UL 979

STANDARD FOR SAFETY

Water Treatment Appliances

UL Standard for Safety for Water Treatment Appliances, UL 979

Third Edition, Dated August 26, 2024

Summary of Topics

This new edition of UL 979 dated August 26, 2024 incorporates editorial changes including renumbering and reformatting to align with current style, as well as the following changes in requirements:

– Revisions based on the latest version of UL 4200A; Section 9

– Editorial corrections; 38.1, 38.3, 48.7

– Replacement of the reference to the 5th Edition of UL 60335-1 by an undated reference to UL 60335-1; 30.5.2

– Addition of a reference to UL 60730-2-22; 6.16.4.1

– Updates to Section 5, Undated References, and the addition of a list of Referenced Standards; 5.2

– Clarification of the Frequency During Tests; 39.1

The new requirements are substantially in accordance with Proposal(s) on this subject dated March 8, 2024, June 8, 2024, and July 19, 2024.

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UL 979

Standard for Water Treatment Appliances

First Edition – May, 2005
Second Edition – September, 2016

Third Edition

August 26, 2024

This UL Standard for Safety consists of the Third Edition.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover electrically operated water treatment appliances for household, commercial use, and industrial use. These appliances are intended for installation and use in accordance with the National Electrical Code, NFPA 70, and are rated 600 V or less.

1.2 These requirements cover appliances utilizing features that treat water through the use of cation exchange water softeners, ionization, filters, ultraviolet radiation, ozone generation, and reverse osmosis.

1.3 These requirements do not cover water treatment appliances for use with pools or spas, water distillers, aquariums, or other equipment connected to plumbing that is covered by individual requirements.

1.4 These requirements do not cover appliances for use in hazardous locations as defined in the National Electrical Code, NFPA 70.

1.5 These requirements do not cover the aesthetic effects or the effectiveness of water treatment.

2 Glossary

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

2.2 APPLIANCE – A collective term to designate all products covered by this Standard.

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

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

2.5 APPLIANCE, PERMANENTLY-CONNECTED – An appliance intended to be permanently connected electrically.

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

2.7 APPLIANCE, PORTABLE – An appliance with the following characteristics:

a) The appliance is cord- and plug-connected;

b) The operating literature and installation instructions illustrate connecting the water lines to the output of a sink-type faucet. The connection to the sink-type faucet does not require tools, or the appliance is provided with its own water container;

c) The operating literature and installation instructions do not portray placing the appliance under the cabinet or a dedicated space, and they only illustrate placing the appliance on a counter top near the sink; and

d) The appliance has feet or keyhole slots and does not have non-keyhole slots or other more permanent mounting means.

2.8 APPLIANCE, STATIONARY – An appliance connected to plumbing and not expected to be moved except during servicing or storage. A stationary appliance may have wheels or casters.

2.9 BARRIER – A partition for the insulation or isolation of electric circuits, for the isolation of electric arcs, or for isolation of moving parts or hot surfaces. In this respect, a barrier may serve as a portion of an enclosure or as a functional part.

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

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

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

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

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

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

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

2.12 CIRCUIT, HIGH-VOLTAGE – A circuit involving a potential of more than 600 V.

2.13 CIRCUIT, LINE-VOLTAGE – A circuit involving a potential of not more than 600 V and having circuit characteristics in excess of those of a low-voltage circuit.

2.14 CIRCUIT, LOW-VOLTAGE – A circuit involving a peak open-circuit potential of not more than 42.4 V supplied by a primary battery, by a Class 2 transformer, or by a combination of a transformer and a fixed impedance that as a unit complies with all performance requirements for a Class 2 transformer. A circuit derived from a line-voltage circuit by connecting a 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.

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

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

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

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

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

2.20 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, fire, or injury to persons, is considered an operating control.

2.21 CONTROL, PROTECTIVE – A device or assembly of devices, the operation of which is intended to reduce the risk of electric shock, fire or injury to persons during 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. (During the testing of the protective control/circuit, the protective functions are verified under normal and single-fault conditions of the control.)

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

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

2.24 DANGEROUS MALFUNCTION – Unintended operation of the appliance that may impair safety. Operating Control functions whose failure would result in a Dangerous Malfunction would be considered Safety Critical Functions. See 30.5.

NOTE: Control functions whose failure might result in a Dangerous Malfunction would include:

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

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

2.25 ENCLOSURE – A part that by itself or in conjunction with barriers:

a) Renders inaccessible all or any parts that may otherwise present a risk of electric shock;

b) Reduces the risk of contact with parts that may cause injury to persons; or

c) Prevents propagation of flame due to electrical disturbances occurring within. A cabinet that serves to enclose electrical components or wiring is considered to be an enclosure.

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

2.27 MAXIMUM WORKING PRESSURE – The maximum operating pressure recommended by the manufacturer.

2.28 MOTOR, ACCESSIBLE – A motor that may be contacted without opening or removing any part and that is located so as to be accessible to contact.

2.29 MOTOR, INACCESSIBLE – A motor that is accessible only by opening or removing a part of the outer enclosure, such as a panel or service door, which can be removed without the use of tools, or a

motor that is located in such a position or is otherwise guarded or enclosed so that it is unlikely to be contacted.

2.30 OPPOSITE POLARITY – A difference of potential between two points, where shorting of these two points would result in a condition involving overload, rupturing of printed wiring-board tracks, components or fuses, and similar components.

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

2.32 PRESSURE VESSEL – A component of the system intended to hold water under pressure higher than atmospheric pressure.

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

a) The following voltage limits shall be met:

1) The voltage does not exceed 30 V rms;

2) The voltage does not exceed 42.4 V peak;

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

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

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

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

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

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

2.35 ULTRAVIOLET (UV) LAMP SYSTEM – Appliances that directly generates ultraviolet radiation within the equipment for cleaning and disinfection purposes.

2.36 ULTRAVIOLET (UV) RADIATION – Electromagnetic energy with a wavelength of 200 – 400 nm.

NOTE: For ultraviolet (UV) radiation, the range between 100 nm and 400 nm is commonly subdivided into: UV-A (Near UV), from 315 nm to 400 nm; UV-B, from 280 nm to 315 nm; and UV-C, from 100 nm to 280 nm.

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

a) Attaching accessories by means of attachment plugs and receptacles or by means of other separable connectors;

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

c) Making routine operating adjustments necessary to adapt the appliances for its different intended functions; and

d) Any operation described or implied in the operator's manual, whether or not tools are required.

2.38 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.

2.39 WORKING VOLTAGE – The highest voltage to which the insulation or the component under consideration is, or can be, subjected when the equipment is operating under conditions of normal use. Overvoltages that originate outside the equipment are not taken into account.

3 Safety Critical Functions

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

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

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

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

3.3 Functions specified in the table represent the common safety critical circuit functions of typical water treatment units. It is not intended to represent all possible Safety Critical Functions.

Table 3.1
Safety Critical Functions

Function[a]	Hazard	Location of parameters and tests
Motor running overload protection	Risk of fire or electric shock	34.3
Motor locked rotor protection	Risk of fire or electric shock	34.3
Motor short circuit protection	Risk of fire or electric shock	34.3

[a] Functions specified in the table represent the common safety critical circuit functions of water treatment equipment. It is not intended to represent all possible safety critical functions. Any function involved in the control, protection, and monitoring of safety-related attributes of a pump whereby a loss/malfunction of its functionality would represent an unacceptable risk of fire, electric shock, or casualty hazards would be considered a Safety Critical Function.

4 Units of Measurement

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

5 Referenced Publications

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

5.2 The following publications are referenced in this Standard:

ASTM A 653/A 653M, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

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

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

IEC 60127-1, *Miniature Fuses – Part 1 Definitions for Miniature Fuses and General Requirements for Miniature Fuse-Sinks*

IEC 61000-4-2, *Electromagnetic Compatibility (EMC) – Part 4-2: Testing and Measurement Techniques – Electrostatic Discharge Immunity Test*

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*

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 for Equipment with Input Current up to 16 A per Phase*

IEC 61000-4-13, *Electromagnetic Compatibility (EMC) – Part 4-13: Testing and Measurement Techniques – Harmonics and Interharmonics Including Mains Signaling at ac Power Port, Low Frequency Immunity Tests*

IEC 62471, *Photobiological Safety of Lamps and Lamp System*

IES RP-271, *Standard for Recommended Practice for Photobiological Safety for Lamps and Lamp Systems – General Requirements*

NFPA 70, *National Electrical Code*

UL 20, *General-Use Snap Switches*

UL 50, *Enclosures for Electrical Equipment, Non-Environmental Considerations*

UL 62, *Flexible Cords and Cables*

UL 66, *Fixture Wire*

UL 83, *Thermoplastic-Insulated Wires and Cables*

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

UL 101, *Leakage Current for Utilization Equipment*

UL 157, *Gaskets and Seals*

UL 224, *Extruded Insulating Tubing*

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

UL 310, *Electrical Quick-Connect Terminals*

UL 429, *Electrically Operated Valves*

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 507, *Electric Fans*

UL 508, *Industrial Control Equipment*

UL 508A, *Industrial Control Panels*

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

UL 514A, *Metallic Outlet Boxes*

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

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

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

UL 758, *Appliance Wiring Material*

UL 773A, *Nonindustrial Photoelectric Switches for Lighting Control*

UL 778, *Motor-Operated Water Pumps*

UL 796, *Printed Wiring Boards*

UL 810, *Capacitors*

UL 817, *Cord Sets and Power-Supply Cords*

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

UL 867, *Electrostatic Air Cleaners*

UL 935, *Fluorescent-Lamp Ballasts*

UL 943, *Ground-Fault Circuit-Interrupters*

UL 943B, *Appliance Leakage-Current Interrupters*

UL 969, *Marking and Labeling Systems*

UL 1004-1, *Rotating Electrical Machines – General Requirements*

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 1053, *Ground-Fault Sensing and Relaying Equipment*

UL 1059, *Terminal Blocks*

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

UL 1097, *Double Insulation Systems 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 1441, *Coated Electrical Sleeving*

UL 1446, *Systems of Insulating Materials – General*

UL 1449, *Surge Protective Devices*

UL 1557, *Electrically Isolated Semiconductor Devices*

UL 1565, *Positioning Devices*

UL 1577, *Optical Isolators*

UL 1581, *Reference Standard for Electrical Wires, Cables, and Flexible Cords*

UL 1642, *Lithium Batteries*

UL 1699, *Arc-Fault Circuit-Interrupters*

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

UL 2054, *Household and Commercial Batteries*

UL 2111, *Overheating Protection for Motors*

UL 2353, *Single- and Multi-Layer Insulated Winding Wire*

UL 2459, *Insulated Multi-Pole Splicing Wire Connectors*

UL 4200A, *Products Incorporating Button Batteries or Coin Cell Batteries*

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

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

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

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

UL 5085-3, *Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers*

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

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

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 60730-2-2, *Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Thermal Motor Protectors*

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

UL 60730-2-7, *Automatic Electrical Controls – Part 2-7: Particular Requirements for Timers and Time Switches*

UL 60730-2-8, *Automatic Electrical Controls – Part 2-8: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements*

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

UL 60730-2-15, *Automatic Electrical Controls – Part 2-15: Particular Requirements for Automatic Electrical Air Flow, Water Flow and Water Level Sensing Controls*

UL 60730-2-18, *Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Water and Air Flow Sensing Controls, Including Mechanical Requirements*

UL 60730-2-22, *Automatic Electrical Controls – Part 2-22: Particular Requirements for Thermal Motor Protectors*

UL 60947-1, *Low-Voltage Switchgear and Controlgear – Part 1: General Rules*

UL 60947-4-1, *Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters*

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

UL 61010-1, *Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements*

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

UL 61800-5-1, *Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal, and Energy*

UL 62368-1, *Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements*

CONSTRUCTION

6 Components

6.1 General

6.1.1 A component of a product covered by this Standard shall:

a) Comply with the requirements for that component as indicated in 6.2 – 6.26;

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

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

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

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

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

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

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

Exception No. 2: A component that complies with a UL component standard other than those specified in 6.2 – 6.26 is acceptable if the UL component standard:

a) Is compatible with the ampacity and overcurrent protection requirements in NFPA 70, where applicable;

b) Considers long-term thermal properties of polymeric insulating materials in accordance with UL 746B; and

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

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

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

6.1.3 A component not anticipated by the requirements of this end product standard, not specifically covered by the component standards in 6.2 – 6.26, and that involves a risk of electric shock, fire, or personal injury, shall be additionally investigated in accordance with the applicable UL standard, and shall comply with 6.1.1 (b) – (d).

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

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

6.2 Attachment plugs, receptacles, connectors, and terminals

6.2.1 Attachment plugs, receptacles, appliance couplers, appliance inlets (motor attachment plugs), and appliance (flatiron) plugs, shall comply with UL 498. See 6.2.9.

Exception No. 1: Attachment plugs and appliance couplers integral to cord sets or power supply cords are investigated in accordance with the requirements of UL 817 are not required to comply with UL 498.

Exception No. 2: A fabricated pin terminal assembly need not comply with UL 498 if it complies with Accessibility, Section 10; Mechanical Assembly, Section 13; Live Parts, Section 17; Electrical Insulation, Section 18; Spacings, Section 22, of this end product standard; and the applicable performance requirements when tested in the end product.

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

Exception No. 1: Other sizes of quick-connect terminals shall be investigated with respect to crimp pull out, insertion-withdrawal, temperature rise, and all tests shall be conducted in accordance with UL 310.

Exception No. 2: A connector that complies with UL 310 may be used with an appropriately sized tab that complies with Tabs Used in Electrical Quick-Connect Terminals, Section 20. The connector is the part of a quick-connect terminal that is pushed onto the male tab, and the tab is the part that receives the female connector.

6.2.3 Single and multiple 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. See 6.2.9.

6.2.4 Wire connectors shall comply with UL 486A-486B.

6.2.5 Splicing wire connectors shall comply with UL 486C.

6.2.6 Multi-pole splicing wire connectors that are intended to facilitate the connection of hard-wired utilization equipment to the branch-circuit conductors of buildings shall comply with UL 2459. See 6.2.9.

6.2.7 Equipment wiring terminals for use with all alloys of copper, aluminum, or copper-clad aluminum conductors, shall comply with UL 486E.

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

Exception: A fabricated part performing the function of a terminal block need not comply with UL 1059 if the part complies with the requirements of Wiring Terminals and Leads, 15.3; Live Parts, Section 17;

Electrical Insulation, Section 18; and Spacings, Section 22, of this end product standard; and the applicable performance requirements when tested in the end product. This exception does not apply to protective conductor terminal blocks.

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

6.3 Batteries and battery chargers

6.3.1 A lithium ion (Li-On) single cell battery shall comply with the requirements for secondary lithium cells in UL 1642.

6.3.2 Rechargeable nickel cadmium (Ni-Cad) cells and battery packs shall comply with the applicable construction and performance requirements of this end product standard.

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

6.3.4 Primary batteries (non-rechargeable) that comply with the relevant UL standard and 6.1 are considered to fulfill the requirements of this Standard.

6.3.5 A Class 2 battery charger shall comply with one of the following:

a) UL 1310;

b) UL 60950-1, with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS"; or

c) UL 62368-1, that complies with the limited power source requirements (LPS) requirements and is marked "LPS."

6.3.6 A non-Class 2 battery charger shall comply with one of the following:

a) UL 1012;

b) UL 60950-1; or

c) UL 62368-1.

6.4 Boxes and raceways

6.4.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3, Wiring Methods and Materials, of NFPA 70 and that comply with the relevant UL standard (such as UL 514A, UL 514C, UL 514D) and 6.1 are considered to comply with the requirements of this end product standard.

6.5 Capacitors and filters

6.5.1 The component requirements for a capacitor are not specified. A capacitor complying with UL 810 is considered to comply with the requirements of 24.1.

6.5.2 Electromagnetic interference filters with integral enclosures that comply with one of the following standards are considered to comply with the requirements of 24.1.

a) UL 1283; or

b) UL 60384-14.

6.5.3 Capacitors that comply with UL 60384-14, are considered to comply with the requirements of 24.1.

6.6 Controls

6.6.1 General

6.6.1.1 Auxiliary controls shall be evaluated to the requirements in (a) or (b):

a) Using the applicable requirements of this end product standard and the requirements in Controls – End Product Test Parameters, Section 29; or

b) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.1.2 Operating (regulating) controls shall be evaluated to either the requirements in (a) or (b):

a) Using the applicable component standard requirements specified in 6.6.2 – 6.6.7 and the parameters in Controls – End Product Test Parameters, Section 29, unless otherwise specified in this end product standard; or

b) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.1.3 Operating controls that rely upon software for the normal operation of the end product that manage a Safety Critical Function shall comply with:

a) UL 60730-1, or

b) Using the requirements for UL 60335-1, based requirements, Section 30.

6.6.1.4 Protective Electronic Circuits shall be evaluated to either the requirements in (a) or (b):

a) Using the applicable component standard requirements specified in 6.6.2 – 6.6.7 and if applicable, the parameters in Controls – End Product Test Parameters, Section 29, unless otherwise specified in this end product standard; or

b) Using the requirements for UL 60335-1, based requirements, Section 30.

6.6.1.5 Solid-state Protective Electronic Circuits that do not rely upon software as a protective component shall comply with:

a) UL 60730-1, except for the Controls Using Software requirements; or

b) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.1.6 Solid-state Protective Electronic Circuits that rely upon software as a protective component shall comply with:

a) UL 60730-1; or

b) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.1.7 An electronic, auxiliary or operating control (e.g. a non-protective control) that does not manage a Safety Critical Function, need only be subjected to the applicable requirements of this end product standard.

6.6.2 Electromechanical and electronic controls

6.6.2.1 A control, other than as specified in 6.6.3 – 6.6.7, shall comply with:

a) UL 60730-1; or

b) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.3 Liquid level controls

6.6.3.1 A liquid level control shall comply with:

a) UL 508; or

b) UL 60730-1; and

1) UL 60730-2-15; or

2) UL 60730-2-18; or

c) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.3.2 A switch employed as part of a water level detection mechanism is to comply with one of the switch standards specified in 6.23.

6.6.4 Motor and speed controls

6.6.4.1 A control used to start, stop, regulate or control the speed of a motor shall comply with:

a) UL 508;

b) UL 61800-5-1;

c) UL 60730-1;

d) UL 60947-1, and UL 60947-4-1; or

e) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.5 Pressure controls

6.6.5.1 A pressure control shall comply with one of the following; see also 27.8 and 27.9:

a) UL 508;

b) UL 60730-1; and UL 60730-2-6; or

c) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.6 Temperature controls

6.6.6.1 A temperature control shall comply with:

a) UL 508;

b) UL 60730-1; and UL 60730-2-9; or

c) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.6.6.2 A temperature sensing positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) thermistor, that is part of a circuit that manages a Safety Critical Function shall comply with:

a) UL 60730-1; and UL 60730-2-9, with Annex J; or

b) UL 1434.

6.6.6.3 A thermal cutoff shall comply with UL 60691.

6.6.7 Timer controls

6.6.7.1 A timer control shall comply with:

a) UL 60730-1; and UL 60730-2-7; or

b) Using the requirements for Electronic Circuits Evaluated to UL 60335-1, based requirements, Section 30.

6.7 Cords, cables, and internal wiring

6.7.1 A cord set or power supply cord shall comply with UL 817.

6.7.2 Flexible cords and cables shall comply with UL 62. Flexible cord and cables are considered to fulfill this requirement when preassembled in a cord set or power supply cord complying with UL 817.

6.7.3 Internal wiring composed of insulated conductors shall comply with UL 758.

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

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

b) UL 83;

c) UL 66; or

d) The applicable UL standard(s) for other insulated conductor types specified in Chapter 3, Wiring Methods and Materials, of NFPA 70.

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

6.8 Cooling fan

6.8.1 A cooling (ventilation) fan shall comply with the applicable requirements of UL 507.

Exception: A component type motor-operated fan that is completely enclosed within the end product enclosure that complies with the applicable requirements of this end product standard, is considered to comply with 6.8.1.

6.8.2 Low voltage component fans that comply with UL 507, are considered to fulfill the requirements in Motors, Section 34.

6.9 Film-coated wire (magnet wire)

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

6.9.2 Film coated wire in intimate combination with one or more insulators, and incorporated in an insulation system rated Class 120 (E) or higher, shall comply with the magnet wire requirements in UL 1446.

6.10 Gaskets and seals

6.10.1 Gaskets and seals that comply with the applicable requirements of UL 157, are considered to fulfill the requirements in Seals, Gaskets, and Diaphragms, Section 33.

6.11 Ground-fault, arc-fault, and leakage current detectors/interrupters

6.11.1 Ground-fault circuit-interrupters (GFCI) for protection against electrical shock shall comply with UL 943. The following statement, or equivalent, shall be included as a marking near the GFCI, or as an instruction in the manual: "Press the TEST button (then RESET button) every month to assure proper operation."

6.11.2 Appliance-leakage-current interrupters (ALCI) for protection against electrical shock shall comply with UL 943B. An ALCI is not considered an acceptable substitute for a GFCI when a GFCI is required by NFPA 70.

6.11.3 Equipment ground-fault protective devices shall comply with UL 1053, and the applicable requirements of UL 943.

6.11.4 Arc-fault circuit-interrupters (AFCI) shall comply with UL 1699. See Arc-Fault and Leakage Current Detectors/Interrupters, Section 35.

6.11.5 Leakage-current detector-interrupters (LCDI) and any shielded cord between the LCDI and appliance shall comply with UL 1699. See Arc-Fault and Leakage Current Detectors/Interrupters, Section 35.

6.12 Heaters and heating elements

6.12.1 Electric resistance heating elements shall comply with the construction requirements of:

a) UL 499; or

b) UL 1030.

Exception: Heating wire (e.g. rope heater) that complies with UL 758, and the requirements of this end product standard are considered to fulfill this requirement.

6.12.2 Thermistor-type heaters (e.g. PTC and NTC heaters) shall comply with UL 1434.

6.13 Insulation systems

6.13.1 Materials used in a Class 105 (A) insulation system shall comply with 25.3.

6.13.2 Materials used in an insulation system that operates above Class 105 (A) temperatures shall comply with UL 1446.

6.13.3 All insulation systems employing integral ground insulation shall comply with the requirements specified in UL 1446.

6.14 Light sources and associated components

6.14.1 Lampholders and indicating lamps with integral lamp/lampholder (e.g. neon pilot lamp) shall comply with UL 496.

Exception: Lampholders forming part of a luminaire that complies with the applicable UL luminaire standard are considered to comply with this requirement.

6.14.2 Lighting ballasts shall comply with:

a) UL 935; or

b) UL 1029.

Exception No. 1: Ballasts forming part of a luminaire that complies with the applicable UL luminaire standard are considered to comply with this requirement.

Exception No. 2: Ballasts for other light sources shall comply with the applicable UL standard(s).

6.14.3 Automatic starters for electric discharge lamps shall comply with UL 542. Holders for automatic starters shall comply with UL 496.

6.14.4 Light emitting diode (LED) light sources shall comply with UL 8750.

Exception No. 1: LED light sources forming part of a luminaire that complies with the applicable UL luminaire standard are considered to comply with this requirement.

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

6.15 Marking and labeling systems

6.15.1 A marking and labeling system shall comply with UL 969, under the specified environmental conditions; see 70.2.

6.16 Motors and motor overload protection

6.16.1 General

6.16.1.1 General-purpose type motors having a NEMA frame size shall comply with the requirements specified in 6.16.2. This includes fractional HP motors rated up to 1 HP (typically NEMA frame sizes 42, 48, or 56), and integral HP motors rated 1 HP and greater (typically NEMA frame sizes 140 – 449T).

6.16.1.2 Motors not enclosed, or partially enclosed, by the end product enclosure shall comply with the requirements specified in 6.16.2.

6.16.1.3 Component type motors completely enclosed within the end product enclosure shall comply with the requirements specified in 6.16.2 or 6.16.3.

6.16.1.4 Motors located in a low voltage circuit are evaluated for the risk of fire and personal injury in accordance with the applicable requirements of this end product standard.

6.16.2 General-purpose type motors

6.16.2.1 A general-purpose type motor shall comply with UL 1004-1.

6.16.3 Component type motors

6.16.3.1 Component type motors shall comply with either 6.16.3.2 or 6.16.3.3.

6.16.3.2 The motor shall comply with UL 1004-1, except as noted in Table 6.1.

Table 6.1
Superseded Requirements

UL 1004-1 exempted requirement	Superseded by the requirements in this Standard
Current and Horsepower Relation	Paragraph 34.3.3
Cord-Connected Motors	Section 14
Factory Wiring Terminals and Leads	Section 19
Electrical Insulation	Section 18
Non-Metallic Functional Parts	Sections 8, 18, 34
Solid-State Controls, 7.2	Paragraph 6.6
Non-metallic enclosure thermal aging, 9.1.4	Paragraph 8.8
Motor enclosure, 9.2 – 9.4	Section 8
Grounding	Section 16
Ventilation Openings: only applicable where the openings are on surfaces considered to be the appliance enclosure.	Section 8

Table 6.1 Continued on Next Page

Table 6.1 Continued

UL 1004-1 exempted requirement	Superseded by the requirements in this Standard
Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts	Section 10
Protection Against Corrosion	Section 11
Available fault current ratings for motor start and running capacitors, 26.6: not applicable for cord and plug connected appliances.	Section 24
Switch: not applicable to centrifugal starting switches	Section 28
With the exception of Resilient Elastomer Mounting and Electrolytic Capacitor Tests requirements, the performance tests in UL 1004-1 are not applicable	All applicable performance tests
Only the following marking requirements are applicable: manufacturer's name or identification; rated voltage; rated frequency; number of phases if greater than 1; and multi-speed motors, other than a shaded-pole or a permanent-split-capacitor motor, shall be marked with the amperes and horsepower at each speed.	Paragraph 70.6

6.16.3.3 The motor shall comply with the applicable component requirements for Components, Section 6, the following construction requirements, and the applicable performance requirements (when tested in conjunction with the end product), of this end product standard:

a) Protection Against Corrosion, Section 11;

b) Terminal Compartment, Section 15 (15.2);

c) Grounding, Section 16;

d) Electrical Insulation, Section 18;

e) Internal Wiring, Section 19;

f) Spacings, Section 22;

g) Capacitors, Section 24; and

h) Motors, Section 34.

6.16.4 Motor overload protection

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

a) UL 2111;

b) UL 1004-3; or

c) UL 60730-1; and

1) UL 60730-2-2; or

2) UL 60730-2-22;

in conjunction with UL 1004-3 (to evaluate the motor-protector combination).

6.16.4.2 Impedance protection shall comply with UL 1004-2.

6.16.4.3 Electronic protection integral to the motor shall comply with UL 1004-7.

6.16.4.4 Except as indicated in 6.16.4.3, electronically protected motor circuits shall comply with UL 60730-1. If software is relied upon to perform a safety function, it shall be considered software Class B. See Motor and Speed Controls, 6.6.4, for basic control requirements.

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

6.17 Overcurrent protection

6.17.1 Fuses shall comply with UL 248-1; and the applicable Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable UL standard for fuses are considered to comply with this requirement.

6.17.2 Fuseholders shall comply with UL 4248-1, and the applicable Part 2 (e.g. UL 4248-9).

6.17.3 Circuit breakers shall comply with UL 489.

Exception: Circuit breakers used in telecommunications circuitry that comply with UL 489A, need not comply with UL 489.

6.17.4 Circuit breakers having integral ground fault circuit interrupter capability for protection against electrical shock shall additionally comply with UL 943.

6.17.5 Supplementary protectors shall comply with UL 1077.

6.17.6 Fusing resistors shall comply with UL 1412.

6.18 Polymeric materials

6.18.1 Unless otherwise specified in this end product standard, polymeric electrical insulating materials and enclosures shall comply with the applicable requirements of UL 746C.

6.18.2 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements of UL 746C. This requirement is not applicable to exterior surfaces of polymeric enclosure materials or parts provided that the metallized coating or paint does not offer a continuous path for an internal flame to propagate externally.

6.19 Power supplies

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

a) UL 1310;

b) UL 60950-1, with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS";

c) UL 61010-1, with NEC Class 2 output (output category 2); or

d) UL 62368-1, that complies with the limited power source requirements (LPS) requirements and is marked "LPS."

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

a) UL 1012;

b) UL 60950-1;

c) UL 61010-1, with NEC Class 1 output (output category 1); or

d) UL 62368-1.

6.20 Printed wiring boards

6.20.1 Printed wiring boards, including the coatings, shall comply with UL 796; see 18.6.

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

6.20.2 A printed-wiring board containing circuitry in a line-connected circuit or a safety circuit shall comply with the direct-support requirements for insulating materials in UL 746C.

6.20.3 Unless otherwise specified, the flammability class and temperature rating shall be that specified for insulating materials in UL 746C.

6.21 Semiconductors and small electrical and electronic components

6.21.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with UL 1557. If considered necessary, the dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of Dielectric Voltage-Withstand Test, Section 46.

6.21.2 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this end product standard shall comply with UL 1577. If considered necessary, the dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of Dielectric Voltage-Withstand Test, Section 46. The dielectric test voltage is to be applied between the input and output terminals of the optical isolator.

6.21.3 Surge protective devices are to comply with UL 1449, and be a type suitable for the end-use application.

6.21.4 Except as specified in 6.21.5, component requirements are not specified for small electronic components on printed wiring boards, including diodes, transistors, resistors, inductors, integrated circuits, and capacitors not directly connected to the supply source.

6.21.5 Where an electronic component is determined to be a critical component during the Component Breakdown Test specified in 47.2, UL 60730-1, shall be applied. See 29.4 for the test parameters to be used.

6.21.6 A critical component is a component that performs one or more safety-related functions whose failure results in a condition, such as the risk of fire, electric shock, or injury to persons, in the end product application.

6.21.7 Portions of a circuit comprised of a microcontroller or other programmable device that performs a back-up, limiting, or other safety function intended to reduce the risk of fire, electric shock, or injury to persons shall comply with UL 60730-1, Annex H.

6.22 Supplemental insulation, insulating bushings, and assembly aids

6.22.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill 19.14 or a performance requirement of this Standard. In such cases:

a) Insulating tape shall comply with UL 510;

b) Sleeving shall comply with UL 1441; or

c) Tubing shall comply with UL 224.

6.22.2 Wire positioning devices shall comply with Electrical Insulation, Section 18, and Separation of Circuits, Section 21. A device that complies with UL 1565, is considered to fulfill this requirement.

6.22.3 Insulating bushings that comply with 6.1 and UL 635 are considered to fulfill the requirements of this Standard. Tests specified in this Standard (e.g. Strain Relief Test) may still need to be performed to confirm the combination of the insulating bushing and the supporting part are suitable.

6.23 Switches

6.23.1 Switches shall comply with one of the following, as applicable:

a) UL 61058-1;

b) UL 20; or

c) UL 773A.

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

6.23.2 A clock-operated switch, in which the switching contacts are actuated by a clock-work, by a gear-train, by electrically-wound spring motors, by electric clock-type motors, or by equivalent arrangements shall comply with UL 60730-1 and UL 60730-2-7.

6.23.3 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, shall comply with the requirements for an operating control with Type 1 action for 6,000 cycles of operation, or as a manual control for 5,000 cycles of operation, in accordance with UL 60730-1, and UL 60730-2-7.

6.23.4 A timer or time switch, incorporating electronic timing circuits or switching circuits, with or without separable contacts, that functions as a protective control, shall comply with the requirements for a protective control; see 6.6.1.3.

6.24 Transformers

6.24.1 General-purpose transformers shall comply with UL 5085-1; and UL 5085-2.

Exception: A transformer that complies with UL 1411, and that is used in a circuit involving an audio or video component complies with the intent of this requirement.

6.24.2 Class 2 and Class 3 transformers shall comply with UL 5085-1; and UL 5085-3.

Exception: Transformers located in a low voltage circuit that do not involve a risk of fire or personal injury need not comply with this requirement.

6.25 Valves (electrically operated) and solenoids

6.25.1 Electrically operated valves shall comply with the:

a) UL 429; or

b) UL 60730-1; and UL 60730-2-8.

Exception: Automatic valves intended for use with natural gas, manufactured gas, LP-gas or LP-gas-air mixtures shall comply with the Standard for Automatic Valves for Gas Appliances, ANSI Z21.21a/CSA 6.6.

6.25.2 Solenoids shall comply with the applicable construction and performance requirements of this end product standard, or with the Outline of Investigation for Solenoids, UL 906.

6.26 Water pumps

6.26.1 A motor-operated water pump shall comply with the following UL 778.

Exception: A component type motor-operated pump that is completely enclosed within the end product enclosure that complies with the applicable requirements of this end product standard, is considered to comply with 6.26.1.

6.27 Power-switching semiconductors (mounted to accessible metal parts)

6.27.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with UL 1557. It shall have a minimum isolation voltage of 1500 V.

6.28 Thermistors

6.28.1 Thermistors shall comply with UL 1434. The thermistors shall be suitable for the application at the specified electrical and thermal ratings.

7 General

7.1 An appliance shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

7.2 An appliance shall be acceptable for both indoor and outdoor use unless marked for restricted use in accordance with 70.8.

7.3 A waste connection or drain outlet of appliances connected to a potable water system shall be designed and constructed to provide for connection to the sanitary waste system through an air gap of 2 pipe diameters or 1 inch (25.4 mm), whichever is larger.

7.4 A low voltage circuit shall be judged under the requirements for primary circuits in this Standard unless the transformer or power supply that supplies the circuit complies with 31.1 or 31.3.

8 Frame and Enclosure

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

8.2 An edge, projection, or corner of an enclosure, opening, frame, guard, knob, handle, or similar part, of an appliance shall be smooth and rounded and not sufficiently sharp to cause a cut-type injury when contacted during normal use or maintenance.

8.3 A door or cover of an enclosure shall be provided with a means for securing the door or cover in place in the closed position.

8.4 A device, such as a lampholder, fuseholder, or circuit breaker, of the replaceable type shall be designed and installed so that persons servicing the lamps, fuses, circuit breakers, or other devices will not unintentionally contact any uninsulated live part other than a screwshell or the clips of a fuseholder.

8.5 The enclosure of an appliance shall be complete. The enclosure shall not depend on adjacent walls or equipment to complete the enclosure.

8.6 Mounting holes shall be located or guarded so that nails or similar hangers shall not come in contact with any bare, covered, or uninsulated live part.

8.7 Among the factors to be considered when determining the acceptability of an enclosure are:

a) Physical strength;

b) Resistance to impact;

c) Moisture-absorptive properties;

d) Flammability;

e) Resistance to corrosion;

f) Resistance to distortion at temperatures to which the enclosure is subjected under conditions of intended use;

g) For a sheet-metal enclosure, in addition to the factors in (a) – (f), the size and shape of the metal, the thickness of the metal, and the conditions of intended use;

h) For a nonmetallic enclosure exposed to an ultraviolet radiation weathering source, resistance to degradation from exposure to ultraviolet radiation; and

i) For a nonmetallic enclosure, all of the factors are to be considered with respect to thermal aging.

8.8 A polymeric enclosures shall comply with UL 746C. When determining compliance with UL 746C, the polymeric (including epoxy potting compounds) enclosure shall comply with the following:

a) Material Properties – The material shall comply with the “Material property considerations” in Table 8.1 of UL 746C.

b) Impact Test – A minimum impact of 5 foott-lbf (6.8 J) shall apply to all enclosure materials. In addition to the test requirements specified in UL 746C, any cracking of a polymeric material that

would be exposed to water is considered unacceptable. All other parts constructed of materials that do not comply with the enclosure requirements shall be removed during this test.

c) Abnormal Operations – See Abnormal Operation Tests, Section 47.

d) Mold-Stress Relief Distortion – In addition to the test requirements specified in UL 746C, any cracking of a polymeric material that would be exposed to water is considered unacceptable. All other parts constructed of materials that do not comply with the enclosure requirements shall be removed during this test.

e) Strain Relief – This test is only required if the strain relief means is secured to the enclosure or is an integral part of the polymeric enclosure.

f) UV Resistance – To determine if a non-metallic material is capable of withstanding UV radiation, the material shall be subjected to one of the following tests:

a) For materials exposed to UV-A or UV-B radiation (e.g., outdoor use), the materials shall be subjected to the UL 746C, Ultraviolet Light Exposure Test; or

b) For materials exposed to UV-C radiation, the materials shall be subjected to the tests of IEC 60335-1, Annex T.

This testing is not required if the material recognition included UL 746C UV Exposure testing for materials exposed to UV-A or UV-B radiation, or IEC 60335-1 Annex T exposure testing for materials exposed to UV-C radiation.

g) Flammability – Minimum flammability rating of polymeric enclosures shall be 5VA, 5VB, V-0, V-1, V-2 for portable appliances and 5VA for all other appliances.

h) Water Exposure and Immersion – Polymeric materials shall comply with UL 746C.

i) Dimensional Stability – Polymeric materials shall comply with UL 746C.

j) Conduit Connections – Products permanently connected electrically shall comply with the requirements in UL 746C.

8.9 The polymeric housing of a component is not considered to be an appliance enclosure unless this part is the sole insulation (excluding air) between a live part and an external surface of the appliance.

8.10 Industrial control panel enclosures shall comply with the requirements for enclosed panels in UL 508A.

8.11 Cast- and sheet-metal portions of the enclosure shall not be thinner than indicated in Table 8.1.

Table 8.1
Minimum Thicknesses of Metal Enclosure Material

Metal	At small, flat, unreinforced surfaces and at surfaces that are reinforced by curving, ribbing and similar methods or are otherwise of a shape and size or size to provide physical strength		At surfaces to which a wiring system is to be connected in the field		At relatively large unreinforced flat surfaces	
	Inch	(mm)	Inch	(mm)	Inch	(mm)
Die-cast	3/64	–	1.2	–	5/64	(2.0)
Cast malleable Iron	1/16	–	1.6	–	3/32	(2.4)
Other cast metal	3/32	(2.4)	–	–	1/8	(3.2)
Uncoated sheet steel	0.026[a]	(0.66)[a]	0.032	(0.81)	0.026	(0.66)
Galvanized sheet steel	0.029[a]	(0.74)[a]	0.034	(0.86)	0.029	(0.74)
Nonferrous sheet metal	0.036[a]	(0.91)[a]	0.045	(1.14)	0.036	(0.91)

[a] Thinner sheet metal may be employed if found to be acceptable when the enclosure is curved, ribbed, or otherwise reinforced, or if the shape or size, or both, of the surface is such that the necessary mechanical strength is provided.

8.12 The enclosure of a remotely or automatically controlled appliance shall reduce the risk of molten metal, burning insulation, flaming particles, or the like from falling on combustible materials, including the surface upon which the appliance is supported.

8.13 The requirement in 8.12 will necessitate that a switch, a relay, a solenoid, or the like be individually and completely enclosed, except for terminals, unless it can be shown that malfunction of the component would not result in a risk of fire, or there are no openings in the bottom of the appliance enclosure. It will also necessitate the use of a barrier of noncombustible material:

a) Under a motor unless:

1) The structural parts of the motor or of the appliance provide the equivalent of such a barrier;

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

i) Open main winding;

ii) Open starting winding;

iii) Starting switch short-circuited; and

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

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

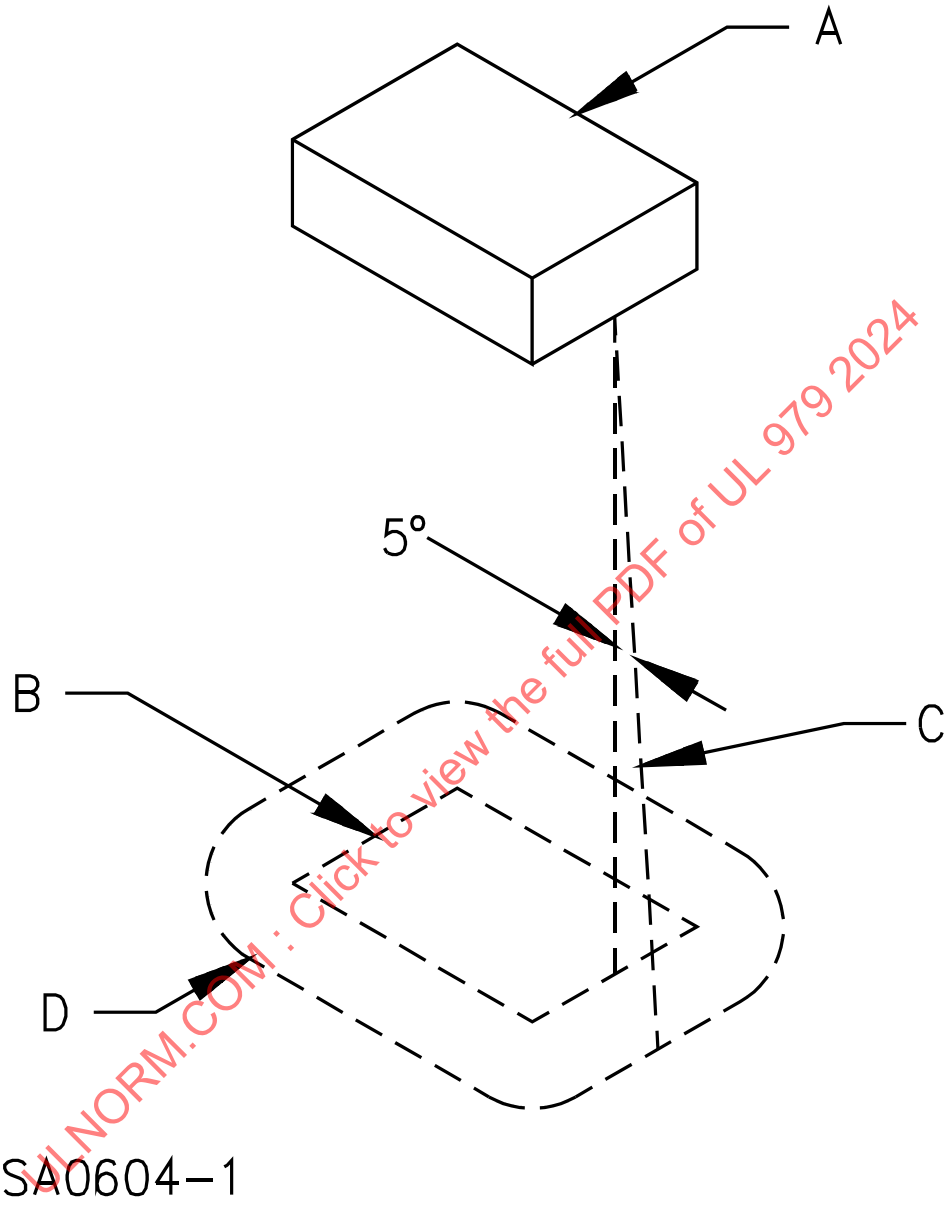
4) The motor complies with the requirements in one of the standards specified in 6.16.4, and the temperature of the motor winding will not exceed 150 °C during the first 72 hours of operation with the rotor of the motor locked.

b) Under wiring, unless the wiring complies with the VW-1 (Vertical-Specimen) Flame Test in UL 1581.

8.14 The barrier mentioned in 8.13 shall be horizontal, shall be located as illustrated in Figure 8.1, and shall not have an area less than that described in that illustration. Openings for drainage, ventilation, and similar purposes may be employed in the barrier, if such openings would not permit molten metal, burning insulation, or similar material to fall on combustible material.

Figure 8.1

Location and Extent of Barrier



NOTES:

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

B – Projection of outline of component on horizontal plane.

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

1) Tangent to the component;

2) 5° from the vertical; and

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

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

9 Button Batteries or Coin Cell Batteries

9.1 The battery compartment of an appliance or any accessory, such as a wireless control, incorporating one or more button batteries or coin cell batteries shall comply with UL 4200A, if the appliance or any accessory:

a) Is intended for use with one or more single cell batteries having a diameter of 32 mm (1.25 inch) maximum with a diameter greater than its height; and

b) The appliance is intended for consumer use.

Exception: These requirements apply to consumer products containing button batteries or coin cells batteries. They do not apply to products that by virtue of their dedicated purpose and instructions are not intended to be used in locations where they may be accessed by children, such as products for dedicated professional use or commercial use in locations where children are not normally or typically present.

10 Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts

10.1 To reduce the risk of unintentional contact that involves 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:

a) For an opening that has a minor dimension as described in 10.5 of less than 1 inch (25.4 mm), an uninsulated live part, a moving part, or film-coated wire shall not be contacted by the probe illustrated in Figure 10.1; or

b) For an opening that has a minor dimension as described in 10.5 of 1 in or more, an uninsulated live part, a moving part, or film-coated wire shall be spaced from the opening as specified in Table 10.1.

Exception: An opening in a motor need not comply with these requirements if it complies with the requirements in 10.2.

Figure 10.1

Articulate Probe with Web Stop

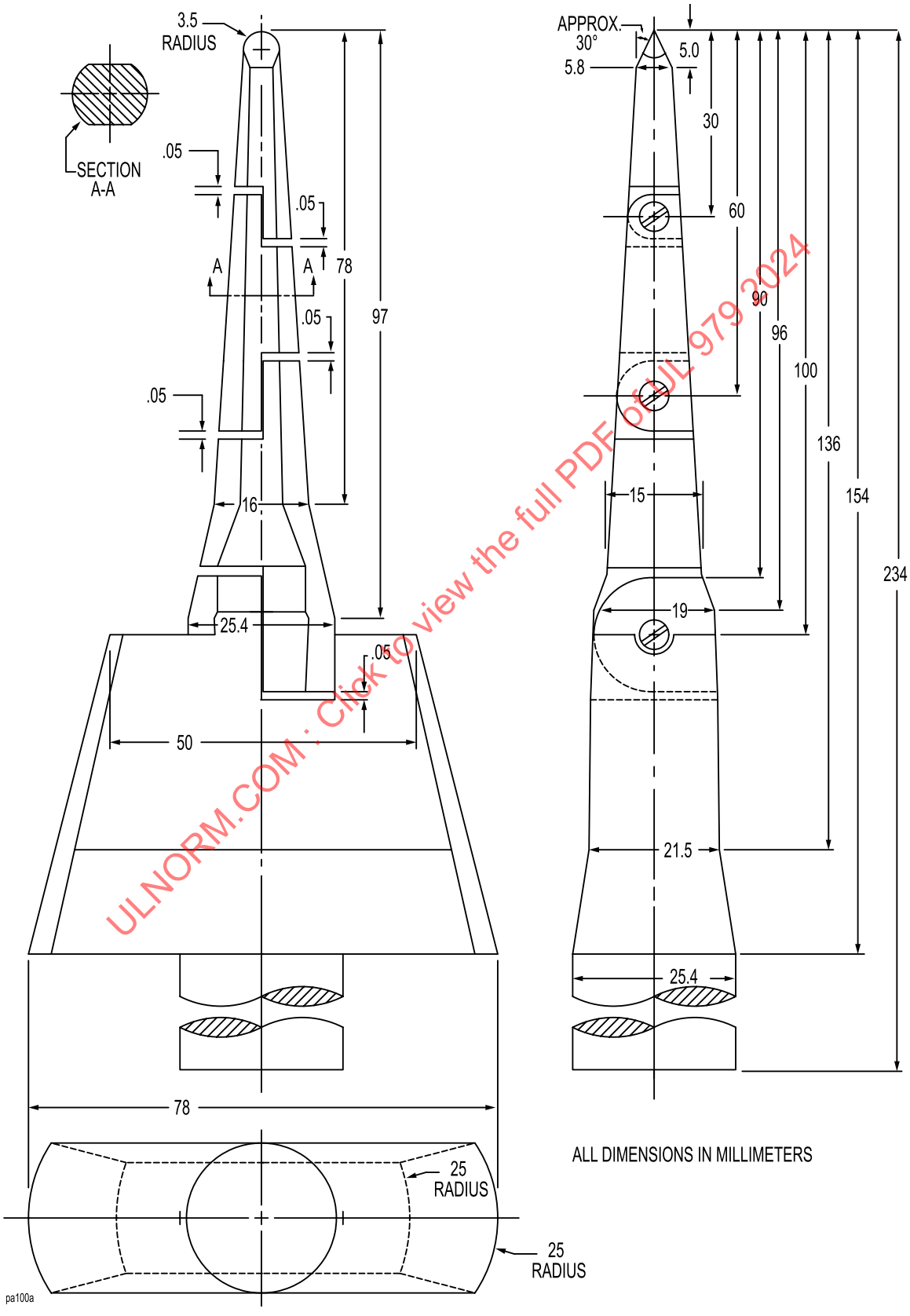


Table 10.1
Minimum Distance from an Opening to a Part Involving a Risk of Electric Shock or Injury to Persons

Minor dimension[a] of opening		Minimum distance from opening to part	
Inch	(mm)[b]	Inch	(mm)[b]
3/4[c]	(19.1)	4-1/2	(114.0)
1[c]	(25.4)	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(191.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(445.0)
d		30	(762.0)

[a] See 8.5 for a description of the minor dimension of an opening.

[b] Between 3/4 inch (19.1 mm) and 2-1/8 inch, (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 (25.4 mm) applies to a motor only.

[d] More than 2-1/8 inch, (54.0 mm) but no more than 6 inch (152 mm).

10.2 With respect to a moving part or film-coated wire within the enclosure of a motor as specified in the Exception to 10.1:

a) An opening that has a minor dimension, as described in 10.5, of less than 3/4 inch (19.1 mm) is acceptable if:

1) In an indirectly accessible motor, an uninsulated live part or a moving part cannot be contacted by the probe illustrated in Figure 10.2;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 10.3; and

3) In a directly accessible motor, an uninsulated live part or a moving part cannot be contacted by the probe illustrated in Figure 10.4.

b) An opening that has a minor dimension of 3/4 in or more is acceptable if an uninsulated live part, a moving part, or film-coated wire is spaced from the opening as specified in Table 10.1.

Figure 10.2

Probe for Moving and Uninsulated Live Parts

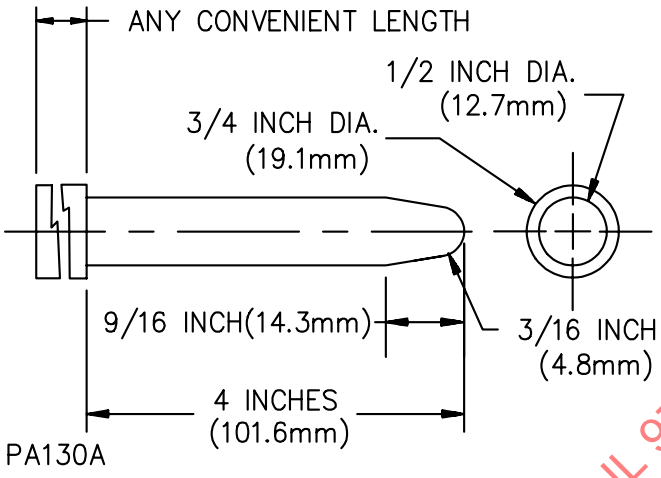


Figure 10.3

Probe for Film-Coated Wire

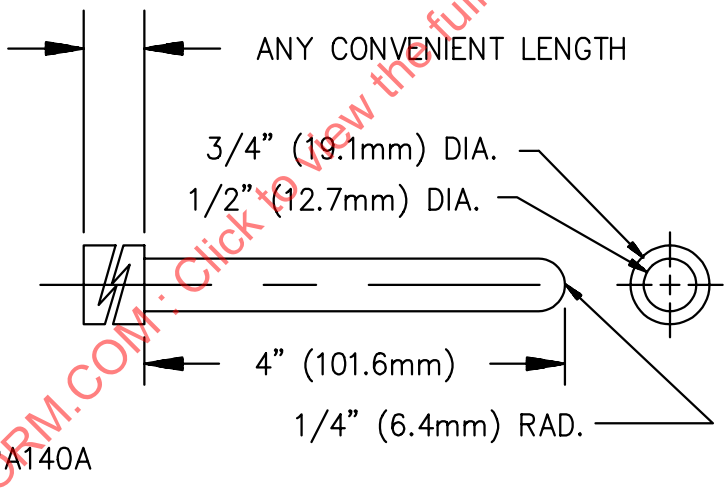
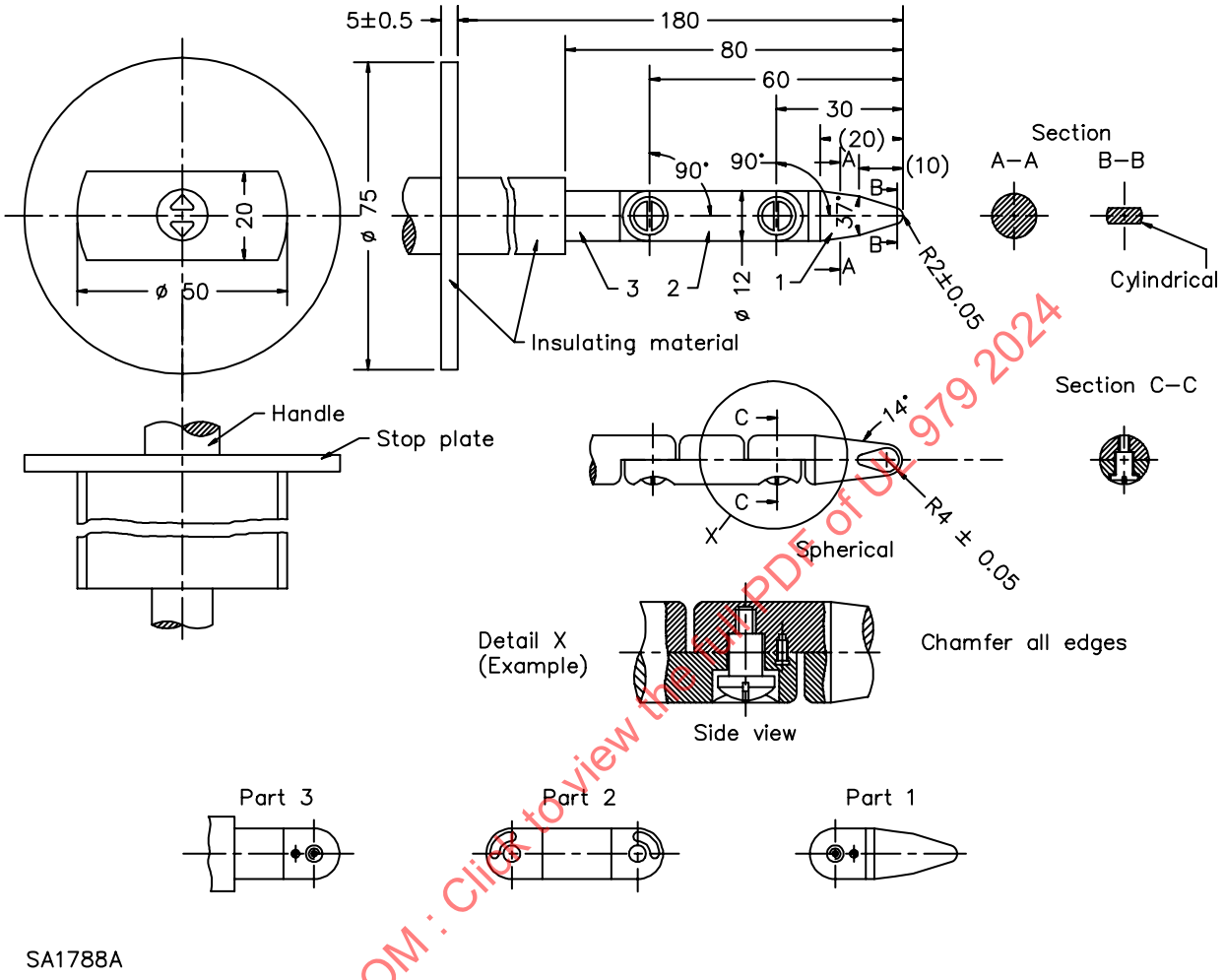


Figure 10.4

Articulated Probe



10.3 The probes specified in 10.1 and 10.2 and illustrated in Figure 10.1 – Figure 10.4 shall be applied to any depth that the opening will permit, and shall 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 10.1 and Figure 10.4 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

10.4 The probes illustrated in Figure 10.1 – Figure 10.4 shall be used as measuring instruments to determine the accessibility provided by an opening, and not as instruments to determine the strength of a material; they shall be applied with the minimum force necessary to determine accessibility.

10.5 With reference to 10.1 and 10.2, 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.

10.6 During the examination of an appliance to determine compliance with 10.1 or 10.2, a part of the enclosure that can 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.

10.7 A moving part shall be enclosed or guarded to reduce the risk of injury to persons.

10.8 With reference to 10.7, the degree of protection required of the enclosure depends upon the general design and intended use of the appliance. The factors to be taken into consideration in determining the acceptability of an exposed moving part are:

a) The degree of exposure;

b) The sharpness of the moving part;

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

d) The speed of movement of the part; and

e) The risk of fingers, arms, or clothing being drawn into the moving part.

10.9 A component that requires inspection, replacement, cleaning, or other servicing shall be accessible. Excluding the lamp compartment, such a component shall be readily accessible without the use of tools not available to other than service personnel, if the component is intended to be manually operated, manually adjusted, or periodically serviced.

10.10 A cord-connected appliance that is provided with keyhole slots, notches, hanger holes, or similar openings, for mounting the appliance on a wall, shall be constructed so that the mounting means is not accessible without removing the appliance from the supporting means.

10.11 When determining compliance with 10.10, any part of the enclosure or barrier that can be removed without the use of tools to gain access to the mounting means are to be removed.

11 Protection Against Corrosion

11.1 An iron or steel part shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means, if the failure of the part results in a risk of fire, electric shock, or injury to persons.

Exception: This requirement does not apply to bearings, laminations, or to minor parts of iron or steel (such as washers, screws, and similar parts).

11.2 A sheet-steel cabinet or an electrical enclosure intended for outdoor use shall be protected against corrosion by the means specified in Table 11.1 or by other metallic or nonmetallic coatings that have been shown to provide equivalent resistance.

Exception: This requirement does not apply to enclosures that comply with outdoor use requirements in UL 50.

Table 11.1
References for Requirements for Protection Against Corrosion

Type of cabinet or enclosure	Minimum thickness of steel	
	0.056 inch (1.42 mm) and thicker	Less than 0.056 inch (1.42 mm) thick
Outer cabinet that protects a motor, wiring, or encloses current-carrying parts	11.3	11.4
Inside enclosure that protects current-carrying parts other than a motor	11.3	11.4
Outer cabinet that is the sole enclosure of current-carrying parts	11.4	11.4

11.3 With reference to Table 11.1, as applicable, one of the following coatings shall be used:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G60 or A60 in ASTM A 653/A 653M, with no less than 40 % of the zinc on any one side, based on the minimum single-spot test requirement in this designation. The weight of the coating shall be established in accordance with ASTM A90, or by any method that has been determined to be similar. An A60 (alloyed) coating shall also comply with 11.6.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of no less than 0.00041 inch (0.0104 mm) on each surface, with a minimum thickness of 0.00034 inch (0.0086 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 57. An annealed coating shall also comply with 11.6.

c) Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on each surface. The acceptability of the paint is to be determined by consideration of the composition or, when required, by the corrosion tests specified in 11.5.

d) A single coat of an organic finish of the epoxy or alkyd-resin type over phosphate- or oxide-treated steel in a form that has been shown to be equivalent to mill-galvanized steel as noted in (a).

11.4 With reference to Table 11.1, as applicable, one of the following coatings shall be used:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in ASTM A 653/A 653M, with no less than 40 % of the zinc on any side, based on the minimum single-spot-test requirement in this designation. The weight of the zinc coating shall be established in accordance with ASTM A90, or by any method that has been determined to be similar.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of no less than 0.00061 inch (0.01549 mm) on each surface with a minimum thickness of 0.00054 inch (0.01372 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 57. An annealed coating shall also comply with 11.6.

c) A cadmium coating no less than 0.001 inch (0.0254 mm) thick on both surfaces. The thickness of the coating shall be established in accordance with the Metallic Coating Thickness Test, Section 57.

d) A zinc coating that complies with 11.3 (a) or (b), with one coat of outdoor paint as specified in 11.3(c) on each surface.

e) A cadmium coating no less than 0.00075 inch (0.01905 mm) thick on both surfaces, with one coat of outdoor paint on both surfaces, or no less than 0.0005 inch (0.0127 mm) thick on both surfaces, with two coats of outdoor paint on each surface. The thickness of the cadmium coating shall be established in accordance with the Metallic Coating Thickness Test, Section 57, and the paint shall be as specified in 11.3(c).

11.5 With reference to Table 11.1 and Table 11.2, other finishes, including paints, metallic finishes, and combinations of the two may be acceptable when comparative tests with galvanized sheet steel (without annealing, wiping, or other surface treatment) that are in compliance with 11.3(a) or 11.4(a) indicate that they provide equivalent resistance. Among the factors considered when evaluating the acceptability of such coating systems are exposure to salt spray, moist carbon dioxide-sulfur dioxide-air mixtures, moist hydrogen sulfide-air mixtures, ultraviolet light, and water.

Table 11.2
Aluminum Alloys

Sand-cast	Permanent-mold cast	Die-cast	Machined-bar and rod stock
319.0	319.0	360.0	5052
356.0	356.0	A360.0	5056
443.0	A356.0	413.0	5456
B443.	443.0	A413.0	6061
514.0	B443.0	C443.0	6063
B514.0	B514.0	518.0	
520.0	535.0		
535.0			
A712.0			

11.6 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 additionally painted in the bent or formed area when the bending or forming process damages the zinc coating. An area on the inside surface of a cabinet or enclosure that water does not enter during the rain test is not required to be painted.

11.7 When flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is considered to be damaged. Simple sheared or cut edges and punched holes are not considered to be formed, but extruded and rolled edges and holes shall comply with the requirement in 11.6.

11.8 A nonferrous cabinet and enclosure may be used without coatings for protection against corrosion. The use of dissimilar metals in contact with each other where corrosion could produce openings is not acceptable.

11.9 Painting alone is not acceptable for protecting sheet metal against corrosion. Copper, stainless steel and other materials having inherent resistance to atmospheric corrosion need not be additionally painted.

12 Exposure to Water

12.1 An appliance shall prevent water from coming into contact with insulated or uninsulated live parts. A water handling part shall be constructed of materials suitable for the application and shall have the strength to resist the uses and abuses to which it is liable to be subjected.

12.2 An appliance incorporating a brine tank and electrical controls in a common housing shall have an overflow drain in the housing. The overflow drain shall not have a valve.

12.3 An appliance having electrodes placed in water shall be constructed so that power is supplied to the electrodes by a transformer or solid-state circuitry so that the secondary is isolated from the primary circuit.

13 Mechanical Assembly

13.1 An appliance shall not be adversely affected by the vibration of normal operation.

13.2 A switch, fuseholder, lampholder, receptacle, plug connector, or other component that is handled by the user shall be mounted securely, and shall be prevented form turning.

Exception No. 1: The requirement that a switch be prevented from turning does not apply to a switch that is normally operated by mechanical means rather than by direct contact if all three of the following conditions are met:

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

b) The means for mounting makes it unlikely that operation can loosen the switch.

c) The spacings cannot be reduced below the minimum acceptable values if the switch does rotate.

Exception No. 2: A lampholder of a type where the lamp cannot be replaced (such as a neon pilot or indicator light in which the lamp is sealed in by a nonremovable jewel) need not be prevented from turning if rotation cannot reduce spacings below the minimum specified in Spacings, Section 22.

14 Supply Connections – Cord Connected Appliances

14.1 General

14.1.1 A cord-connected appliance shall be provided with a length of flexible cord and an attachment plug for connection to the branch-circuit supply.

Exception: A submersible appliance intended for connection to an underwater junction box is not required to have an attachment plug.

14.1.2 A cord-connected appliance shall be provided with a cord not less than 6 feet (1.8 m) in length and have an equipment-grounding conductor and a grounding type attachment plug cap. The equipment-grounding conductor shall be finished to show a green color with or without one or more yellow stripes. The length of an attached flexible cord includes the attachment plug. The length of a cord set includes the fittings.

14.1.3 For a portable, household, counter-top, appliance, the flexible cord:

a) Shall be Type S, SE, SJ, SJE, SJEO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, SP-2, SPE-2, SPT-2, ST, STO, or STOO; and

b) Shall include an equipment-grounding conductor.

14.1.4 For other than a portable, household, counter-top, appliance, the cord:

a) Shall be Type S, SE, SJ, SJE, SJEO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, or STOO;

b) Shall include the suffix "W" following the cord type, unless the appliance is marked for indoor use only; and

c) Include an equipment-grounding conductor.

14.1.5 A power-supply cord shall be rated for use at a voltage not less than the rated voltage of the appliance and shall not have an ampacity, as given for the type in NFPA 70, lower than the current rating of the appliance.

14.1.6 The attachment-plug for connection to the branch-circuit supply shall have an American National Standard pin configuration and American National Standard ratings. It shall be of a type suitable for use:

a) With a current not less than 125 % of the rated current of the appliance; and

Exception: The current rating of the attachment plug shall not be less than the current rating of the appliance when the appliance is intended for non-continuous use (intermittent use) operation. Continuous operation is defined as 3 or more hours of continuous use.

b) At a voltage equal to the rated voltage of the appliance. If the appliance can be adapted for use on two or more different supply voltages by field alteration of internal connections, the attachment plug provided with the appliance shall be rated for the voltage for which the appliance is connected when it is shipped from the factory. See 70.14.

14.1.7 A household appliance intended for use with a detachable cord set shall not be provided with terminal pins that will accommodate a standard flatiron or appliance plug.

14.1.8 A three-wire to two-wire, grounding-type adapter shall not be provided with an appliance.

14.1.9 If an appliance incorporates a removable cord set, the arrangement shall not expose live part under normal conditions.

14.2 Strain relief

14.2.1 Strain relief shall be provided so that mechanical stress on a flexible cord is not transmitted to terminals, splices, or wiring within the appliance.

14.2.2 A metal strain-relief clamp or band used with Type SP-2 or SPE-2 cord shall be provided with auxiliary insulation over the cord for mechanical protection.

14.2.3 A clamp of any material – metal or otherwise – is not acceptable for use on Type SPT-2 cord.

Exception No. 1: The construction may be acceptable if the cord is protected by varnished-cloth tubing or the equivalent under the clamp.

Exception No. 2: A clamp may be used if it has been investigated and found to be acceptable.

14.2.4 For cord Types S, SO, ST, STO, SJ, SJT, or SJTO, a clamp may be employed and the auxiliary insulation is not required unless it is determined that the clamp can damage the cord insulation.

14.2.5 Means shall be provided to prevent an attached flexible cord from being pushed into the enclosure of the appliance through the cord-entry hole when such displacement results in:

a) Subjecting the cord to mechanical damage;

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.

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

14.2.6 If a knot in a flexible cord serves as strain relief, the surfaces that the knot can contact shall be free from projections, sharp edges, burrs, fins, and similar features that can cause abrasion of the insulation on the conductors.

14.3 Bushings

14.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that is reliably secured in place, and has a smooth, rounded surface against which the cord can bear. A cord hole in wood, porcelain, phenolic composition, or other nonconducting material having a smooth, rounded surface is considered to be equivalent to a bushing.

14.3.2 An insulating bushing shall be provided if:

a) Type SPT-2 cord is employed;

b) The wall or barrier is of metal; or

c) The construction is such that the cord might be subjected to strain or motion.

Exception: An insulated metal grommet having insulating material that is not less than 1/32 inch (0.8 mm) thick and fills completely the space between the grommet and the metal in which it is mounted may be used instead of an insulating bushing.

14.3.3 Ceramic materials and some molded compositions are generally acceptable for insulating bushings.

14.3.4 A separate bushing shall not be made of wood or of hot-molded shellac-and-tar compositions.

14.3.5 A vulcanized fiber bushing shall not be less than 3/64 inch (1.2 mm) thick and shall be formed and secured in place so that the bushing is not adversely affected by moisture.

14.3.6 A separate soft-rubber, neoprene, or polyvinyl chloride bushing shall not be employed in an appliance.

Exception No. 1: A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be employed in the frame of a motor or in the enclosure of a capacitor attached to a motor if the bushing is:

a) Not less than 3/64 inch (1.2 mm) thick; and

b) Located so that the bushing will not be exposed to oil, grease, oily vapor, or other substances having a deleterious effect on the compound employed.

Exception No. 2: A bushing of soft-rubber, neoprene, or polyvinyl chloride may be employed at any point in an appliance if used in conjunction with a type of cord for which an insulating bushing is not required. If a bushing of one of these materials is used anywhere in the appliance, the edges of the hole in which the bushing is mounted shall be smooth and free from burrs, fins, or similar features.

14.3.7 At any point in an appliance, a bushing of the same material as, and molded integrally with, the supply cord is acceptable on a Type SPT-2 or harder-service cord if the built-up section is not less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

15 Supply Connections – Permanently-Connected Appliances

15.1 General

15.1.1 Other than noted in 14.1.3 and 14.1.4, an appliance intended for permanent connection to the power supply shall have provision for connection of one of the wiring systems that would be acceptable for the appliance.

15.2 Terminal compartment

15.2.1 A terminal box or compartment in which power-supply connections to a permanently connected appliance are to be made shall be located so that the connections can be readily inspected after the appliance is installed as intended.

15.2.2 A terminal compartment intended for connection of a supply raceway shall be attached to the appliance so as to be prevented from turning.

15.2.3 If it is intended that supply connections be made directly to a motor, the terminal compartment on the motor shall comply with the requirements for terminal compartments in UL 1004-1.

15.3 Wiring terminals and leads

15.3.1 A permanently-connected appliance shall be provided with wiring terminals for the connection of conductors having a current rating acceptable for the appliance; or the appliance shall be provided with leads for such connection.

15.3.2 Wiring terminals for the supply conductors shall be provided with a pressure wire connector securely fastened in place – for example, firmly bolted or held by a screw.

Exception: A No. 10 (4.8 mm diameter) or larger wire-binding screw or stud-and-nut combination may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in place.

15.3.3 A wiring terminal shall be prevented from turning.

15.3.4 The free length of a lead inside an outlet box or wiring compartment shall be 6 inch (150 mm) or more if the lead is intended for field connection to an external circuit.

15.3.5 A wire-binding screw or stud-and-nut combination at a wiring terminal shall not be smaller than No. 10 (4.8 mm diameter).

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

Exception No. 2: A No. 6 (3.5 mm diameter) screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) conductor in a low-voltage circuit.

15.3.6 A wire-binding screw shall thread into metal.

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

Exception: An alloy plate may be not less than 0.030 inch (0.76 mm) thick if the tapped threads have the necessary mechanical strength.

15.3.8 A terminal plate formed from stock having the thickness specified in 15.3.7 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

15.3.9 Upturned lugs or a cupped washer shall be capable of retaining a 14 AWG (2.1 mm^2) supply conductor under the head of the screw or washer.

15.4 Identified terminals and leads

15.4.1 A permanently-connected appliance rated 125 V or 125/250 V, 3-wire, or less and employing a lampholder of the Edison-base screwshell type, or a single-pole switch or overcurrent protective device other than an automatic control without a marked off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit.

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

15.4.3 A lead intended for the connection of a grounded power-supply conductor shall be finished white or gray color and shall be readily distinguishable from the other leads.

16 Grounding

16.1 General

16.1.1 An appliance shall be provided with grounding means as described in 16.1.2 – 16.1.8.

Exception: An appliance protected by a system of double insulation in accordance with UL 1097, shall not be provided with a means for grounding.

16.1.2 When a grounding means is supplied, whether required or not, it shall be in accordance with 16.1.3 and, when the appliance is cord-connected, shall comply with the requirements in 16.1.4. All dead-metal parts that are likely to become energized shall be reliably connected to the means for grounding.

16.1.3 The following may be used as means for grounding:

a) In an appliance intended to be permanently connected, an equipment-grounding terminal or lead.

b) In a cord-connected appliance, an equipment-grounding conductor in the cord.

16.1.4 The grounding conductor of a supply cord shall be secured to the frame or enclosure of the appliance by means of a screw that is not likely to be removed during any servicing operation not involving the power-supply cord, or by another means that has been determined to be equivalent. The screw shall be of a corrosion-resistant material or made resistant to corrosion by a means that will not inhibit electrical conductivity between the screw and any other conductor. A lock washer shall be employed so that the screw is not subject to loosening if vibration is likely. Solder alone shall not be used for securing the grounding conductor.

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

Exception: Interlocked plugs, receptacles, and connectors that are not energized when the equipment-grounding connection is made or broken is not required to comply with this requirement.

16.1.6 If an appliance is supplied with a means for separate connection to more than one power supply, each such connection shall be supplied with a means for grounding.

16.1.7 A terminal solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the application.

16.1.8 A small metal part such as an adhesive attached foil marking, a screw other than the equipment-grounding screw, a handle or similar part that is on the exterior of the enclosure and separated from all electrical components is not considered likely to become energized, and is not required to comply with 16.1.1.

16.2 Identification

16.2.1 The surface of the insulation of a grounding conductor of a flexible cord or a 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.

16.2.2 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.

16.2.3 A pressure wire connector intended for connection of an equipment-grounding conductor shall be identified by:

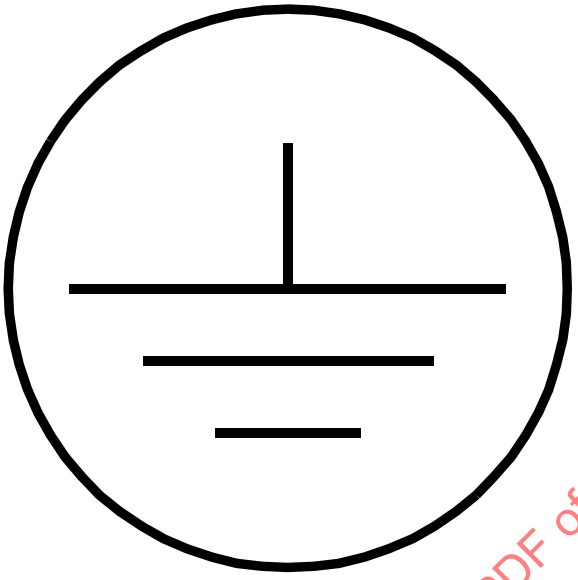
a) Being marked "G," "GR," "GND," "Ground," "Grounding," or the like;

b) A marking on a wiring diagram provided on the appliance; or

c) The symbol shown in Figure 16.1 on or adjacent to the connector or on a wiring diagram provided on the appliance.

Figure 16.1

Grounding Symbol



IEC417, Symbol 5019

17 Live Parts

17.1 A current-carrying part shall be of silver, copper, a copper-base alloy, or of other metal suitable for the particular application.

17.2 An uninsulated live part shall be secured to the surface on which it is mounted, and supporting insulating material shall be secured in place to prevent the part from turning or shifting that would reduce the spacings below the minimum values indicated in Spacings, Section 22.

17.3 Friction between surfaces is not acceptable as a means of preventing shifting or turning of live parts, but a suitable lock washer properly applied may be acceptable.

18 Electrical Insulation

18.1 An insulating washer, bushing, or similar part that is an integral part of the appliance, and a base or support for the mounting of a current-carrying part, shall be of a moisture-resistant material that is not adversely affected by the temperatures to which the part, base, or support is subjected under conditions of intended use. Molded parts shall be constructed so that the parts have the strength and rigidity to withstand the stresses of intended service.

18.2 Insulating material shall be acceptable for the particular application. Materials such as mica and certain refractory materials are acceptable for use as the sole support of live parts. Other materials not acceptable for general use, such as magnesium oxide, are acceptable if used in conjunction with other insulating materials, or if located and protected so that the risk of mechanical damage and the absorption of moisture are reduced.

18.3 With reference to 18.2, the factors that are to be considered when it is necessary to investigate a material to determine acceptability with respect to thermal aging are as follows:

a) Mechanical strength;

b) Insulation resistance;

c) Heat-resistant qualities;

d) The degree to which it is enclosed or protected; and

e) Any other features having a bearing on the risk of fire, electric shock, or injury to persons involved in conjunction with the conditions of service.

18.4 A polymeric material used for direct or indirect support of a live part or used as electrical insulation shall comply with the applicable requirements in UL 746C.

18.5 In the mounting or supporting of a small fragile insulating part, a screw or other fastening means is not to be so tight as to result in cracking or breaking with expansion and contraction. Generally, such a part should be slightly loose.

18.6 A printed-wiring board shall comply with UL 796, and shall be Classed V-0, V-1, or V-2 in accordance with UL 94.

19 Internal and External Wiring and Connections

19.1 Unless internal wiring complies with the requirements of this Standard when investigated as an uninsulated live part, insulated internal wiring of the appliance – including an equipment-grounding conductor – shall consist of wire of a type or types that is acceptable for the particular application when the following are taken in to account:

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

b) Exposure to oil, grease, or other substances that have a harmful effect on the insulation; and

c) Exposure to moisture.

19.2 Thermoplastic-insulated wire employed for internal wiring shall be building wire or appliance wiring material acceptable for the conditions of use.

19.3 Wiring and connections between parts of the appliance shall be protected or enclosed. See 19.15 for requirements for interconnecting cords and cables.

19.4 With reference to exposure of insulated wiring through an opening in the enclosure of the appliance, wiring is considered to be protected as required in 19.3 if, when judged as though it were film-coated wire, the wiring would be acceptable according to 19.13. Internal wiring not protected may be used if the wiring is secured within the enclosure so that it is not subject to stress or mechanical damage.

19.5 A wireway shall be smooth and free from sharp edges, burrs, fins, moving parts, or similar features that can damage the insulation on conductors.

19.6 A hole through which an insulated wire or wires pass in a sheet-metal wall within the overall enclosure of the appliance shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which the wire or wires can bear.

19.7 A splice or connection shall be mechanically secure and shall provide reliable electrical contact.

19.8 A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection results in a risk of fire, electric shock, or injury to persons.

Exception: A connection is not required to be made mechanically secure before being soldered if a soldering or brazing material having a softening or melting point greater than 454 °C (849 °F) is used.

19.9 With reference to 19.7, a lead is considered mechanically secure when one or more of the following conditions are met:

a) The lead has at least one full wrap around a terminal.

b) The lead has at least one right-angle bend where the lead is passed through an eyelet or opening.

c) The lead is twisted with one or more other leads.

d) The lead is strapped in place, or the equivalent, adjacent to the soldered connection to hold the lead end in place.

Exception: On a printed-wiring board that is soldered by a machine process in which the soldering time and solder temperature are automatically controlled, bending over of a lead after it as been passed through a hole in the board is not required.

19.10 The placing of a lead along a flat surface and soldering (identified as tack soldering) is not acceptable unless it can be demonstrated that a risk of fire, electric shock, or injury to persons is not likely to occur with the lead detached.

Exception: Tack soldering of a component is acceptable if, when any one of the component's leads is unsoldered, and the component and unsoldered lead are moved to any position, the component or unsoldered lead cannot contact any part involving a risk of fire, electric shock, or injury to persons.

19.11 A wire-binding screw or nut shall be provided with a lock washer under the head of the screw or under the nut to prevent the screw or nut from becoming loosened due to vibration if such loosening can result in shifting of parts, thereby reducing spacings or otherwise resulting in a risk of fire, electric shock, or injury to persons. See Spacings, Section 22.

19.12 An open-end spade lug is not acceptable unless additional means – such as upturned ends on the tangs of the lug – are provided to hold the lug in place if the wire-binding screw or nut becomes loosened.

19.13 The means of connecting stranded internal wiring to a wire-binding screw shall be such that loose strands of wire will be prevented from contacting other live parts – not always of the same polarity as the wire – and from contacting dead-metal parts. This can be accomplished by using a pressure terminal connector, soldering lug, or crimped eyelet, and by soldering all strands of the wire together, or by means that have been determined to be the equivalent.

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

19.15 A flexible cord or a cable assembly is acceptable for external interconnections if flexibility is essential. The cord or cable shall be of a type that is acceptable for the service or use involved and shall be provided with bushings and strain relief. See Supply Connectors – Cord Connected Appliances, Section 14.

20 Tabs Used in Electrical Quick-Connect Terminals

20.1 General

20.1.1 A tab shall comply with the material requirements in 20.2, and the dimensional requirements in 20.3.

20.2 Material requirements

20.2.1 A tab shall be made of plain or plated copper alloy, nickel, nickel alloy, or the materials specified in Supply Connections – Permanently-Connected Appliances, Section 15.

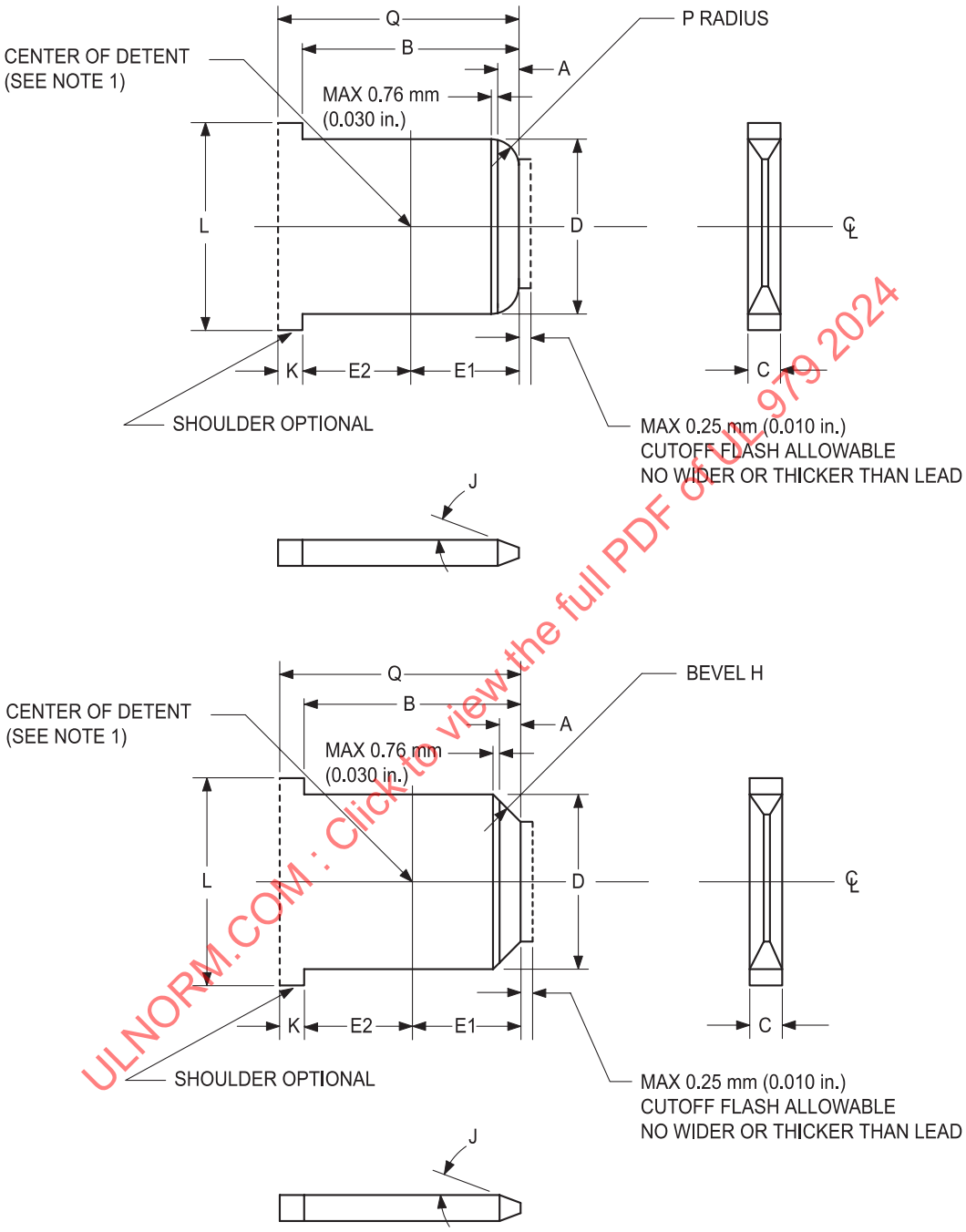
20.2.2 After shearing or removal, a tab that is provided on a feeder strip reel need not be plated on the edge of the connector or tab where it was originally attached to the strip.

20.3 Dimensional requirements

20.3.1 A production tab shall have the configuration shown in Figure 20.1 to Figure 20.3 and the dimensions specified in Table 20.1 and Table 20.2. Figure 20.2 illustrates dimple detents and Figure 20.3 illustrates hole detents.

Figure 20.1

Tab Dimensions



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NOTE 1: For dimple and hole detent dimensions F, G, M, and N, see Figure 20.2 and Figure 20.3.

NOTE 2: Bevel "H" need not be a straight line if it is within the confines shown, and it may be a radius of "P".

NOTE 3: "Q" dimension is for tabs without shoulders.

NOTE 4: "L" dimension not specified.

Figure 20.2

Dimensions of Dimple Detents

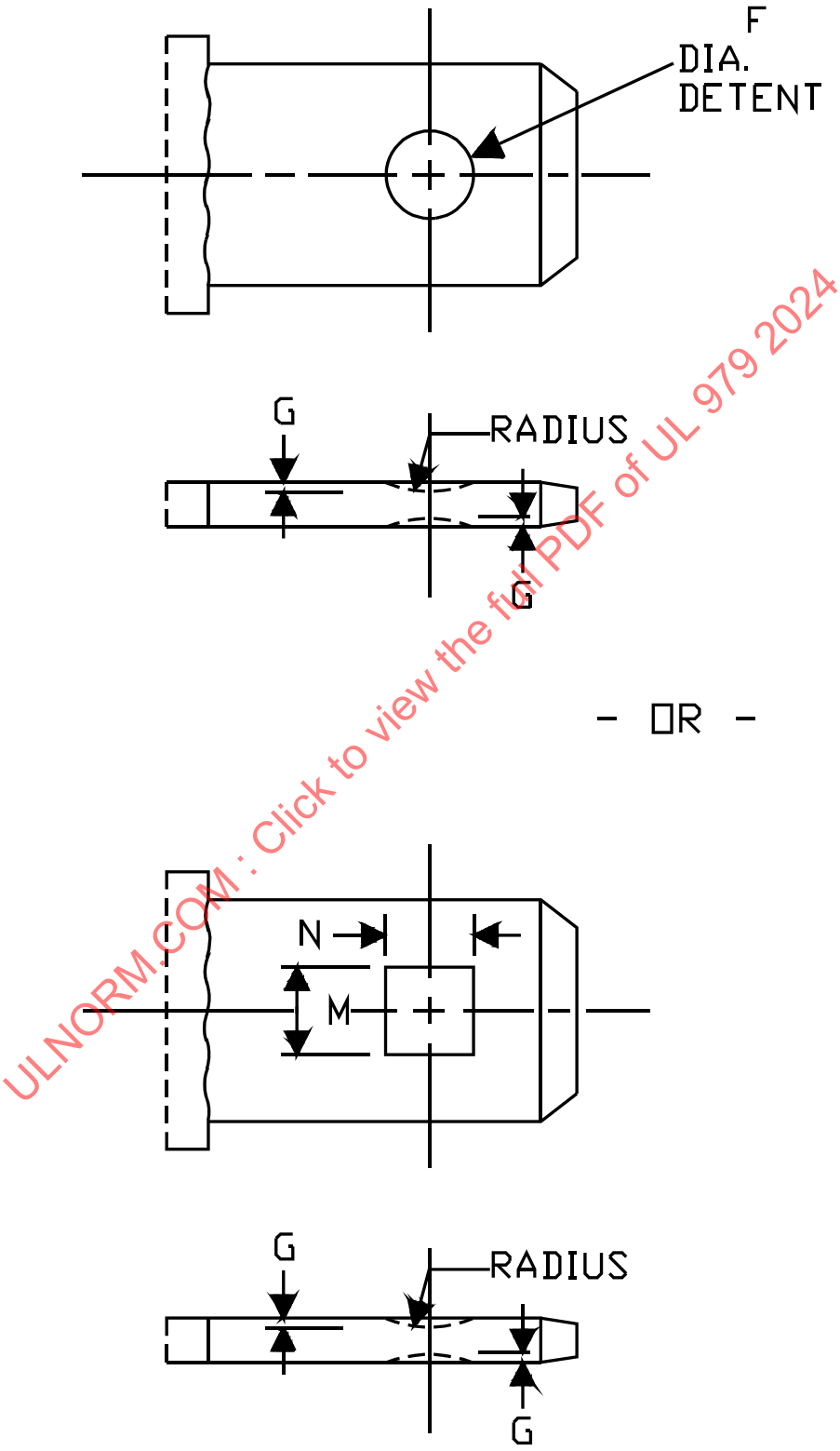

Figure 20.3

Dimensions of Hole Detents

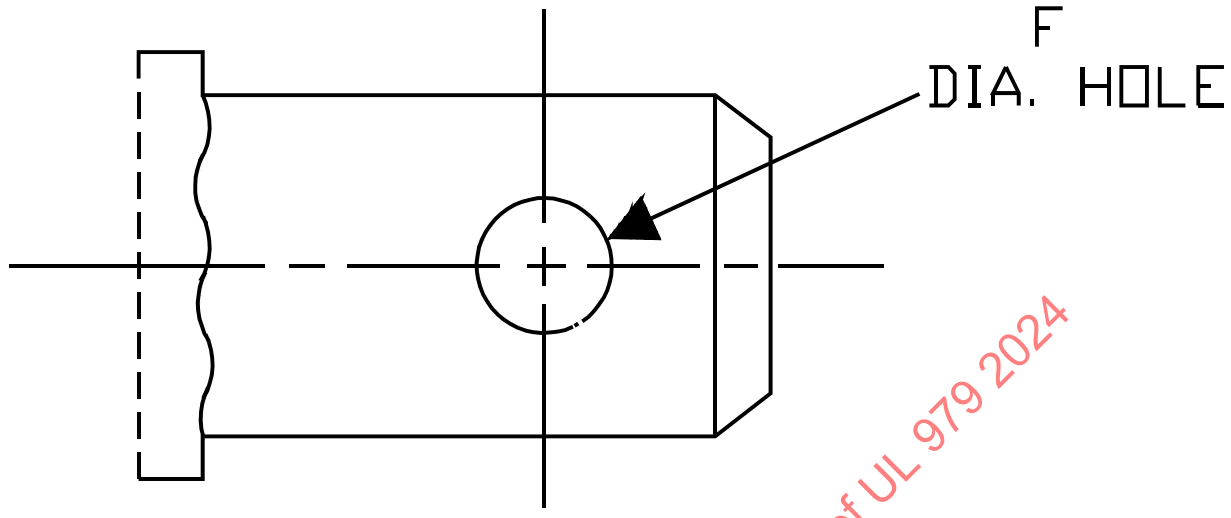

Table 20.1
Tab Dimensions in Inches

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
0.110 × 0.020 with dimple	0.024 0.012	0.275	0.021 0.019	0.114 0.106	0.071 0.051	0.221 0.215	0.051 0.043	12° 8°	0.067 0.055	0.055 0.039	0.055 0.012	0.319
0.110 × 0.020 with hole	0.024 0.012	0.275	0.021 0.019	0.114 0.106	0.071 0.051	0.221 0.215	0.051 0.043	12° 8°			0.055 0.012	0.319
0.110 × 0.032 with dimple	0.024 0.012	0.275	0.033 0.030	0.114 0.106	0.071 0.051	0.221 0.215	0.051 0.043	12° 8°	0.067 0.055	0.055 0.039	0.055 0.012	0.319
0.110 × 0.032 with hole	0.024 0.012	0.275	0.033 0.030	0.114 0.106	0.071 0.051	0.221 0.215	0.051 0.043	12° 8°			0.055 0.012	0.319
0.125 × 0.032 with dimple	0.025 0.015	0.275	0.033 0.031	0.128 0.122	0.070 0.056	0.221 0.215	0.051 0.045	12° 8°	0.067 0.057	0.053 0.043	0.055 0.015	0.320
0.125 × 0.032	0.025	0.275	0.033	0.128	0.070	0.221	0.051	12°			0.055	0.320

Table 20.1 Continued on Next Page

Table 20.1 Continued

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
with hole	0.015		0.031	0.122	0.056	0.215	0.045	8°			0.015	
0.125 × 0.020 with dimple	0.025 0.015	0.275	0.021 0.019	0.128 0.122	0.070 0.056	0.221 0.215	0.051 0.045	12° 8°	0.067 0.057	0.053 0.043	0.055 0.015	0.320
0.125 × 0.020 with hole	0.025 0.015	0.275	0.021 0.019	0.128 0.122	0.070 0.056	0.221 0.215	0.051 0.045	12° 8°			0.055 0.015	0.320
0.187 × 0.020 with dimple	0.035 0.024	0.244	0.021 0.019	0.190 0.181	0.110 0.091	0.153 0.147	0.060 0.050	12° 8°	0.067 0.055	0.059 0.047	0.067 0.024	0.287
0.187 × 0.020 with hole	0.035 0.024	0.244	0.021 0.019	0.193 0.184	0.134 0.117	0.128 0.122	0.060 0.050	12° 8°			0.067 0.024	0.287
0.187 × 0.032 with dimple	0.040 0.027	0.244	0.033 0.030	0.190 0.181	0.110 0.091	0.153 0.147	0.060 0.050	12° 8°	0.067 0.055	0.059 0.047	0.071 0.027	0.287
0.187 × 0.032 with hole	0.040 0.024	0.244	0.033 0.030	0.193 0.184	0.134 0.117	0.128 0.122	0.060 0.050	12° 8°			0.071 0.027	0.287
0.205 × 0.020 with dimple	0.040 0.027	0.244	0.021 0.019	0.210 0.201	0.110 0.091	0.153 0.147	0.075 0.063	12° 8°	0.098 0.086	0.080 0.070	0.067 0.024	0.287
0.205 × 0.020 with hole	0.040 0.027	0.244	0.021 0.019	0.210 0.201	0.134 0.117	0.128 0.122	0.075 0.063	12° 8°			0.067 0.024	0.287
0.205 × 0.032 with dimple	0.040 0.027	0.244	0.033 0.030	0.210 0.201	0.110 0.091	0.153 0.147	0.075 0.063	12° 8°	0.098 0.086	0.080 0.070	0.071 0.027	0.287
0.205 × 0.032 with hole	0.040 0.027	0.244	0.033 0.030	0.210 0.201	0.134 0.117	0.128 0.122	0.075 0.063	12° 8°			0.071 0.027	0.287
0.250 × 0.032 with dimple	0.040 0.027	0.307	0.033 0.030	0.253 0.244	0.161 0.142	0.163 0.157	0.080 0.063	12° 8°	0.098 0.086	0.080 0.070	0.071 0.027	0.350
0.250 × 0.032 with hole	0.040 0.020	0.307	0.033 0.030	0.253 0.244	0.186 0.169	0.137 0.131	0.080 0.063	12° 8°			0.071 0.027	0.350

Table 20.2
Tab Dimensions in Millimeters

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
2.8 × 0.5 with dimple	0.6 0.3	7.0	0.54 0.47	2.90 2.70	1.8 1.3	5.61 5.46	1.3 1.1	12° 8°	1.7 1.4	1.4 1.0	1.4 0.3	8.1
2.8 × 0.5 with hole	0.6 0.3	7.0	0.54 0.47	2.90 2.70	1.8 1.3	5.61 5.46	1.3 1.1	12° 8°			1.4 0.3	8.1
2.8 × 0.8 with dimple	0.6 0.3	7.0	0.84 0.77	2.90 2.70	1.8 1.3	5.61 5.46	1.3 1.1	12° 8°	1.7 1.4	1.4 1.0	1.4 0.3	8.1
2.8 × 0.8 with hole	0.6 0.3	7.0	0.84 0.77	2.90 2.70	1.8 1.3	5.61 5.46	1.3 1.1	12° 8°			1.4 0.3	8.1
3.2 × 0.8 with dimple	0.6 0.3	7.0	0.84 0.79	3.25 3.10	1.8 1.4	5.61 5.46	1.3 1.1	12° 8°	1.7 1.4	1.4 1.1	1.4 0.3	8.1
3.2 × 0.8 with hole	0.6 0.3	7.0	0.84 0.79	3.25 3.10	1.8 1.4	5.61 5.46	1.3 1.1	12° 8°			1.4 0.3	8.1
3.2 × 0.5 with dimple	0.6 0.3	7.0	0.54 0.48	3.25 3.10	1.8 1.4	5.61 5.46	1.3 1.1	12° 8°	1.7 1.4	1.4 1.1	1.4 0.3	8.1
3.2 × 0.5 with hole	0.6 0.3	7.0	0.54 0.48	3.25 3.10	1.8 1.4	5.61 5.46	1.3 1.1	12° 8°			1.4 0.3	8.1
4.8 × 0.5 with dimple	0.9 0.6	6.2	0.54 0.47	4.80 4.60	2.8 2.3	3.89 3.73	1.5 1.3	12° 8°	1.7 1.4	1.5 1.2	1.7 0.6	7.3
4.8 × 0.5 with hole	0.9 0.6	6.2	0.54 0.47	4.90 4.67	3.4 3.0	3.25 3.10	1.5 1.3	12° 8°			1.7 0.6	7.3
4.8 × 0.8 with dimple	1.0 0.7	6.2	0.84 0.77	4.80 4.60	2.8 2.3	3.89 3.73	1.5 1.3	12° 8°	1.7 1.4	1.5 1.2	1.8 0.7	7.3
4.8 × 0.8 with hole	1.0 0.6	6.2	0.84 0.77	4.90 4.67	3.4 3.0	3.25 3.10	1.5 1.3	12° 8°			1.8 0.7	7.3
5.2 × 0.5 with dimple	1.0 0.7	6.2	0.54 0.47	5.30 5.10	2.8 2.3	3.89 3.73	1.9 1.6	12° 8°	2.5 2.2	2.0 1.8	1.7 0.6	7.3
5.2 × 0.5 with hole	1.0 0.7	6.2	0.54 0.47	5.30 5.10	3.4 3.0	3.25 3.10	1.9 1.6	12° 8°			1.7 0.6	7.3
5.2 × 0.8 with dimple	1.0 0.7	6.2	0.84 0.77	5.30 5.10	2.8 2.3	3.89 3.73	1.9 1.6	12° 8°	2.5 2.2	2.0 1.8	1.8 0.7	7.3
5.2 × 0.8 with hole	1.0 0.7	6.2	0.84 0.77	5.30 5.10	3.4 3.0	3.25 3.10	1.9 1.6	12° 8°			1.8 0.7	7.3
6.3 × 0.8 with dimple	1.0 0.7	7.8	0.84 0.77	6.40 6.20	4.1 3.6	4.14 3.99	2.0 1.6	12° 8°	2.5 2.2	2.0 1.8	1.8 0.7	8.9
6.3 × 0.8 with hole	1.0 0.5	7.8	0.84 0.77	6.40 6.20	4.7 4.3	3.48 3.33	2.0 1.6	12° 8°			1.8 0.7	8.9

20.3.2 All portions of a production tab shall be flat, its surfaces not deviating more than 0.010 inch/inch (0.010 mm/mm), and free of burrs greater than 10 % of the tab thickness, or raised plateaus.

20.3.3 With regard to 20.3.2, in an area 0.050 inch (1.3 mm) surrounding the detent, a raised plateau over the stock thickness of 0.001 inch (0.03 mm) per side is acceptable.

20.3.4 For an optional shoulder, the minimum dimension shall be 0.045 inch (1.14 mm). See dimension "K" of Figure 20.1. There shall not be any obstructions within 0.045 inch (1.14 mm) of the "K" dimension end of the area defined by dimension "B."

20.3.5 If the detent is located with reference to a shoulder, it shall be located on the tab in accordance with dimension "E2." If no shoulder is provided, the detent shall be located on the tab in accordance with dimension "E1." The center of a hole or detent shall be within 0.003 inch (0.08 mm) of the centerline of the tab. The depth of a dimple, dimension "G" on Figure 20.2, shall not be less than 0.003 inch (0.08 mm).

20.3.6 Bevel "H" shall be approximately 45°. See Note 2 to Figure 20.1.

20.3.7 Dimensional measurements shall not include plating, burrs, or flatness tolerance.

21 Separation of Circuits

21.1 Separation between different internal wiring circuits (factory-installed conductors)

21.1.1 Insulated conductors shall be segregated or separated by barriers from each other.

Exception: Conductors provided with insulation rated for the highest voltage involved are not required to be segregated or separated.

21.1.2 Insulated conductors shall be segregated or separated by barriers from uninsulated live parts connected to different circuits.

21.1.3 Segregation accomplished by clamping, routing, or equivalent means that provides a minimum permanent 1/4-inch (6.4-mm) separation between applicable conductors complies with 21.1.1 and 21.1.2.

21.2 Separation between different field wiring circuits (field-installed conductors)

21.2.1 The appliance shall be constructed so that field-installed conductors of any circuit are segregated – see 21.4 – or separated by barriers – see 21.5 – from field-installed conductors connected to any other circuit. Table 21.1 summarizes the requirements.

Exception No. 1: Segregation or separation is not required between conductors of different Class 2 circuits.

Exception No. 2: Segregation or separation is not required between conductors of different Class 3 circuits if each circuit is wired with CL3, CL3R or CL3P, or equivalent conductors.

Exception No. 3: Segregation or separation is not required between conductors of Class 2 and Class 3 circuits provided that both circuits are insulated for the maximum voltage of either circuit – see 70.15.

Exception No. 4: Segregation or separation is not required when both circuits are other than Class 2 or Class 3 provided that the Class 1, Electric Light, or Power circuits are wired with conductors rated for the maximum voltage of either circuit.

Exception No. 5: Segregation or separation is not required between conductors of a limited energy (Class 2 or Class 3) circuit and a non-limited energy (Class 1, Electric Light, or Power) circuit provided that:

a) The limited energy conductors are intermingled in order to accommodate the connection of the limited energy circuit to the appliance;

b) The non-limited energy circuit is 150 V_{ac} or less to ground; and

c) The appliance is marked to indicate that the limited energy circuit is to be wired with Types CL3, CL3R, CL3P, or the equivalent conductors as shown in Table 21.2. See 70.15.

Exception No. 6: Segregation or separation is not required between conductors of a limited energy (Class 2 or Class 3) circuit and a non-limited energy (Class 1, Electric Light, or Power) circuit provided that:

a) The limited energy conductors are intermingled in order to accommodate the connection of the limited energy circuit to the appliance;

b) The non-limited energy circuit is 150 V_{ac} or less to ground; and

c) The appliance is marked to indicate that the limited energy circuit is to be wired with conductors suitable for Class 1, Electric Light, or Power circuits. See 70.16.

Table 21.1
Segregation or Separation Between Field-Installed Conductors

Circuit type		Applicable paragraph	Comments
Circuit 1	Circuit 2		
Non-limited energy	Non-limited Energy	Exception 4 to 21.2.1	Segregation or separation is not required
Non-limited energy	Class 2	Exceptions 5 and 6 to 21.2.1	Markings needed requiring higher voltage insulation on Class 2 field-installed conductors
Non-limited energy	Class 3	Exceptions 5 and 6 to 21.2.1	Markings needed requiring higher voltage insulation on Class 3 field-installed conductors
Class 2	Class 2	Exception 1 to 21.2.1	Segregation or separation is not required
Class 3	Class 2	Exception 3 to 21.2.1	Markings needed requiring higher voltage insulation on field-installed conductors
Class 3	Class 3	Exception 2 to 21.2.1	Segregation or separation is not required

Table 21.2
Cable Substitutes for Type CL3, CL3P, and CL3R Cables

Cable type	Cable substitutes
CL3	CL3P, CL3R, CM, CMG, CMP, CMR, FPL, FPLP, FPLR, and PLTC
CL3P	CMP and FPLP
CL3R	CL3P, CMP, CMR, FPLP, and FPLR

21.3 Separation between field wiring circuits (field-installed conductors) and internal wiring circuits (factory-installed conductors)

21.3.1 Separation between field-installed conductors and factory-installed conductors shall be as described in 21.2. Table 21.3 summarizes the requirements.

Exception No. 1: Factory-installed conductors that can intermingle with field-installed conductors shall be provided with insulation rated for the highest voltage of either circuit.

Exception No. 2: In addition to the requirements in 21.2, an appliance that permits field-installed conductors to intermingle with factory-installed conductors shall be marked to indicate that the field-installed conductors are to be provided with insulation rated for the highest voltage of either circuit. See 70.15, 70.16, and 70.18.

Table 21.3
Segregation or Separation Between Factory-Installed and Field-Installed Conductors

Circuit type		Applicable paragraph	Comments
Factory-installed conductors	Field-installed conductors		
Non-limited energy	Non-limited energy	Exception 4 to 21.2.1; Exceptions 1 and 2 to 21.3.1	Both conductors need to be rated for the highest voltage involved
Non-limited energy	Class 2	Exception 5 to 21.2.1	Markings needed requiring higher voltage insulation on field-installed conductors
Non-limited energy	Class 3	Exceptions 5 and 6 to 21.2.1	Markings needed requiring higher voltage insulation on field-installed conductors
Class 2	Non-limited energy	Exception 1 to 21.3.1	Factory-installed conductors need insulation rated for the highest voltage involved
Class 2	Class 2	Exception 1 to 21.2.1	Segregation or separation is not required
Class 2	Class 3	Exception 1 to 21.3.1	Factory-installed conductors need insulation rated for the highest voltage involved
Class 3	Non-limited energy	Exception 1 to 21.3.1	Factory-installed conductors need insulation rated for the highest voltage involved.
Class 3	Class 2	Exception 3 to 21.2.1; Exception 2 to 21.3.1	Markings needed requiring higher voltage insulation on field-installed conductors
Class 3	Class 3	Exception 2 to 21.2.1	Segregation or Separation is not required

21.3.2 Insulated field-installed conductors shall be segregated or separated by barriers from uninsulated live parts connected to a different circuit.

Exception No. 1: Insulated non-limited energy field-installed conductors are not prohibited from contacting wiring terminals of different non-limited energy circuits.

Exception No. 2: Field-installed conductors of a limited energy circuit are not prohibited from contacting terminals of a different limited energy circuit provided that the short-circuiting of the terminals does not result in a risk of fire, electric shock, or injury to persons.

21.4 Segregation methods

21.4.1 Segregation accomplished by clamping, routing, or equivalent means that provides a minimum permanent 1/4-inch (6.4-mm) separation between applicable conductors complies with 21.2.1 and 21.3.1.

21.4.2 When field-installed conductors are segregated in accordance with 21.4.1, the segregation of the conductors complies with 21.4.1 when the segregation is from each other, from uninsulated live parts and from factory-installed conductors by locating openings in an enclosure for the various conductors – with respect to the terminals or other uninsulated live parts – so that a minimum permanent 1/4-inch (6.4-mm) separation is provided.

21.4.3 With reference to 21.4.2, if the number of openings in the enclosure does not exceed the minimum required for the proper wiring of the appliance, and if each opening is located opposite a set of terminals, a conductor entering an opening shall be connected to the terminal opposite that opening. If more than the minimum number of openings are provided, the effect of a conductor entering an opening other than the one opposite the terminal to which the conductor is intended to be connected and the likelihood of the conductor contacting insulated conductors or uninsulated live parts connected to a different circuit is to be investigated.

21.4.4 To determine if the appliance complies with 21.4.1, 21.4.2, and 21.4.3, the appliance is to be wired as intended for service with:

a) Six to twelve in of slack left in each conductor; and

b) No more than average care exercised in stowing the slack into the wiring compartment.

21.5 Separation methods

21.5.1 With respect to 21.2.1 and 21.3.1, if the intended uses of the appliance is such that in some applications a barrier is required while in some other applications no barrier is required, a removable barrier or one having openings for the passage of conductors is not prohibited. Instructions for the use of such a barrier shall be a permanent part of the appliance. Complete instructions in conjunction with a wiring diagram is not prohibited from being used in lieu of a barrier if, upon investigation, the combination is determined to comply with these requirements.

21.5.2 Conductors from a non-limited energy (Class 1, Electric Light, or Power) field-installed circuit and from a limited energy (Class 2 or Class 3) field-installed circuit that are routed through a single opening in an enclosure of a permanently connected appliance complies with the intent of 21.2.1 if the limited energy conductors are separated from the non-limited energy conductors by a continuous and firmly fixed nonconductor such as flexible tubing. Tubing that complies with UL 224, is acceptable. The voltage rating of the tubing shall not be less than the maximum voltage rating of the non-limited energy conductors. The tubing shall be provided as part of an installation kit with the appliance. See 70.17.

22 Spacings

22.1 General

22.1.1 The spacings in a circuit shall comply with Table 22.1.

Exception No. 1: Minimum 1/32 inch (0.8 mm) through air and over surface spacings before potting for parts that are potted in an insulating compound may be applied. A thermoplastic potting compound is to be evaluated with regard to its acceptability for the application. If an investigation is necessary to determine if a material may be used, such investigation is to be conducted in accordance with UL 746C. Consideration is to be given to:

a) The mechanical strength of the material, resistance to hot wire ignition, resistance to high-current-arc ignition, resistance to high-voltage-arc ignition, dielectric strength, insulation resistance, and heat-resistant qualities, in both the aged and unaged conditions;

b) The degree to which the material is enclosed; and

c) Any other feature affecting the risk of fire, electric shock, electrical high-energy current levels, or injury to persons.

Exception: All factors are to be considered with regard to conditions of actual service.

Exception No. 2: On a printed-wiring board, the over surface spacing may be reduced to 1/32 inch (0.8 mm) if the board is coated with a conformal coating complying with UL 746C.

Exception No. 3: On a printed-wiring board, spacing requirements (other than for spacings to ground, between different circuits, and at field wiring terminals) may be waived between traces of different potentials connected in the same circuit if:

a) The spacings comply with the Printed-Wiring Board Shorted-Trace Test, Section 63;

b) The printed-wiring board has a flammability classification of V-0, in accordance with the requirements in UL 94; and

c) The printed-wiring board is constructed from a base material having a minimum Comparative Tracking Index (CTI) Performance Level Category rating of 2 in accordance with UL 746C.

Table 22.1
Spacings in Line-Voltage Circuits

Location involved	Voltage, AC	Minimum spacings			
		Through air		Over surface	
		Inch	(mm)	Inch	(mm)
Between field-wiring terminals of opposite polarity	0 – 150	1/4	(6.4)	1/4	(6.4)
	151 – 300	1/4	(6.4)	3/8	(9.5)
	301 – 600	3/8	(9.5)	1/2	(12.7)
Between uninsulated live parts of opposite polarity or between an uninsulated live part and a grounded part other than the enclosure[a]	0 – 50	1/16	(1.6)	1/16	(1.6)[b]
	51 – 150	1/8	(3.2)	1/4	(6.4)[b]
	151 – 300	1/4	(6.4)	3/8	(9.5)[b]
	301 – 600	3/8	(9.5)	1/2	(12.7)
Between an uninsulated live part and the walls of the metal enclosure, or other accessible dead metal part, including fittings for conduit or armored cable[c]	0 – 600	1/2	(12.7)	1/2	(12.7)

[a] In a portable appliance using a fractional horsepower motor rated 300 V or less, the spacing through air or over surface may be 3/32 inch (2.4 mm) minimum; and if the motor rating does not exceed either 1/3 hp (250 W output) or 150 V, the spacings may be 1/16 in minimum.

[b] For printed-wiring boards, see Exception No. 1 – 3 to 22.3.1.

[c] 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 spacings between the metal piece and uninsulated live parts.

22.1.2 An insulating barrier or liner used as the separation (with or without an air spacing) between uninsulated live parts and grounded dead-metal parts, including the enclosure, or between uninsulated live parts of opposite polarity, shall be of a material that has been determined to be acceptable for the mounting of uninsulated live parts. The material shall not be less than 0.028 inch (0.71 mm) thick.

Exception No. 1: Insulating material less than 0.028 inch thick may be used if it has been investigated and determined to be acceptable for the application.

Exception No. 2: A barrier or liner that is used with not less than one-half the required spacing through air may be less than 0.028 inch but not less than 0.013 inch (0.33 mm) thick if the barrier or liner is of a material that:

a) Has been investigated and determined to be acceptable for the mounting of an uninsulated live part;

b) Is of the necessary mechanical strength if exposed or otherwise likely to be subjected to mechanical damage;

c) Is reliably held in place; and

d) Is located so that it will not be adversely affected by operation of the appliance in service.

22.1.3 When used in conjunction with a minimum 1/32-inch (0.79-mm) air spacing, fiber not less than 0.028 inch (0.71 mm) thick may be used:

a) As the sole separation between the enclosure and an uninsulated part electrically connected to a grounded-circuit conductor; or

b) For an uninsulated live part.

22.1.4 Insulation between a crossover lead and the turns of the winding to which it is connected, the adjacent winding, the metallic enclosure, and the core, shall be one of the following:

a) Electrical grade paper, waxed or otherwise treated to resist the absorption of moisture, having a total thickness not less than 0.013 inch (0.33 mm);

b) Other insulating material mechanically and thermally equivalent to that of (a) having a dielectric breakdown strength of 2500 V or more in the thickness used.

Exception No. 1: The spacings specified in Table 22.1 may be provided in lieu of insulation.

Exception No. 2: Any type and thickness of insulation, or a through air spacing, between a crossover lead and the winding to which it is connected may be used if either:

a) The insulation withstands the dielectric voltage-withstand test potential described in 46.1.1 with the potential applied between the coil leads and with the coil lead cut at the point where it enters the inner layer; or

b) The insulation withstands the induced-potential test described in 46.2.

Exception No. 3: This requirement does not apply to insulation between a Class 2 secondary crossover lead and:

a) The secondary winding to which the crossover lead is connected;

b) The metallic enclosure; and

c) The core.

22.1.5 A slot in a molded bobbin for guiding the crossover or start lead (unspliced at the windings) of a magnet-coil may be used as crossover-lead insulation if:

a) The slot provides a graduated through air spacing to the winding, increasing to the end turns; and

b) The magnet-coil winding withstands the induced potential test described in 46.2.1 – 46.2.3.

22.1.6 The spacings in a component shall not be less than the minimum spacings required for the component or the spacings specified in Table 22.1, whichever are smaller.

22.1.7 Regarding spacing requirements, film-coated magnet wire is considered to be an uninsulated live part.

22.1.8 The spacings within a motor shall comply with the requirements in UL 1004-1.

22.2 Low-voltage and isolated limited-energy circuits

22.2.1 Spacings between components of low-voltage and isolated limited-energy circuits are not specified.

22.3 High-voltage circuits

22.3.1 Spacings between an insulated or uninsulated high-voltage part and:

a) Insulated or uninsulated line-voltage circuit parts;

b) Other high-voltage parts of opposite polarity; and

c) Dead metal shall comply with Table 22.2.

Exception No. 1: The spacing requirements in Table 22.2 may be waived if a barrier or liner, as described in 22.1.2, is used.

Exception No. 2: The spacing requirements in Table 22.2 may be waived if epoxy potting compounds or conformal coatings, as described in Exceptions Nos. 1 and 2 to 22.1.1, respectively, are used.

Exception No. 3: On a printed wiring board, the spacing requirements in Table 22.2 may be waived between traces of different potentials located in the same high-voltage circuit if:

a) The appliance complies with the Printed-Wiring Board Shorted-Trace Test, Section 63;

b) The printed wiring board has a flammability classification of V-0 in accordance with the requirements in UL 94; and

c) The printed wiring board has a minimum Comparative Tracking Index (CTI) Performance Level Category rating of 1 in accordance with UL 746C.

Exception No. 4: High-voltage wiring need not comply with Table 22.2.

Exception No. 5: The high-voltage secondary circuit of an electrostatic appliance shall comply with the spacing requirements in UL 867.

Table 22.2
Minimum Acceptable Spacings

Potential involved, V	Location	Minimum spacings, in (mm)	
		601 – 1000 V	1001 – 1500 V
Between any uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded part other than the enclosure, or an exposed metal part	Through air	0.55 (14.0)	0.70 (17.8)
	Through oil	0.45 (11.4)	0.60 (15.2)
	Over surface air	0.85 (21.6)	1.20 (30.5)
	Over surface oil	0.62 (15.7)	0.70 (17.8)
Between any uninsulated live part and the walls of a metal enclosure, including fittings for conduit or armored cable	Through air or oil	0.80 (20.3)	1.20 (30.5)
	Over surface	1.00 (25.4)	1.65 (41.9)

23 Spacings On Printed Wiring Boards

23.1 As an alternative to the spacing requirements of Table 22.1, the spacing requirements in UL 840 are able to be used. The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure.

23.2 The following end use factors from this Standard shall be applied:

a) For the applicable Overvoltage Category, see Table 29.1;

b) For the applicable Material Group, see Table 29.2;

c) For the applicable Pollution Degree, see Table 29.3.

23.3 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product. This voltage limiting device or system shall comply with UL 1449, and be a type suitable for the end-use application.

23.4 All printed wiring boards are identified as having a minimum comparative tracking index (CTI) of 100 without further investigation, for evaluation to UL 840.

24 Capacitors

24.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line (such as a capacitor for radio-interference elimination or power factor correction) shall be housed within an enclosure or container such that the plates are not subject to mechanical damage and the risk of emission of flame or molten material resulting from malfunction of the capacitor is reduced. The container shall be of metal providing strength equivalent to uncoated steel having an average thickness of 0.020 inch (0.51 mm). Sheet metal having an average thickness less than 0.026 inch (0.66 mm) shall not be used.

Exception No. 1: The individual container of a capacitor may be of thinner sheet metal or may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the appliance and provided that such a box, case, and the like is rated for the enclosure of current-carrying parts.

Exception No. 2: The individual enclosure of an electrolytic capacitor with means for venting is required to be such as to reduce the risk of mechanical damage only, and the requirement for minimum enclosure thickness does not apply. The individual enclosure of an electrolytic capacitor not provided with means for venting but provided with an opening more than 1/16 inch (1.6 mm) wide between the capacitor enclosure and the motor need not comply with the requirement for enclosure thickness if it complies with 62.1.

24.2 If a capacitor that is not a part of a capacitor motor or a capacitor-start motor is so connected in an appliance that capacitor breakdown would result in any risk of fire or electric shock, thermal or overcurrent protection shall be provided in the appliance to reduce such a risk.

24.3 A capacitor employing a dielectric medium of wax or of liquid other than askarel shall comply with UL 810.

24.4 Capacitors other than as used in 24.1 – 24.3 shall comply with the requirements in UL 60384-14, and be rated for the intended application, including operating voltage, subclass, Upper and Lower Temperature rating. The duration of the damp-heat test shall be 21 days for indoor use appliances and 56 days for appliances permanently installed outdoors.

25 Lampholders

25.1 A lampholder shall be of the unswitched type and shall have a body of porcelain or other suitable molded composition. A lampholder employing fiber or similar absorptive material shall not be used.

25.2 A lampholder having an aluminum screw shall not be used.

25.3 A household appliance shall be constructed so that an ultraviolet radiation lamp compartment can be accessed only through an interlocked enclosure panel. The interlock shall interrupt power to the lamp.

25.4 The actuator of a switch employed as an interlock shall be located or guarded so as to reduce the risk of injury to persons resulting from unintentional operation of the switch. The actuator shall be guarded by recessing, ribs, barriers, or the like.

26 Parts Subject to Pressure

26.1 General

26.1.1 A part of an appliance that is subjected to air, vapor, or water pressure during normal or anticipated abnormal operation shall withstand a pressure in accordance with 26.2 – 26.4.

Exception No. 1: A system designed to utilize only atmospheric pressure or gravity flow are not subject to the pressure test requirement.

Exception No. 2: A component downstream from the system on/off valve that is not subject to pressure under the off mode and contains no media subject to plugging or is not designed to contain media is not subject to the pressure test.

Exception No. 3: A section of a pressure system constructed of continuous tubing or of lengths of tubing connected by conventional tubing fittings or hard-soldered, brazed, or welded joints if study and analysis indicate that the strength of the part is adequate for the purpose. See Table 26.1 for pressure ratings of common types of tubing.

Exception No. 4: This requirement does not apply to a pressure vessel bearing the ASME code inspection symbol – other than the UM symbol – provided the vessel is marked with a value of working pressure not less than that to which it is subjected during normal or abnormal operation.

Table 26.1
Minimum Wall Thickness for Copper and Steel Tubing

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

26.1.2 If a test is necessary to determine compliance with 26.1.1, the part shall comply with the Hydrostatic Strength Test, Section 56.

26.2 Parts subject to air or vapor pressure

26.2.1 A pressure vessel having an inside diameter more than 6 in (152 mm), subjected to a pressure more than 15 psig (102 kPa), and eligible to be covered by the National Board of Boiler and Pressure Vessel Inspectors shall be marked in accordance with the appropriate boiler and pressure vessel code symbol of the American Society of Mechanical Engineers (ASME) for a working pressure not less than the pressure determined in accordance with 26.2.3 (a) – (c).

26.2.2 A pressure vessel, because of its application, not covered by the scope of the inspection procedure of the ASME code shall comply with 26.2.3.

26.2.3 A part of an appliance that is subjected to air or vapor pressure during normal or anticipated abnormal operation shall withstand a pressure corresponding to five times:

a) The relief-valve pressure setting provided in the system;

b) The maximum pressure that can be developed in the system – but not greater than the relief valve setting; or

c) The marked maximum pressure to which the system might be exposed by an external pressure source.

26.3 Parts subject to municipal water pressure

26.3.1 If a part has a capacity that does not exceed 120 gal (454 L) and is subject to household water pressure, the part shall be subjected to the Hydrostatic Strength Test described in Section 56 at 300 psi (2068 kPa) for 15 min.

26.4 Parts subject to pump pressure

26.4.1 A part of an appliance that is subjected to water pressure generated only by pumps integral to the appliance during normal or anticipated abnormal operation shall withstand a pressure corresponding to 1.5 times the maximum working pressure, or 1.5 times the maximum setting of a pressure relief device, whichever is greater.

27 Pressure-Relief Devices

27.1 A means for relieving pressure shall be provided for the complete appliance in which pressure might be generated by an external source of heat.

Exception: A part of a system installed in the plumbing of a commercial or industrial installation is not required to have a separate pressure relief device.

27.2 A means for relieving pressure – a pressure-relief device, a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent means – shall be employed to comply with 26.2.1.

27.3 There shall not be a shutoff valve between the pressure-relief means and the parts that it is intended to protect.

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

27.5 The start-to-discharge pressure setting of a pressure-relief device shall not be higher than the marked working pressure. The discharge rate of the device shall be adequate to relieve the pressure.

27.6 A pressure-relief device shall:

a) Be connected as close as possible to the part of the appliance that it is intended to protect;

b) Be installed so that it is readily accessible for inspection and repair, and cannot be readily rendered inoperative so that it will not perform its intended function; and

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

1) Operation of the device will not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture; and

2) The risk of scalding persons is reduced.

27.7 A pressure-relief device having an adjustable setting shall be investigated at the maximum setting unless the adjusting means is reliably sealed at a lower setting.

27.8 If a pressure-relief device is required in accordance with 27.5, a control depended upon to limit the pressure in a vessel shall:

a) Have a maximum pressure setting of not more than 90 % of the rating of the pressure-relief device. Compliance with UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series; or

b) Operate so that the pressure-relief device described in 27.7 does not operate during or after the test described in 27.9.

27.9 A pressure-limiting control shall perform under rated load for 30,000 cycles of operation with no shift in calibration greater than 5 % above the initial calibration pressure setting. An adjustable control is to be tested at its highest pressure setting unless the adjusting means is reliably sealed at a lower setting.

28 Switches and Controls

28.1 A switch or other control device shall not have current and voltage ratings less than those of the circuit (load) that it controls.

28.2 If unintentional operation of a switch can result in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such operation is unlikely.

28.3 A switch with a marked off position shall open all ungrounded conductors. If the appliance is cord connected and not provided with a polarized attachment plug cap, all supply conductors shall be considered to be ungrounded regardless of the voltage rating of the appliance.

28.4 The current rating of a switch or other control device that controls a solenoid, a magnet, a transformer, an electric-discharge-lamp ballast, or another inductive load shall be at least twice the rated full-load current of the component that it controls unless the switch is rated for the particular application.

28.5 A switch that controls a lampholder for an incandescent lamp other than a 15-W or smaller pilot or indicating lamp shall be of a type that is acceptable for use with tungsten-filament lamps.

28.6 A switch or other device controlling a motor shall be rated in horsepower. A switch or other device controlling a coil shall be rated for pilot duty.

28.7 A switch or other device not having a rating as specified in 28.6 shall comply with the Switch and Control Overload Test, Section 59.

28.8 Switches that comply with UL 61058-1, shall be rated as specified in 28.9 – 28.11.

28.9 Power switches shall be rated as follows:

a) For a voltage not less than the rated voltage of the appliance;

b) For a current not less than the rated current of the appliance;

c) For Continuous Duty;

d) With respect to load:

1) Switches for motor-operated appliances: for resistance and motor load if the switch would encounter this load in normal use; or

2) Switches may be regarded as switches for a declared specific load and may be classified based upon the load conditions encountered in the appliance under normal load.

e) For ac if the appliance is rated for ac;

f) For dc if the appliance is rated for dc.

28.10 Ratings and load classifications for switches other than power switches shall be based on the conditions encountered in the appliance under normal load .

28.11 Switches shall also be rated with respect to endurance as follows:

a) Power switches: 6000 cycles;

b) Power switches provided with series electronics shall be subject to an additional 1000 cycles of operation with the electronics bypassed;

c) Switches other than power switches, such as speed selector switches, that may be switched under electrical load: 1000 cycles;

d) The following non-power switches are not required to be rated for endurance:

1) Switches not intended for operation without electrical load, and which can be operated only with the aid of a tool or are interlocked so that they cannot be operated under electrical load; or

2) Switches for 20 mA load as classified in UL 61058-1.

29 Controls – End Product Test Parameters

29.1 General

29.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in Controls, 6.6.

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

29.2 Auxiliary controls

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

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

Exception: An auxiliary control that complies with a component standard(s) specified in Controls, 6.6 is considered to comply with this requirement.

29.3 Operating controls (regulating controls)

29.3.1 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using UL 60730-1:

a) Control action Types 1 or 2;

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

c) Installation class 2 in accordance with IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 29.1;

e) For the applicable Material Group, see Table 29.2; and

f) For the applicable Pollution Degree, see Table 29.3.

Table 29.1
Overvoltage Categories

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

Table 29.2
Material Group

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

Table 29.3
Pollution Degrees

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

29.3.2 The following test parameters shall be among the items considered when judging the acceptability of an operating control investigated using a standard other than UL 60730-1:

a) Control action Types 1 or 2;

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

c) For the applicable Overvoltage Category, see Table 29.1;

d) For the applicable Material Group, see Table 29.2; and

e) For the applicable Pollution Degree, see Table 29.3.

29.4 Protective controls (limiting controls)

29.4.1 An electronic control that performs a protective function shall comply with the applicable requirements in 6.6 while tested using the parameters in this section. Examples of protective controls include:

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

b) An interlock function to de-energize a motor;

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

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

29.4.2 The following test parameters shall be among the items considered when determining the acceptability of an electronic protective control investigated using UL 60730-1:

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

b) Power supply voltage dips, variation and interruptions within a temperature range of 10 °C (18 °F) and the maximum ambient temperature determined by conducting the Temperature Test, Section 44;

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

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

e) Electrostatic Discharge Test;

f) Radio-Frequency Electromagnetic Field Immunity:

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

2) Immunity to radiated electromagnetic fields, field strength of 10 V/m shall be used;

g) Thermal Cycling Test shall be conducted at ambient temperatures of 10.0 ±2 °C (50.0 ±3 °F) and the maximum ambient temperature determined by conducting the Temperature Test; see Section 44. The test shall be conducted for 14 days;

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Temperature Test, Section 44; and

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

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

29.4.4 Controls using a temperature sensing device – A temperature sensing positive temperature coefficient (PTC) or negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control, shall be tested using the following number of cycles when testing a sensing device in accordance with the endurance test:

a) For a device employed as a operating device – 6,000 cycles;

b) For a device employed as a protective device – 100,000 cycles; and

c) For a device employed as a combination operating and protective device – 100,000 cycles.

30 Electronic Circuits Evaluated to UL 60335-1 Based Requirements

30.1 Identification of safety critical circuit functions

30.1.1 General

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

30.1.1.2 Safety Critical Functions shall be identified as either Protective Electronic Circuits as detailed in 30.2 or as those of operating circuits that mitigate Dangerous Malfunctions as detailed in 30.3.

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

30.1.1.4 See Section 3 and Table 3.1 for common Safety Critical Functions.

30.2 Protective electronic circuits

30.2.1 An electrical component shall not be connected across the contacts of a Protective Electronic Circuit.

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

30.3 Operating circuits that mitigate a dangerous malfunction of the appliance

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

30.3.2 An electronic disconnection circuit whose failure could result in a Dangerous Malfunction shall have at least two components whose combined operation provides the load disconnection.

30.4 Evaluation of the different types of electronic circuits

30.4.1 All types of circuits

30.4.1.1 All circuit functions mandated by this Standard shall be validated. This includes operating functions not designated as Safety Critical Functions.

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

30.4.1.3 When the applicable component/hardware faults specified in 48.5.10 are imposed one at a time they shall not result in:

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

b) The loss of any Safety Critical Function either in that circuit or others.

30.4.1.4 The risk of electrically generated fire from the faults of 48.5.10 is considered to be mitigated in Low-Power Circuits.

30.5 Circuits that provide safety critical functions

30.5.1 In addition to the requirements of 30.4, circuits that provide Safety Critical Functions shall incorporate measures to control the fault/error conditions that would impair the safety functions.

30.5.2 The evaluation of the programmable component shall be in accordance with Annex R of UL 60335-1.

30.5.3 Circuits that provide Safety Critical Functions that rely upon a programmable component for one or more of its safety functions shall be subjected to the test of the Programmable Component Reduced Supply Voltage Test, 48.6, unless restarting at any point in the operating cycle after interruption of

operation due to a supply voltage dip will not result in a hazard. The test is carried out after removal of all batteries and other components intended to maintain the programmable component supply voltage during mains supply voltage dips, interruptions and variations.

30.5.4 Circuits that provide Safety Critical Functions shall maintain their required functions when subjected to the EMC related stresses specified in the Electromagnetic Compatibility (EMC) Requirements – Immunity, 48.7.

30.5.5 The tests of 48.7 are carried out with surge protective devices disconnected, unless they incorporate spark gaps.

31 Transformers and Power Supplies

31.1 A Class 2 transformer shall comply with the applicable requirements in UL 5085-1, and UL 5085-3.

31.2 A power transformer shall comply with the applicable requirements in UL 5085-1, and UL 5085-2.

31.3 A Class 2 power supply shall comply with the requirements in UL 1310.

32 Switch Mode Power Supplies

32.1 Bridging components – switch mode power supplies

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

32.1.2 An optical isolator that is relied upon to provide feedback between primary and secondary circuits of a switch mode power supply shall comply with UL 1577. It shall have a minimum isolation voltage of 1500 V.

32.1.3 A capacitor connected between primary and accessible secondary circuits shall comply with Capacitors, Section 24. This shall consist of a single Class Y1 capacitor or two Class Y2 capacitors connected in series.

32.2 Transformer insulation system

32.2.1 Insulation used within a transformer of switch mode power supply shall comply with UL 1446, for the specified temperature class of the insulation system or UL 2353.

33 Seals, Gaskets, and Diaphragms

33.1 If the deterioration or breakage of a liquid seal or similar component increases the risk of electric shock, the seal or component shall be investigated.

33.2 The investigation to determining compliance with 33.1 depends upon the material of which it is composed, its size and shape, the mode of application in the appliance, and similar factors. The investigation may include visual inspection for determination of cracks, deformation, and similar defects, after artificial aging, as well as comparison of hardness, tensile strength, and elongation before and after artificial aging.

33.3 With reference to 33.1 and 33.2, a noncomposite material, when tested to compare its tensile strength and elongation before and after artificial aging, is acceptable if these properties are found to be not less than the minimum corresponding values specified in UL 157. The maximum service temperature specified in UL 157 corresponds to the temperature of the component during the heating test.

34 Motors

34.1 Construction

34.1.1 A motor shall be acceptable for the application, and shall be capable of handling the maximum normal load of the appliance as described in the Temperature Test, Section 44, without resulting in a risk of fire, electric shock, or injury to persons.

34.1.2 A motor winding shall resist the absorption of moisture.

34.1.3 With reference to the requirement in 34.1.2, film-coated wire is not required to be additionally treated to resist absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials are to be provided with impregnation or otherwise treated to resist moisture absorption.

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

34.2 Brush wear out

34.2.1 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 are retained to the degree necessary not to cause accessible dead metal parts to become energized, and live parts to become accessible.

34.3 Overload protection

34.3.1 An appliance shall incorporate thermal or overload protection in accordance with 34.3.2.

34.3.2 Motor-overload protection required for an appliance shall consist of thermal protection complying with the applicable requirements in UL 2111, or UL 1004-2, UL 1004-3, or the tests of UL 1004-3 and the circuit requirements in Section Electronic Circuits Evaluated to UL 60335-1 Based Requirements, 30.

Exception No. 1: The duration of the temperature test and endurance test, both under locked-rotor conditions, is not required to comply with UL 2111, or UL 1004-2, or UL 1004-3 when:

a) The appliance includes a control that positively and reliably limits the length of time the appliance operates; and

b) The total duration of the test is not less than the operating time of the control employed in the appliance.

Exception No. 2: A motor intended to move air only by means of an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor shaft is not required to have running-overload protection.

Exception No. 3: A shaded-pole motor with a 2:1 or smaller ratio between locked-rotor and no-load currents and a 1-A or smaller difference between no-load and locked-rotor currents is considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

34.3.3 If a requirement in this Standard refers to the horsepower rating of a motor and the motor is not rated in horsepower, use is to be made of the appropriate table of NFPA 70, that gives the relationships between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating-current motor is to be used if the appliance is marked for use on alternating current only; otherwise the table applying to direct-current motors is to be used.

35 Arc-Fault and Leakage Current Detectors / Interrupters

35.1 When required by this end product standard, or when provided as part of an end product, an AFCI or LCDI shall comply with 6.11 and 35.2 – 35.4.

35.2 An arc-fault circuit-interrupter (AFCI) or leakage-current detector-interrupter (LCDI) shall be installed as an integral part of the attachment plug or located in the supply cord within 4 inches (102 mm) of the attachment plug.

35.3 Arc fault detection testing shall include the applicable tests in UL 1699, required for cord-type arc-fault circuit-interrupters.

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

35.4 An AFCI or LCDI provided as part of an appliance intended for outdoor use shall comply with the applicable outdoor use requirements of this end product standard.

36 Adhesives Used to Secure Parts

36.1 An adhesive that is relied upon to reduce a risk of fire, electric shock, or injury to persons shall comply with the requirements for adhesives in UL 746C.

36.2 The requirement in 36.1 applies to an adhesive used to secure a conductive part, including a nameplate, that may, if loosened or dislodged:

a) Energize an accessible dead-metal part;

b) Make a live part accessible;

c) Reduce spacings below the minimum acceptable values; or

d) Short-circuit live parts.

36.3 Whether the conditions mentioned in 36.2 (a) – (d) can occur is to be considered with respect to both a part inside the device, and a part on the outside of the device that may affect the appliance in which the device is to be installed.

37 Double Insulation

37.1 An appliance constructed with double insulation and marked as such shall comply with UL 1097, in addition to requirements of this Standard. Where requirements supersede requirements in UL 1097, the more severe shall apply.

38 Protection from Overexposure to Ultraviolet (UV) Radiation

38.1 Appliances shall be investigated for emission of ultraviolet radiation in accordance with the ultraviolet irradiance test in Section 58. Appliances that use UV lamps systems that produce less than

0.1 μW/cm^2 are not considered to present a photobiological hazard risk and, therefore not required to comply with 38.2 – 38.3.

NOTE: UV lamps that produce less than 0.1 μW/cm^2 are considered Risk Group 0 (RG0).

38.2 Interlocks and interlock systems used to minimize risk of overexposure to ultraviolet (UV) radiation shall be reliable, see 38.3. The actuator of an interlock shall be located so the unintentional operation is unlikely and it is not able to be defeated with the articulated probe of Figure 10.1. The interlock shall be reliable and not easily defeated by improper disassembly or reassembly of the equipment.

38.3 An interlock and interlock system that is required to reduce a risk of overexposure to ultraviolet (UV) radiation shall withstand 100,000 cycles of operation controlling a load not less than that controlled in the product, and shall function normally upon completion of the test.

38.4 UV lamp systems that emit ultraviolet radiation at wavelengths less than 250 nm shall comply with the ozone requirements specified in Section 50.

38.5 The appliance shall be provided with a visual indication to the user when the UV lamp system is activated.

PERFORMANCE

39 General

39.1 Other than as noted in 39.2, an appliance shall comply with the tests described in Sections 40 – 66. The tests shall be conducted at the test potential specified in Table 39.1. An appliance having a single frequency rating is to be tested at that frequency. An appliance rated ac/dc or dc-60 Hz is to be tested on direct current or 60-Hz alternating current, whichever results in higher temperatures. An appliance rated 25 – 60 Hz or 50 – 60 Hz or 50 / 60 Hz is to be tested on 60-Hz alternating current.

Table 39.1
Test Voltages

Appliance voltage rating, V[a]	Test potential, V
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
440 – 480	480
550 – 600	600
550 – 600	600

[a] If a single voltage rating of a appliance does not fall within any of the indicated voltage ranges, the appliance is to be tested at its rated voltage. If a range of voltages is specified and one or more of the values fall within one of the indicated voltage ranges, the appliance is to be tested at the test potential specified for the indicated range or the highest value of the rating, whichever is greater. If a range of voltages is specified and none of the values fall within any of the indicated voltage ranges, the appliance shall be tested at the highest value in the specified range. For an appliance with a dual rating, the appliance is to be tested based on both ratings unless it can be shown that testing based on one rating would represent testing based on the other rating.

39.2 Whenever a test requires that the appliance be connected to an unheated water source, the temperature of the water shall be 20 ±3 °C (68 ±5 °F). For appliances that the manufacturer indicates, by marking on the appliance or in the operating instructions, may be connected to a hot-water source, tests shall be conducted at the maximum specified temperature, but not less than 60 ±2 °C (140 ±3.6 °F).

39.3 The cheesecloth specified in tests shall be bleached cotton cloth running 14 – 15 yd^2/lb (26 – 28 m^2/kg) and having what is known in the trade as a count of 32 by 28, that is, for any square inch, 32 threads in one direction and 28 threads in the other direction (for any square centimeter, 13 threads in one direction and 11 threads in the other direction).

40 Power Input Test

40.1 The power input to the equipment shall not exceed the marked rating by more than 10 % when it is operated under the conditions of normal use while connected to a supply circuit as specified in Table 39.1.

41 Leakage Current Test

41.1 A cord connected appliance shall comply with UL 101.

41.2 In a test to determine whether an appliance of the immersed-electrode type complies with the requirement in 41.1, the hard-water solution described in 44.4 is to be used.

42 Leakage Current Following Humidity Conditioning Test

42.1 A cord connected appliance shall comply with UL 101, following exposure for 48 h to air having a relative humidity of 88 ±2 % at a temperature of 32 ±2 °C (90 ±4 °F).

42.2 A sample of the appliance is to be heated to a temperature just above 34 °C (93 °F) to reduce the likelihood of condensation of moisture during conditioning. The heated sample is to be placed in the humidity chamber and conditioned for 48 hours under the conditions specified in 42.1. Following the conditioning and while still in the chamber, the sample is to be tested unenergized. Either while the sample is still in the humidity chamber or immediately after it has been removed from the chamber, the sample is to be energized and tested as described in UL 101. The test is to be discontinued when the leakage current stabilizes or decreases.

43 Resistance of Grounding Test

43.1 The resistance between the point of connection of the equipment-grounding means at or within the appliance and any other point in the grounding circuit of the appliance shall not exceed 0.1 Ω.

43.2 Compliance with the requirement in 43.1 is to be determined by:

a) A resistance-measuring instrument; or

b) Passing an alternating current of at least 25 A from a power supply of not more than 12 V from the grounding pin of the attachment plug cap to a point in the grounding circuit, and then measuring the resulting drop in potential between the two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

44 Temperature Test

44.1 An appliance, when tested under the conditions of maximum normal load described in 44.3, shall not attain a temperature at any point sufficiently high to constitute a risk of fire, to damage any material employed in the appliance, or to exhibit greater rises in temperature above an ambient of 25 °C (77 °F) than indicated for specific points as indicated in Table 44.1 and Table 44.2.

Table 44.1
Maximum Temperature Rises

Materials and components	°C	(°F)
A. MATERIALS		
1. Class 105 (A) insulation system on coil windings of an AC motor having a frame diameter 7 inches (178 mm) or less, not including a universal motor, and on a vibrator coil[a,b]:		
a. In an open motor and on a vibrator coil:		
Thermocouple method or resistance method	75	(135)
b. In a totally enclosed motor:		
Thermocouple method or resistance method	80	(144)
2. Class 105 (A) insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches (178 mm), of a DC motor, and of a universal motor[a,b]:		
a. In an open motor:		
Thermocouple method	65	(117)
Resistance method	75	(135)
b. In a totally enclosed motor:		
Thermocouple method	70	(126)
Resistance method	80	(144)
3. Class 130 (B) insulation systems on coil windings of an AC motor having a frame diameter of 7 inches (178 mm) or less not including a universal motor[a,b]:		
a. In an open motor:		
Thermocouple or resistance method	95	(171)
b. In a totally enclosed motor:		
Thermocouple method or resistance method	100	(180)
4. Class 130 (B) insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches (178 mm), of a DC motor, and of a universal motor[a,b]:		
a. In an open motor:		
Thermocouple method	85	(153)
Resistance method	95	(171)
b. In a totally enclosed motor:		
Thermocouple method	90	(162)
Resistance method	100	(180)
5. Class 155 (F) insulation systems on coil windings of an AC motor having a frame diameter of 7 inches (178 mm) or less, not including a universal motor[b]:		
a. In an open motor:		
Thermocouple or resistance method	120	(216)
b. In a totally enclosed motor:		
Thermocouple or resistance method	125	(225)
B. COMPONENTS		
1. Capacitors:		
a. Electrolytic[c,d]	40	(72)
b. Other types[d]	65	(117)

Table 44.1 Continued on Next Page

Table 44.1 Continued

Materials and components	°C	(°F)
2 Fuses:		
a. Class G, J, L, T, and CC:		
Tube	100	(180)
Ferrule or blade	85	(153)
Others[e]	65	(117)
3. Relay, solenoid, and coils (except motor coil windings and transformers) with:		
a. Class 105 (A) insulated systems:		
Thermocouple method	65	(117)
Resistance method	85	(153)
b. Class 130 (B) insulation systems:		
Thermocouple method	85	(153)
Resistance method	95	(171)
4. Coils of a Class 2 transformer:		
a. Class 105 (A) insulation systems:		
Thermocouple method	65	(117)
Resistance method	85	(153)
b. Class 130 (B) insulation systems:		
Thermocouple method	85	(153)
Resistance method	95	(171)
C. CONDUCTORS		
1. Rubber- or thermoplastic-insulated wires and cords[e,f]	35	(63)
2. Copper		
a. Tinned or bare strands having:		
i) A diameter less than 0.015 inches (0.38 mm)	125	(125)
ii) A diameter of 0.015 inches or more	175	(315)
b. Plated with nickel, gold, silver, or a combination of these	225	(405)
D. ELECTRICAL INSULATION – GENERAL		
1. Fiber used as electrical insulation	65	(117)
2. Phenolic composition used as electrical insulation or as a part the deterioration of which is capable of resulting in a risk of fire or electric shock[e]:		
a. Laminated	100	(180)
b. Molded	125	(125)
3. Varnished-cloth insulation	60	(108)
E. SURFACES		
1. A surface of flammable material upon which an appliance is capable of being placed or mounted in service, and a surface that may be adjacent to the appliance when it is so placed or mounted	65	(117)
2. Any point within a terminal box or wiring compartment of a permanently connected appliance in which power-supply conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with 70.24	35	(63)
3. Wood or other flammable material, including the inside surface of the test enclosure and the surface supporting the appliance.	65	(117)

Table 44.1 Continued on Next Page

Table 44.1 Continued

Materials and components	°C	(°F)
[a] At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature measured by means of a thermocouple that is greater than the maximum temperature specified in this table complies with the intent of this requirement as long as the temperature, as measured by the resistance method, is not more than that specified. The temperature measured by means of a thermocouple is not prohibited from being greater than the specified value by: 1. 5 °C (9 °F) for Class 105 (A) insulation on coil windings of an AC motor having a diameter of 7 inches (178 mm) or less, open type; 2. 10 °C (18 °F) for Class 130 (B) insulation on coil windings of an AC motor having a diameter of 7 inches (178 mm) or less, open type; 3. 15 °C (27 °F) for Class 105 (A) insulation on coil windings of an AC motor having a diameter of more than 7 inches (178 mm), open type; 4. 20 °C (36 °F) for Class 130 (B) insulation on coil windings of an AC motor having a diameter of more than 7 inches (178 mm), open type. [b] This is the diameter measured in the plane of the laminations of the circle circumscribing the stator frame, excluding lugs, fins, boxes, and similar parts, used solely for motor mounting, cooling, assembly, or connection. [c] For an electrolytic capacitor that is physically integral with or attached to a motor, the maximum temperature rise on insulating material integral with the capacitor enclosure shall not be more than 65 °C (117 °F). [d] A capacitor that operates at a temperature of more than 65 °C (117 °F) complies with the intent of this requirement when evaluated on the basis of its marked temperature limit. [e] These limitations do not apply to compounds and components that have been investigated and rated for use at higher temperatures. [f] A rubber-insulated conductor with a motor, a rubber-insulated motor lead, and a rubber-insulated conductor of a flexible cord entering a motor that is subjected to a higher temperature complies with the intent of this requirement when the conductor is provided with sleeving or a braid that has been investigated and rated for use at the higher temperature. This does not apply to thermoplastic-insulated wires or cords.		

Table 44.2
Maximum Surface Temperatures

Location	Composition of surface	
	Metal, °C (°F)	Nonmetallic, °C (°F)
Handles or knobs that are grasped for lifting, carrying or holding	55 °C (131 °F)	75 °C (167 °F)
Handles or knobs that are contacted but do not involve lifting, carrying, or holding; and other surfaces subject to contact and user maintenance	60 °C (140 °F)	85 °C (185 °F)
Surfaces other than a heating function surface and known to be hot due to proximity to the heating function surface	70 °C (158 °F)	95 °C (203 °F)
NOTE: If the test is conducted at a room temperature of other than 25 °C (77 °F), the results are to be corrected to that temperature. [a] A handle, knob, or similar device, made of a material other than metal, that is plated or clad with metal having a thickness of 0.005 inches (0.127 mm) or less is considered to be, and is investigated as, a nonmetallic part.		

44.2 All values in Table 44.1 are based on an assumed ambient of 25 °C (77 °F), but the test may be conducted at any ambient temperature within the range of 10 – 40 °C (50 – 104 °F). However, if the operation of an automatic thermal control during the test limits the temperature under observation, no observed temperature higher than 25 °C (77 °F) plus the specified maximum rise is acceptable.

44.3 In testing an appliance, maximum normal load is considered to be the load that approximates as closely as possible the most severe conditions of normal use. It is not a deliberate overload, but is intended to simulate conditions of actual use that may be more severe than the maximum load conditions of actual use that may be more severe than the maximum load conditions recommended by the manufacturer of the appliance.

44.4 An immersed-electrode type appliance is to be operated with a hard water solution of 0.018 oz (0.5 g) of calcium sulphate ($CaSO_4 \cdot 2H_2O$) per 35 fl oz (L) of distilled water.

44.5 For appliances having a reservoir for salt (NaCl), the reservoir is to be filled with salt.

44.6 An appliance that is rated for use at more than one voltage or for a range of voltages and contains a tapped transformer or other means of being adapted to different supply voltages is to be tested at the most unfavorable combination of supply voltage and internal adjustment.

Exception: An appliance may be tested while connected in accordance with the manufacturers instructions if all three of the following conditions are met:

a) A clear, permanent marking is provided adjacent to the cord or supply compartment to warn the user that internal adjustments must be made when the appliance is installed or moved.

b) Detailed instructions clearly showing the adjustments that must be made for various voltages are permanently attached to the appliance. These instructions may be on the outside or on the inside of the overall enclosure where visible at the point at which adjustments for supply voltage must be made.

c) The means provided for adjusting for different voltages comply with the requirements for wiring terminals in 15.3.

44.7 If an appliance obviously is not intended for continuous operation, the heating test may be modified to take into consideration the probable occasional or periodic short-time operation of the appliance.

44.8 Thermal equilibrium is to exist only if successive readings indicate no change when taken at the conclusion of each of three consecutive equal intervals of time, the duration of each interval being whichever of the following is longer:

a) 5 minutes; or

b) 10 % of the total test time elapsed previous to the start of the first interval.

44.9 When thermocouples are used in determining temperature in an appliance, it is standard practice to employ thermocouples consisting of 30 AWG (0.05 mm^2) iron and constant wire and a potentiometer type instrument; and such equipment is used whenever referee temperature measurements by thermocouples are necessary.

44.10 Thermocouples are to be made of wires not larger than 24 AWG (0.21 mm^2). The thermocouple wire is to conform with the requirements for Special Tolerances thermocouples as listed in the Tolerances on Initial Values of EMF versus Temperature tables in ASTM E230/E230M.

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

44.12 The preferred method of measuring the temperature of a coil is the resistance change-of-method; but temperature measurements by either the thermocouple or resistance method are acceptable; except that the thermocouple method is not to be employed at any point where supplementary insulation is employed.

44.13 With reference to 44.12, when thermocouples are used for measuring the temperatures of a coil, at least two thermocouples are to be used. The thermocouples are to be placed on the surface of the

magnet wire which is the upper surface based on the orientation during testing. An additional thermocouple is to be placed on a surface subjected to heating by another source, such as another transformer or a hot resistor.

44.14 The change-of-resistance method consists of the determination of the temperature of a copper winding by comparing the resistance of the winding at the beginning of the test with its resistance at the end of the test, also taking into consideration ambient (room) temperature at the beginning and end of the test period according to the following formula:

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

in which:

Δt is the temperature rise;

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

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

k is 234.5 for copper and 225.0 for aluminum;

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

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

44.15 Because it is generally necessary to de-energize the winding before measuring R, the value of R at shutdown may be determined by taking several resistance measurements at short intervals, beginning as quickly as possible after the instant of shutdown. A curve of the resistance values and the time may be plotted and extrapolated.

44.16 A protective device shall not open or cycle during the heating test.

44.17 Doors and covers that can be closed during operation of the appliance are to be closed during the test.

44.18 A permanently connected appliance is to be tested with 4 feet (1.22 m) of wire attached to each field wiring terminal. The wire is to be sized in accordance with Article 310 of NFPA 70.

45 Burnout Test

45.1 An appliance employing water valves, or relays shall be subjected to the following conditions without emission of flame or molten metal from the enclosure and without otherwise becoming a risk of fire:

a) A solenoid on a water valve shall be capable of being operated continuously without water in the system; and

b) A solenoid or relay shall be energized having the plunger of a solenoid or relay blocked in the open position with water in the system.

45.2 The appliance shall be covered with a double layer of white cheesecloth and supported on a softwood surface covered with a double layer of white tissue paper. The test shall be continued for 7 hours unless the ultimate results occur sooner. The power-supply circuit shall include a fuse of the maximum current rating that is accommodated by the fuseholder of the branch circuit to which the appliance would

normally be connected, but not less than 20 A. During the test exposed dead metal parts of the appliance are to be connected to ground through a 3-A nontime-delay fuse.

46 Dielectric Voltage-Withstand Test

46.1 General

46.1.1 The appliance shall withstand without breakdown for 1 minute the application of 60 Hz sinusoidal potential that is twice the maximum rated primary voltage plus 1000 V between the primary circuit and exposed or grounded dead metal.

Exception: A direct-current potential may be used for a direct-current circuit.

46.1.2 A transformer shall withstand for 1 minute without breakdown the application of 60 Hz sinusoidal potential as follows:

a) 125 % of the maximum measured or rated secondary voltage, whichever is higher, between primary and secondary windings, and between secondary and resonating windings.

Exception: This test is to be omitted if any point of the secondary winding is grounded. If the resonating winding and the high-voltage windings are common, the test between the resonating winding and the secondary winding is to be omitted.

b) 150 % of the maximum rated primary voltage applied to the ends of the primary winding with one end of the primary winding connected to the enclosure.

Exception: A direct-current potential may be used for a direct-current circuit.

46.1.3 With reference to 46.1.2(b), the frequency may be adjusted higher if needed. If the transformer does not have a grounded secondary winding, this test is to be conducted first with one end of the secondary, and then the other end, connected to the common connection of the primary and enclosure. If the transformer has a point other than an end point of its secondary windings grounded, the test is to be performed as described, but without an electrical connection between either end of the secondary and the common connection of the primary and enclosure.

46.1.4 Each component of an appliance that is subjected to dc potentials during normal operation of the appliance shall withstand without breakdown for 1 minute, the application of a dc potential of 150 % of the rated or measured dc voltage, whichever is greater, between that component and grounded metal.

46.1.5 If the application of a dc potential of 150 % of the measured dc voltage of one point causes the rated dc potential of another point to be more than 150 % of the maximum voltage at these points, other places in the circuit may be grounded to prevent the excessive voltage condition from occurring.

46.1.6 Each meter provided with an appliance is to be disconnected from the circuit when the appliance is subjected to the dielectric voltage-withstand tests described in 46.1.1 – 46.1.5. Each meter is then to be separately subjected to the dielectric voltage-withstand tests in 46.1.1 and 46.1.4.

46.1.7 In determining compliance 46.1.1 – 46.1.6, the applied potential is to be increased from zero until the required test voltage is reached, and is to be held at that voltage for 1 minute. The increase in the applied potential is to be at a substantially uniform rate that is and as rapid as is consistent with the value correctly indicated by a voltmeter.

46.2 Induced potential test

46.2.1 Three samples of a magnet coil winding as described in 22.1.4 and 22.1.5 are to be subjected to this test. While in a heated condition from operation as described Temperature Test, Section 44, the primary winding of each transformer shall withstand without breakdown an alternating potential of twice the rated voltage of the winding.

46.2.2 The potential is to be:

a) Applied for 7200 electrical cycles if the test potential frequency is 120 Hz or more; and

b) 60 seconds if the frequency is less than 120 Hz.

A higher test frequency may be necessary so the core is not saturated. The test voltage is to be started at one-quarter or less of the full value and increased to full value in not more than 15 seconds. After being held for the time specified, the voltage is to be reduced within 5 seconds to one-quarter or less of the maximum value and the circuit is to be opened.

46.2.3 With reference to 46.2.1, a transformer may be conditioned in an oven to obtain the temperature reached in the Temperature Test, Section 44, before conducting the induced-potential test.

47 Abnormal Operation Tests

47.1 General

47.1.1 The appliance shall not present a risk of fire or electric shock as a result of the following tests. Each abnormal test shall be followed by a dielectric voltage-withstand test as required by 46.1.1 applied between the transformer primary and secondary windings and between the line and exposed dead-metal parts.

47.1.2 A risk of fire or electric shock is considered to exist if any of the following occur:

a) Opening of the grounding fuse;

b) Charring of cheesecloth;

c) Emission of flame or molten material from the appliance enclosure and output cord, if provided;

d) Any opening that develops in the enclosure that exposes live parts at a potential of more than 42.4 V peak to any other part or to ground; or

e) Loss of structural integrity to a degree where a plug-in unit cannot be removed from a receptacle immediately after the test without deformation or a risk of electric shock.

47.1.3 Each test is to be conducted on a separate sample unless agreeable to those concerned that more than one test can be conducted on the same sample.

47.1.4 The grounding means, if provided, is to be connected to ground through a 3-A, nontime-delay fuse.

47.1.5 The appliance is to be draped with a double layer of cheesecloth conforming to the outline of the appliance.

47.1.6 The temperatures specified are based on an assumed ambient temperature of 25 °C (77 °F), but a test may be conducted at any ambient temperature of 21 – 30 °C (70 – 86 °F). However, if the operation

of an automatic thermal control during the test limits the temperatures under observation, no temperatures higher than indicated is acceptable.

47.2 Component breakdown test

47.2.1 The components in an appliance, such as diodes, resistors, transistors, capacitors, and similar components, are to be shorted or opened, one at a time. The appliance is to be connected to the maximum test voltage and operated until ultimate conditions are observed, or for 4 hours if cycling of an automatically reset protector occurs. This test need not be conducted for component breakdowns that result in open or short-circuiting of the output, in short-circuiting of the transformer, or for a component in a low-voltage circuit.

47.3 No water test

47.3.1 An appliance shall be operated as described in the Temperature Test, Section 44, except the appliance is not to be connected to a water source and any water reservoirs are to be left empty. This test is to be conducted for 7 hours, or until ultimate results are achieved, whichever is less.

47.4 Ventilation fan test

47.4.1 An appliance shall be operated as described in the Temperature Test, Section 44, with the fan blades blocked to prevent their rotation. This test is to be continued for 7 hours, or until ultimate results are achieved, whichever is less.

47.5 Switch mode power supplies

47.5.1 Overload tests

47.5.1.1 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.

47.5.1.2 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.

47.5.1.3 For this test, any protective devices such as a fuse, manual reset circuit protector, thermal protector, etc is allowed to remain in the circuit.

47.5.1.4 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 hour. If this value cannot be derived from the specification, it is to be established by test.

47.5.1.5 If no overcurrent protection is provided, the maximum overload is the maximum power output obtainable from the power supply.

47.5.1.6 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.

47.5.1.7 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.