neoprene or thermoplastic conductor insulation that does not comply with 14.4 shall have insulation not less than 1/32 inch (0.8 mm) thick. In addition such wiring shall be:

a) Contained within a separate metal enclosure, conduit, electrical metallic tubing, metal raceways, or the equivalent;

b) Contained within insulating tubing that complies with UL 224 and having a wall thickness not less than 0.028 inch (0.71 mm);

c) Not longer than 3 inches (76.2 mm) and intended to facilitate connection to electrical components. Such wiring shall be protected against damage by its location or routing; or

d) Arranged so that the wires are:

1) Not subjected to movement by air or vibration;

2) Secured at intervals and bunched together to form a cable;

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3) Routed in a manner to prevent hooking by a route or service person, including being located away from reset buttons, test switches, or similar components;

4) Located in a compartment which is provided with a complete base pan or similar bottom closure;

5) Routed to prevent contact through openings in the outer enclosure or cabinet when the wiring is evaluated as if it were film-coated wire in accordance with 11.1; and

6) Not routed between stationary and movable parts.

14.6 Wiring with rubber insulation that does not comply with 14.4 shall have insulation not less than 3/64 inch (1.2 mm) thick. In addition such wiring shall comply with 14.5(a), (b), or (c).

14.7 Wiring with conductor insulation that does not comply with 14.4 shall have insulation not less than 1/64 inch (0.4 mm) thick. In addition such wiring shall be located inside an enclosure within the appliance cabinet and not likely to be contacted by a route person.

14.8 Wiring that may be exposed to the route person shall be routed or secured to prevent it from being unintentionally hooked or damaged.

Table 14.1
Wiring material ampacities

AWG	(mm^2)	Ampacity, A[a]
22	(0.41)	4
20	(0.66)	7
18	(0.82)	10
16	(1.3)	13
14	(2.1)	18
12	(3.3)	25
10	(5.3)	30
8	(8.4)	40
6	(13.3)	55
4	(21.2)	70
2	(33.6)	95
1	(42.4)	110

[a] The ampacities shown apply to appliance wiring materials with insulation rated not less than 194°F (90°C). For types of wires other than appliance wiring materials, the ampacity shall be determined from Tables 310.15(B)(16) and 310.15(B)(21) in ANSI/NFPA 70, for the type of wire employed. The correction factors of the referenced tables need not be applied.

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14.9 If any failure of low-voltage wiring may cause malfunctioning of a pressure-limiting device, motor overload-protective device, or other protective device, where short-circuiting or grounding may result in a risk of fire, electric shock, or injury to persons, such wiring shall comply with 14.1 – 14.8.

14.10 All internal wiring of an appliance shall be supported and routed to prevent damage due to contact with sharp edges, including screw threads, burrs, fins, moving parts, and the like that may abrade the insulation of the conductor or otherwise damage the wiring. Metal clamps and guides used for routing stationary internal wiring shall have smooth, rounded edges. Wire positioning devices shall comply with UL 1565.

14.11 If appliances require frequent opening of the door for coin or currency collecting or replenishing, lubricating, control adjustment, relamping, and other incidental operations, the internal wiring shall be installed and protected so that it is not likely to be damaged during such normal service operations. Strain relief means shall be provided for wires or cords at an attachment plug or other electrical component that may be removed or disconnected during such service operations.

14.12 If wiring extends from the cabinet to a hinged door or other parts that may be moved, stranded conductors shall be used. The arrangement shall prevent undue twisting or stressing of conductors as a result of the movement. Wiring and any supplementary insulation provided shall be subjected to the flexing test in Section 62, Flexing of Internal Wiring Test, if movement of the wiring is likely to cause a risk of fire, electric shock, or injury to persons.

14.13 Wiring which is color coded green or green with one or more yellow stripes shall be used only for grounding conductors. Wiring used for other purposes shall not be identified with the above color codes.

14.14 A hole in a wall, a panel, or a barrier through which insulated wires or cords pass and on which they may bear shall be provided with smoothly rounded bushings or shall have smooth, rounded surfaces upon which the wires or cords may bear to prevent abrasion of the insulation. Bushings shall comply with UL 635 or be fabricated from materials, such as ceramic, wood, phenolic, porcelain, cold-molded composition, or fiber and be reliably secured in place.

14.15 Compartments intended to enclose wires, including those that enclose field-wiring, shall be free of any sharp edge, burr, fin, moving part, or the like that may abrade the insulation on the conductor or otherwise damage the wiring.

14.16 Mounting screws and nuts shall be designed or located so that sharp edges will not damage wiring. A screw shall have a flat or blunt end. The end of the screw shall have no burrs, fins, or sharp edges that may abrade wire insulation, and shall not project more than 3/16 inch (4.8 mm) into a wireway.

15 Splices and Connections

15.1 All splices and connections shall:

a) Comply with UL 486A-486B or UL 486C; and

b) Be mechanically secure and shall provide reliable electrical contact.

15.2 A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection could result in a risk of fire, electric shock, or injury to persons. A wire lead shall not be tack soldered, by laying the wire lead on the flat surface of a terminal. The following methods of mechanical securement, before soldering, are acceptable:

a) Insertion of the lead through a hole in a terminal plate or a printed circuit board;

b) Bending a wire lead around a terminal projection;

c) Insertion of the lead into a U-shaped or V-shaped slot in the terminal; or

d) Other equivalent means.

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15.3 A splice shall be located and supported so that it is not subject to mechanical damage. The insulation on a splice shall be equivalent in thickness, voltage rating, and temperature rating of the insulation on the conductors.

15.4 If the voltage involved is less than 250 volts, insulation consisting of two layers of thermoplastic tape, or of one layer of friction tape on top of one layer of rubber tape, is acceptable on a splice. In determining if splice insulation consisting of coated fabric, thermoplastic, or other type of tubing is acceptable, consideration is given to such factors as its dielectric properties, heat-resistant and moisture-resistant characteristics, and the like.

15.5 In reference to 15.4, thermoplastic tape shall not be wrapped over a sharp edge.

15.6 A splicing device, such as a fixture-type splicing connector, or a pressure wire connector, may be used if it employs insulation acceptable for the temperature and voltage to which it is subjected.

15.7 A wire binding assembly shall form a secure electrical connection and have adequate ampacity.

15.8 At a terminal, a stranded conductor shall be secured by a soldered or pressure terminal connector, or the conductor shall be soldered or otherwise assembled to prevent loose strands after assembly. An open slot connector shall not be used unless it is designed to prevent disconnection resulting from loosening of the clamping means.

15.9 The shank of a terminal connector shall be protected by insulating tubing if the spacings can be reduced below the acceptable minimum by slight loosening of the clamping means.

15.10 Except as specified in 15.11, the insulation on the shank shall be vulcanized fiber, varnished cloth, mica, phenolic composition and be:

a) Not less than 0.028 inch (0.71 mm) thick; or

b) Not less than 0.013 inch (0.3 mm) thick if insulation of this thickness is used in conjunction with a through-air spacing of not less than one-half of the required through-air spacing.

15.11 If an insulating material other than those specified in 15.10 is used to insulate a terminal connector shank, the material shall have insulating, mechanical and flammability properties that are equivalent to the materials specified in 15.10. The insulating material shall have these properties at the thickness used.

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

15.13 With reference to 15.12, a wire-binding screw or a pressure terminal connector used as a terminating device shall be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling, vibration, and the like.

15.14 Quick connecting assemblies shall comply with UL 310, form a secure electrical connection, and be capable of carrying the current involved.

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16 Separation of Circuits

16.1 Unless provided with insulation rated for the highest voltage involved, insulated conductors of different circuits – internal wiring shall:

a) Be separated by barriers or segregated; and

b) Be separated by barriers or segregated from an uninsulated live part connected to a different circuit.

16.2 Segregation of insulated conductors may be accomplished by clamping, routing, or equivalent means that will maintain a minimum separation of 1/4 inch (6.4 mm) from insulated or uninsulated live parts of a different circuit.

16.3 Field-installed conductors of any circuit shall be segregated or separated by barriers from:

a) Factory-installed conductors connected to any other circuits unless the conductors of both circuits are or will be insulated for the maximum voltage of either circuit; and

b) An uninsulated live part of a different circuit unless the conductors will be insulated for the maximum voltage of either circuit.

16.4 Field-installed conductors of any circuit shall be segregated or separated by barriers from field-installed conductors connected to any other circuit.

16.5 If a barrier is used to provide separation between factory- or field-installed conductors of different circuits, or between factory- or field-installed conductors and an uninsulated live part of a different circuit, it shall comply with Section 6, Barriers, and be rigid insulating material.

16.6 If Class 2, Class 3 and power-limited fire alarm circuit conductors are to occupy the same enclosure as electric light, power, Class 1, or nonpower-limited fire alarm circuit conductors, both of the following conditions shall be met:

a) The enclosure shall provide a minimum of two conductor entry openings so that the Class 2, Class 3 and power-limited fire alarm circuit conductors may be segregated from electric light, power, Class 1 and nonpower-limited fire alarm circuit conductors. The installation document shall completely detail the entry routing of all conductors into the enclosure.

b) The enclosure shall be constructed so that, with all field-installed wiring connected to the product, a minimum of 1/4 inch (6.4 mm) spacing is provided between all Class 2, Class 3 and power-limited fire alarm circuit conductors and all electric light, power, Class 1 and nonpower-limited fire alarm circuit conductors. Compliance with this requirement may be achieved by specific wire routing configurations that are detailed in the installation document. If a wire routing scheme will not maintain a separation of 1/4 inch (6.4 mm), barriers shall be used to provide separation.

Exception: This requirement need not apply provided all circuit conductors operate at 160 volts or less to ground and:

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a) The Class 2, Class 3 and power-limited fire alarm circuits are installed using CL3, CL3R, or CL3P, or substitute cable permitted by ANSI/NFPA 70, and the Class 2, Class 3 and power-limited fire alarm circuit conductors extending beyond the cable jacket are separated a minimum of 1/4 inch or by nonconductive tubing or by a nonconductive barrier from all other conductors; or

b) The Class 2, Class 3 and power-limited fire alarm circuit conductors are installed as a Class 1, or higher, circuit.

SPACINGS

17 High-Voltage Circuits

17.1 A high-voltage circuit is one complying with 2.5(a).

17.2 Other than as noted in 17.3 – 17.6, the spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part shall not be less than the values specified in Tables 17.1 and 17.2.

17.3 The through air and over surface spacings at an individual component part are to be judged on the basis of the total volt-ampere consumption of the load or loads that the component controls. For example, a component that controls only a motor is judged on the basis of the volt-amperes of the motor. A component that controls loads in addition to a motor is to be judged on the basis of the sum of the volt-amperes of the loads so controlled; except that a component that independently controls separate loads is to be judged on the basis of the volt-amperes of the larger load. The volt-ampere values for the load referred to above are to be determined by the marked rating of the load; except that for loads that are not required to have a marked rating, the measured input is to be used in determining the volt-ampere values.

17.4 With reference to 17.2 and 17.3, the spacings to the enclosure are not to be applied to an individual enclosure of a component part within a cabinet.

17.5 All uninsulated live parts connected to different circuits shall be spaced from one another as though they were parts of opposite polarity and shall be judged on the basis of the highest voltage involved.

17.6 The spacing requirements in Table 17.1 do not apply to the inherent spacings of a component part of an appliance such as a snap switch, controller, attachment plug, and the like for which spacings are judged on the basis of the requirements for the component. The electrical clearance resulting from the assembly of a component into the complete appliance, including clearance to dead metal or the cabinet, shall be as specified in this section.

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Table 17.1
Spacings at other than field-wiring terminals

Coin, currency, or credit mechanism	Potential involved, volts	Minimum spacings, inch (mm)[a]		
		Between any uninsulated live part and an uninsulated live part of opposite polarity, uninsulated grounding part other than the cabinet, or exposed metal part		Between any uninsulated live part and the walls of a metal cabinet including fittings for conduit or armored cable[b,c]
		Through air or oil	Over surface	Shortest distance
Self contained	0 – 300	1/16	1/16	1/4
	301 – 600	1/4	1/4	1/4
Installed on or within another appliance:				
1. Refrigerated vending machine:				
a. Within a refrigerated or air-handling compartment				
Rating of machine:				
0 – 2000 volt-amperes	0 – 300	1/8	1/4	1/4
More than 2000 volt-amperes	0 – 150	1/8	1/4	1/2
	151 – 300	1/4	3/8	1/2
	301 – 600	3/8	1/2	1/2
b. Within a nonrefrigerated or a nonair-handling compartment				
Rating of machine:				
0 – 2000 volt-amperes	0 – 125	1/16	1/16	1/4
	126 – 250	3/32	3/32	1/4
2. Nonrefrigerated vending machine, amusement machine, or office appliance	0 – 50	3/64	3/64	3/64
	51 – 125	1/16	1/16	1/16
	126 – 250	3/32	3/32	3/32
	251 – 600	3/8	1/2	1/2
3. Coin-operated phonograph	0 – 300	1/8[d]	1/8[d]	1/8[d]
4. Coin-operated and commercial clotheswasher and electric clothes dryer	0 – 125	1/16	1/16	1/16
	126 – 250	3/32	3/32	3/32
5. Dispensing device	0 – 50	3/64	3/64	–
	51 – 125	1/16	1/16	–
	126 – 250	3/32	3/32	–

[a] SI equivalents of the values in this table are 3/64 inch (1.2 mm), 1/16 inch (1.6 mm), 3/32 inch (2.4 mm), 1/8 inch (3.2 mm), 1/4 inch (6.4 mm), 3/8 inch, (9.5 mm), 1/2 inch (12.7 mm).

[b] The spacing to a metal cabinet does not apply to the housing or frame of a device intended for installation within an end-product cabinet.

[c] For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce the spacing between the metal piece and uninsulated live parts.

[d] On the printed wiring board or at other locations where the relative arrangement of parts is such that permanent separation of parts is maintained, the minimum spacing may be less than 1/8 inch, but shall not be less than 1/16 inch.

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Table 17.2
Spacings at wiring terminals

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

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

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18 Low-Voltage Circuits

18.1 A low-voltage circuit is one complying with 2.7(b).

18.2 A circuit derived from a high-voltage circuit, by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low-voltage circuit as described in 18.1.

18.3 There is no specification for insulating material, spacings, and components in a low-voltage circuit, other than as may be required to prevent contact with an uninsulated live part of other circuits – for example, wiring is to be reliably routed – and as indicated in 18.4.

18.4 The spacings for low-voltage electrical components that are installed in a circuit that includes a motor overload protective device, or other protective device, where a short or grounded circuit may result in unsafe operation of the appliance shall comply with the following:

a) The spacing between an uninsulated live part and the wall of a metal enclosure, including fittings for the connection of conduit or metal-clad cable, shall not be less than 1/8 inch (3.2 mm). See 17.4.

b) The spacing between wiring terminals, regardless of polarity, and between the wiring terminal and a dead metal part – including the enclosure and fittings for the connection of conduit – that may be grounded when the device is installed shall not be less than 1/4 inch (6.4 mm).

c) The spacing between uninsulated live parts, regardless of polarity, and between an uninsulated live part and a dead metal part, other than the enclosure, that may be grounded when the appliance is installed shall not be less than 1/32 inch (0.8 mm), provided that the construction of the parts is such that spacings will be maintained.

19 Isolated, Power-Limited Circuits

19.1 An isolated, power-limited circuit is one derived from an isolated secondary winding of a transformer and having characteristics complying with 2.7(c).

19.2 A circuit derived from a line-voltage circuit by connecting resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be an isolated, power-limited circuit.

19.3 The spacing between uninsulated live parts of opposite polarity and between such parts and dead metal that may be grounded in service is not specified for parts of circuits that are isolated, power-limited circuits. The spacing is based on acceptable performance of applicable dielectric voltage-withstand and abnormal operation tests specified in 59.6 and 63.4.3.

19.4 The spacings for isolated, power-limited circuit components that are installed in a circuit that includes a motor overload-protective or other protective device, where a short or grounded circuit may result in unsafe operation of the appliance, shall comply with the spacings specified in Tables 17.1 and 17.2. For voltages in excess of those specified in the table, the spacings shall be in accordance with the largest spacings specified for the application.

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19.5 The requirements for internal wiring and insulating materials in Internal Wiring, Section 14, and Insulating Materials, Section 25, respectively, are applicable to isolated, power-limited circuits.

20 Electronic Circuits

20.1 The requirements in 20.2 and 20.3 do not apply to circuits derived from low-voltage circuits and isolated, power-limited circuits as described in Low-Voltage Circuits, Section 18, and Isolated, Power-Limited Circuits, Section 19.

20.2 Spacings between uninsulated live parts of a circuit containing a component, such as a rectifier, a vacuum tube, a resistor, a capacitor, a transistor, or other solid-state device and grounded dead metal parts, including the enclosure, and other circuits, shall be in accordance with Table 17.1.

20.3 Spacings between live parts of opposite polarity in a circuit containing a component as mentioned in 20.2 are not specified if:

a) The circuit withstands the dielectric voltage-withstand test described in 59.2;

b) No risk of fire or electric shock results from the tests described in the Electronic Circuits Test, Section 73; and

c) The location and relative arrangement of components are such that acceptable separation will be maintained.

21 Alternate Spacings – Clearances and Creepage Distances

21.1 Except as indicated in 21.2, the spacings requirements in UL 840, are applicable as an alternative to the specified spacings requirements in the following sections:

a) Section 17, High-Voltage Circuits;

b) Section 18, Low-Voltage Circuits;

c) Section 19, Isolated, Power-Limited Circuits; and

d) Section 20, Electronic Circuits.

21.2 The spacings requirements in UL 840 shall not be used for spacings between field wiring terminals or between uninsulated live parts and a metal enclosure.

21.3 The following factors shall be taken into consideration when judging compliance of an appliance with UL 840.

a) Hermetically sealed or encapsulated enclosures are identified as pollution degree 1;

b) Coated printed wiring boards are identified as pollution degree 1 when they comply with one of the following:

1) Printed wiring board coating performance test of UL 840; or

2) Conformal coating requirements as outlined in UL 746E;

c) Indoor use appliances are identified as pollution degree 2;

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d) Outdoor use appliances are identified as pollution degree 3;

e) Category II is the overvoltage category; and

f) Printed wiring boards are considered as having a minimum comparative tracking index (CTI) of 100 unless further investigated for a higher CTI index.

21.4 Clearance B (Controlled Overvoltage) clearances as specified in UL 840 shall be achieved by providing an overvoltage device or system as an integral part of the appliance.

ELECTRICAL COMPONENTS

22 Motors

22.1 A motor shall be investigated and found to be acceptable for the application, and shall be capable of operating at the maximum normal load of the appliance without introducing a risk of fire, electric shock, or injury to persons.

22.2 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:

a) To prevent accessible dead metal parts from becoming energized; and

b) To prevent live parts from becoming accessible.

23 Overcurrent Protection

23.1 General

23.1.1 An overcurrent- or thermal-protective device shall be acceptable for the application.

23.1.2 Fuses used for compliance with 23.1.1 shall comply with UL 248-1, in conjunction with UL 248-4, UL 248-5, UL 248-8, UL 248-9, UL 248-10, UL 248-11, UL 248-12, or UL 248-15, as applicable for the class of fuse.

23.1.3 Circuit breakers used to comply with 23.1.1 shall comply with UL 489. In addition, circuit breakers used in telecommunications circuitry shall comply with UL 489A.

23.1.4 Circuit breakers used to protect circuits having more than one ungrounded conductor and no grounded neutral shall be of the multipole common trip type arranged to open all ungrounded conductors. The use of external handle ties does not in itself constitute a common trip mechanism.

23.1.5 An overcurrent protective device required to comply with 23.1.1 shall be electrically connected in the ungrounded side of the circuit.

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23.1.6 If an appliance includes a motor that requires separate protection, and if the overcurrent protection of a branch circuit to which the appliance can properly be connected does not provide acceptable protection for the motor, such protection shall be included in the appliance.

23.1.7 If an appliance includes circuits that would not be provided with acceptable overcurrent protection by a branch circuit to which the appliance can properly be connected, the circuits shall have overcurrent protection rated not more than 20 amperes provided as part of the appliance.

23.1.8 The functioning of an overcurrent-protective device provided as part of an appliance – whether such a device is required– shall not result in a risk of fire, electric shock, or injury to persons.

23.1.9 A fusing resistor or supplementary protector shall not be used in place of a circuit breaker or protective control.

23.1.10 Fusing resistors shall comply with UL 1412.

23.1.11 Supplementary protectors shall comply with UL 1077.

23.1.12 A supplementary fuse shall comply with UL 248-1, in conjunction with UL 248-14.

23.2 Motors

23.2.1 Each motor shall be protected from overheating due to any condition of load up to and including stalled rotor.

Exception No. 1: A motor that is protected against locked-rotor conditions used for air-handling only, such as a direct-drive blower motor or a ventilating fan.

Exception No. 2: A shaded-pole motor having a difference of 1 ampere or less between no-load and locked-rotor currents and having a 2-to-1 or smaller ratio between locked-rotor and no-load currents if it is protected against locked rotor only.

Exception No. 3: A motor in a cord-connected, manually controlled, attended appliance; and those used in circuits as described in 18.1.

23.2.2 The motor protection required by 23.2.1 shall be accomplished by one of the following:

a) Protective electronic circuit(s) in accordance with 23.2.3 and 23.2.4 or complying with UL 1004-7;

b) Impedance protection complying with UL 1004-2;

c) Thermal protection complying with UL 1004-3; or

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

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23.2.3 A protective electronic circuit providing motor protection in accordance with 23.2.2(a) shall comply with one of the following:

a) *Deleted.*

b) UL 60730-1 and the specific applicable UL 60730 Part 2 Standard.

c) Paragraph 26.31 and the Protective Electronic Circuits Tests, Section 75; or

d) Not create any risk of fire, electric shock or injury to persons under abnormal conditions with the protective electronic circuit rendered ineffective (open or short-circuited), e.g. use of a redundant circuit or control.

23.2.4 Software in a protective electronic circuit required as part of a motor protective device or system shall comply with one of the following:

a) *Deleted;*

b) UL 60730-1, as well as the specific applicable Part 2 and be software Class B;

c) Software Evaluation, Annex R in UL 60335-1 and be software Class B; or

d) Not create any risk of fire, electric shock or injury to persons under abnormal conditions with the software rendered ineffective, e.g. use of independent redundant protective devices.

23.2.5 With reference to 23.2.3 and 23.2.4, the factors outlined in Table 23.1 shall be considered when evaluating a protective electronic circuit.

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Table 23.1
Factors to be considered when evaluating protective electronic circuits

No.	Factor
1	Conducting failure-mode and effect analysis (FMEA) for the protective circuits and functions.
2	Electrical supervision of critical components resulting in the control becoming permanently inoperative and disconnecting power.
3	Temperature ranges as follows: Indoor Equipment: 32.0 ±3.6°F (0.0 ±2°C) and 104 ±3.6°F (40.0 ±2°C) Protected Locations and Outdoor Equipment: -31.0 ±3.6°F (-35.0 ±2°C) and 104 ±3.6°F (40.0 ±2°C)
4	Cycling test duration: 14 days
5	Endurance test duration: 100,000 cycles
6	Radio-frequency electromagnetic field immunity: a) To conducted disturbances – test level 3 b) To radiated electromagnetic fields – Evaluate in accordance with 75.3.4 and 75.3.2.
7	Humidity exposure: Indoor Equipment: 70 – 80°F (21.1 – 26.7°C) and minimum 50 percent relative humidity Protected Locations and Outdoor Equipment: 70 – 80°F (21.1 – 26.7°C) and minimum 98 percent relative humidity
8	Electrical fast transient/burst immunity: Protected Locations and Outdoor Equipment: test level 4 Indoor Equipment: test level 3
9	Surge immunity: Protected Locations and Outdoor Equipment: installation Class 4

Table 23.1 Continued on Next Page

Table 23.1 Continued

No.	Factor
	Indoor Equipment: installation Class 3
10	Electrostatic Discharge with a Severity Level of 3 having: a) Contact discharge at 6 kV to accessible metal parts; and b) Air discharge at 8 kV to accessible parts of insulating material
11	Voltage Dips and Interruptions: Evaluate in accordance with 75.3.8 and 75.3.2.
12	Harmonics and Interharmonics: Evaluate in accordance with 75.3.9 and 75.3.2.
13	Calibration (deviation and drift): Evaluate in accordance with 26.19 for a temperature protective control or 26.20 for a pressure protective control.

24 Live Parts

24.1 A current-carrying part shall be of silver, copper, copper alloy, stainless steel or other metal investigated and found to be acceptable for the application.

24.2 In reference to 24.1, ordinary iron or steel shall not be used for a current-carrying part unless it is provided with a corrosion-resistant coating or located within a motor or associated governor.

24.3 Uninsulated live parts and components that have uninsulated live parts shall be secured to the base or mounting surface so that they will be prevented from turning or shifting in position if such displacement could result in a reduction of spacings below the minimum values specified in High-Voltage Circuits, Section 17. See 9.3.

24.4 Friction between surfaces is not acceptable as a means to prevent shifting or turning of live parts, but a properly applied lock washer is acceptable.

24.5 A lampholder, fuseholder and a circuit breaker shall be installed or protected so that adjacent uninsulated high-voltage live parts, other than the screw shell of a lampholder or plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder will not be exposed to contact by persons servicing the lamp, fuse or circuit breaker. A separation of less than 4 inches (102 mm) from the insulating body of a fuse is considered to be adjacent. Also, a fuse that is incapable of being positively gripped or held by any part of the fuseholder while current-carrying parts are exposed at any time during replacement is acceptable.

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25 Insulating Materials

25.1 Uninsulated live parts shall be mounted on porcelain, phenolic composition, or other material that has been investigated and found to be acceptable for the application.

25.2 Electrical insulation grade vulcanized fiber may be used for an insulating bushing, a washer, a separator, or a barrier, but not as the sole support for an uninsulated live part if shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

25.3 Thermoplastic materials may be employed for the sole support of uninsulated live parts, if found to have adequate mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric strength, and other properties acceptable for the application in accordance with UL 746A and UL 746C. These properties are also to be considered with respect to thermal aging of the material in accordance with UL 746B.

25.4 A molded part shall have the mechanical strength and rigidity necessary to withstand the stresses of actual service.

25.5 Electrical insulation that does not comply with 25.1 – 25.4 shall comply with one of the following:

a) Film-coated wire or materials used in an insulation system that operates at or above Class 105 (Class A) shall comply with UL 1446. The requirements for film-coated wire or materials used in insulation systems that operate below Class 105 (Class A) are unspecified.

b) Insulating tape shall comply with UL 510.

c) Insulating sleeving shall comply with UL 1441.

d) Insulating tubing shall comply with UL 224.

26 Switches and Controllers

26.1 Except as indicated in 26.2, a motor controller shall be provided for all motors.

26.2 If an appliance is not provided with a motor controller as required by 26.1, it shall be either:

a) A permanently connected appliance employing a motor rated 1/8 horsepower (93 W output) or less that is normally left running and is constructed so that it cannot be damaged by overload or inability to start, such as a clock motor and the like; or

b) A cord-connected appliance employing a motor rated 1/3 horsepower (249 W output) or less.

26.3 A switch that is employed as the on-off device for the appliance shall open all ungrounded supply-circuit conductors directly or indirectly. The equipment-grounding conductor shall not be interrupted. The on-off positions of the switch shall be clearly marked.

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26.4 A single-pole switching device, including an automatic control having a marked ″off″ position, shall not be connected to the identified (grounded) conductor.

26.5 If a switch or circuit breaker is mounted such that movement of the operating handle, either vertically or rotationally, between the on and off positions results in one position being above the other position, then the upper position shall be the on position. The requirement does not apply to a switch or circuit breaker that is operated horizontally or that is operated rotationally and the on and off positions are at the same level, nor to a switching device having two on positions such as a transfer switch or a double throw switch.

26.6 A switch or other control device shall have a rating not less than that of the load that it controls. Items to consider in determining the device rating include the voltage, current, power factor, control device ambient temperature and other similar parameters. Power factor requirements for each specific load type are specified in 74.5(a) – (d).

26.7 A switch that may break a motor load under locked-rotor conditions shall have a current interrupting capacity not less than the locked-rotor or maximum operating current of the motor.

26.8 If a switch controls more than one motor or a motor plus another load, it shall have a current interrupting capacity not less than the locked-rotor load or maximum operating current of the largest motor plus the full load or maximum operating current of the other motor or other load.

26.9 A switch or other similar device used to control an inductive load (other than a motor), such as a transformer or an electric-discharge-lamp ballast, shall:

a) Be rated for not less than twice the full-load current of the transformer or ballast; or

b) Have an inductive rating at least equal to the load it controls.

26.10 A switch that controls a medium-base lampholder of other than a pilot or indicating light shall:

a) Have a T or L rating equal to the tungsten-filament lamp load;

b) Be a general-use alternating-current snap switch, a circuit breaker, or a nonautomatic circuit interrupter suitable for controlling tungsten-filament lamps at their full ampacity;

c) Have an alternating-current ampacity of six times or more of the tungsten-filament lamp load; or

d) Have an electrical rating equivalent to (a), (b) or (c).

26.11 As an alternative to compliance with 26.6, 26.7, 26.8, 26.9 or 26.10, a switch or other similar controlling device shall comply with the Overload and Endurance Test – Switching Devices, Section 74.

26.12 If malfunction of a protective (limiting) control results in a risk of fire due to overheating of a coin and currency changer and actuator, a backup protective control shall be provided to limit temperature.

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26.13 A protective control shall:

a) Be an integral part of the appliance; and

b) Control the load(s) directly except as indicated in 26.18.

26.14 Except as specified in 26.17, a protective control shall comply with one of the following:

a) *Deleted*

b) UL 60730-1 and UL 60730-2-6. The endurance cycle requirements in Table AA.1DV of UL 60730-2-6 for cut-outs shall be applied.

c) UL 60730-1 and UL 60730-2-9. The endurance cycle requirements in Table CC.2 of UL 60730-2-9 for cut-outs shall be applied.

d) *Deleted*

e) UL 508;

f) *Deleted*

g) UL 61058-1, or

h) Paragraph 26.31 and the Protective Electronic Circuits Tests, Section 75.

26.15 In reference to 26.14 (e) – (h), the endurance cycle requirements in UL 60730-2-9, Table CC.2, for cut-outs shall be applied to such controls.

26.16 In reference to 26.14 (b), (c), (g) and (h), when determining the acceptability of a protective control, the control pollution degree shall be as specified in 21.3 (a) – (d). If the protective control:

a) Has a protective electronic circuit, the items in Table 23.1 shall be considered; and

b) Uses software as a required part of the protective electronic circuit, the software shall comply with 23.2.4(b).or (c).

26.17 In reference to 26.14, a device providing motor overload protection shall comply with the requirements in Motors, Section 23.2.

26.18 If a protective control indirectly controls the load through a switching device, the switching device shall comply with the endurance cycle requirements for protective controls in 26.14 and 26.15 and be an integral part of the appliance.

26.19 The cutout calibration temperature of a heater protective (temperature-limiting) control shall be ±10°F (±6°C) of its maximum marked set-point temperature.

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26.20 The cutout calibration pressure of a pressure protective (limiting) control shall not exceed 105 percent of its maximum marked setting.

26.21 Except as specified in 26.26, an operating control, including of the electronic type, shall comply with:

a) One of the standards specified in 26.14;

b) The requirements in this Standard as far as they reasonably apply; or

c) UL 244A, UL 508C, or UL 917.

26.22 If a thermal cutoff or similar device is employed to prevent a risk of fire due to overheating of an appliance during abnormal operation as specified in 26.12, it shall comply with UL 60691.

26.23 A general-use snap switch shall comply with UL 20.

26.24 Female devices (such as receptacles, appliance couplers, and connectors) that are intended, or that may be used, to interrupt current, shall be suitably rated for current interruption of the specific type of load, when evaluated with its mating plug or connector.

26.25 If an operating control complying with 26.21 indirectly controls the load through a switching device, the endurance cycle requirements in 26.27(e) shall be applied to the switching device.

26.26 An operating control not complying with 26.21 shall:

a) Shall be powered entirely by no more than one low-voltage circuit;

b) Comply with UL 508; or

c) Comply with the low-power test requirement determined as specified in 19.11.1, of UL 60335-1.

26.27 An operating control that complies with 26.21 shall also comply with the following:

a) For electronic controls – Installation Class 2 for electromagnetic compatibility (EMC) shall be in accordance with the voltage surge testing in 75.3.6 and comply with the results specified in 75.3.2;

b) Category II shall be the overvoltage category;

c) Insulating materials shall have a minimum comparative tracking index (CTI) of 100 (Material Group III);

d) The applicable pollution degree shall be as specified in 21.3 (a) – (d); and

e) The endurance cycle requirements specified by either:

1) Table CC.2 of UL 60730-2-9, with the operating control (limiters) endurance cycle requirements being applied; or

2) The Overload and Endurance Test – Switching Devices, Section 74.

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26.28 Appendix A, Operating and Protective (″Safety Critical″) Control Functions, shall be referenced to determine whether a control function is considered to result in a risk of electrical shock, fire or injury to persons.

26.29 If a control can be used to reduce the risk of fire, electric shock or injury to persons under abnormal operating conditions of the appliance, but a redundant control (of similar or different design) operates to perform the identical function, the circuit shall be evaluated to determine which control will be relied upon as the protective control. The control determined to be the protective control shall comply with the protective control requirements in 26.14. The control determined to be the operating control is not required to comply with the protective control requirements but shall comply with the operating control requirements in 26.26 or with 26.21 and 26.27.

26.30 A thermistor shall comply with the Requirements for Controls Using Thermistors, Annex J in UL 60730-1 or UL 1434. The calibration shall be as specified in 26.19. If a thermistor is used:

a) To reduce the risk of fire, electric shock or injury to persons under abnormal operating conditions of the appliance, the minimum number of endurance cycles shall be 100,000.

b) In other sensing applications of the appliance, the minimum number of endurance cycles shall be 6,000.

26.31 A protective control as referenced in 23.2.3(c) or 26.14(h) and having a protective electronic circuit:

a) In which electronic disconnection of the circuit could fail, shall have at least two components whose combined operation provides the load disconnection;

b) Shall prevent a risk of fire, electric shock or injury to persons under the relevant fault conditions specified in Fault Conditions Abnormal Tests, Section 75.2;

c) In which an overcurrent protective device opens during application of any of the fault conditions specified in Fault Conditions Abnormal Tests, Section 75.2, shall utilize an overcurrent protective device complying with the requirements applicable to that component. The fault condition causing the overcurrent protective device to open shall be repeated and the overcurrent protective device shall again open the protective electronic circuit. If the overcurrent protective device complies with IEC 60127-1, as well as an applicable Part 2, then the protective device shall additionally comply with the Fuse-Link Test, Section 75.5;

d) In which a conductor of the printed wiring board becomes open-circuited during the fault conditions test in Fault Conditions Abnormal Tests, Section 75.2, then:

1) The printed wiring board shall comply with the Needle-Flame Test, Annex E of UL 60335-1 or have a minimum flammability rating of V-0 when tested in accordance with the vertical flame test described in UL 94;

2) Any loosened conductor shall not reduce spacings below the values specified in the relevant Sections 17 – 21; and

3) The specific test in which the printed wiring became open-circuited shall be repeated a second time. There shall be no risk of fire, electric shock or injury to persons and spacings shall not be reduced below the values specified in the relevant Sections 17 – 21;

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e) Shall maintain its required functions when subjected to the EMC related stresses specified in the Electromagnetic Compatibility (EMC) Tests, Section 75.3; and,

f) That relies upon a programmable component for one or more of its safety functions shall be subjected to the Programmable Component Reduced Supply Voltage Test, Section 75.4, unless restarting at any point in the operating cycle after interruption of operation due to a supply voltage dip will not result in a risk of fire, electric shock or injury to persons. The test shall be

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carried out after removal of all batteries and other components intended to maintain the programmable component supply voltage during supply source (mains) voltage dips, interruptions and variations.

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27 Remotely Operated Appliances

27.1 Any appliance function enabled in response to external communication or data signals shall be considered when determining normal and abnormal conditions of the appliance.

27.2 Except as specified in 27.3, a manual control shall be provided on an appliance such that actuation of the control is required before the appliance can be operated in any mode that permits remote operation, external communication or receiving/sending data signals.

27.3 In reference to 27.2, an appliance not provided with a manual control for actuating remote operation, external communication or receiving/sending data signals shall be:

a) Capable of remote operation, external communication or receiving/sending data signals only within line-of-sight; or

b) Limited only to monitoring external communication or data signals.

27.4 An appliance shall include a means to manually disconnect, disable or override any remote operation commands, external communication or data signals. If the appliance attachment plug and receptacle serve as the manual means to disconnect data signals or remote operation commands, the appliance shall comply with 26.2(b) and 79.11.

27.5 A control that operates in response to remote operation commands, external communication or data signals shall not introduce an operating condition or state that could lead to a risk of fire, electric shock or injury to persons. In addition, such a control shall not:

a) Render inoperative any protective control or protective control function within the appliance;

b) Alter the order of control response such as by forcing a protective control to operate instead of another control that would normally be intended to respond;

c) Reset any protective manual reset feature;

d) Supersede the response of any protective control; or

e) Alter the response to or expected performance of:

1) User actuation of controls, movement of doors, covers, grills, filters or the like; or

2) User interaction with any parts of the appliance that could result in exposure of hazardous electrical parts, moving parts, hot parts or radiation.

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27.6 Compliance with 27.5 shall be determined by one of the following:

a) Using methods appropriate for determining the performance and reliability of protective control functions in accordance with Switches and Controllers, Section 26; or

b) Examining the appliance circuit diagram(s) to determine that a control which operates in response to remote operation commands, external communication or data signals operates wholly independent of the appliance protective controls and therefore is incapable of adversely affecting the operation of any protective controls.

28 Coil Windings

28.1 Coil windings of a motor, a relay, a transformer, a solenoid, or the like shall be impregnated, dipped, varnished, or equivalently treated to resist absorption of moisture.

28.2 Film-coated or equivalently coated wire is not required to be given additional treatment to reduce the risk of moisture absorption.

29 Transformers

29.1 A transformer shall withstand the abuses to which it will likely be subjected to in normal service. The coils shall be wound in a workmanlike manner and impregnated or otherwise enclosed to exclude moisture.

29.2 A transformer (including an autotransformer), shall comply with UL 5085-1 in conjunction with UL 5085-2 or UL 5085-3 as applicable.

29.3 A transformer intended to be connected across a supply circuit shall be housed within its own enclosure or within the appliance cabinet.

29.4 The primary and secondary windings of a transformer designed to furnish power to a low-voltage circuit described in 18.1 or an isolated-limited-energy circuit described in 19.1 shall be insulated from each other with no interconnection between windings.

30 Capacitors

30.1 A capacitor shall comply with 30.2 or with one of the following:

a) UL 810, if the capacitor is provided as a part of a capacitor-run motor; or

b) If the capacitor is connected across the line, such as a capacitor for radio-interference elimination or power-factor correction, it shall comply with UL 60384-14.

30.2 If a capacitor does not comply with 30.1, it shall comply with all of the following:

a) A capacitor shall be housed within an enclosure or container that protects the plates against mechanical damage and that prevents the emission of flame or molten material resulting from deterioration or breakdown of the capacitor. The container shall comply with 30.3 or be of metal providing strength and protection not less than that of uncoated sheet steel having a minimum thickness of 0.020 inch (0.51 mm);

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b) The materials and construction of a capacitor or its enclosure within an appliance, including a means for venting, shall be such that no excessive pressure can develop in the capacitor because of a short circuit in the capacitor or the circuit in which it is connected; and

c) Under both normal and abnormal conditions of use, the capacitor shall not vent or rupture and expel the dielectric medium.

30.3 In reference to 30.2(a), if a capacitor sheet-steel container is less than 0.020 inch thick or is a material other than metal:

a) The material shall be equivalent to that specified and shall be provided with additional supporting material that is otherwise acceptable for live parts; or

b) The capacitor shall be mounted within an enclosure.

30.4 In reference to 30.1(b), if a capacitor complies with UL 60384-14, it shall have specifications as follows:

a) Operating voltage – Not less than 110 percent of the appliance rated voltage.

b) For capacitors connected across the line (phase-to-phase) – Subclass X1 (≤ 4.0 kV) or X2 (≤ 2.5 kV) for impulse voltage (based on minimum Overvoltage Category of II).

c) For capacitors connected from line to ground – Subclass Y1 or Y2 for any appliances having a rated voltage not exceeding 500 volts; or as an alternate, subclass Y4 if an appliance has a rated voltage not exceeding 150 volts.

d) Upper category temperature – Based on the maximum capacitor surface temperature measured during the Normal Temperature Test, Section 56, but not less than 185°F (85°C).

e) Lower category temperature – Based on the minimum surface temperature for which the capacitor has been designed to operate when installed within an appliance as intended, but not greater than 14°F (-10°C).

f) Duration of the damp-heat steady-state test – Not less than 21 days.

g) Passive flammability category B or C. As an alternate, a polymeric capacitor case shall have a V-0 flame rating as described in UL 94.

30.5 The voltage rating of a capacitor other than a motor-starting or motor-running capacitor shall equal or exceed the maximum steady-state potential to which the capacitor is subjected during operation or user servicing of the appliance at rated voltage.

30.5.1 In reference to 30.1(b), a capacitor shall consist of a single Class Y1 capacitor or two Class Y2 capacitors connected in series if it is connected between:

a) Two line conductors in a primary circuit;

b) One line conductor and the neutral conductor;

c) Primary and accessible secondary circuits; or

d) The primary circuit and protective earth (equipment grounding conductor connection).

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30.6 Except as indicated in 30.7 a means, such as a bleeder resistor, shall be provided to drain the charge stored in a capacitor to the extent that the potential, measured between the terminals of the capacitor 1 minute after the capacitor has been disconnected from its source of energy, is less than 50 volts and the energy stored, is less than 20 joules as determined by the following equation:

$$J = 5 \times 10^{-7} CV^2$$

in which:

J is the stored energy in Joules;

C is the capacitance in Microfarads; and

V is the potential in Volts.

30.7 A capacitor is not required to comply with 30.6 if a tool is required to remove a panel to reach the capacitor and the appliance is marked as indicated in 80.9.

31 Printed Wiring

31.1 A printed-circuit board shall comply with the requirements in UL 796, and shall be classed V-0, V-1, or V-2 in accordance with the requirements in UL 94. The use of a material classed V-2 requires the use of a closed bottom in the appliance beneath the material or an acceptable barrier.

Exception: A printed-wiring board that contains only Class 2 circuits provided deterioration or breakage of the bond between the conductor and the base material would not result in a risk of fire or electric shock.

31.2 A resistor, a capacitor, an inductor, or other part that is mounted on a printed-circuit board to form a printed-circuit assembly shall be secured so that it cannot be displaced by a force likely to be exerted on it during assembly, normal operation, or servicing of the appliance so as to cause a risk of fire or electric shock.

31.3 A barrier or a partition that provides mechanical protection and electrical insulation of a component connected to the printed-circuit board shall comply with Barriers, Section 6.

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32 Receptacles

32.1 A receptacle that involves energy capable of causing electric shock and is provided for the attachment of an accessory shall be designed so that no bare live parts are accessible.

32.2 A conventional parallel-slot receptacle shall involve line power only.

32.3 A receptacle intended to accommodate a single-prong, shielded plug for a single application shall not involve energy capable of causing electric shock.

32.4 A receptacle shall comply with UL 498, and be of the grounding type. The grounding contact of the receptacle shall be electrically bonded to the grounding means of the appliance.

32.5 Unless intended to be connected to a power supply separate from that supplying other loads, a receptacle shall be rated at 15 or 20 amp, 125 or 250 V.

32.6 For a line-powered, cord-connected appliance, a receptacle involving line power shall conform to the configuration applicable to the attachment plug on the supply cord.

Exception: A receptacle intended for an accessory that cannot be employed separately may be of a different configuration. See 13.16.

32.7 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 (3.8 mm) beyond a conductive surrounding surface.

32.8 Receptacles shall be mounted with the receptacle face not less than 60 degrees from the horizontal and located so that liquid due to overflow, splashing, leakage, and cleaning will not enter.

32.9 Overcurrent protection shall be provided as part of the appliance for each receptacle. The overcurrent protection shall be provided in accordance with Overcurrant Protection – General, Section 23.1.

32.10 A receptacle shall be wired so that the white or silver terminal is connected to the identified (grounded) conductor.

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33 Field Installation

33.1 An open-type control and coin or currency mechanism shall be:

a) Installed within the appliance at the factory;

Exception: If an accessory mechanism is intended for installation in the field, the accessory and the appliance shall comply with the requirements in 33.2 – 33.7, 79.14, 79.15; and 79.16.

b) Acceptable for the temperatures involved; and

c) Capable of controlling the connected load or loads.

33.1.1 A product shall comply with all the requirements of this standard with or without an accessory installed.

33.2 The installation of an accessory shall be restricted to an arrangement that can be accomplished by receptacles and plug-in connectors. Unless bonding for grounding is accomplished automatically by normal mounting of the accessory in the appliance, a separate bonding conductor shall be provided in the receptacle and plug-in connector.

33.3 Any installation that requires the cutting of wiring, or the soldering of connections by the installer, is not acceptable. Installations that require cutting, drilling, or welding, where such operations may damage electrical components and wiring within the enclosure, are not acceptable.

33.4 A strain-relief means shall be provided for the wiring in the accessory if there is a possibility of transmitting stress to the terminal connections during installation.

33.5 If the connections are made by terminals or leads, they shall be identified on the accessory and the wiring diagram.

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

33.7 The accessibility of live parts shall comply with the requirements in the Accessibility of Uninsulated Live Parts, Film-Coated Wire, And Moving Parts, Section 11.

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34 Batteries and Battery Chargers

34.1 A lithium ion (Li-On) single cell battery shall comply with the requirements for secondary lithium cells in UL 1642. A lithium ion muiltiple cell battery, and a lithium ion battery pack, shall comply with the applicable requirements for secondary lithium cells or battery packs in UL 2054.

34.2 Rechargeable nickel cadmium (Ni-Cad) and nickel metal-hydride (Ni-MH) battery cells and packs shall comply with the requirements in this Standard and with the applicable requirements for secondary cells or battery packs in UL 2054.

34.3 A battery charger shall comply with 43.1.

35 Connectors

35.1 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 UL 1977.

36 Electrical Cable, Conduit and Tubing

36.1 Aluminum or steel armored cable shall comply with UL 4. Nonmetallic sheathed cables shall comply with UL 719.

36.2 Flexible metal conduit shall comply with UL 1. Rigid steel conduit shall comply with UL 6.

36.3 Electrical steel tubing shall comply with UL 797.

37 Electromagnetic Interference Filters

37.1 Electromagnetic interference filters shall comply with UL 1283 or UL 60939-3.

38 Fuseholders

38.1 Fuseholders shall comply with UL 4248-1, in conjunction with UL 4248-4, UL 4248-5, UL 4248-8, UL 4248-9, UL 4248-11, UL 4248-12, or UL 4248-15, as applicable for the class of fuseholder.

38.2 A plug fuseholder used in a high-voltage circuit shall be wired in the unidentified (ungrounded) conductor with the screw shell connected toward the load.

38.3 An extractor fuseholder used in a high-voltage circuit shall be wired in the unidentified (ungrounded) conductor with the accessible contact connected toward the load.

38.4 In reference to 38.1, a fuseholder provided for the protection specified in 23.1.7 shall be Type S or shall be Edison-base with a factory-installed, nonremovable Type S adapter or other noninterchangeable type.

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39 Heating Elements

39.1 A heating element shall:

a) Comply with the construction requirements of either UL 499 or UL 1030; and

b) Be protected against mechanical damage and contact with outside objects.

39.2 A heating element shall be supported to prevent sagging, loosening or any other adverse conditions of the element that results from continuous heating.

40 Lighting Systems

40.1 General

40.1.1 Lampholders and indicating lamps shall comply with UL 496.

40.1.2 Light Emitting Diode (LED) light sources shall comply with UL 8750.

40.1.3 If an appliance is intended to be connected to the identified (grounded) conductor of a power supply circuit, a lampholder with a screw shell base shall be wired so that the screw shell will be connected to the identified conductor.

40.2 Electric-Discharge Lighting Systems

40.2.1 Lighting ballasts shall comply with UL 935 or UL 1029.

40.2.2 Fluorescent lamp starters shall comply with UL 542.

40.2.3 Equipment for use with electric-discharge lighting systems in appliances shall be constructed for an open-circuit potential of not more than 1000 volts.

40.2.4 An appliance employing electric-discharge lamps shall be provided with a ballast intended for the operation of lamps of the size for which the cabinet is constructed and shall be wired in accordance with the diagram or instructions on the ballast.

40.2.5 An appliance provided with an instant-start ballast which involves a potential of more than 300 volts but not more than 600 volts shall be provided with lampholders of the circuit-interrupting type at the low-voltage end of the lamps; except that nonshort-circuiting type lampholders may be used if the appliance is plainly marked (visible during relamping) in letters at least 1/8 inch (3.2 mm) in height to indicate that it is for use with instant-start lamps.

Exception: Nonshort-circuiting type lampholders may be used if the appliance is plainly marked (visible during relamping) in letters at least 1/8 inch (3.2 mm) in height to indicate that it is for use with instant-start lamps.

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40.2.6 An electric-discharge lighting system shall have no live parts normally exposed that may be contacted by persons.

40.2.7 An electric-discharge lighting system which involves a potential of more than 300 volts shall be such that no uninsulated live parts will be accessible when the lamps are in place or removed, or while they are being inserted or removed.

40.2.8 The terminals of a lamp are considered to be live parts when any terminal of that lamp is in contact with an uninsulated live part involving a potential of more than 300 volts.

40.2.9 Except where electric lampholders having recessed inaccessible contacts intended for use with lamps having recessed inaccessible contacts are employed, compliance with 40.2.7 will require:

a) The use of lampholders so constructed and wired that when a lamp is removed, the potential in that lamp circuit is less than 300 volts; or

b) That the primary circuit be open during the relamping operation and all live parts be inaccessible when the lamps are removed and the primary circuit is reestablished.

40.2.10 Lampholders and ballasts installed in moist areas of an appliance shall be constructed of moisture resistant materials or treated to resist absorption of moisture.

40.2.11 Except as indicated in 40.2.12, ballasts shall be provided with a housing of nonflammable, moisture-resistant material.

40.2.12 In reference to 40.2.11, a ballast not provided with a housing shall be a reactor-type ballast of the open-core-and-coil type and be either completely enclosed or be provided within a compartment that complies with 40.2.13.

40.2.13 A vent opening in an open-core-and-coil reactor type ballast compartment in the form of a slot or louver shall be not more than 3/8 inch (9.5 mm) wide or more than 1-1/2 inch^2(9.68 cm^2) in area, and any other ventilating openings shall be not more than 1/2 inch^2(12.7 mm^2). Ventilating openings shall not be located in the top or bottom of a ballast compartment mounted on a vertical surface and shall be located not less than:

a) 5 inches (127 mm) from surfaces of flammable material; or

b) 1/2 inch (12.7 mm) from surfaces of flammable material if the openings are perpendicular to or face completely away from the flammable material.

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41 Optical Isolators and Semiconductor Devices

41.1 An optical isolator shall comply with UL 1577, if it is relied upon to provide isolation between:

a) Primary and secondary circuits;

b) Extra-low-voltage safety circuits; or

c) Other high-voltage circuits.

41.1.1 In addition to complying with 41.1, an optical isolator relied upon to provide feedback between primary and secondary circuits of a switch mode power supply unit shall have a minimum isolation voltage of 1500 V.

41.2 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with UL 1557. If the switching semiconductor is used as part of a switch mode power supply unit, it shall have a minimum isolation voltage of 1500V.

42 Outlet Boxes, Fittings and Cover Plates

42.1 An outlet box shall comply with UL 514A, for metallic outlet boxes or UL 514C, for nonmetallic outlet boxes, flush device boxes, and covers. A fitting shall comply with UL 514B. A cover plate shall comply with UL 514D.

43 Power Supplies

43.1 A power supply shall comply with one of the following:

a) For a Class 2 Power Supply, UL 1310 or UL 60950-1;

b) For a power supply that is other than Class 2, UL 1012 or UL 60950-1; or

c) For a switch mode power supply unit not complying with (a) or (b), the relevant requirements in this Standard, including the Switch Mode Power Supply Units – Overload Test, Section 63A, shall be applied.

43.2 *Deleted*

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44 Terminal Blocks

44.1 Terminal blocks shall comply with UL 1059, and, if applicable, be suitably rated for field wiring.

44.2 In reference to 44.1, if a fabricated part performs the function of a terminal block, the part shall comply with Terminals, Section 12.3, Live-Parts, Section 24, and Insulating Materials, Section 25, and the spacings requirements as applicable to the type of circuit as specified below:

a) High-Voltage Circuits, Section 17; or

b) Low-Voltage Circuits, Section 18.

44.3 If a fabricated terminal block complies with the alternate spacings requirements in Alternate Spacings – Clearances and Creepage Distances, Section 21, but not with the spacings requirements in High-Voltage Circuits, Section 17, the terminal block shall not be used for field wiring.

45 Wireways, Auxiliary Gutters and Associated Fittings

45.1 Wireways, auxiliary gutters and associated fittings shall comply with UL 870.

46 Information Technology Equipment

46.1 Information technology equipment such as a printer, visual display unit, router, communication connectors/data ports or computer shall comply with UL 60950-1.

PROTECTION AGAINST RISK OF INJURY TO PERSONS

47 Scope

47.1 The performance and construction requirements in Sections 47 – 54 are applicable to appliances covered by this standard that may involve a risk of injury to persons in normal operation.

47.2 There are risks of injury to persons inherent in some appliances that, if completely eliminated, would defeat the utility of the appliance. The requirements in Sections 46 – 52 are intended to minimize such risks, while retaining the normal function of such an appliance.

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48 General

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

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

48.3 Among the factors to be considered in judging the acceptability of an exposed moving part are degree of exposure necessary to perform its intended function, sharpness of the moving part, likelihood of unintentional contact therewith, speed of the moving part, and likelihood that a part of the body would be endangered or that clothing would be entangled by the moving part. These factors are to be considered with respect to both intended operation of the appliance and its reasonably foreseeable misuse.

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

49 Sharp Edges

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

49.2 If referee measurements are necessary to determine that a part as mentioned in 49.1 is not sufficiently sharp to constitute a risk of injury to persons, the method described in UL 1439, is to be employed.

50 Surface Temperatures

50.1 During the normal temperature test, the temperature of a surface that may be contacted by the user shall not be more than the value specified in Table 50.1. The results of a test that is conducted at a room temperature of other than 25°C (77°F) are to be corrected to 25°C (77°F). The appliance is to be at room temperature at the beginning of the test.

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Table 50.1
Maximum surface temperature

Location or type of surface	Composition of surface[a]			
	Metallic,		Nonmetallic,	
	°C	(°F)	°C	(°F)
A handle, a lever, or a knob likely to be grasped	50	(122)	60	(140)
Accessible surfaces in work areas	60	(140)	85	(185)
Surfaces subject to casual contact	70	(158)	95	(203)

[a] A material, other than metal, that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is judged as a nonmetallic part.

51 Stability Test

51.1 Under all conditions of route person servicing and normal use, a freestanding appliance shall not become physically unstable to the degree that it becomes a risk of injury. Unless the manufacturer's instructions specify that the appliance is to be fastened to the floor or wall, a freestanding appliance shall not overturn when subjected to the tests in 51.2 and 51.3. Conduit connections are not to be relied upon for support during this test.

51.2 An empty appliance with service doors, covers, and panels closed is to be placed on a plane surface inclined at an angle at 10 degrees with the horizontal. Accessories that are intended for use with the appliance are to be installed.

51.3 For this test, the appliance is to be empty, provided with the intended accessories installed, and placed on a level surface in accordance with the manufacturer's instructions. If leveling screws are provided, they are to be adjusted equally to raise the appliance 1 inch (25.4 mm) above floor level. A force of 35 pounds (156 N) is to be applied vertically downward at the edge of the main service door farthest from the hinges, with the door opened at an angle of 90 degrees with the cabinet. If it is necessary to open more than one door to gain access to the currency or coin storage compartment, all such doors are to be opened. Any subassembly that swings out of the cabinet for servicing is to be positioned so that the tendency of the appliance to overturn is maximum. If more than one such subassembly is provided, the one that provides the most unstable condition is to be used during this test.

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51.4 A mounting or support system for an appliance that requires securing to a wall, or other support surface shall be subjected to separate evaluation to determine its reliability, ease of operation, likelihood of continued use, and other conditions pertinent to the system.

52 Switches and Controllers

52.1 If an automatically reset protective device is employed, automatic restarting of the motor shall not result in a risk of injury to persons.

52.2 The requirement in 52.1 may necessitate the use of an interlock in the appliance if moving parts or the like might cause a risk of injury to persons upon the automatic restarting of the motor.

53 Cover or Door

53.1 A cover or a door that may cause injury to persons upon unintentional closing shall be counterweighted, spring-loaded, or provided with an automatic latch to retain it in the open position. The action members of the latches shall be enclosed or guarded.

54 Risk of Injury to Service Person

54.1 An acceptable guard shall be provided over a part that is in motion during servicing and that presents a risk of injury such as pinching, snagging, cutting, and the like to a service person or route person when a cover, a door, a panel, or other closure is opened or removed.

54.2 A guard that must be removed during servicing of a part as mentioned in 54.1 shall be arranged so it can be easily removed and replaced.

PERFORMANCE

55 General

55.1 An appliance with one frequency rating is to be tested at that frequency. An appliance with a dual frequency rating is to be tested at 60 hertz if 60 hertz is included in the rating and may also be tested at the second frequency if such testing is warranted.

55.2 Values of voltage and current are root-mean-square (rms) values, unless otherwise stated.

55.3 For a coin and currency mechanism that is intended for installation within the appliance cabinet, the device is to be placed inside a close-fitting compartment to represent the most adverse conditions likely to occur in the intended application of the mechanism.

55.4 Unless otherwise specified, an appliance is to be tested at the potential specified in Table 55.1.

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Table 55.1
Test voltages

Rated voltage	Normal test voltage	Input test voltage	Overvoltage	Undervoltage
24	24	24	26.4	20.4
110 – 120	120	Rated	132	102
200 – 208	208	Rated	229	177
220 – 240	240	Rated	264	204
254 – 277	277	Rated	305	235
440 – 480	480	Rated	528	408
550 – 600	600	Rated	660	510
Other	Rated	Rated	110 percent Rated	85 percent Rated

55.5 Except as specified in 55.6, during any test in which temperatures are measured, temperatures shall be monitored until maximum temperatures are attained. Thermal equilibrium is to be considered to exist when three successive readings indicate the same or decreasing temperatures. Readings shall be taken at the end of not less than three consecutive periods, the duration of each period being not less than 5 minutes.

55.6 In reference to 55.5, if temperatures on the component being monitored cycle between higher and lower temperatures due to the component cycling as part of the test (for example a load cycling on and off due to operation of a protective device), equilibrium is to be considered obtained when three successive peak temperatures indicate the same or decreasing temperatures.

55.7 In reference to 55.5 and 55.6, the recorded temperature shall be the highest of the three readings.

56 Input Test

56.1 The current, volt-ampere, or wattage input to an appliance shall not be more than 110 percent of the rated value when the appliance is operated under the condition of maximum load as described in 58.6 and when connected to a supply circuit of the voltage specified in Table 55.1 and rated frequency.

Exception: For a battery-operated appliance, the input is to be measured with the appliance in the charging mode during the test in 58.6 after operating for five minutes. The battery is to be fully discharged in accordance with the battery manufacturer's instructions at the start of the test.

56.2 If a user accessible 15 or 20 ampere receptacle is provided on an appliance, the measured ampere input of the appliance shall be increased by an amount equal to 80 percent of the receptacle rating.

56.3 If a receptacle is not user accessible, but is accessible to a route or service person, the measured ampere input shall be increased by an amount equal to the watt or ampere rating marked on the appliance in accordance with 79.12.

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57 Leakage Current Test

57.1 When tested in accordance with 57.3 – 57.8, the leakage current of a cord-connected appliance and an open-type coin or currency mechanism rated 250 volts or less shall not be more than:

a) 0.5 milliampere for a portable appliance;

b) 0.75 milliampere for an appliance intended to be fastened in place or located in a dedicated space; or

c) 3.5 milliamperes for an appliance:

1) Requiring electromagnetic interference suppression;

2) Rated 20A or less, with a nominal frequency of 50 or 60 Hz;

3) Having a 2 or 3-wire supply cord employing a standard attachment plug; and

4) Intended for use on supply circuits not exceeding 150 volts to ground.

57.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of an appliance and ground or other exposed surfaces of the appliance.

57.3 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 if simultaneously accessible, and from one surface to another if simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that are considered as not presenting a risk of electric shock. If all accessible surfaces are bonded together and connected to the grounding conductor of the power-supply cord, the leakage current can be measured between the grounding conductor and the grounded supply conductor.

57.4 If a conductive surface other than metal is used for the cabinet or part of the cabinet, the leakage current is to be measured using a metal foil with an area of 10 by 20 centimeters in contact with the surface. If the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the appliance.

57.5 The measurement circuit for leakage current is to be as illustrated in Figure 57.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

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

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; and

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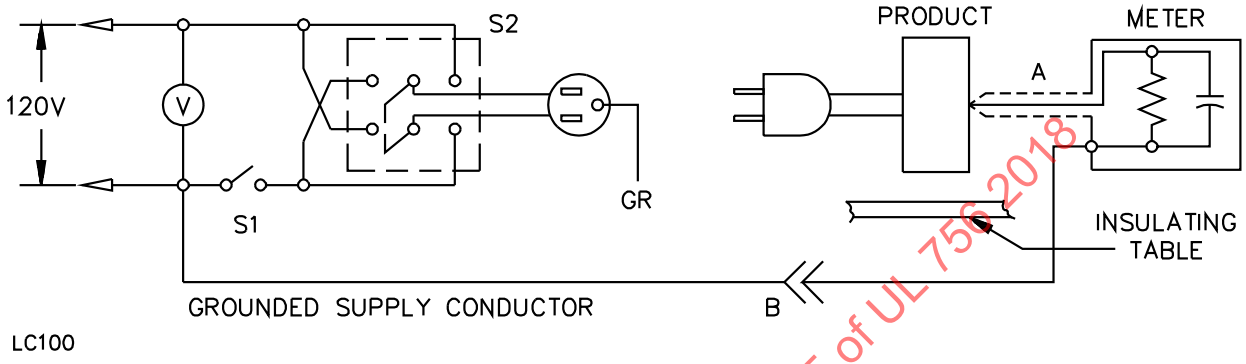
c) Over a frequency range of 0 – 100 kilohertz, the measurement circuit is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 or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

Figure 57.1
Leakage current measurement circuits



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

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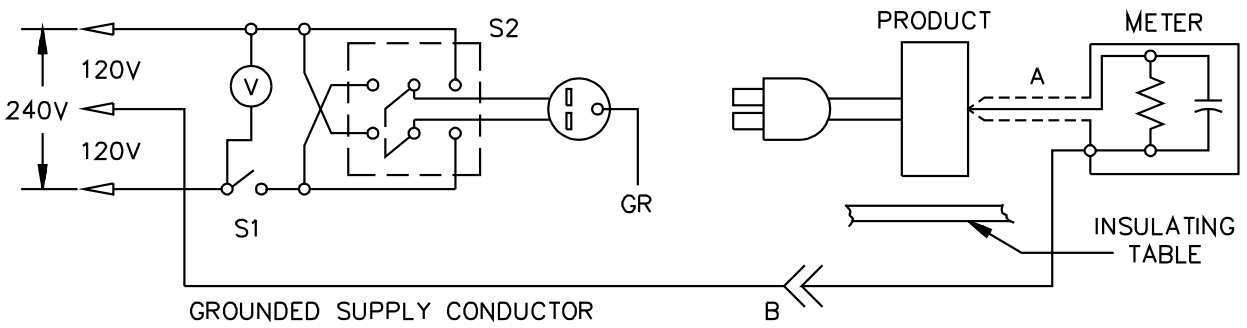

LC200

Appliance intended for connection to a 3-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 appliance to another.

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

57.7 A sample of the appliance is to be tested for leakage current starting with the as-received condition – as-received being without prior energization except as may occur as part of the production-line testing – but with its grounding conductor, if any, open at the attachment plug. The supply voltage is to be adjusted to the normal test voltage specified in Table 55.1. The test sequence with reference to the measuring circuit is to be as follows:

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

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

c) The leakage current is to be monitored until thermal stabilization is attained. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is attained as specified in 55.5 – 55.7.

57.8 Normally, a sample will be carried through the complete leakage-current-test program as described in 57.7, without interruption for other tests. With the concurrence of those concerned, the leakage current tests may be interrupted to conduct other nondestructive tests.

58 Normal Temperature Test

58.1 An appliance, when tested under the conditions described in 58.2 – 58.11, shall not attain a temperature at any point sufficiently high to constitute a risk of fire, to damage any materials employed in the appliance, or to exceed the temperature rises specified in Table 58.1.

Table 58.1
Maximum temperature rises

Material and components	°C	(°F)
1. Varnished-cloth insulation	60	(108)
2. Fuses	65	(117)
3. Fiber employed as electrical insulation	65	(117)
4. Wood or other combustible material, including the surface supporting the appliance	65	(117)
5. Class A insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches (178 mm) and of a DC and a universal motor:[a,b]		
A. In an open motor:		
Thermocouple method[b]	65	(117)
Resistance method	75	(135)
B. In a totally enclosed motor:		
Thermocouple method	70	(126)
Resistance Method	80	(144)
6. Phenolic composition employed as electrical insulation or as a part the deterioration of which would result in a risk of electric shock or fire	125[c]	(225)[c]
7. Rubber- or thermoplastic-insulated wire and cord[c,d]	35	(63)

Table 58.1 Continued on Next Page

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Table 58.1 Continued

Material and components	°C	(°F)
8. At any point within a terminal box or compartment of a permanently connected appliance	35	(63)
9. Capacitors:		
Electrolytic[e]	40	(72)
Other types[f]	65	(117)
10. Class A insulation systems on coil windings of an AC motor, not including a universal motor, having a frame diameter of 7 inches or less:[a]		
A. In an open motor – thermocouple or resistance method[b]	75	(135)
B. In a totally enclosed motor – thermocouple or resistance method	80	(144)
11. Class 105 insulation system, except as indicated in items 5, 10, and 16:		
Thermocouple method	65	(117)
Resistance method	85	(153)
12. Class 130 insulation systems, except as indicated in items 13 and 14:[b]		
Thermocouple method	85	(153)
13. Class B insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches and of a DC and a universal motor:[a]		
A. In an open motor:		
Thermocouple method[b]	85	(153)
Resistance method	95	(171)
B. In a totally enclosed motor:		
Thermocouple method	90	(162)
Resistance method	100	(180)
14. Class B insulation systems on coil windings of an AC motor, not including a universal motor, having a frame diameter of 7 inches or less:[a]		
A. In an open motor and on vibrator coils:		
Thermocouple or resistance method[b]	95	(171)
B. In totally enclosed motor:		
Thermocouple or resistance method	100	(180)
15. Class F insulation systems on coil windings of an AC motor (not including a universal motor) having a frame diameter of 7 inches or less:[a]		
In an open motor:		
Thermocouple or resistance method	120	(216)
16. Transformer with Class 105 insulation systems:		
Thermocouple method	65	(117)
Resistance method	70	(135)
17. Transformer with Class 130 insulation systems:[c]		
Thermocouple method	85	(153)
Resistance method	95	(171)
18. Sealing compound	g	g
19. Selenium rectifier[c]	50	(90)
20. Silicon rectifier	85	(135)

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

[b] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by means of a thermocouple may be higher by the following amount than the maximum indicated:

1. For Part A of item 5 additional temperature rise is 15°C (27°F).
2. For Part A of item 10 additional temperature rise is 5°C (9°F).
3. For Part A of item 13 additional temperature rise is 20°C (36°F)
4. For Part A of item 14 additional temperature rise is 10°C (18°F)

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Table 58.1 Continued on Next Page

Table 58.1 Continued

Material and components	°C	(°F)
provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table. [c] These limitations do not apply to compounds and components that have been investigated and found acceptable for a higher temperature. [d] Rubber-insulated conductors within a motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise more than 35°C (63°F), if a braid is employed on the conductor of other than a flexible cord. This exception does not apply to thermoplastic-insulated wires or cords. [e] For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be not more than 65°C (117°F). [f] A capacitor that operates at a temperature rise more than 65°C (117°F) may be judged on the basis of its marked temperature limit. [g] The maximum sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature, shall be 15°C (27°F) less than the softening point of the compound as determined in accordance with ASTM E28.		

58.2 An appliance shall withstand 6000 cycles of operation without damage to its operating parts. The appliance is to be programmed for making change representing the most adverse operating conditions, and is to be operated as intended, dispensing coins at 10-second intervals under the conditions specified in 58.1. The appliance is to be operable at the conclusion of the test.

58.3 For a permanently connected appliance, the size of supply-circuit conductors is to be in accordance with that required by ANSI/NFPA 70.

58.4 The potential at the supply terminals is to be maintained at the normal test voltage specified in Table 55.1.

58.5 A thermal- or overcurrent-protective device shall not open the circuit during normal use of the appliance.

58.6 The appliance is to be operated under standby conditions until temperatures become constant. The appliance is then to be operated normally and dispensing change at 10-second intervals until temperatures have stabilized. During this test, the appliance is to be programmed for making change representing the most adverse operating condition. An out-of-change or sold-out condition is then simulated and operation continued in this condition until temperatures become constant.

58.7 All values for temperature rises in Table 58.1 are based on an assumed ambient (room) temperature of 25°C (77°F); however, tests may be conducted, without correction, at any ambient temperature within the range of 10°C – 40°C (50°F – 104°F).

58.8 The temperature of a coil or a winding is to be measured by thermocouples mounted on the outside of the coil wrap. If the coil is inaccessible for mounting these devices – for example, a coil enclosed in a sealing compound – or if the coil wrap includes thermal insulation, such as asbestos, or more than two layers – 1/32 inch (0.8 mm) maximum – of cotton, paper, rayon, or similar insulation, the change-of-resistance method is to be used. For the thermocouple-measured temperature of a coil in a 7-inch (178-mm) diameter or smaller frame alternating-current motor other than a universal motor – items 10, 14, and 15 in Table 58.1 – the thermocouple is to be mounted on the insulation on the conductor that is beneath the coil wrap on the winding.

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58.9 When thermocouples are used in the determination of temperatures, it is common practice to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constantan wires and a potentiometer-type indicating instrument; and such equipment is to be used whenever reference temperature measurements by thermocouples are required. The thermocouples and related instruments are to be accurate and calibrated in accordance with sound laboratory practice. The thermocouple wire is to conform with the requirements listed in ASTM E230/E230M.

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

58.11 The temperature rise of a winding is determined by the resistance method by comparing the resistance of the winding at a temperature to be determined with the resistance at a known temperature according to the formula:

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

in which:

Δt is the temperature rise in °C;

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

r is resistance of the coil at the beginning of the test in ohms;

k is 234.5 for copper, 225.0 for electrical conductor grade (EC) aluminum. Values of the constant k for other grades must be determined;

t_1 is room temperature at the beginning of the test in °C; and

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

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59 Dielectric Voltage-Withstand Test

59.1 An appliance shall withstand for 1 minute without breakdown the application of an alternating potential of 1000 volts plus twice maximum rated voltage:

a) Between line-voltage parts and grounded or exposed metal parts or the enclosure;

b) Between line voltage parts of opposite polarity;

c) Between parts of line- and low-voltage circuits;

d) Between line-voltage and isolated, power-limited circuits; and

e) Between the terminals of a capacitor used for radio-interference elimination or arc suppression that are connected in circuits other than that specified in 18.1 and 19.1.

Exception: If acceptable to all parties concerned, the test potential may be a direct-current (dc) potential as specified in Table 76.1, Condition C, and applied for 1 minute.

59.2 If, in accordance with 20.3(a), a dielectric voltage-withstand test is required to determine the adequacy of spacings in an electronic circuit, the circuit shall withstand for 1 minute the application between the parts specified in (a) – (d) of a test potential of three times the maximum measured open-circuit potential but not less than 1270 volts if the electronic circuit is directly connected to the supply circuit. A direct-current source is to be used for a direct-current circuit. A 60-hertz essentially sinusoidal voltage is to be used for testing alternating-current circuits. The potential is to be applied between:

a) Live parts of opposite polarity;

b) Live parts of the electronic circuit and low-voltage circuits;

c) Live parts of the electronic circuit and isolated, power-limited circuits; and

d) Live parts of the electronic circuit and grounded or exposed metal parts or the enclosure.

59.3 With reference to 59.2, a volt-meter having an internal resistance of not less than 2000 ohms per volt is to be used to measure the open-circuit potentials. During the test all electrolytic capacitors, bleeder resistors, and other power-dissipating components are to be disconnected from one side of the circuit, all lamps and electron tubes are to be removed, and ballast tubes or other automatic regulating devices are to be rendered inoperative if necessary to conduct the test.

59.4 A transformer supplying a low voltage circuit, as described in 18.1, shall withstand without breakdown for 1 minute, the application of an alternating potential of 1000 volts plus twice the maximum rated primary voltage, at rated frequency, between primary and secondary windings and between primary winding and the core or the enclosure.

59.5 A power transformer and a transformer supplying an isolated, power-limited circuit shall withstand without breakdown, for 1 minute, the application of an alternating potential of 1000 volts plus twice the maximum rated primary or secondary voltage, at rated frequency, between primary and secondary windings, and shall withstand under the same conditions the application of an alternating potential of 1000 volts plus twice the rated voltage of each winding, at rated frequency, between each winding and the core or the enclosure.

Exception No. 1: The test between primary and secondary windings is not required for an autotransformer.

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Exception No. 2: If acceptable to all parties concerned, the test potential may be a direct-current (dc) potential as specified in Table 76.1, Condition C, and applied for 1 minute.

59.6 To determine whether an appliance or a transformer complies with the requirements in 59.1 – 59.5, the appliance is to be tested by means of a 500-volt-ampere or larger-capacity transformer, the output voltage of which is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter. A direct-current source is to be used for a direct-current circuit.

60 Overvoltage and Undervoltage Test

60.1 An electromagnet for use on direct current shall withstand 10 percent above its rated voltage continuously without damage to the operating coil and operate successfully at 20 percent less than rated voltage. For a device having a voltage rating within one of the ranges given in Table 55.1, the test voltage specified in that table is to be employed.

60.2 An electromagnet for use on alternating current shall withstand 10 percent above its rated voltage continuously without damage to the operating coil and operate successfully at 15 percent less than rated voltage. For a device having a voltage rating within one of the ranges given in Table 55.1, the test voltage specified in that table is to be employed.

60.3 For the operation at minimum voltage, the operating coil is to be subjected to the normal line voltage until constant temperature is reached and then tested immediately for closing at the minimum voltage.

60.4 If the components are normally energized through a transformer, the voltage adjustments are to be made on the primary side of the transformer.

61 Volt-Ampere Capacity Test

61.1 An isolated, power-limited circuit, located entirely within the coin and currency changer and/or actuator shall have a continuous-use capacity of 100 volt-amperes or less when energized from a circuit of rated frequency at the normal test voltage specified in Table 55.1. A transformer having multiple secondary windings is considered to comply with this requirement if it complies with 61.3.

61.2 A single-wound secondary transformer is to attain a temperature rise on the enclosure, core, or coil of at least 50°C (90°F) when the secondary is loaded to the maximum output obtainable or 100 volt-amperes, whichever is less.

61.3 Each secondary winding of a multisecondary transformer is to be loaded in turn with a variable resistor. Starting with a cold transformer for each part of the test, the load resistance is decreased from open-circuit to short-circuit in such a manner that the elapsed time is between 1-1/2 and 2-1/2 minutes. Depending upon the open-circuit voltage of the winding, the maximum outputs obtained by this method are to be as follows:

a) 350 volt-amperes for 0 – 15 volts.

b) 250 volt-amperes for 15.1 – 30 volts.

c) 200 volt-amperes for 30.1 – 1000 volts.

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62 Power-Limited Circuits

62.1 General

62.1.1 All field-wiring circuits that derive energy from power sources located within a product shall be classified as a power-limited or nonpower-limited circuit. A circuit shall be considered nonpower-limited unless otherwise identified in the installation documentation and marking on the product.

62.1.2 The power source (or sources) supplying a power-limited circuit shall be either:

a) Inherently limited requiring no overcurrent protection; or

b) Limited by a combination of a power source and overcurrent protection devices such that a power-limited circuit has electrical characteristics described in Table 62.1 for AC circuits or Table 62.2 for DC circuits.

62.1.3 With regard to 62.1.2, acceptable means for current-limiting include:

a) Transformer winding impedance;

b) A thermal link embedded within the winding overwrap of a transformer;

c) Circuit components (resistors, regulators, transistors, and the like) that comply with the Normal Temperature Test, Section 55, under I_{max} condition; and

d) Current-limiting impedances determined to be suitable for the application (positive temperature coefficient varistor or the like).

Circuit component burnout, permanent (by soldered means or the like) or replaceable fuses, opening of conductors on printed wiring boards, or opening of internal wiring conductors shall not be used as a means of current limiting.

62.1.4 The overcurrent protection device specified in 62.1.2 shall be of the noninterchangeable type such that it cannot be renewed in the field with an overcurrent device having a higher current rating.

62.1.5 When measuring the I_{max} and VA_{max}, all overcurrent protection devices of the control unit shall be short-circuited. However, current limiting devices shall not be bypassed and shall remain functional.

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Table 62.1
Power-source limitations for alternating current Class 2 and Class 3 circuits

	Circuit voltage V_{max}[a] (volts)	Power source maximum nameplate ratings		Current limitations I_{max}[b] (amps)	Power limitiations $(VA)_{max}$[c] (volt-amps)	Maximum overcurrent protection (amps)
		VA (volt-amps)	Current (amps)			
Inherently limited power source (overcurrent protection not required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	8.0	–	–
	Over 20 to 30	100	$100/V_{max}$	8.0	–	–
	Over 30 to 150	$0.005 \times V_{max}$	0.005	0.005	–	–
Class 3	Over 30 to 100	100	$100/V_{max}$	$150/V_{max}$	–	–
Not inherently limited power source (overcurrent protection required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	$1000/V_{max}$	250[d]	5.0
Class 3	Over 20 to 30	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 30 to 100	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 100 to 150	100	$100/V_{max}$	1.0	N.A.	1.0

NOTES

1 Adapted from ANSI/NFPA 70, 1996 Edition, copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

2 For nonsinusoidal AC, V_{max} shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 15 volts for sinusoidal AC and 21.2 volts peak for nonsinusoidal AC.

[a] V_{max}: Maximum output voltage regardless of load with rated input applied.

[b] I_{max}: Maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed, if used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current limiting impedance is used in combination with a nonpower-limited transformer or a stored energy source, such as a storage battery, in order to limit the output current, I_{max} limits apply after 5 seconds.

[c] $(VA)_{max}$: Maximum volt-ampere output after 1 minute of operation regardless of load, and with overcurrent protection bypassed, if used.

[d] If the power source is a transformer, $(VA)_{max}$ is 350 volt-amperes or less where V_{max} is 15 volts or less.

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Table 62.2
Power-source limitations for direct current Class 2 and Class 3 circuits

	Circuit voltage V_{max}[a] (volts)	Power source maximum nameplate ratings		Current limitations I_{max}[b] (amps)	Power limitiations $(VA)_{max}$[c] (volt-amps)	Maximum overcurrent protection (amps)
		VA (volt-amps)	Current (amps)			
Inherently limited power source (overcurrent protection not required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	8.0	–	–
	Over 20 to 30	100	$100/V_{max}$	8.0	–	–
	Over 30 to 60	100	$100/V_{max}$	$150/V_{max}$	–	–
	Over 60 to 150	$0.005 \times V_{max}$	0.005	0.005	–	–
Class 3	Over 60 to 100	100	$100V_{max}$	$150/V_{max}$	–	–
Not inherently limited power source (overcurrent protection required)						
Class 2	0 to 20	$5.0 \times V_{max}$	5.0	$1000/V_{max}$	250[d]	5.0
Class 3	Over 20 to 60	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 60 to 100	100	$100/V_{max}$	$1000/V_{max}$	250	$100/V_{max}$
	Over 100 to 150	100	$100/V_{max}$	1.0	N.A.	1.0

NOTES

1 Adapted from ANSI/NFPA 70, 1996 Edition, copyright National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

2 For DC interrupted at a rate of 10 to 200 hertz, V_{max} shall not be greater than 24.8 volts. Where wet contact (immersion not included) is likely to occur, Class 3 wiring methods shall be used, or V_{max} shall not be greater than 30 volts for continuous DC and 12.4 volts for DC that is interrupted at a rate of 10 to 200 hertz.

[a] V_{max}: Maximum output voltage regardless of load with rated input applied.

[b] I_{max}: Maximum output current under any noncapacitive load, including short circuit, and with overcurrent protection bypassed, if used. When a transformer limits the output current, I_{max} limits apply after 1 minute of operation. Where a current limiting impedance is used in combination with a nonpower-limited transformer or a stored energy source, such as a storage battery, in order to limit the output current, I_{max} limits apply after 5 seconds.

[c] $(VA)_{max}$: Maximum volt-ampere output after 1 minute of operation regardless of load, and with overcurrent protection bypassed, if used.

[d] If the power source is a transformer, $(VA)_{max}$ is 350 volt-amperes or less where V_{max} is 15 volts or less.

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62.2 Maximum voltage

62.2.1 With the circuit energized only from its rated primary power source, the output voltage of the circuit under test is to be measured while the circuit is connected:

a) To its full rated load; and

b) Under open circuit conditions.

The maximum voltage under these two conditions shall be considered V_{max}.

62.3 Maximum current

62.3.1 In order to determine compliance with the I_{max} limitation, a variable load resistor shall be connected across the circuit. While monitoring the current through the load resistor, the load resistor is to be adjusted from open circuit to short circuit as quickly as possible and the highest current noted. The load resistor is then to be readjusted to produce the highest current obtained and the current through the load resistor shall be measured after 1 minute or after 5 seconds as determined by Table 62.1 or Table 62.2.

62.3.2 If the maximum current through the load resistor cannot be maintained for 5 seconds due to current limiting devices (opening of thermal link, power supply foldback, PTC varistor effect, and the like), the circuit load resistor is to be adjusted to a value that will produce a current just above the I_{max} value indicated in Table 62.1 or Table 62.2. The results are in compliance if the I_{max} value stated in Table 62.1 or Table 62.2 cannot be maintained for more than 5 seconds.

62.3.3 If a transformer limits the value of I_{max}, and if I_{max} cannot be maintained for 1 minute due to transformer burnout, a plot of current versus time is to be generated and the graph extrapolated to 1 minute. The results are in compliance if the extrapolated value of I_{max} at 1 minute does not exceed the I_{max} limitations as indicated in Table 62.1 or Table 62.2.

62.4 VA_{max} (Not inherently limited circuits only)

62.4.1 The circuit is to be energized from a rated source of supply and then the circuit under test is to be open-circuited. A variable load resistor, initially set to draw rated circuit current, is then to be connected across the circuit. The circuit voltage and current are to be recorded and the load is to be removed. The resistance of the load is then to be decreased, momentarily reconnected across the circuit while recording the voltage and current, and then removed. This procedure is to be repeated until the load resistance has been reduced to a short circuit. Using the recorded voltage and current, the maximum volt-ampere, VA_{max}, output under each load condition is to be calculated. The load resistor is then to be adjusted to that value which produced the maximum volt-ampere, VA_{max}, calculated and then connected to the circuit. After 1 minute, the voltage and current are again to be measured. The results of this test are in compliance when the calculated volt-ampere, VA, output of the circuit does not exceed the values specified in Table 62.1 or Table 62.2, as appropriate, after 1 minute.

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63 Abnormal Operation Tests

63.1 General

63.1.1 An appliance shall not become a risk of fire or electric shock when operated under abnormal conditions that may occur in actual service, as described in 63.1.2 – 63.4.3.

63.1.2 To determine if a risk of fire exists, a burnout or abnormal heating test is to be conducted on components such as those indicated in 63.2.1 – 63.4.3 or others that the design of the appliance indicates may present a risk of fire. The test is to be conducted with the component installed as intended in the appliance. The appliance is to be connected as in service to a supply circuit maintained at the normal test voltage specified in Table 55.1. For cord-connected appliances, the supply-circuit fuses are to correspond in size to the rating of the attachment plug, except that 20 amperes is the minimum size for appliances rated 150 volts or less.

63.1.3 A risk of fire is considered to exist if there is any emission of flame or molten metal from the appliance, or glowing or flaming of combustible material. Opening of the supply-circuit fuse is acceptable if a risk of fire does not exist.

63.1.4 A risk of electric shock is considered to exist if the appliance does not withstand the dielectric potential specified in 59.1.

63.1.5 If malfunction of a single component may result in an intermittent-duty relay or solenoid being continuously energized, a risk of fire or electric shock shall not result from malfunction.

63.1.6 A burnout test is to be conducted with the device continuously energized until the ultimate result is determined.

63.2 Currency rejection

63.2.1 An appliance employing a dollar bill validator, a note acceptor, or the like is to be operated for 30 minutes in the mode of rejecting paper currency. During this test, the paper currency is to be inserted as fast as the appliance will permit.

63.3 Solenoid burnout

63.3.1 An electromagnetic solenoid is to be tested by blocking the plunger in the position assumed when de-energized. The solenoid is to be energized continuously at the normal test voltage specified in Table 55.1 until burnout of the coil occurs or the temperatures become constant. During the test, the appliance enclosure is to be connected directly to ground.

Exception: A direct-current solenoid need not be tested.

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63.4 Transformer burnout

63.4.1 A power transformer shall be operated continuously while energized at the normal test voltage specified in Table 55.1 with the enclosure connected directly to ground. The load connected to the output terminals is to be a resistance of such value that three times full rated current will be drawn into the primary winding of the transformer, and operation shall be continued until constant temperatures are attained on the enclosure or until burnout occurs.

63.4.2 The circuit on which the transformer is tested is to be protected by fuses rated at least ten times the primary current rating of the transformer, and opening of the fuses is acceptable. The test is to be conducted with the output terminals short-circuited, if such a condition results in less than three times full-rated current being drawn into the primary. If other means of limiting the load to less than three times normal is inherent in or provided as part of the transformer, these features are to be given consideration and the burnout test is to be conducted at the maximum load permitted by the limiting features.

63.4.3 A transformer supplying a low-voltage circuit as described in 18.1 is to be tested in the same manner as a Class 2 transformer, with low-voltage wiring terminals short-circuited, and wiring not conforming to 14.1 and 14.4 short-circuited. A transformer supplying an isolated, power-limited circuit as described in 19.1 or an electronic circuit is tested in accordance with 63.4.1 and 63.4.2, except all secondary windings are directly short-circuited. If a portion of an isolated, power-limited circuit is connected to low-voltage field-wiring terminals, separate samples are to be subjected to the Class 2 transformer test and the shorted secondary test.

63A Switch Mode Power Supply Units – Overload Test

63A.1 The test applies to switch mode power supply units as specified in 43.1(c).

63A.2 Each output winding, or section of a tapped winding, is overloaded in turn, one at a time, while the other windings are kept loaded or unloaded, whichever load conditions of normal use is the least favorable.

63A.3 Overloading is carried out by connecting a variable resistor (or an electronic load) across the power supply output. The resistor is adjusted as quickly as possible and readjusted, if necessary, after 1 minute to maintain the applicable overload. No further readjustments are then permitted.

63A.4 For this test, any protective devices such as a fuse, manual reset circuit protector, thermal protector, etc. are allowed to remain in the circuit.

63A.5 If overcurrent protection is provided by an overcurrent protection device, the overload test current is the maximum current which the overcurrent protection device is just capable of passing for 1 hr. If this value cannot be derived from the specification, it is to be established by test.

63A.6 If no overcurrent protection is provided, the maximum overload is the maximum power output obtainable from the power supply.

63A.7 In case of voltage foldback, the overload is to be slowly increased to the point which causes the output voltage to collapse. The overload is then established at the point where the output voltage recovered and held for the duration of the test.

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63A.8 The duration of the test is to be for 7 hours or until ultimate results are reached. At the conclusion of the test, there shall be no charring or burning of electrical insulation, no opening of any protective device or any circuit component.

64 Flexing of Internal Wiring Test

64.1 The wiring from the appliance to components mounted on the door is to be tested by opening the door as far as possible– restraints such as chains are to remain in place – and then closing it for 6,000 cycles of operation. Following this test, the appliance is to be subjected to the dielectric voltage-withstand test described in 59.1. The wiring is then to be examined for damage.

Exception: Wiring connected in low-voltage circuits need not be tested. See 18.1.

65 Strain Relief Test

65.1 When an appliance is tested in accordance with 65.2 – 65.5, there shall be no such movement of the cord or wiring leads to indicate that stress is transmitted to internal wiring and connections.

65.2 A strain relief means for a power supply cord, including that for an externally-mounted accessory shall be subjected to a direct pull of 35 pounds-force (156 N). The force may be generated by suspending a 35 pound (15.9 kg) weight on the cord of the appliance.

65.3 A strain relief means for wiring leads intended for connection of field-installed supply conductors and power supply conductors of an internally-mounted accessory shall be subjected to a direct pull of 20 pounds-force (89 N). The force may be generated by suspending a 20 pound (9.1 kg) weight on the appliance leads.

65.4 The force specified in 65.2 or 65.3 shall be applied so that the strain relief is stressed from any angle permitted by the construction of the appliance.

65.5 The force shall be applied for not less than 1 minute.

66 Accelerated Aging on Gaskets, Sealing Compounds, and Adhesives

66.1 The requirements in 66.4 – 66.6 apply to gaskets and sealing compounds employed to make an enclosure raintight or rainproof. The requirements in 66.7 apply to adhesives used to secure such gaskets to an enclosure or cover.

66.2 A neoprene or rubber compound, except a foamed material, used for a gasket to seal an enclosure, shall have physical properties as specified in Table 66.1 before and after accelerated aging under the conditions described in Table 66.2.

66.3 Foamed neoprene or rubber compounds used for gaskets to seal an enclosure are to be subjected to accelerated aging under the conditions specified in Table 66.2. The compounds shall not harden or otherwise deteriorate to a degree that will affect their sealing properties.

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66.4 A thermoplastic material used for a gasket to seal an enclosure shall be subjected to accelerated aging under the conditions specified in Table 66.2. Thermoplastic material shall not deform or melt, or otherwise deteriorate to a degree that will affect its sealing properties. Solid polyvinyl-chloride gasket material shall have physical properties as specified in Table 66.1 before and after the accelerated aging.

66.5 Tensile strength and elongation are to be determined using the test methods and apparatus described in ASTM D412.

Table 66.1
Physical properties for gaskets

Physical property	Neoprene or rubber compound		Polyvinyl-chloride materials	
	Before test	After test	Before test	After test
Recovery – Maximum set when 1-inch (25.4 mm) gage marks are stretched to 2-1/2 inches (63.5 mm), held for 2 minutes and measured 2 minutes after release	1/4 inch (6.4 mm)	–	Not specified	
Elongation – Minimum increase in distance between 1 inch gage marks at break	250 percent 1 – 3-1/2 inches (25.4 – 88.9 mm)	65 percent of original	250 percent 1 – 3-1/2 inches (25.4 – 88.9 mm)	75 percent of original
Tensile strength – Minimum force at breaking point	850 psi (5.86 MPa)	75 percent of original	1200 psi (8.27 MPa)	90 percent of original

Table 66.2
Accelerated aging conditions

Measured temperature rise, °C	(°F)	Material	Test program
35	(63)	Rubber or neoprene	70 hours at 100.0 ±2.0°C (212.0 ±3.6°F) in an air-circulating oven.
35	(63)	Thermoplastic	168 hours in an air-circulating oven at 87.0 ±1.0°C (188.6 ±1.8°F)
50	(90)	Rubber or neoprene	168 hours at 100.0 ±2°C (212 ±3.6°F) in an air-circulating oven.
50	(90)	Thermoplastic	240 hours in an air-circulating oven at 100.0 ±1.0°C (212.0 ±1.8°F)
55	(99)	Rubber, neoprene, or thermoplastic	168 hours in an air-circulating oven at 113.0 ±1.0°C (235.4 ±1.8°F)
65	(117)	Rubber or neoprene	240 hours in an air-circulating oven at 121.0 ±1.0°C (249.8 ±1.8°F)
65	(117)	Thermoplastic	168 hours at 121.0 ±1.0°C (249.8±1.8°F) or 1440 hours at 97.0 ±1.0°C (206.6 ±1.8°F) in an air-circulating oven
80	(144)	Rubber, neoprene, or thermoplastic	168 hours in an air-circulating oven at 136.0 ±1.0°C (276.8 ±1.8°F)

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66.6 A sealing compound is to be applied to the surface it is intended to seal. For a temperature rise not exceeding 35°C (63°F), a representative sample of the surface with the sealing compound applied is to be subjected to a test involving exposure in an air oven at 87°C (189°F) for 168 hours. The sealing compound shall not melt, become brittle, or otherwise deteriorate to a degree that will affect its sealing properties as determined by comparing the aged sample to an unaged sample.

66.7 If a gasket is secured by an adhesive, samples of the gasket, adhesive, and mounting surface are to be exposed for 72 hours to each of the following conditions, for a temperature rise not exceeding 35°C (63°F):

a) 100°C (212°F);

b) Immersion in distilled water; and

c) Minus 10°C (14°F).

The force required to peel the gasket from its mounting surface after exposure shall not be less than 50 percent of the value determined on as-received samples but not less than 2 pounds per inch (0.36 kg/cm) width of gasket.

66.8 The temperature rises specified in this section correspond to the maximum temperature rise measured on the gasket during the temperature test. A material other than those mentioned in this section and any material having higher temperature rises, shall provide equivalent resistance to aging and temperatures and shall be nonabsorptive.

67 Tests on Nonmetallic Materials

67.1 Nonmetallic materials are to be evaluated as indicated in Table 67.1.

Table 67.1
Tests on nonmetallic materials – based on nonmetallic material requirements in Sections 7.6 – 7.9

Nonmetallic Component	Applicable Test Number
A part serving as an enclosure for ignition sources	1[a], 2[a], 3[b] or 4[h], 5, 6[c], 7[d], 8, 9, 10, 11, 12, 13, 14
A part serving as a cabinet	Minimum 4[h], 5, 6[c], 7[d], 8, 9, 10, 11, 12, 13, 14
A functional part	Minimum 4[h], 5, 6[c], 7[d], 8, 10, 11
A nonfunctional part	Minimum 4[h], 8

NOTES

1. 5 inch end product flame test[e].
2. 5V rated material[f].
3. V-0, V-1, V-2, HF-1, HF-2 rated materials[f], 3/4 inch End Product Flame Test[e] or 12 mm End Product Flame Test[e].
4. HB or HBF rated material[f], or a material with a flame spread rating of 25 or less and a smoke developed rating of 50 or less[g].
5. Mold Stress-Relief Test[e].
6. Fastener Strength Test, Section 68.
7. Adhesive Test[e].
8. Radiant Panel or Surface Burning Characteristic Test[g]. A flame spread index of not more than 200 applies only to parts forming portions of the external enclosure, or of a decorative part if the total area of the enclosure exceeds 10 ft.^{2}(0.93 m^2).
9. Volume Resistivity Test[e] – Applies only if electrical spacings between uninsulated live parts and the material are less than specified in high-voltage circuits, and low voltage circuits, or if the part is used as indirect support of an uninsulated live part.
10. High Current Arc Resistance to Ignition Test[e] – Applies only if the material is used to enclose uninsulated live parts or to provide indirect support of uninsulated live parts. The test does not apply if uninsulated live parts are located a minimum of 1/32 inch (0.79 mm) from the part. If applicable, no ignition shall occur to: V-0 materials subjected to 15 arcs; V-1, V-2 or 5V materials subjected to 30 arcs, or to HB materials subjected to 60 arcs.
11. Hot Wire Ignition Test[e] – Applies only if the material is within 1/2 inch (12.7 mm) of electrically-heated wires or resistors. If applicable, ignition shall not occur in less than: 10 s for V-0 materials; 15 s for V-1 or 5V materials, or 30 s for V-2 or HB materials.
12. Impact Tests[e] – 5 ft-lb (6.8 J) impact for enclosures containing uninsulated live and hot parts, 1.5 ft-lb (2.0 J) impact for enclosures containing moving parts.

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Table 67.1 Continued

Nonmetallic Component	Applicable Test Number
13. Crush Resistance Test[e] – Only one sample needs to be tested.	
14. UV Light Exposure Test[e] – Applies to a coin and currency changer and actuator intended for outdoor or protected locations and provided with a polymeric cabinet and/or enclosure that could be exposed to sunlight.	
[a] An enclosure provided with a barrier interposed between the material and an ignition source will be tested with the barrier in place.	
[b] A material with a V-2 or HF-2 minimum rating is able to be used to enclose an ignition source if the ignition source is only energized as a result of a continuous action by an attending operator.	
[c] Applies to an enclosure that serves only to reduce the risk of electric shock and having: ultrasonic welds; heat welds; polymeric screws or nuts; metal screws threaded into a polymeric part, or other means where degradation of a polymeric material affects securement.	
[d] Applies only if the adhesive is relied on to maintain the integrity of an enclosure or functional part.	
[e] Tested or rated as described in UL 746C.	
[f] Tested or rated as described in UL 94.	
[g] Tested or rated as described in ASTM E162 or UL 723.	
[h] These materials are able to be used if ignition sources are separated or isolated in accordance with Sections 7.7 – 7.9.	

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