UL 561

STANDARD FOR SAFETY

Floor-Finishing Machines

UL Standard for Safety for Floor-Finishing Machines, UL 561

Seventh Edition, Dated October 31, 2011

SUMMARY OF TOPICS

This revision of ANSI/UL 561 dated June 29, 2021 includes the following changes in requirements:

– Replacing the References to the Standard For Power Conversion Equipment, UL 508C, With Reference to the Standard For Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1; 4.5.4.1 and 4.14.4.4

– Type SJ Power Supply Cords for Commercial Spray Extraction Machines; 10.8

– Addition of UL 969A into UL 561; 46.1

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated January 15, 2021 and April 16, 2021.

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Standard for Floor-Finishing Machines

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This ANSI/UL Standard for Safety consists of the Seventh Edition including revisions through June 29, 2021.

The most recent designation of ANSI/UL 561 as an American National Standard (ANSI) occurred on June 29, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 561 on March 11, 1991. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover electrically powered floor-finishing machines to be used in accordance with the National Electrical Code, NFPA 70. This product category includes the following: a floor polisher, floor scrubber, floor sander, floor scraper, tile remover, rug shampooer, rug and floor washer, and a similar machine for commercial use. A machine such as a sander and wet scrubber with vacuum attachments is also covered.

1.2 These requirements do not cover vacuum cleaning machines, permanently connected machines, or cord-connected machines that are intended to be fastened in place or located in a dedicated space. These requirements do not cover machines rated more than 600 volts, nor do they cover machines involving universal motors rated more than 250 volts. These requirements do not cover floor finishing machines for household use, which are covered in the Standard for Vacuum Cleaners, Blower Cleaners, and Household Floor Finishing Machines, UL 1017/CSA-C22.2 No. 243.

1.3 A machine that uses some other source of energy (such as gas or steam) in addition to electrical energy will be investigated under these requirements and under such additional requirements as applicable to the machine under consideration.

2 General

2.1 Terminology

2.1.1 In the following text, a requirement that applies to one type of equipment (polisher, scrubber, or the like) is identified by a specific reference in that requirement to the type of equipment involved. In the absence of such specific reference, or if the term product or machine is used, it is understood that the requirement applies to all types of equipment covered by the standard.

2.2 Units of measurement

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

2.2.2 Unless indicated otherwise, all voltage and current values mentioned in this standard are root mean square (rms).

2.3 Undated references

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

3 Glossary

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

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

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

3.4 COMMERCIAL USE PRODUCT – A product not intended for use only in the home.

3.5 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.

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

3.7 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.

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

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

3.10 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.

Note – During the evaluation of the protective control/circuit, the protective functions are verified under normal and single-fault conditions of the control.

3.11 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.

3.12 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.

3.13 HAND-GUIDED PRODUCT – A portable product which during intended use is contacted by the hand of the user for purposes of electrical or physical control, but not for complete support.

3.14 HAND-SUPPORTED PRODUCT – A portable product that is completely supported by the user during the performance of its intended function. The hand of the user may also be used to exercise electrical or physical control of the operation of the product.

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

3.16 LOW-VOLTAGE CIRCUIT – A circuit involving a peak open-circuit potential of not more than 42.4 volts 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.

3.17 MEASUREMENT INDICATION UNIT (MIU) – The output voltage across the meter, in millivolts RMS, read from the measurement instrument in Figure 29.1, divided by 500 ohms. (The instrument indication is equal to the RMS value in milliamperes when the frequency is 60 Hz – sinusoidal current. The reading may not be a direct indication of the RMS or other common amplitude quantifier of leakage current when the leakage current is of a complex waveform or frequency other than 50 or 60 Hz).

4 Components

4.1 General

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

a) Comply with the requirements for that component as indicated in 4.2 – 4.24;

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

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

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

e) Not contain mercury.

Note – 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.

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

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

b) Is superseded by a requirement in this end product standard,

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 4.2 – 4.24 is acceptable if:

a) The component also complies with the applicable component standard of 4.2 – 4.24; or

b) The component standard:

1) Is compatible with the ampacity and overcurrent protection requirements of the National Electrical Code, ANSI/NFPA 70, where applicable;

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

3) Any use limitations of the other component standard 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 that complies with the relevant component standard may assume user expertise not common in household applications.

4.1.2 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 component standard(s) need not be applied.

4.1.3 A component not anticipated by the requirements of this end product standard, not specifically covered by the component standards in 4.2 – 4.24, 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 4.1.1(b) – (e).

4.1.3.1 With regard to 4.1.3, reference to construction and performance requirements in another UL end product standard is applicable where that standard anticipates normal and abnormal use conditions consistent with the application of UL 561.

4.2 Attachment Plugs, receptacles, connectors, and terminals

4.2.1 Attachment plugs, receptacles, appliance couplers, appliance inlets (motor attachment plugs), and appliance (flatiron) plugs, shall comply with the Standard for Attachment Plugs and Receptacles, UL 498. See 4.2.9.

Exception No. 1: Attachment plugs and appliance couplers integral to cord sets or power supply cords are investigated in accordance with the requirements in the Standard for Cord Sets and Power-Supply Cords, UL 817 and need not comply with UL 498.

Exception No. 2: A fabricated pin terminal assembly(ies) need not comply with UL 498 if it complies with Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 6, Live Parts, Section 13, Insulating Material, Section 16, and Spacings, Section 26 of this end product standard, as well as the applicable performance requirements when tested in the end-product.

4.2.2 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 in), intended for internal wiring connections in appliances, or for the field termination of conductors to the appliance, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception 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 15. 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.

4.2.3 Single and multipole connectors for use in data, signal, control and power applications within and between electrical equipment, and that are intended for factory assembly to copper or copper alloy conductors, or for factory assembly to printed wiring boards, shall comply with the Standard for Component Connectors for Data, Signal, Control and Power Applications, UL 1977. See 4.2.9.

4.2.4 Wire connectors shall comply with the Standard for Wiring Connectors, UL 486A-UL486B.

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

4.2.6 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 the Standard for Multi-Pole Splicing Wire Connectors, UL 2459. See 4.2.9.

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

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

Exception: A fabricated part performing the function of a terminal block need not comply with UL 1059 if the part complies with the requirements of Live Parts, Section 13, Internal Wiring, Section 14, Insulating Material, Section 16, and Spacings, Section 26 of this end product standard, as well as the applicable performance requirements when tested in the end-product. This exception does not apply to protective conductor terminal blocks.

4.2.9 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.

4.3 Boxes, conduits, and raceways

4.3.1 Electrical boxes and the associated bushings, conduits, fittings, and raceways of the types specified in the National Electrical Code, ANSI/ NFPA 70, and that comply with the relevant UL standard (such as Flexible Metal Conduit, UL 1, Metallic Outlet Boxes, UL 514A, Conduit, Tubing, and Cable Fittings, UL 514B, Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C, Cover Plates for Flush-Mounted Wiring Devices, UL 514D, and Components, General, 4.1 are considered to comply with the requirements of this end product standard.

4.4 Capacitors and filters

4.4.1 The component requirements for capacitors are specified in Capacitors, Section 23.

4.4.2 Electromagnetic interference filters with integral enclosures that comply with one of the following standards are considered to comply with the requirements in 23.1.

a) The Standard for Electromagnetic Interference Filters, UL 1238; or

b) The Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14, UL 60384-14.

4.5 Controls

4.5.1 General

4.5.1.1 Auxiliary controls shall be evaluated using the applicable requirements of this end product standard and the requirements in Auxiliary controls, 22.2, unless otherwise specified in this end product standard; see 4.5.1.4.

4.5.1.2 Operating (regulating) controls shall be evaluated using the applicable component standard requirements specified in 4.5.2 – 4.5.7, and if applicable, the parameters in Operating controls (regulating controls), 22.3, unless otherwise specified in this end product standard; see 4.5.1.4.

4.5.1.2.1 Operating controls that rely upon software for the normal operation of the end product where deviation or drift of the operating parameters of the control may result in an increased risk of electric shock, fire, or injury to persons, shall comply with:

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

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

4.5.1.3 Solid-state protective (limiting) controls shall be evaluated using the applicable component standard requirements specified in 4.5.2 – 4.5.7, and if applicable, the parameters in Protective controls (limiting controls), 22.4, unless otherwise specified in this end product standard.

4.5.1.3.1 Solid-state protective controls that do not rely upon software as a protective component shall comply with:

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

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

4.5.1.3.2 Protective controls that rely upon software as a protective component shall comply with:

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

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

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

4.5.2 Electromechanical and electronic controls

4.5.2.1 A control, other than as specified in 4.5.3 – 4.5.7, shall comply with:

a) The Standard for Solid-State Controls for Appliances, UL 244A;

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

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

4.5.3 Liquid level controls

4.5.3.1 A liquid level control shall comply with the:

a) Standard for Solid-State Controls for Appliances, UL 244A;

b) Standard for Temperature-Indicating and –Regulating Equipment, UL 873;

c) Standard for Industrial Control Equipment, UL 508; or

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

1) Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Water Level Controls of the Float Type for Household and Similar Applications, UL 60730-2-16A;

2) Standard for 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 60730-2-18.

4.5.4 Motor and speed controls

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

a) Standard for Solid-State Controls for Appliances, UL 244A;

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

c) Standard for Industrial Control Equipment, UL 508;

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

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

f) Standard for Switchgear and Controlgear, Low-Voltage – Part 1: General Rules, UL 60947-1, and the Standard for Switchgear and Controlgear, Low-Voltage – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1A.

4.5.5 Pressure controls

4.5.5.1 A pressure control shall comply with one of the following the:

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

b) Standard for Industrial Control Equipment, UL 508; or

c) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Automatic Electrical Pressure Sensing Controls Including Mechanical Requirements, UL 60730-2-6.

4.5.6 Temperature controls

4.5.6.1 A temperature control shall comply with the:

a) Standard for Solid-State Controls for Appliances, UL 244A;

b) Standard for Temperature-Indicating and –Regulating Equipment, UL 873;

c) Standard for Industrial Control Equipment, UL 508; or

d) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

4.5.6.2 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 comply with the:

a) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9, with Annex J; or

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

4.5.6.3 A thermal cutoff shall comply with the Standard for Thermal-Links (Thermal Cutoffs) for Use in Electrical Appliances and Components, UL 60691.

4.5.7 Timer controls

4.5.7.1 A timer control shall comply with the:

a) Standard for Solid-State Controls for Appliances, UL 244A; or

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

4.6 Cords, cables, and internal wiring

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

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

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

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

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

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

c) The Standard for Fixture Wire, UL 66; or

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

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

4.7 Film-coated wire (magnet wire)

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

4.7.2 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 the Standard for Systems of Insulating Materials – General, UL 1446.

4.8 Gaskets and seals

4.8.1 Gaskets and seals that are relied upon to prevent water entrance into electrical compartments and flooding of electrically live parts shall comply with the Flooding Test, Section 37.

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

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

4.9.2 Appliance-leakage-current interrupters (ALCI) for protection against electrical shock shall comply with the Standard for Appliance-Leakage-Current Interrupters, UL 943B.

Note – An ALCI is not considered an acceptable substitute for GFCI when the National Electrical Code, ANSI/NFPA 70, requires a GFCI.

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

4.9.4 Arc-fault circuit-interrupters (AFCI) shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699. See Arc-Fault, and Leakage Current Detectors/Interrupters, Section 20.

4.9.5 Leakage-current detector-interrupters (LCDI) and any shielded cord between the LCDI and appliance shall comply with the Standard for Arc-Fault Circuit-Interrupters, UL 1699. See Arc-Fault, and Leakage Current Detectors/Interrupters, Section 20.

4.10 Heating elements and heaters

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

a) Standard for Electric Heating Appliances, UL 499; or

b) Standard for Sheathed Heating Elements, UL 1030.

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

4.11 Insulation systems

4.11.1 Materials used in a Class 105 (A) insulation system shall comply with Insulation Systems, Section 18.

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

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

4.12 Light sources and associated components

4.12.1 Lampholders and indicating lamps shall comply with the Standard for Lampholders, UL 496.

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

4.12.2 Lighting ballasts shall comply with the:

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

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

Exception No. 1: Ballasts forming part of a luminaire that complies with an 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).

4.12.3 Light emitting diode (LED) light sources shall comply with the Standard for Light Emitting Diode (LED) Light Sources For Use In Lighting Products, UL 8750.

Exception No. 1: LED light sources forming part of a luminaire that complies with an 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.

4.13 Marking and labeling systems

4.13.1 A marking and labeling system shall comply with the Permanence of Marking Test, Section 42.

Exception: A marking or labeling system that complies with the applicable requirements of the Standard for Marking and Labeling Systems, UL 969, is considered to comply with the requirement.

4.14 Motors and motor overload protection

4.14.1 General

4.14.1.1 General-purpose type motors having a NEMA frame size shall comply with the requirements specified in 4.14.2. 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).

4.14.1.2 Motors not enclosed, or partially enclosed, but the end product enclosure shall comply with the requirements specified in 4.14.2 or 4.14.3.2.

4.14.1.3 Component type motors completely enclosed within the end product enclosure shall comply with the requirements specified in 4.14.2 or 4.14.3.

4.14.2 General-purpose type motors

4.14.2.1 A general-purpose type motor shall comply with the Standard for Rotating Electrical Machines - General Requirements, UL 1004-1.

4.14.3 Component type motors

4.14.3.1 Component type motors shall comply with either 4.14.3.2 or 4.14.3.3.

4.14.3.2 The motor shall comply with the Standard for Rotating Electrical Machines - General Requirements, UL 1004-1 except as noted in Table 4.14.3.

Table 4.14.3
Superseded requirements

Rotating Electrical Machines - General Requirements, UL 1004-1 Exempted Requirements	Superseded by UL 561 Requirements
Cord-Connected Motors	Supply Connections, Section 10
Factory Wiring Terminals and Leads	Live Parts, Section 13
Electrical Insulation	Insulating Material, Section 16
Non-Metallic Functional Parts	Insulating Material, Section 16
Solid-State Controls, 7.2	Controls, 4.5
Non-metallic enclosure thermal aging, 9.1.4	Frame and Enclosure, Section 5
Motor enclosure, 9.2 - 9.4	Frame and Enclosure, Section 5
Grounding	Grounding, Section 27
Ventilation Openings, only applicable where the openings are on surfaces considered to be the appliance enclosure	Frame and Enclosure, Section 5 and Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 6
Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts	Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 6
Protection Against Corrosion	Resistance to Corrosion, Section 9
Available fault current ratings for motor start and running capacitors, 26.6: not applicable for cord and plug connected appliances	Capacitors, Section 23
Switch, is not applicable to centrifugal starting switches	Switches and Controls, Section 21
With the exception of the Resilient Elastomer Mounting and Electrolytic Capacitor Tests, the performance tests in the Standard for Rotating Electrical Machines - General Requirements, UL 1004-1 are not applicable	All applicable performance tests
Only 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	45.1

4.14.3.3 The motor shall comply with the applicable component requirements in Components, Section 4, the following construction requirements, and the applicable performance requirements (when tested in conjunction with the end product), of this end product standard:

a) Resistance to Corrosion, Section 9.

b) Live Parts, Section 13.

c) Internal Wiring, Section 14.

d) Insulating Material, Section 16.

e) Motors and Motor Protection, Section 17 and Motor Circuit Overload Protection, Section 19.

f) Capacitors, Section 23.

g) Spacings, Section 26.

h) Grounding, Section 27.

4.14.4 Motor overload protection

4.14.4.1 Thermal protection devices integral with the motor shall comply with the:

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

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

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

4.14.4.2 Impedance protection shall comply with the:

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

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

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

4.14.4.4 Except as indicated in 4.14.4.3, electronically protected motor circuits shall comply with one of the following. See 4.5.4 for basic control requirements.

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

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

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

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

4.15 Overcurrent protection

4.15.1 Fuses shall comply with the Standard for Low-Voltage Fuses - Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part 2 (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable UL standard for the fuse are considered to comply with this requirement.

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

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

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

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

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

4.16 Polymeric materials and enclosures

4.16.1 Unless otherwise specified in this end product standard, polymeric electrical insulating materials and enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

4.16.2 Metallized or painted polymeric parts or enclosures shall comply with the applicable requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, 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.

4.17 Power supplies

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

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

b) The Standard for Information Technology Equipment, Part 1: General Requirements, UL 60950-11, with an output marked "Class 2", or that complies with the limited power source (LPS) requirements and is marked "LPS".

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

a) The Standard for Power Units Other Than Class 2, UL 1012; or

b) The Standard for Information Technology Equipment, Part 1: General Requirements, UL 60950-1.

4.18 Printed wiring boards

4.18.1 Printed wiring boards, including the coatings, shall comply with the Standard for Printed Wiring Boards, UL 796.

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.

4.18.2 A printed-wiring board containing circuitry in a line-connected circuit or a safety circuit shall comply with the direct-support requirements for polymeric electrical insulating materials in Section 4.16 of this end product standard.

4.18.3 Unless otherwise specified, the flammability class and temperature rating shall be that specified in Polymeric materials and enclosures, 4.16 of this end product standard.

4.19 Pumps

4.19.1 Motor-operated water and liquid pumps shall comply with the applicable requirements of the Standard for Motor-Operated Water Pumps, 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 4.19.1.

4.20 Semiconductors and small electronic components

4.20.1 A power switching semiconductor device that is relied upon to provide isolation to ground shall comply with the Standard of Safety for Electrically Isolated Semiconductor Devices, UL 1557. The dielectric voltage withstand tests required by UL 1557 shall be conducted applying the criteria of the Dielectric Voltage-Withstand Test, Section 34 of this end product standard.

4.20.2 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 the Standard for Safety for Optical Isolators, UL 1577. The dielectric voltage withstand tests required by UL 1577 shall be conducted applying the criteria of the Dielectric Voltage-Withstand Test, Section 34 of this end product standard. The dielectric test voltage is to be applied between the input and the output terminals of the optical isolator.

4.20.3 Except as specified in 4.20.4, 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.

4.20.4 Where an electronic component is determined to be a critical component during the testing of UL 561, Abnormal Operation Test – Electronic Components Test, Section 40, one of the following standards shall be applied. See Protective controls (limiting controls), 22.4 of this end product standard for the test parameters to be used.

a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, including its Follow-Up Program; and as applicable, the Standard for Software in Programmable Components, UL 1998 for controls that rely upon software as a protective component; or

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

4.20.4.1 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.

4.20.4.2 A critical component may also be identified using a failure-mode and effect analysis (FMEA) in accordance with Failure-Mode and Effect Analysis (FMEA), in the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

4.20.4.3 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 the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, Annex H.

4.21 Supplemental insulation, insulating bushings, and assembly aids

4.21.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to fulfill 14.9 and 14.10 or a performance requirement of this standard. In such cases:

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

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

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

4.21.2 Wire positioning devices shall comply with 4.16.1. A device that complies with the Standard for Positioning Devices, UL 1565, is considered to comply with this requirement.

4.21.3 Insulating bushings that comply with Components, General, Section 4.1 of this end product standard, and the Standard for Insulating Bushings, UL 635, are considered to comply with 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.

4.22 Switches

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

a) The Standard for Special-Use Switches, UL 1054;

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

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

d) The Standard for Nonindustrial Photoelectric Switches for Lighting Control, 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.

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

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

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

4.22.3 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 6000 cycles of operation, or as a manual control for 5000 cycles of operation, in accordance with the following:

a) The Standard for Solid-State Controls for Appliances, UL 244A; or

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

4.22.4 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 4.5.1.3.

4.23 Transformers

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

4.23.2 Class 2 and Class 3 transformers shall comply with the Standard for Low Voltage Transformers: General Requirements, UL 5085-1; and the Standard for Low Voltage Transformers: Class 2 and Class 3 Transformers, UL 5085-3.

Exception: Transformers located in a Class 2 circuit, and that do not involve a risk of fire or personal injury, need not comply with this requirement.

4.24 Valves (electrically operated) and solenoids

4.24.1 Electrically operated valves shall comply with the:

a) Standard for Electrically Operated Valves, UL 429; or

b) Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Electrically Operated Water Valves, Including Mechanical Requirements, 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 ANSI Z21.21a/CSA 6.5a (Automatic Valves for Gas Appliances).

ALL APPLIANCES

CONSTRUCTION

5 Frame and Enclosure

5.1 A product shall be formed and assembled so that it will have the strength and rigidity needed 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 resulting reduction of spacings, loosening, or displacement of parts, or other serious defects.

5.2 A product shall be provided with an enclosure to house each part that may present a risk of fire, electric shock, or injury to persons under any condition of use.

5.3 The minimum thickness of cast metal shall be in accordance with Table 5.1.

Table 5.1
Minimum thicknesses of cast metal

Metal	Minimum thickness			
	At reinforced surfaces,[a]		At unreinforced flat surfaces,	
	inch	mm	inch	mm
Die-cast metal	3/64	1.2	5/64	2.0
Cast malleable iron	1/16	1.6	3/32	2.4
Other cast metal	3/32	2.4	1/8	3.2

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

5.4 An enclosure of sheet metal is judged with respect to its size, shape, and thickness, considering the intended use of the complete product.

5.5 Among the factors taken into consideration when judging a nonmetallic enclosure or an enclosure of magnesium are:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Combustibility, and

e) Resistance to distortion at temperatures to which the material may be subjected under conditions of intended or unintended use.

5.6 The enclosure of a product for use in wet locations shall be such that water will not come into contact with uninsulated live parts when the product is subjected to a splash test or other test to simulate conditions that may occur during actual use.

5.7 The door or cover of an enclosure shall be hinged or otherwise attached in an equivalent manner if:

a) It gives access to any overload protective device that may require replacement or

b) It is necessary to open the cover in connection with the operation of the protective device.

5.8 Means shall be provided for holding the door or cover over a fuseholder in a closed position, and the door or cover shall be tight fitting.

5.9 An edge, projection, or corner of an enclosure, opening, frame, guard, knob, handle, or the like, of a product shall not be sharp so as to cause a cut type injury when contacted during intended use or user maintenance.

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

6.1 To reduce the likelihood of unintentional contact that may involve a risk of electric shock from an uninsulated live part or film-coated wire or injury to persons from a moving part, an opening in an enclosure shall comply with either (a) or (b).

a) For an opening that has a minor dimension, as defined in 6.5, less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 6.1.

b) For an opening that has a minor dimension of 1 inch or more, such a part or wire shall be spaced from the opening as specified in Table 6.1.

Exception No. 1: A motor other than one used in either a hand-guided product or a hand-supported portion of a product need not comply with these requirements if the motor complies with the accessibility requirements in 6.2.

Exception No. 2: If a moving part as specified in these requirements is exposed for its intended function, the moving part need not be enclosed or guarded to reduce the likelihood of unintentional contact that may involve a risk of injury to persons.

6.2 With respect to a part or wire as specified in 6.1, in an integral enclosure of a motor as specified in Exception No. 1 to 6.1:

a) An opening that has a minor dimension, as defined in 6.5, less than 3/4 inch (19.1 mm) is acceptable if:

1) A moving part cannot be contacted by the probe illustrated in Figure 6.2;

2) Film-coated wire cannot be contacted by the probe illustrated in Figure 6.3;

3) In a directly accessible motor, as defined in 6.6, an uninsulated live part cannot be contacted by the probe illustrated in Figure 6.4; and

4) In an indirectly accessible motor, as defined in 6.6, an uninsulated live part cannot be contacted by the probe illustrated in Figure 6.2.

b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 6.1.

6.3 The probes specified in 6.1 and 6.2 and illustrated in Figure 6.1 – Figure 6.4 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 6.1 and Figure 6.4 shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

Figure 6.1

Articulate probe with web stop

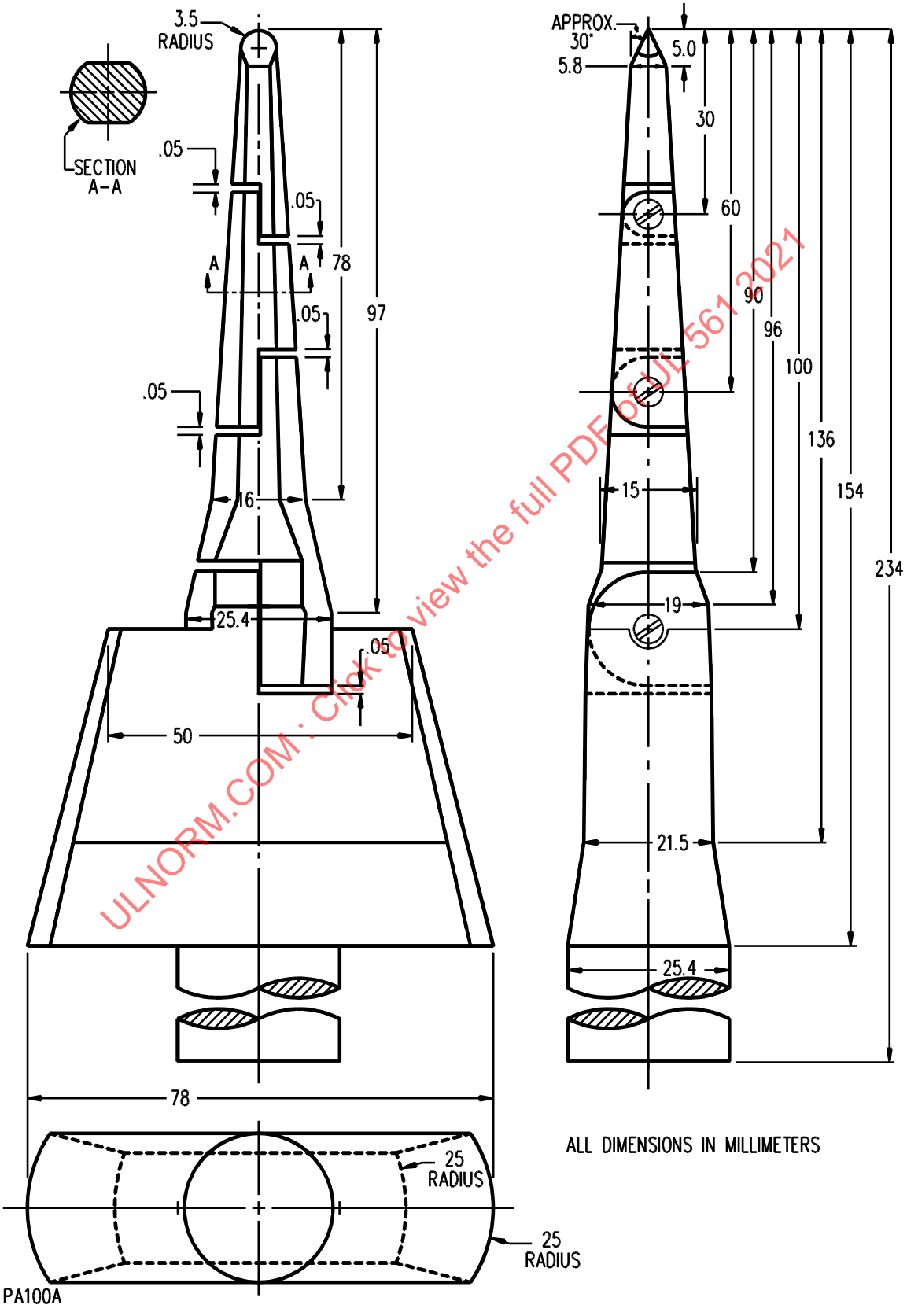


Table 6.1
Minimum distance from an opening to a part that may involve a risk of electric shock or injury to persons

Minor dimensions of opening,[a]		Minimum distance from opening to part,	
inches	mm[b]	inches	mm[b]
3/4[c]	19.1	4-1/2	114
1[c]	25.4	6-1/2	165
1-1/4	31.8	7-1/2	191
1-1/2	38.1	12-1/2	318
1-7/8	47.6	15-1/2	394
2-1/8	54.0	17-1/2	445
See footnote d		30	762

[a] 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.

[b] Interpolation is to be used to determine a value between values specified in the table.

[c] Any dimension less than 1 inch applies to a motor only.

[d] More than 2-1/8 inches, but not more than 6 inches (152.4 mm).

Figure 6.2

Probe for moving parts and uninsulated live parts

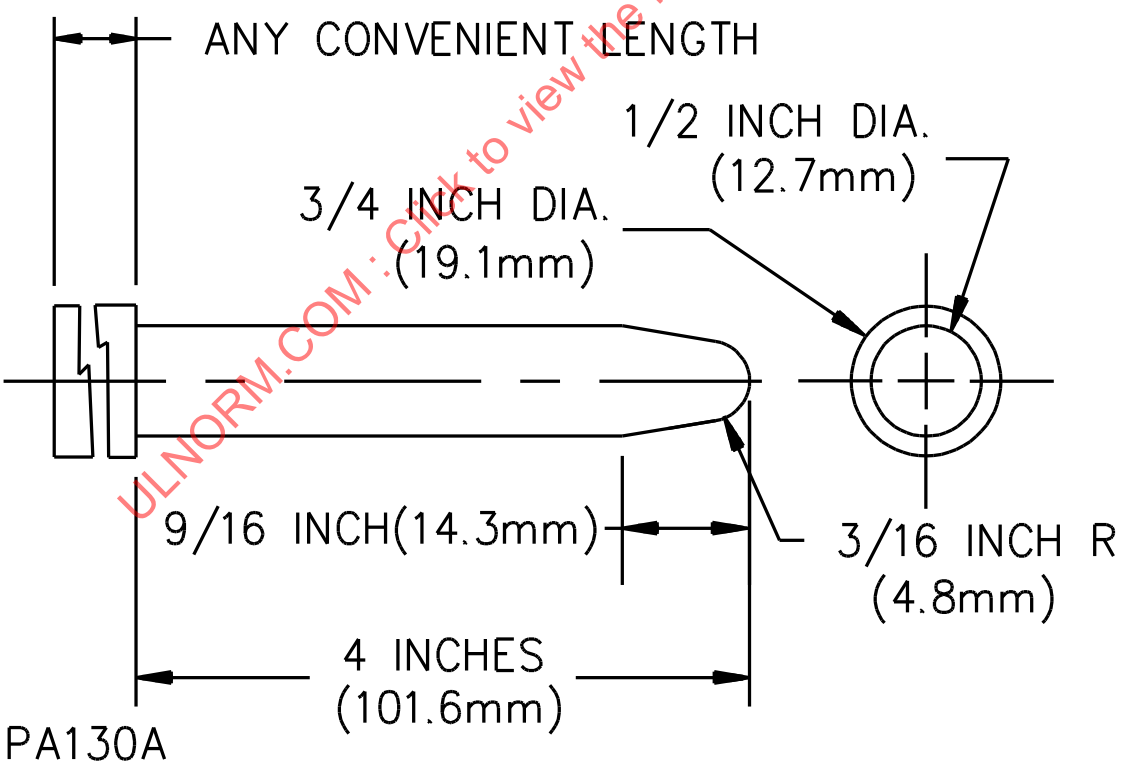


Figure 6.3

Probe for film-coated wire

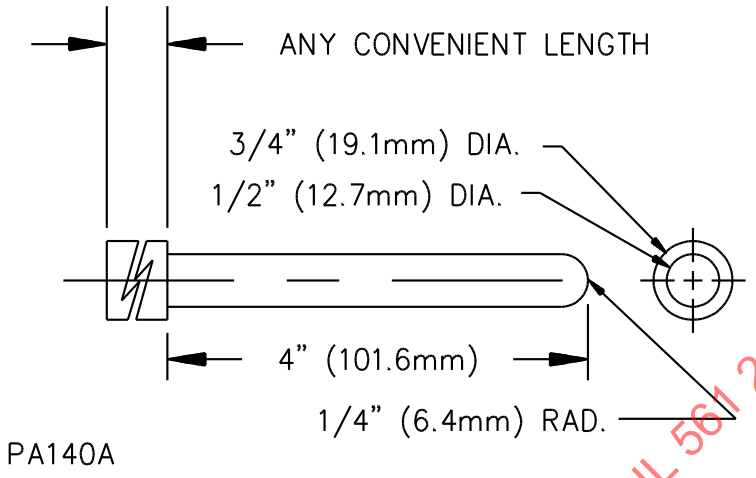
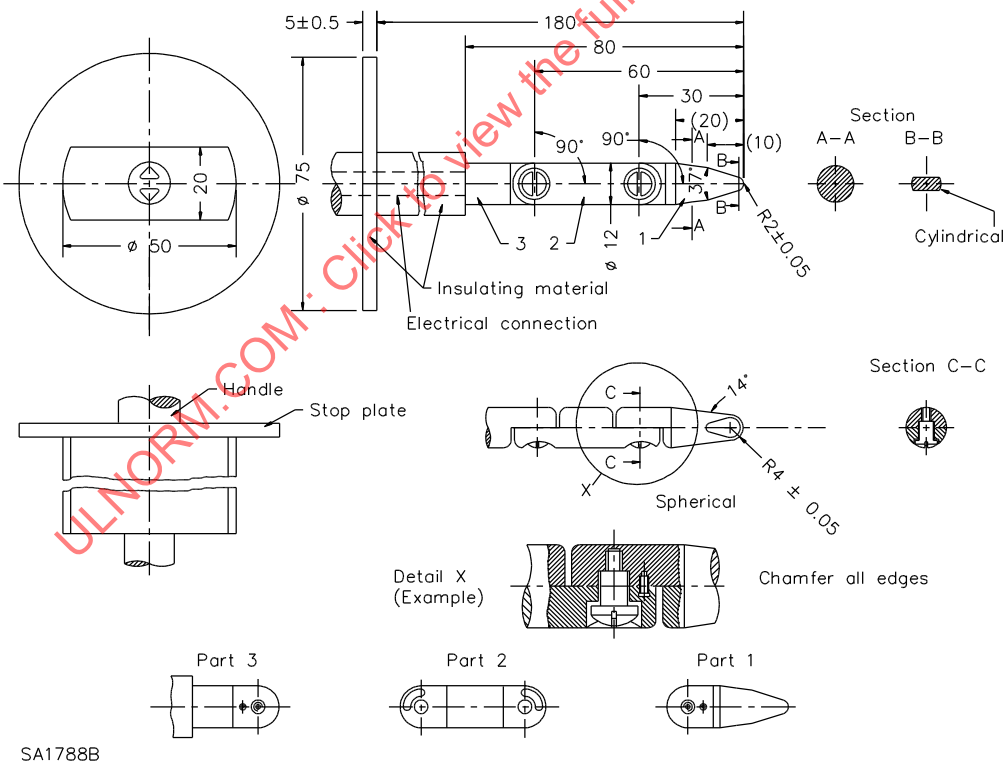


Figure 6.4

IEC articulate probe



6.4 The probes specified in 6.3 shall be used as measuring instruments to judge the accessibility provided by an opening, and not as instruments to judge the strength of a material. The probes shall be applied with the minimum force necessary to determine accessibility.

6.5 With reference to the requirements specified in 6.1 and 6.2, 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.

6.6 With reference to the requirement specified in 6.2, an indirectly accessible motor is a motor that is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, which can be opened or removed without the use of tools, or is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted. A directly accessible motor is a motor that can be contacted without opening or removing any part or is located so as to be accessible to contact.

6.7 During the examination of a product to determine whether it complies with the requirements specified in 6.1 or 6.2, a part of the enclosure that may be opened or removed by the user without the use of tools (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

Exception: A part of the enclosure that may be opened or removed by the user without the use of tools to provide access to moving parts (but not live parts) for normal user maintenance need not be opened or removed if the enclosure part is marked as specified in 45.11 and the instruction manual includes the statement specified in 47.3.

6.8 With reference to the requirements specified in 6.1 and 6.2, insulated brush caps are not required to be additionally enclosed.

7 Mechanical Assembly

7.1 The assembly of a product that involves a motor or other vibrating unit shall be such that the product will not be affected adversely by the vibration of intended operation. Brush caps shall be tightly threaded or otherwise constructed so that they will not loosen.

7.2 A switch (other than a through-cord switch), a lampholder, a receptacle, a motor-attachment plug, or similar component shall be mounted securely and shall be restricted from turning.

Exception No. 1: The requirement that a switch be restricted from turning can be waived if all of the following conditions are met:

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

b) The means of mounting the switch is such that the operation of the switch is unlikely to result in the switch becoming loosened.

c) The spacings are not reduced below the minimum values specified in Table 26.1 if the switch does rotate.

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

Exception No. 2: A lampholder of the type in which 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 restricted from turning if the rotation cannot reduce spacings below the minimum values specified in Table 26.1.

7.3 The means by which the turning specified in 7.2 is restricted is to include more than friction between surfaces. For example, a lock washer, properly applied, is acceptable as a means to restrict turning of a device having a single-hole mounting means.

7.4 A brush holder assembly shall be constructed so that when a brush is worn out – no longer able to perform its function– the brush, spring, and other parts of the assembly shall be retained to the degree that:

a) An accessible dead metal part does not become energized and

b) A live part does not become accessible.

8 Enclosure

8.1 General

8.1.2 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.

9 Resistance to Corrosion

9.1 Iron and steel parts shall be made resistant to corrosion by painting, galvanizing, plating, or other equivalent means if the malfunction or breakdown of such unprotected parts would be likely to result in a risk of fire, electric shock, or injury to persons.

Exception: In certain instances in which the oxidation of iron or steel due to the exposure of the metal to air and moisture is not likely to be appreciable – thickness of metal and temperature also being factors– surfaces of sheet steel and cast iron parts within an enclosure may not be required to be made resistant to corrosion. The requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like.

9.2 A container for liquid shall be made resistant to the possible corrosive effect of the liquid intended to be used in the container.

10 Supply Connections

10.1 A product shall be provided with either a detachable or a nondetachable power supply cord not less than 15 feet (4.57 m) long, including fittings.

Exception: A product that complies with 10.6 need not comply with this requirement.

10.2 The power supply cord shall be rated for use at a voltage not less than the rated voltage of the product and shall have an ampacity not less than the current rating of the product.

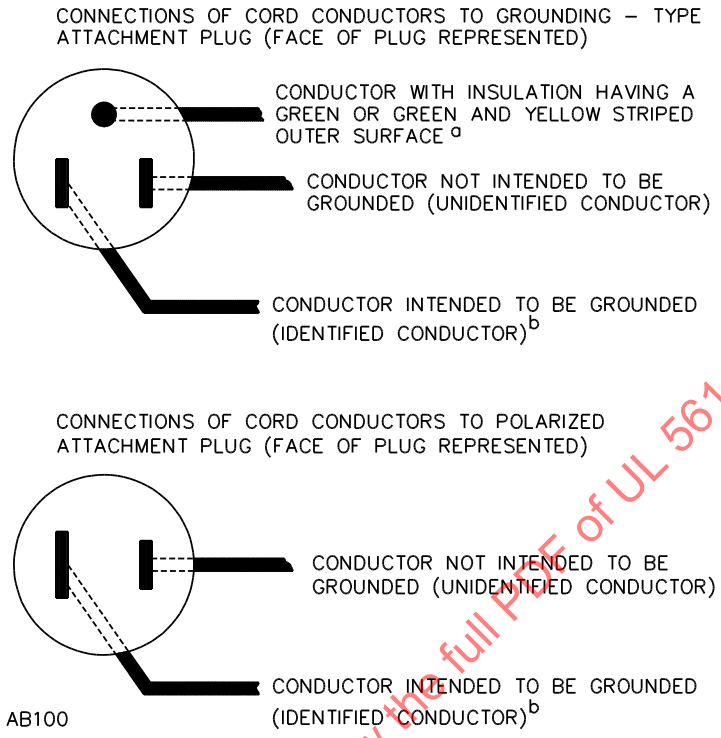
10.3 The voltage rating of the attachment plug shall correspond to the voltage rating of the product and the ampacity of the attachment plug shall be not less than the current rating of the product. If the product may be field adapted for use with two or more different supply voltages, the attachment plug on the power supply cord provided with the product shall be rated for the supply voltage selected at the factory.

10.4 The attachment plug shall be of a three-wire grounding type. The attachment plug connections shall comply with the three wire plug in Figure 10.1.

Exception: A double insulated product shall be provided with a power-supply cord that does not include a grounding conductor, and has a two-blade polarized attachment plug as shown in the two wire plug in Figure 10.1. See Supply Connections, Section 52. Also see 47.5.

Figure 10.1

Connection to attachment plug



[a] In the above illustration, the blade to which the green conductor is connected may have a U-shaped or a circular cross section.

[b] Signifies a conductor identified in accordance with Table 10.1.

Table 10.1
Polarity identification of flexible cords

Method of identification	Acceptable combinations	
	Wire intended to be grounded[a]	All other wires
Color of braids on individual conductors	Solid white or gray – without tracer	Solid color other than white or gray – without tracer
Color of braids on individual conductors	Color other than white or gray, with tracer in braid	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	Solid white or gray[b]	Solid color other than white or gray
Color of insulation on individual conductors	Light blue[c]	Solid color other than light blue, white, or gray
Other means	Tin or other white metal on all strands of the conductor	No tin or other white metal on the strands of the conductor

[a] A wire finished to show a green color with or without one or more yellow stripes or tracers is to be used as an equipment grounding conductor.

[b] Only for cords having no braid on any individual conductor.

[c] For jacketed cord.

10.5 A product intended for use with a detachable power supply cord shall not be provided with terminal pins that will accommodate a standard flatiron or appliance plug.

10.6 A product may be provided with not more than 18 inches (457 mm) of nondetachable power supply cord if:

a) It is likely that the product will be connected by means of an extension cord during operation and the manufacturer recommends the use of a suitably rated extension cord; or

b) The manufacturer provides with the product a suitably rated extension cord that is not less than 15 feet (4.57 m) long, including fittings.

10.7 A three- to two-wire, grounding-type adapter shall not be provided with a product.

10.8 For rug shampooers and extraction type floor cleaning machines, rated 300 V or less, the cord shall be Type SJ, SJO, SJT, or SJTO; for all other products, the cord shall be Type S, SO, ST, or STO; or the cord shall be of a type at least equally as serviceable for the intended use.

10.9 If a product incorporates a disconnecting means (such as a cord connector in the cord between the handle and the motor), the construction shall be such that no live part will be exposed when used as intended. The probe illustrated in Figure 6.1 shall be used to determine if live parts are accessible.

11 Strain Relief

11.1 Strain relief shall be provided so that mechanical stress on a flexible cord is not transmitted to terminals, splices, or internal wiring. The strain relief shall comply with the requirements of the Strain Relief Test, Section 35.

11.2 A clamp (metal or otherwise) is not acceptable for use on Type SVT cord. However, if the cord is protected by auxiliary varnished-cloth tubing or the equivalent under the clamp, the construction may be acceptable. For heavier types of thermoplastic-insulated cord, clamps may be used. In such cases, the auxiliary insulation is not required unless it is determined that the construction of the clamp is damaging to the cord insulation.

11.3 Means shall be provided so that the flexible cord is not pushed into the product through the cord-entry hole when such displacement:

a) Subjects the cord to damage or to exposure to a temperature higher than that for which the cord is rated or

b) Reduces spacings (such as to a metal strain-relief clamp) below the minimum values specified in Table 26.1.

See the Push-Back Relief Test, Section 36.

11.4 If a knot in a flexible cord serves as strain relief, the surface contacting the knot shall be free from projections, sharp edges, burrs, fins, and the like, that may cause abrasion of the insulation on the conductors.

12 Bushings

12.1 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 secured in place and has a smooth, well-rounded surface against which the cord may bear. If the wall or barrier is of metal or if the construction is such that the cord may be subjected to strain or motion, an insulating bushing shall be provided.

12.2 A hole in a sheet metal wall, through which insulated wires pass within the overall enclosure of a product, shall be provided with a smooth, well-rounded bushing or shall have smooth, well-rounded surfaces upon which the wires may bear, so that there is no abrasion of the insulation. A flexible cord used for external connections as specified in the Exception to 14.1 shall be provided with strain relief and bushing complying with 11.1 – 11.4 and 12.4, unless the construction is such that the cord is not subjected to stress or motion.

12.3 If the hole through which the cord passes is in wood, porcelain, phenolic composition, or other nonconducting material, a smooth, well-rounded surface is considered to be equivalent to an insulating bushing.

12.4 Ceramic materials and some molded compositions are acceptable for an insulating bushing; but separate bushings of wood or of hot-molded shellac and tar compositions are not acceptable.

12.5 Vulcanized fiber may be used if the bushing is not less than 1/16 inch (1.6 mm) thick, with a minus tolerance of 1/64 inch (0.4 mm) for manufacturing variations, and if formed and secured in place so that it will not be adversely affected by ordinary moisture.

12.6 A separate soft-rubber, neoprene, or polyvinyl chloride bushing may be used in the frame of a motor or in the enclosure of a capacitor attached to a motor provided that:

a) The bushing is not less than 1/16 inch (1.6 mm) thick, with a minus tolerance of 1/64 inch (0.4 mm) and

b) The bushing is located so that it will not be exposed to oil, grease, oily vapor, or other substances having a harmful effect.

Exception: A bushing of any of the materials mentioned above may be used at any point in a product if used in conjunction with a type of cord for which an insulating bushing is not required. If a bushing of soft rubber, neoprene, or polyvinyl chloride is used anywhere in the product, the edges of the hole in which the bushing is mounted shall be smooth and free from burrs, fins, and the like.

12.7 At any point in a product, a bushing of the same material as, and molded integrally with, the supply cord is acceptable 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.

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

13 Live Parts

13.1 A current-carrying part shall be of silver, copper, a copper alloy, or equivalent metals.

13.2 Stainless steel or another corrosion-resistant alloy may be used for a current-carrying part. Other steel or iron that has a corrosion-resistant coating may be used as a current-carrying part if:

a) It is part of a component, the requirements for which cover such use or

b) It is part of a motor or governor.

13.3 An uninsulated live part shall be secured to the base or mounting surface so that it will be restricted from turning or shifting in position, if such motion may result in a reduction of spacings below the minimum values specified in Table 26.1.

13.4 Friction between surfaces is not acceptable to restrict shifting or turning of live parts, but a lock washer may be acceptable.

14 Internal Wiring

14.1 The wiring and connections between parts of the product shall be protected or enclosed.

Exception: A length of flexible cord may be used for external connections if flexibility is essential.

14.2 With reference to exposure of insulated wiring through an opening in the enclosure of a product, the protection of such wiring required in 14.1 is considered to exist if, when judged as though it were film-coated wire, the wiring would comply with the requirements in 6.1 and 6.2. Internal wiring not so protected may be acceptable if it is secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

14.3 Wires within an enclosure, compartment, raceway, or the like shall be located or protected to reduce the risk of damage to conductor insulation that might result from contact with any sharp edge, burr, fin, moving part, or the like.

14.4 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of the product.

14.5 The internal wiring of a product shall consist of wires of a type or types that will withstand:

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

b) Exposure to oil or grease; and

c) Other conditions of service to which it is likely to be subjected.

14.6 Thermoplastic-insulated wire used for internal wiring shall be standard building wire or appliance-wiring material acceptable for the purpose.

14.7 If wiring is located so that it may be in proximity to combustible material or may be subjected to damage, it shall be in armored cable, rigid metal conduit, electrical metallic tubing, metal raceway, or the equivalent.

14.8 Each splice and connection shall be mechanically secure and shall provide a secure electrical contact. A soldered connection shall be made mechanically secure before being soldered if breaking or loosening of the connection may result in risk of fire or electric shock. This will necessitate the use of locknuts or other means to restrict wire-binding screws and nuts from becoming loosened.

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

14.10 If a wire-binding screw construction or a pressure wire connector is used as a terminating device for aluminum, it shall be acceptable for use with aluminum under the conditions involved (for example, temperature, heat cycling, vibration, and the like).

14.11 An aluminum conductor, insulated or uninsulated, used as internal wiring, such as for connection between current-carrying parts, or as motor windings, shall be terminated at each end by a method acceptable for the combination of metals involved at the connection point.

14.12 With reference to 14.11, a wire-binding screw or a pressure terminal connector used as a terminating device shall be acceptable for use with aluminum under the conditions involved (for example, temperature, heat cycling, vibration, and the like).

14.13 Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or one layer of friction tape on top of one layer of rubber tape, is acceptable on a splice if the voltage involved is less than 250 volts. In determining if splice insulation consisting of coated-fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, heat-resistant and moisture-resistant characteristics, and the like. Thermoplastic tape wrapped over a sharp edge is not acceptable.

14.14 Where stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall be positively restricted from contacting other uninsulated live parts that are not always of the same polarity as the wire and dead metal parts. This may be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or equivalent means.

15 Tabs Used in Electrical Quick-Connect Terminals

15.1 General

15.1.1 A tab shall comply with the Material requirements in 15.2, and the dimensional requirements in 15.3.

15.2 Material requirements

15.2.1 A tab shall be made of plain or plated copper alloy, nickel, nickel alloy, or the materials specified in Live Parts, Section 13.

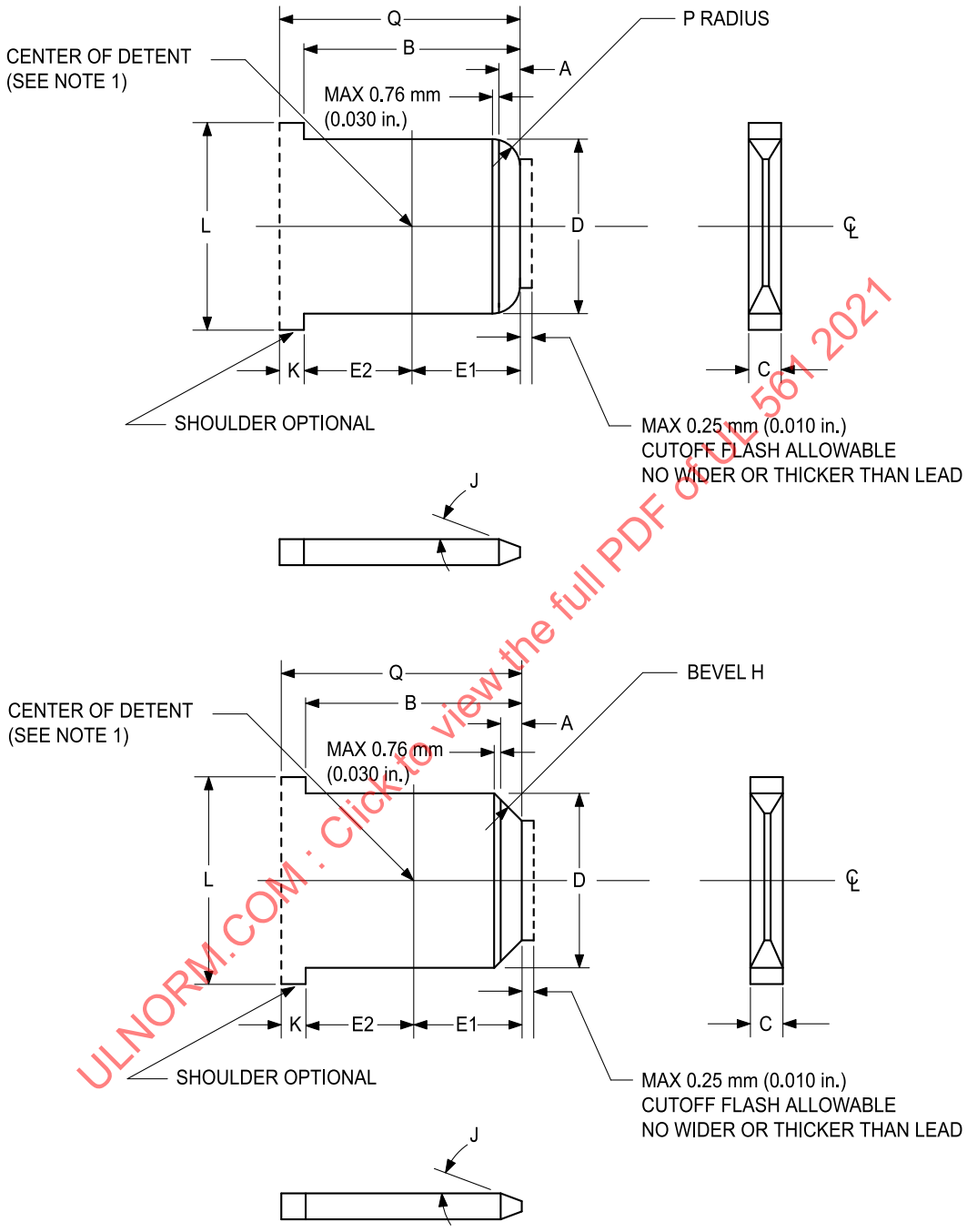
15.2.2 After shearing or removal, a tab that is provided on a feeder strip reel need not be plated on the edge of the connector or tab where it was originally attached to the strip.

15.3 Dimensional requirements

15.3.1 A production tab shall have the configuration shown in Figure 15.1 – Figure 15.3 and the dimensions specified in Table 15.1 and Table 15.2. Figure 15.2 illustrates dimple detents and Figure 15.3 illustrates hole detents.

Figure 15.1

Tab dimensions



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Note 1 – For dimple and hole detent dimensions F, G, M, and N, see Figure 15.2 and Figure 15.3.

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 be specified.

Figure 15.2

Dimensions of dimple detents

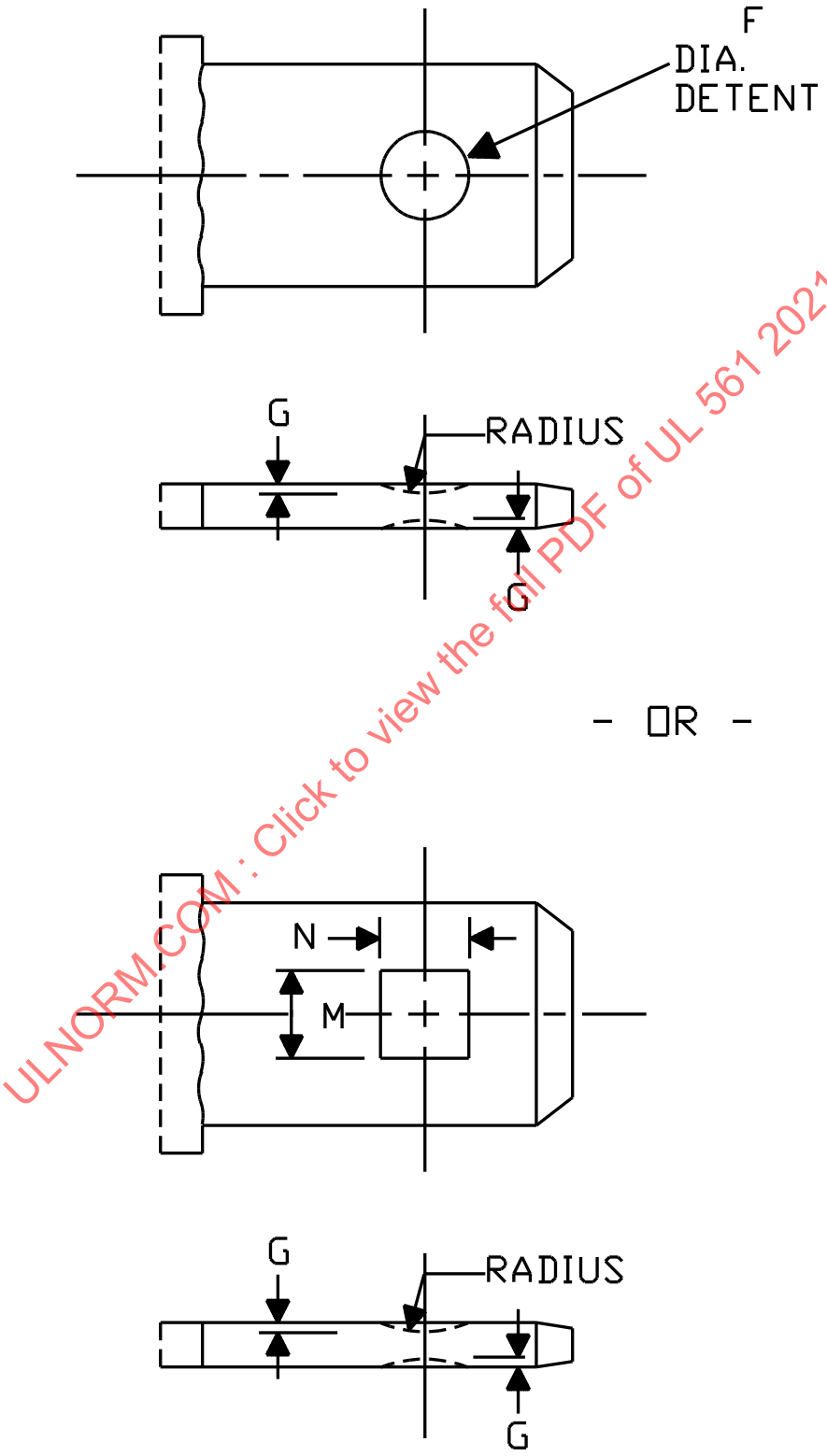


Figure 15.3

Dimensions of hole detents

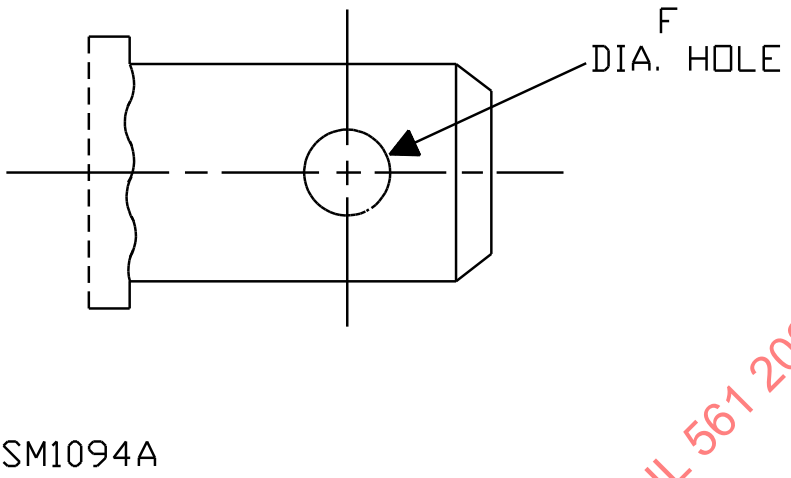


Table 15.1
Tab dimensions in inches

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
0.110 x 0.020 with dimple	0.024		0.021	0.114	0.071	0.221	0.051	12°	0.067	0.055	0.055	
	0.012	0.275	0.019	0.106	0.051	0.215	0.043	8°	0.055	0.039	0.012	0.319
0.110 x 0.020 with hole	0.024		0.021	0.114	0.071	0.221	0.051	12°	–	–	0.055	
	0.012	0.275	0.019	0.106	0.051	0.215	0.043	8°	–	–	0.012	0.319
0.110 x 0.032 with dimple	0.024		0.033	0.114	0.071	0.221	0.051	12°	0.067	0.055	0.055	
	0.012	0.275	0.030	0.106	0.051	0.215	0.043	8°	0.055	0.039	0.012	0.319
0.110 x 0.032 with hole	0.024		0.033	0.114	0.071	0.221	0.051	12°	–	–	0.055	
	0.012	0.275	0.030	0.106	0.051	0.215	0.043	8°	–	–	0.012	0.319
0.125 x 0.032 with dimple	0.025		0.033	0.128	0.070	0.221	0.051	12°	0.067	0.053	0.055	
	0.015	0.275	0.031	0.122	0.056	0.215	0.045	8°	0.057	0.043	0.015	0.320
0.125 x 0.032 with hole	0.025		0.033	0.128	0.070	0.221	0.051	12°	–	–	0.055	
	0.015	0.275	0.031	0.122	0.056	0.215	0.045	8°	–	–	0.015	0.320
0.125 x 0.020 with dimple	0.025		0.021	0.128	0.070	0.221	0.051	12°	0.067	0.053	0.055	
	0.015	0.275	0.019	0.122	0.056	0.215	0.045	8°	0.057	0.043	0.015	0.320
0.125 x 0.020 with hole	0.025		0.021	0.128	0.070	0.221	0.051	12°	–	–	0.055	
	0.015	0.275	0.019	0.122	0.056	0.215	0.045	8°	–	–	0.015	0.320
0.187 x 0.020 with dimple	0.035		0.021	0.190	0.110	0.153	0.060	12°	0.067	0.059	0.067	
	0.024	0.244	0.019	0.181	0.091	0.147	0.050	8°	0.055	0.047	0.024	0.287
0.187 x 0.020 with hole	0.035		0.021	0.193	0.134	0.128	0.060	12°	–	–	0.067	
	0.024	0.244	0.019	0.184	0.117	0.122	0.050	8°	–	–	0.024	0.287
0.187 x 0.032 with dimple	0.040		0.033	0.190	0.110	0.153	0.060	12°	0.067	0.059	0.071	
	0.027	0.244	0.030	0.181	0.091	0.147	0.050	8°	0.055	0.047	0.027	0.287
0.187 x 0.032 with hole	0.040		0.033	0.193	0.134	0.128	0.060	12°	–	–	0.071	
	0.024	0.244	0.030	0.184	0.117	0.122	0.050	8°	–	–	0.027	0.287
0.205 x 0.020 with dimple	0.040		0.021	0.210	0.110	0.153	0.075	12°	0.098	0.080	0.067	
	0.027	0.244	0.019	0.201	0.091	0.147	0.063	8°	0.086	0.070	0.024	0.287

Table 15.1 Continued on Next Page

Table 15.1 Continued

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
0.205 x 0.020 with hole	0.040		0.021	0.210	0.134	0.128	0.075	12°	–	–	0.067	
	0.027	0.244	0.019	0.201	0.117	0.122	0.063	8°	–	–	0.024	0.287
0.205 x 0.032 with dimple	0.040		0.033	0.210	0.110	0.153	0.075	12°	0.098	0.080	0.071	
	0.027	0.244	0.030	0.201	0.091	0.147	0.063	8°	0.086	0.070	0.027	0.287
0.205 x 0.032 with hole	0.040		0.033	0.210	0.134	0.128	0.075	12°	–	–	0.071	
	0.027	0.244	0.030	0.201	0.117	0.122	0.063	8°	–	–	0.027	0.287
0.250 x 0.032 with dimple	0.040		0.033	0.253	0.161	0.163	0.080	12°	0.098	0.080	0.071	
	0.027	0.307	0.030	0.244	0.142	0.157	0.063	8°	0.086	0.070	0.027	0.350
0.250 x 0.032 with hole	0.040		0.033	0.253	0.186	0.137	0.080	12°	–	–	0.071	
	0.020	0.307	0.030	0.244	0.169	0.131	0.063	8°	–	–	0.027	0.350

Table 15.2
Tab dimensions in millimeters

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

Table 15.2 Continued on Next Page

Table 15.2 Continued

Nominal size	A	B (min)	C	D	E1	E2	F	J	M	N	P	Q (min)
with dimple	0.7		0.77	5.10	2.3	3.73	1.6	8°	2.2	1.8	0.7	
5.2 x 0.8 with hole	1.0		0.84	5.30	3.4	3.25	1.9	12°	–	–	1.8	
	0.7	6.2	0.77	5.10	3.0	3.10	1.6	8°	–	–	0.7	7.3
6.3 x 0.8 with dimple	1.0		0.84	6.40	4.1	4.14	2.0	12°	2.5	2.0	1.8	
	0.7	7.8	0.77	6.20	3.6	3.99	1.6	8°	2.2	1.8	0.7	8.9
6.3 x 0.8 with hole	1.0		0.84	6.40	4.7	3.48	2.0	12°	–	–	1.8	
	0.5	7.8	0.77	6.20	4.3	3.33	1.6	8°	–	–	0.7	8.9

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

15.3.3 With regard to 15.3.2, in an area 0.050 in (1.3 mm) surrounding the detent, a raised plateau over the stock thickness of 0.001 in (0.03 mm) per side is acceptable.

15.3.4 For an optional shoulder, the minimum dimension shall be 0.045 in (1.14 mm). See dimension "K" of Figure 15.1. There shall not be any obstructions within 0.045 in (1.14 mm) of the "K" dimension end of the area defined by dimension "B".

15.3.5 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 in (0.08 mm) of the centerline of the tab. The depth of a dimple, dimension "G" on Figure 15.2, shall not be less than 0.003 in (0.08 mm).

15.3.6 Bevel "H" shall be approximately 45°. See Note 2 to Figure 15.1.

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

16 Insulating Material

16.1 Material for mounting an uninsulated live part shall be porcelain, phenolic composition, or equivalent material.

16.2 Vulcanized fiber may be used as an insulating bushing, washer, separator, or barrier, but not as the sole support of an uninsulated live part where shrinkage, current leakage, or warpage may introduce a risk of fire, electric shock, or injury to persons. Thermoplastic material is not considered acceptable for the sole support of an uninsulated live part, but may be used if found to have mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric voltage-withstand, and other equivalent properties.

16.3 A small molded part, such as a brush cap, shall be constructed such that it has the strength and rigidity necessary to withstand the stresses of actual service. A brush cap shall be secured or located so as to be resistant to damage that may result during intended use.

17 Motors and Motor Protection

17.1 A motor shall be capable of handling the maximum load of the product as described in 33.2.1 – 33.2.5 without introducing a risk of fire, electric shock, or injury to persons.

17.2 A motor winding shall resist the absorption of moisture.

17.3 With reference to the requirement in 17.2, film-coated wire is not required to be additionally treated to reduce the risk of absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials shall be provided with impregnation or otherwise treated to reduce the risk of moisture absorption.

18 Insulation Systems

18.1 Class A insulation systems shall consist of a combination of magnet wire and major component insulation materials evaluated and found to operate as intended in its end use.

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

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

19 Motor Circuit Overload Protection

19.1 If a motor is provided with an overload protective device, the overload protective device shall not operate during intended operation of the product and shall not introduce a risk of fire, electric shock, or injury to persons under stalled rotor or limited short-circuit conditions as described in the Abnormal Operation Test, Section 39.

20 Arc-Fault and Leakage Current Detectors/Interrupters

20.1 When required by this end-product standard, or when provided as part of an end-product, an AFCI or LCDI shall comply with Ground-fault, arc-fault, and leakage current detectors/interrupters, Section 4.9, 20.2, and 20.3.

20.2 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 in (102 mm) of the attachment plug.

20.3 Arc fault detection testing shall include the applicable Arc-Fault Circuit-Interrupters, UL 1699 tests 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.

21 Switches and Controls

21.1 A switch or other control device shall have a current and voltage rating not less than that of the load it controls and shall comply with the Overload Test, Section 41.

21.2 With reference to the requirement in 21.1, the ampacity of a switch that controls an inductive load other than a motor, such as a transformer or an electric-discharge-lamp ballast, shall be not less than twice the rated full-load current of the transformer or ballast unless the switch has been investigated and found acceptable for the application.

21.3 A cord-connected product that uses a motor rated more than 1/3 horsepower (249 watts) shall be provided with a manually operated motor-control switch.

21.4 A switch that controls a medium-base lampholder of other than a pilot or indicating light shall be rated for use with tungsten-filament lamps.

21.5 A line-connected, single-pole switch for appliance on-off operation shall be connected to the ungrounded conductor of the power supply cord. Table 10.1 specifies the identification of the power supply cord conductor intended to be grounded.

22 Controls – End Product Test Parameters

22.1 General

22.1.1 Spacings of controls shall comply with the electrical spacing, or clearances and clearance distance requirements of the applicable control standard as determined in Controls, Section 4.5.

22.1.2 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.

22.2 Auxiliary controls

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

22.2.2 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, Section 4.5 is considered to comply with this requirement.

22.3 Operating controls (regulating controls)

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

a) Control action Types 1 or 2;

b) Unless otherwise specified in UL 561, manual and automatic controls shall be tested for 6,000 cycles with under maximum normal load conditions, and 50 cycles under overload conditions.

c) Installation class 2 per IEC 61000-4-5;

d) For the applicable Overvoltage Category, see Table 22.1;

e) For the applicable Material Group, see Table 22.2;

f) For the applicable Pollution Degree, see Table 22.3.

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

a) Control action Types 1 or 2;

b) Unless otherwise specified in UL 561, 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 22.1;

d) For the applicable Material Group, see Table 22.2;

e) For the applicable Pollution Degree, see Table 22.3.

Table 22.1
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 Class 2 circuits if a short circuit between the parts involved may result in operation of the controlled equipment that would increase the risk of fire of electric shock.	

Table 22.2
Material group

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

Table 22.3
Pollution degrees

Appliance control microenvironment	Pollution degree
No pollution or only dry, nonconductive pollution. The pollution has no influence. Typically hermetically sealed or encapsulated control without contaminating influences, or printed wiring boards with a protective coating can achieve this degree.	1
Normally, only nonconductive pollution. However, a temporary conductivity caused by condensation may be expected. Typically indoor appliances for use in 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

22.4 Protective controls (limiting controls)

22.4.1 An electronic control that performs a protective function shall comply with the applicable requirements in Controls, Section 4.5 while tested using the parameters in this section. Examples of protective controls are: a control used to sense abnormal temperatures of components within the appliance; an interlock function to de-energize a motor; temperature protection of the motor due to locked rotor, running overload, loss of phase; or other function intended to reduce the risk of electric shock, fire, or injury to persons.

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

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

b) Power Supply Voltage Dips, Variation and Interruptions within a temperature range of 10°C and the maximum ambient temperature determined by conducting the Normal Temperature Test; see Section 33;

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

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

e) Electrostatic Discharge Test;

f) Radio-frequency electromagnetic field immunity:

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

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

g) Thermal Cycling test shall be conducted at ambient temperatures of 10.0 +2°C and the maximum ambient temperature determined by conducting the Normal Temperature Test; see Section 33 in this end-product standard. The test shall be conducted for 14 days; and

h) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Normal Temperature Test; see Section 33 in this end-product standard;

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

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

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

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

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

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

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

f) The Computational Investigation is not applicable to appliances covered by this end product standard;

g) When the Demonstrated Method Test is conducted, the multiplier for the test acceleration factor is to be 576.30 for intermittent use appliances, or 5763.00 for continuous use appliances. The test acceleration factor equation is to be based on a 25°C use ambient;

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

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

j) Conduct a failure-mode and effect analysis (FMEA).

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

22.4.4 Unless otherwise specified in UL 561, protective controls shall be evaluated for 100,000 cycles for Type 2 devices, and 6,000 cycles for Type 1 devices, with rated current.

22.5 Controls using a temperature sensing device

22.5.1 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 – 6000 cycles,

b) For a device employed as a protective device - 100,000 cycles,

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

23 Capacitors

23.1 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 the emission of flame or molten material resulting from malfunction or breakdown of the capacitor will be reduced. The container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm). Sheet metal having a thickness less than 0.026 inch (0.66 mm) is not to be used.

Exception: The individual container of a capacitor may be of sheet metal less than 0.026 inch thick or may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the product and provided that such housing is acceptable for the enclosure of live parts.

23.2 If a product uses a combination rectifier and electrolytic capacitor, no risk of fire, electric shock, or injury to persons shall result when either the rectifier or the capacitor is short-circuited.

23.3 The total rated capacitance of all capacitors connected from one side of the line to the frame or enclosure of a product shall be not more than 0.10 microfarad.

23.4 A capacitor provided with a dielectric medium more combustible than askarel shall not cause a risk of fire or electric shock and shall be protected to reduce the risk of expelling the dielectric medium.

23.5 A capacitor complying with the requirements for protected oil-filled capacitors in the Standard for Capacitors, UL 810, is considered to be constructed to reduce the risk of expelling the dielectric medium.

23.6 For a capacitor provided with a liquid dielectric medium more combustible than askarel and provided with an expansion mechanism to reduce the risk of expelling the dielectric medium, the spacing from a terminal of the capacitor, including an attached wire connector, to:

a) An electrically isolated part or a part constructed of a nonconductive material shall be at least 1/2 inch (12.7 mm).

b) An uninsulated live part of opposite polarity or an uninsulated dead metal part that is either accessible or grounded shall be at least 1/2 inch (12.7 mm) plus the applicable electrical spacings in Table 26.1.

24 Lampholders

24.1 A lampholder for a low-voltage lamp – for example, a 6-volt lamp – shall not be tapped across a part of a winding of a motor if the motor is rated more than 230 volts.

24.2 The screw shell of an Edison-base lampholder shall be connected to the terminal or lead that is intended to be connected to the grounded conductor of the power-supply circuit.

25 Receptacles

25.1 Other than a receptacle for interconnection of components, a 15- or 20-ampere general use attachment plug receptacle shall not be provided.

25.2 A receptacle provided for interconnection of a component to the main unit shall be of the polarized type if the component contains an Edison-base lampholder or a single-pole switch for component on-off operation.

25.3 A receptacle provided for interconnection of a component in an appliance provided with a means for grounding shall be of the grounding type. The grounding contact of the receptacle shall be positively and reliably electrically connected to dead metal that will be grounded when the appliance is in use.

26 Spacings

26.1 The spacings between uninsulated live parts of opposite polarity and between an uninsulated live part and a dead metal part that is exposed to contact by persons or may be grounded shall be not less than the value specified in Table 26.1.

Exception No. 1: The inherent spacings of a component of the product, such as a snap switch, are judged on the basis of the requirements for the component in question.

Exception No. 2: For a repulsion motor, a repulsion-induction motor, or a repulsion-start induction motor, the spacings requirements do not apply to the commutator, the brush assembly, and the jumpers that short-circuit the brushes.

Exception No. 3: The spacings may be as specified in 26.5.

26.2 If an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces, or if a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the minimum spacings values specified in Table 26.1 will be maintained.

26.3 In a product incorporating two or more motors of different sizes, the spacings inside each motor are to be judged on the basis of the size of that motor, and the spacings elsewhere in the product are to be judged on the basis of the size of the largest motor in the product.

Table 26.1
Spacings at other than wiring terminals

Potential involved, volts	Parts involved	Minimum spacings							
		Motor diameter 7 inches (178 mm) or less,[a]				Motor diameter more than 7 inches,[a]			
		Over surface,		Through air,		Over surface,		Through air,	
		inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
0 – 125	Commutator or collector rings of a motor	1/16	1.6	1/16	1.6	3/16[b]	4.8[b]	1/8[b]	3.2[b]
	Elsewhere in the motor or appliance	3/32[c]	2.4[c]	3/32[c]	2.4[c]	1/4[b, d]	6.4[b, d]	1/8[b, d]	3.2[b, d]
126 – 250	Commutator or collector rings of a motor	1/16	1.6	1/16	1.6	3/16[b]	4.8[b]	3/16[b]	4.8[b]
	Elsewhere in the motor or appliance	3/32	2.4	3/32	2.4	1/4[b, d]	6.4[b, d]	1/4[b, d]	6.4[b, d]
251 – 600	Commutator or collector rings and live parts of the brush rigging of a motor	1/4	6.4	1/4[e]	6.4[e]	3/8	9.5	1/4	6.4
	Elsewhere in the motor	1/4[d]	6.4[d]	1/4[d]	6.4[d]	3/8[d, f]	9.5[d, f]	3/8[d, f]	9.5[d, f]
	Elsewhere in the appliance	1/2	12.7	3/8	9.5	1/2	12.7	3/8	9.5

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

[b] Spacings of not less than 3/32 inch are acceptable throughout a universal motor.

[c] For a motor rated 1/3 horsepower (249 watts) or less, these spacings may be not less than 1/16 inch.

[d] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 inch (over surface and through air) between film-coated wire, rigidly supported and held in place on a coil, and a dead metal part is acceptable.

[e] Through-air spacings involving a collector ring may be not less than 1/8 inch.

[f] Spacings not less than 1/4 inch are acceptable between live parts and dead metal parts within a subassembly and between parts in different subassemblies, of the following types only:

a) A terminal board not intended for field wiring;

b) Centrifugally-operated starting, auxiliary, and interlock switches;

c) A starting relay; and

d) A capacitor.

This applies only to subassemblies mounted on or inside a motor.

26.4 Any uninsulated conductor of the rotor circuit is regarded as a dead metal part with respect to the stator circuit, and the appropriate spacings shall be maintained between uninsulated stator and rotor conductors.

26.5 If an isolated dead metal part is interposed between or is in close proximity to:

a) Live parts of opposite polarity;

b) A live part and an exposed dead metal part; or

c) A live part and a dead metal part that may be grounded,

the spacing may be not less than 3/64 inch (1.2 mm) between the isolated dead metal part and any one of the other parts previously mentioned, provided the total spacing between the isolated dead metal part and the two other parts is not less than the minimum value specified in Table 26.1.

26.6 An insulating lining or barrier of vulcanized fiber or similar materials used where spacing would otherwise not comply with the minimum spacing value specified in Table 26.1 shall be not less than 1/32 inch (0.8 mm) thick and shall be located or of such material so that it will not be adversely affected by arcing. Vulcanized fiber not less than 1/64 inch (0.4 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

Exception: Thinner insulating material may be used if, upon investigation, it is found to be acceptable for the application.

26.7 All uninsulated live parts connected to different line-voltage or low-voltage circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirements in 26.1, and shall be judged on the basis of the highest voltage involved.

26.8 For parts of low-voltage circuits the spacings between uninsulated live parts of opposite polarity and between such parts and dead metal that may be grounded in service is not specified.

26.9 At terminal screws and studs to which connection may be made in the field by means of wire connectors, eyelets, and the like, spacings shall be not less than those specified in Table 26.1 when such connectors, eyelets, and the like are positioned such that minimum spacings – between points of opposite polarity and to dead metal parts – exist.

27 Grounding

27.1 A product shall be provided with a grounding conductor and attachment plug complying with the requirements in 27.4 and 27.5.

Exception: An appliance may be provided with a suitable system of double insulation in lieu of a means for grounding. Such an appliance shall not be provided with a means for grounding.

27.2 If a grounding means is provided on a product, all exposed dead metal parts and all dead metal parts within the enclosure that:

a) Are exposed to contact during any user servicing operation and

b) Are likely to become energized

shall be bonded to the equipment grounding means in accordance with 27.6.

27.3 An equipment-grounding conductor in the cord is considered to constitute a grounding means.

27.4 The grounding conductor of a supply cord shall be secured to the frame or enclosure of the product by means of a screw that is not likely to be removed during any servicing operation not involving the power-supply cord or by other equivalent means. Solder alone shall not be used for securing the grounding conductor. Servicing as mentioned in this paragraph includes repair of the product by a qualified serviceman.

27.5 The grounding conductor shall be connected to the grounding member of an attachment plug. The grounding member shall be fixed.

Exception: The grounding member of the attachment plug on a portable hand-guided or hand-supported product may be of the movable, self-restoring type.

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

Hinged or pivoting joints are not considered acceptable for bonding unless they are provided with an additional conductive connection, such as a bonding jumper.

28 Reduction of Risk of Injury to Persons

28.1 If the intended operation of a product involves a risk of injury to persons, means shall be provided to reduce the risk.

28.2 The details of a guard, safety release, interlock, and the like need not be specified, but the need for such accessories and their acceptability is to be determined from a study of the complete product, its operating characteristics, and the likelihood of injury to persons resulting from other than gross negligence.

28.3 An off position shall be plainly marked on a motor control switch (other than a momentary-contact switch) of an energized product with moving parts that are likely to cause injury to persons.

28.4 If an automatic reset protective device is used in a product, the automatic restarting of a motor shall not result in any risk of injury to persons.

28.5 The requirement in 28.4 necessitates the use of an interlock in the product if moving parts or the like could result in a risk of injury to persons upon the automatic restarting of the motor.

PERFORMANCE

29 Leakage Current Test

29.1 The leakage current of a cord-connected product rated 240 volts or less shall be not more than 0.5 MIU when tested in accordance with 29.3 – 29.7.

29.2 Leakage current refers to all currents, including capacitively coupled currents, that may be conveyed between exposed conductive surfaces of a product and ground or other exposed conductive surfaces of a product.

29.3 All exposed conductive surfaces are to be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively if simultaneously accessible and from one surface to another if simultaneously accessible. Parts are considered to be exposed surfaces unless guarded by an enclosure as specified in 6.1 and 6.2. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that are not considered to involve a risk of electric shock. If all accessible surfaces are bonded together and connected to the grounding conductor of the power-supply cord, the leakage current can be measured between the grounding conductor and the grounded supply conductor. If exposed dead metal parts of the product are connected to the neutral supply conductor, this connection is to be open during the test.

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

29.5 The measurement instrument shall be as described in the Standard for Leakage Current for Appliances, UL 101. The measurement circuit for leakage current is to be as shown in Figure 29.1.

29.6 Unless the meter is being used to measure leakage current between two parts of a product, it is to be connected between the accessible parts and the grounded supply conductor.

29.7 A sample of the product is to be tested for leakage current starting with the as-received condition but with its grounding conductor, if any, open at the attachment plug. The as-received condition is without prior energization except as may occur as part of the production-line testing. The supply voltage is to be adjusted to the voltage specified in 32.2. The test sequence, with reference to the measuring circuit – Figure 29.1 – is to be as follows:

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

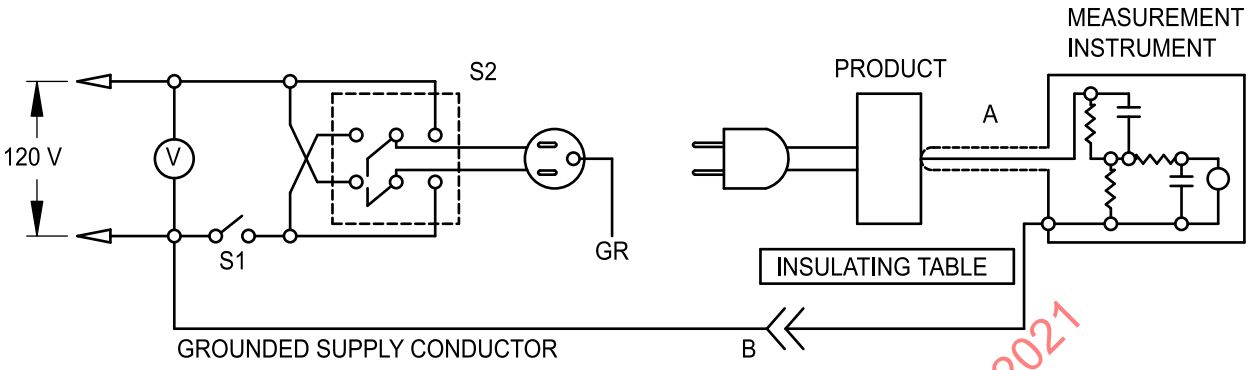
b) Switch S1 is then to be closed, energizing the product, and within 5 seconds the leakage current is to be measured using both positions of switch S2, and with the product switching devices in all their intended operating positions.

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

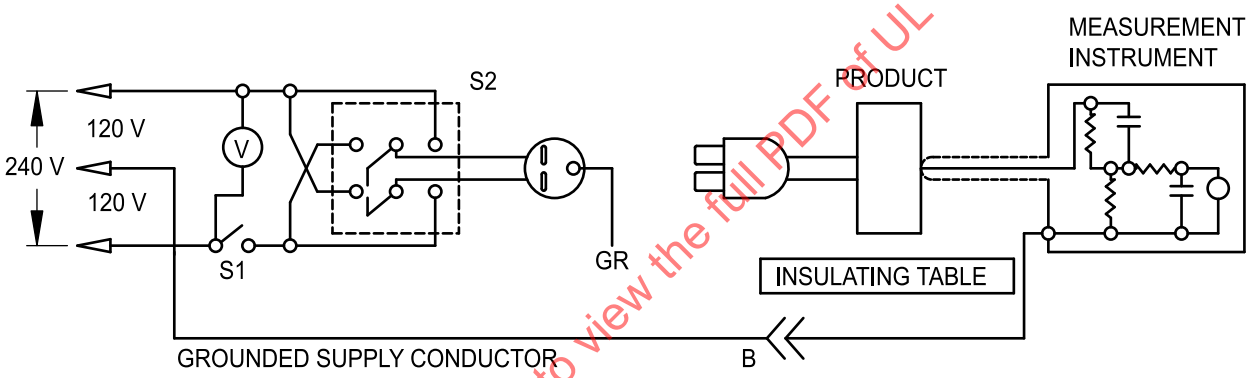
29.8 Usually a sample will be carried through the complete leakage current test, as specified in 29.7, without interruption for other tests. With the concurrence of those concerned, the leakage current test may be interrupted for the purpose of conducting other nondestructive tests.

Figure 29.1

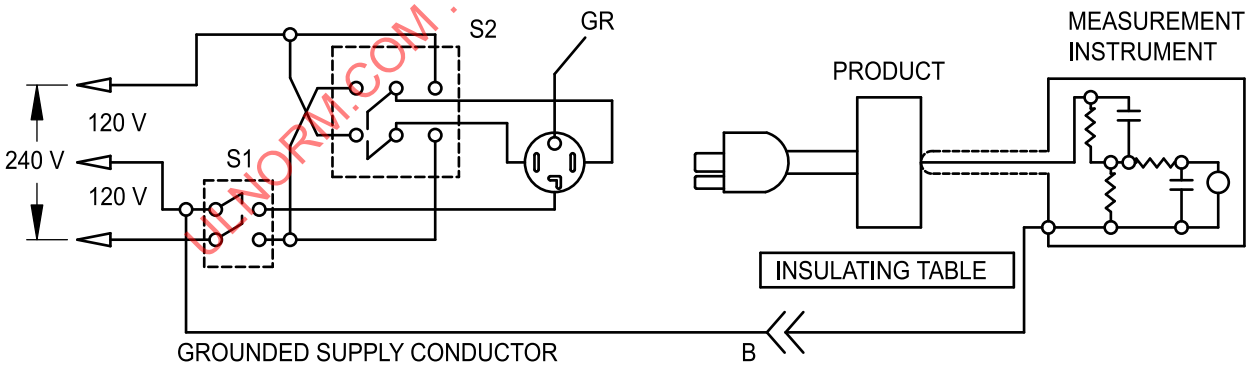
Leakage current measurement circuits



Product intended for connection to a 120-volt power supply, as illustrated above.



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



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

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A – Probe with shielded lead.

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

30 Leakage Current Test After Humidity Conditioning

30.1 A product shall comply with the requirements for leakage current in 29.1 following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2°C (90 ±4°F).

30.2 To determine whether a product complies with the requirement in 24.1, a sample of the product that has been preheated to a temperature just above 34.0°C (93°F) is to be contained in a chamber under the time, humidity, and temperature conditions specified. After the conditioning, while still in the chamber, the sample is to be tested unenergized as described in 29.7 (a). The sample, either in or immediately after removal from the chamber, is to be energized and tested as described in 29.7 (b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

31 Starting Current Test

31.1 A product provided with a 15- or 20-ampere attachment plug shall be subjected to a starting current test as described in 31.2 on a circuit protected by a 15- or 20-ampere time delay fuse, as appropriate. A product rated greater than 20 amperes shall be subjected to a starting current test as described in 31.2 on a circuit protected by an appropriately rated nontime delay fuse. The test shall be conducted at a voltage as specified in 32.2.

Exception: A time delay fuse may be used with a product rated over 20 amperes if the product is marked in accordance with 45.5.

31.2 In a test to determine if a product complies with the requirement in 31.1, the product is to be started three times with the product at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of intended operation (the beginning of the operating cycle, in the case of an automatic appliance), and the motor is to be allowed to come to rest between successive starts. The results are acceptable if the machine starts and operates as intended during each test cycle; that is, the fuse does not open and there is no tripping of an overload protector used as part of the unit.

32 Input Test

32.1 The current or wattage input to a product shall be not more than 110 percent of the rated value when the product is operated under the condition of maximum intended load as described in 33.2 and when connected to a supply circuit of rated frequency at a voltage as specified in 32.2.

32.2 If the marked voltage rating is a single value within either of the ranges 110 – 120 or 220 – 240 volts, the applied voltage for the starting current, leakage current, and current input tests shall be 120 or 240 volts, respectively. If the single value is outside these ranges, the applied voltage shall be that single value. If a marked voltage is a range of voltages, the applied voltage shall be the highest of the range, or 120 or 240 volts, as appropriate, whichever is higher.

33 Temperature Test

33.1 General

33.1.1 A product shall be tested as described in 33.1.8 – 33.2.5 and shall not reach a temperature at any point sufficiently high to cause a risk of fire, to damage any materials in the product, or to exceed the temperature rises specified in Table 33.1.

33.1.2 The temperature of a coil or winding is to be measured by means of thermocouples mounted on the outside of the coil wrap. If the coil is inaccessible for mounting thermocouples (for example, a coil in sealing compound) or if the coil wrap includes thermal insulation or more than 1/32 inch (0.8 mm) of

cotton, paper, rayon, or similar insulation, the change of resistance method is to be used. For the thermocouple-measured temperature of a coil of an alternating current motor (other than a universal motor) having a frame diameter of 7 inches (178 mm) or less (items A1 and A3 of Table 33.1), the thermocouple is to be mounted on the integral insulation of the coil conductors (for example, film-coated wire).

33.1.3 At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by means of a thermocouple may be higher than the maximum indicated in Table 33.1 by the following amount:

Subitem of item in Table 33.1	Additional temperature rise, °C	(°F)
1 of A (part a)	5	9
2 of A (part a)	15	27
3 of A (part a)	10	18
4 of A (part a)	20	36
3 of B	15	27

33.1.4 With reference to the requirement in 33.1.3, if the coil wrap is not caused to exceed its temperature limitation by radiation from an external source, the temperature of the coil may be measured by means of a thermocouple on the integral insulation of the coil conductors (for example, film-coated wire).

33.1.5 All values for temperature rises in Table 33.1 are based on an assumed ambient temperature of 25°C (77°F). Tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

33.1.6 If a product incorporates a reel for the power-supply cord, one-third of the length of the cord is to be unreeled for the temperature test.

33.1.7 A short length of rubber or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of adequate dielectric voltage withstand strength is used on the individual conductors of the cord so that the risk of deterioration of the conductor insulation will be reduced.

33.1.8 For the temperature test, the voltage of a direct-current supply circuit is to be 115 volts or 230 volts, and that of an alternating-current circuit is to be 120 or 240 volts, depending on whether the product has a nominal voltage rating of 115 or 230 volts. If the product has a single frequency rating, the test is to be made at that frequency. A product rated ac/dc or 60 hertz/dc is to be tested on direct current or 60-hertz alternating current, whichever results in higher temperatures. A product rated 25 – 60 hertz or 50 – 60 hertz is to be tested on 60-hertz alternating current.

33.1.9 A small product of the hand-supported type (such as a sander) shall not attain a temperature of more than 125°C (257°F) on any exterior surface that may contact combustible material and there shall be no emission of smoke or molten material.

33.1.10 To determine if a product complies with the requirement in 33.1.9, the product is to be operated at the voltage and frequency indicated in 33.1.8 until constant temperatures are attained. The product may be stationary during the test. Simulation of actual service conditions need not be attempted.

Table 33.1
Maximum temperature rises

Materials and components parts	°C	(°F)
A. MOTORS		
1. Class A insulation systems on coil windings of AC motors having a diameter of 7 inches (178 mm) or less (not including universal motors) and on vibrator coils[a, b]:		
a. In open motors and on vibrator coils:		
Thermocouple or resistance method	75	135
b. In totally enclosed motors:		
Thermocouple or resistance method	80	144
2. Class A insulation systems on coil windings of AC motors having a diameter of more than 7 inches (178 mm), of DC motors, and of universal motors[a, b]:		
a. In open motors:		
Thermocouple method	65	117
Resistance method	75	135
b. In totally enclosed motors:		
Thermocouple method	70	126
Resistance method	80	144
3. Class B insulation systems on coil windings of AC motors having a diameter of 7 inches (178 mm) or less (not including universal motors) [a, b]:		
a. In open motors:		
Thermocouple or resistance method	95	171
b. In totally enclosed motors:		
Thermocouple or resistance method	100	180
4. Class B insulation systems on coil windings of AC motors having a frame of more than 7 inches (178 mm), of DC motors, and of universal motors[a, b]:		
a. In open motors:		
Thermocouple method	85	153
Resistance method	95	171
b. In totally enclosed motors:		
Thermocouple method	90	162
Resistance method	100	180
B. COMPONENTS		
1. Capacitors:		
a. Electrolytic	40[c]	72[c]
b. Other types	65[d]	117[d]
2. Fuses	65	117
3. Class 105 insulation systems on windings of relays, solenoids, and the like:		
Thermocouple method	65	117
Resistance method	85	153
4. Class 130 (Class B) insulation systems, except as indicated in subitems 3 and 4 of item A[a]:		
Thermocouple method	85	153
5. Sealing compound	e	e
C. CONDUCTORS		
1. Rubber- or thermoplastic-insulated wires and cords	35[f,g]	63[f,g]

Table 33.1 Continued on Next Page

Table 33.1 Continued

Materials and components parts	°C	(°F)
D. ELECTRICAL INSULATION – GENERAL		
1. Fiber employed as electrical insulation	65	117
2. Phenolic composition employed as electrical insulation or as a part whose malfunction would result in an unacceptable condition	125[f]	225[f]
3. Varnished-cloth insulation	60	108
E. SURFACES		
1. Wood and other combustible material	65	117
2. Handles or knobs that are grasped for lifting, carrying, or holding:		
a. Metal surface[h]	25	45
b. Nonmetallic surface	35	63
3. Handles or knobs that are contacted, but do not involve lifting, carrying, or holding and other surfaces subject to contact in operation and user maintenance:		
a. Metal surface[h]	35	63
b. Nonmetallic surface	60	108

[a] See 33.1.3.

[b] See note a of Table 26.1.

[c] For an electrolytic capacitor that is physically integral with or attached to a motor, the temperature rise on insulating material integral with the capacitor enclosure may be not more than 60°C (108°F).

[d] A capacitor that operates at a temperature rise of more than 65°C (117°F) may be judged on the basis of its marked temperature limit.

[e] Except in the case of a thermal setting material, the maximum sealing compound temperature, when corrected to a 25°C (77°F) ambient temperature is 15°C (27°F) less than the softening point of the compound as determined by the Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

[f] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that are known to have special heat-resistant properties.

[g] Rubber-insulated conductors within a Class-A-insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35°C (63°F), provided that a braid is used on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.

[h] A handle, knob, or the like made of material other than metal that is plated or clad with metal having a thickness of 0.005 inch (0.13 mm) or less is considered to be and is judged as a nonmetallic part.

33.1.11 With reference to those tests that are to be continued until constant temperatures are attained, thermal equilibrium is considered to exist when three successive readings taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5 minute intervals, indicate no change.

33.1.12 A thermocouple is to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). When a thermocouple is used in determining temperatures in electrical equipment, it is standard practice to use a thermocouple consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument; and such equipment is to be used whenever referee temperature measurements by a thermocouple are necessary. The thermocouple wire is to comply with the requirements specified in the Initial Calibration Tolerances for Thermocouples table in the Standard for Temperature Measurement Thermocouples, ANSI/ISA MC96.1.

33.2 Maximum intended load

33.2.1 In tests on a product, maximum intended load is considered to be that load which approximates as closely as possible the most severe conditions of intended use. It is not a deliberate overload except as the conditions of actual use are likely to be somewhat more severe than the maximum load conditions that are recommended by the manufacturer of the product. Test loads that have been found to be close approximations of the most severe conditions of intended use are indicated in 33.2.2 – 33.2.5 for some

common forms of products. However, products having features not covered by these test procedures may be tested as necessary to meet the intent of these requirements.

33.2.2 Each product shall be tested in the operation for which it is intended that produces maximum intended load. Other than as indicated in 33.2.5, a product shall be operated until constant temperatures are attained.

33.2.3 If the product includes a heater that can be energized independently of a vibrator or motor, an additional test is to be conducted with only the heater energized until temperatures become constant.

33.2.4 The temperature test on a floor-polishing machine is to consist of 1 hour of continuous operation of the machine on a previously polished composition-tile surface.

33.2.5 The test on a combination floor scrubber, polisher, and sander is to consist of continuous operation in the intended manner, polishing a previously polished composition-tile surface until constant temperatures are attained.

34 Dielectric Voltage-Withstand Test

34.1 A product shall withstand for 1 minute without breakdown the application of a 60-hertz essentially sinusoidal potential between live parts and dead metal parts or between live parts of opposite polarity for a test on a capacitor as mentioned in (c). For primary circuits, the test potential shall be:

a) One thousand volts for a product using a motor rated 1/2 horsepower (373 watts) or less and 250 volts or less.

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

c) One thousand volts or 1000 volts plus twice rated voltage (depending upon the value of the test potential applied to the product as a whole), between the terminals of a capacitor used for radio-interference elimination or arc suppression.

34.2 For the secondary circuit of a product employing a transformer or autotransformer, the test potential shall be:

a) One thousand volts plus twice the operating voltage if the secondary operates at 251 – 600 volts.

b) One thousand volts if the secondary operates at 51 – 250 volts.

c) Five-hundred volts if the secondary operates at 50 volts or less.

Exception: Does not apply if the secondary circuit is supplied from a Class 2 transformer.

34.3 The product is to be tested using a transformer with an output voltage that is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test level is reached, and is to be held at that level for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by a voltmeter. The product is to be at the maximum operating temperature reached during intended use.

35 Strain Relief Test

35.1 When tested as specified in 35.2, the strain relief means shall withstand for 1 minute, without displacement, a direct pull of 35 pounds (156 N) applied to the cord, with the connections within the product disconnected.

35.2 A 35-pound (15.9-kg) weight is to be suspended on the cord and supported by the product so that the strain relief means will be stressed from any angle made possible by the construction of the product. The strain relief is acceptable if, at the point of disconnection of the conductors, there is no movement of the cord to indicate that stress would have resulted on the connections.

36 Push-Back Relief Test

36.1 To determine compliance with 11.3, a product shall be tested in accordance with 36.2 without occurrence of any of the conditions specified in 11.3 (a) and (b).

36.2 The power supply cord is to be held 1 inch (25.4 mm) from the point where the cord emerges from the product. The cord is then to be pushed back towards the product until either:

a) The cord buckles or

b) The force required to push the cord into the product exceeds 6 pounds (26.7 N).

37 Flooding Test

37.1 General

37.1.1 A product shall be subjected to the flooding test as described in 37.2.1 – 37.6.1. The results are acceptable if:

a) There is no wetting of live parts, film-coated wire, or insulation likely to be adversely affected by the liquids used with the product;

b) During and after each condition, the product complies with the leakage current test described in 37.1.2; and

c) Following the leakage current test, the product, if it is not double-insulated, complies with the Dielectric Voltage-Withstand Test, All Appliances, Section 34. A double-insulated product shall comply with the Dielectric Voltage-Withstand Test, Double-Insulated Products, Section 63.

Exception: Self-contained carpet/rug cleaning machines that have no accessories or instructions to clean hard floors are not required to be subjected to the polymeric water-handling components test described in 37.6.1. However, if deterioration or breakage of a liquid reservoir provided as part of such an appliance would result in a risk of fire, electric shock, or injury to persons, the container shall be subjected to the impact test for polymeric reservoirs described in 37.7.1 and 37.7.2 and the temperature stability test for polymeric reservoirs described in 37.8.1 and 37.8.2.

37.1.2 The leakage current test required in 37.1.1 shall be conducted as described in the Leakage Current Test, All Appliances, Section 29. The results are acceptable if, for other than a double-insulated product, the leakage current does not exceed 0.5 MIU. The leakage current for a double-insulated product shall not exceed 0.5 MIU for accessible metal parts and 3.5 MIU for inaccessible metal parts. In addition, the tests in 37.5.1 and 37.6.1 shall be conducted with switch S1 open, the control switch in the on position, and the product connected to the rated supply voltage. Leakage current is to be monitored for a minimum of 5 minutes after the leakage current has stabilized or decreased.

37.2 Component malfunction or breakdown

37.2.1 A malfunction or breakdown of a timer switch, a float or pressure-operated switch, or a boot or diaphragm shall not cause flooding of the electrical components of a product that uses water or other electrically conductive liquids during operation. The product is to be operated until ultimate conditions occur with the boot or diaphragm completely removed, or with the timer, float, or pressure-operated switch defeated, whichever is appropriate. If a product uses more than one of these features, the test is to be repeated with each feature removed or defeated in turn. Only one feature is to be removed or defeated during each test.

37.3 Wet pick-up

37.3.1 A product that discharges water through a compartment enclosing any electrical component is to be operated for 5 minutes after it begins to discharge water from that compartment. A wet pick-up product of any other type is to be operated until it has picked up as much water as its capacity permits. The product is to be operated with the float, if provided, defeated in either case.

37.4 Wet scrubbing

37.4.1 A product intended for floor scrubbing shall be operated for 15 minutes in a flat-bottomed container filled with water to a depth of 1/8 inch (3.2 mm). The container shall be sufficiently large so that the product can move freely.

37.5 Overflow

37.5.1 A product that is supplied with a reservoir that can be overfilled is to be tested as follows: Distilled water with 0.02 ounce of sodium chloride per quart (0.57 g/L) and 0.18 ounce per quart (5.3 g/L) of a low sudsing floor detergent is to be poured into the reservoir through an orifice 3/8 inch (9.5 mm) in diameter. The total amount of test solution is that necessary to fill the reservoir to maximum capacity. Additional solution equal to 15 percent of the capacity but not more than 1 pint (0.47 L), is then to be poured into the reservoir. The product is to be in its intended position when filling the reservoir.

Exception: A product having a reservoir that must be removed to be filled need not comply with this requirement.

37.6 Polymeric water-handling components

37.6.1 To determine if a polymeric reservoir supplied with a product, including attached tubing, complies with 37.1.1, a 1/4 inch (6.4 mm) diameter hole is to be drilled in the reservoir or tubing in the location most likely to result in the liquid reaching a live part. The hole is to be plugged, and the tank or reservoir is to be filled to 50 percent of its capacity with solution described in 37.5.1. The plug is then to be removed such that all of the liquid will flow out. The reservoir is to be in its intended position, and the product is to be in the position that allows maximum exposure to the liquid.

Exception: If the inside diameter of the tubing is less than 1/4 inch, the hole size is to be equal to that diameter.

37.7 Impact test for polymeric reservoirs

37.7.1 When required by the Exception to 37.1.1, a polymeric reservoir shall be subjected to the impact test for polymeric reservoirs as described in 37.7.2. As a result of a single impact on each surface that can be exposed to a blow during intended use, there shall be no cracking or breakage of the reservoir material.

37.7.2 The impact force applied to a part of a reservoir is to be obtained using a solid smooth steel sphere 2 ±0.02 inches (50.5 ±0.5 mm) in diameter and weighing approximately 1.18 lb (0.5 kg). The sphere is to fall freely from rest through a distance of 51 inches (1.3 m) to cause it to strike the top of the reservoir with an impact of 5 ft-lbf (6.8 J). For surfaces other than the top, either the sample is to be supported on the side and subjected to the ball impact mentioned above, or the sphere is to be suspended by a cord and is to fall as a pendulum through the distance required to strike the surface with the specified impact. The reservoir is to be placed so that the surface tested is vertical and in the same vertical plane as the point of support of the pendulum. Parts of the unit under test that may interfere with the cord of the pendulum are to be removed. During the test, the unit is to be placed against a rigid supporting surface to prevent the sample from moving upon impact.

37.8 Temperature stability test for polymeric reservoirs

37.8.1 When required by the Exception to 37.1.1, a polymeric reservoir shall withstand the temperature stability conditions described in 37.8.2 without any shrinkage, warpage, or any other distortion of the reservoir, including attached tubing, that results in one or both of the following conditions:

a) Interference with the operation or user servicing of the product or

b) Openings that allow liquid to leak from the tank.

37.8.2 The complete product is to be placed in a circulating-air oven for 7 hours. The oven is to be maintained at a temperature of 10°C (18°F) higher than the maximum operating temperature of the reservoir measured at the hottest spot on the inside of the reservoir under normal operating conditions, but no less than 70°C (158°F). The product is not to be operated during the test.

38 Cord Reel Flexing Test

38.1 A cord reel supplied with a product shall be subjected to 6000 cycles of operation of reeling and unreeling the cord in the intended manner. Results are acceptable if there is no perceptible abrasion of, or any damage to, the cord insulation and no evidence of significant wear of movable and stationary contacts.

38.2 During the endurance test, the cord is to be unreeled to a length of 30 inches (760 mm) or more, by any convenient method representative of actual service, and is to be recoiled on the reel automatically by the action of the take-up mechanism. The cord is to be unreeled in such direction with respect to the body of the reel that the tendency to abrade the insulation will be the greatest, giving consideration to the intended method of mounting the reel.

39 Abnormal Operation Test

39.1 General

39.1.1 A motor provided with inherent overtemperature protection complying with the requirements in the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Thermally Protected Motors, UL 1004-3, and an impedance-protected motor complying with the requirements in the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Impedance Protected Motors, UL 1004-2, are considered to comply with requirements in 39.2.1 – 39.3.2 without the necessity of further tests.

Exception: Testing of an impedance-protected motor shall not be waived if the motor is subject to some adverse condition, such as restricted ventilation, proximity to an external source of heat, or the like.

UL 1004-2 will replace Part II of UL 2111 and UL 1004-3 will replace Part III of UL 2111.

39.2 Locked rotor

39.2.1 A motor having an automatically reset thermal protector is to be tested as described in 39.2.2. Results are acceptable if there is no permanent damage to the motor, including excessive deterioration of the insulation, and if the device permanently opens the circuit, it shall do so without grounding to the motor frame, damage to the motor, or introduction of a risk of fire.

39.2.2 For the test mentioned in 39.2.1, the rotor of the motor is to be locked, and the motor connected to a supply circuit having a voltage of 100 – 110 percent of the rated voltage of the motor. The protector of the motor shall perform successfully for 15 days.

Exception: The test is to be terminated if the product includes other controls, such as a timer, that will limit the operation to a shorter interval, or the device permanently opens the circuit prior to the expiration of the 15 days.

39.2.3 A manually reset thermal protector of a motor shall interrupt for 50 operations, without damage to itself, the locked-rotor current of the motor with which it is intended to be used when operated with the motor connected to a supply circuit having a voltage of 100 – 110 percent of the rated voltage of the motor. Results are acceptable if there is no permanent damage to the motor.

39.3 Overcurrent

39.3.1 A motor is to be subjected to limited short-circuit currents as described in 39.3.2. Results are acceptable if there is no ignition of cotton surrounding a thermal protector.

39.3.2 Three samples of the device are to be subjected to limited short-circuit currents. For a motor rated 1/2 horsepower (373 watts) or less and 250 volts or less, the current is to be 200 amperes. For a motor having other ratings, but not more than 1 horsepower (746 watts) or more than 600 volts, the current is to be 1000 amperes. The power factor of the test circuit is to be 0.9 – 1.0, and the circuit capacity is to be measured without the device in the circuit. A nonrenewable cartridge fuse is to be connected in series with the device under test. The fuse rating is to be not less than the highest of the following:

a) Four times the rated current of the product;

b) 20 amperes for a product rated 150 volts or less; or

c) 15 amperes for a product rated more than 150 volts.

For a manual reset thermal protector, the test on one sample is to be made by closing the device on the short circuit.

40 Abnormal Operation Test – Electronic Components Test

40.1 General

40.1.1 Equipment shall not cause a risk of fire or electric shock when operating under the abnormal conditions specified in 40.2.

40.1.2 Operation under the abnormal conditions specified in 40.2.1 shall not result in a risk of fire, electric shock, or increased risk of personal injury. A risk of fire, electric shock, or increased risk of personal injury is considered to exist if the test results in any of the following:

a) Ignition of the cheesecloth or the tissue paper;

b) The 3-ampere fuse connected to earth ground opens;

c) Any opening is developed in the overall enclosure that is larger than those permitted by accessibility requirements as covered by the Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 6; or

d) The appliance does not comply with the Dielectric Voltage-Withstand Test, Section 34.

40.1.3 Following the abnormal condition specified in 40.2, the sample is to be subjected to the applicable test potentials described in the Dielectric Voltage-Withstand Test, Section 34.

40.1.4 For the abnormal operation tests specified in 40.2, the appliance is to be connected to a supply circuit protected by a 30-ampere time-delay fuse marked Type D. It is to be placed on a white tissue paper covered softwood surface. A single layer of cheesecloth is to be draped loosely over the entire product. Exposed noncurrent-carrying metal parts are to be connected to earth ground through a 3-ampere nontime delay type fuse. The supply circuit connection is to be such that the maximum potential exists between the protective device of the product, if any, and the chassis.

40.2 Electronic components

40.2.1 A single malfunction (short or open) of any circuit component, such as a resistor, capacitor, solid state device, and the like, shall not result in a risk of fire, electric shock, or increased risk of personal injury. For a discrete, multiple (more than two) terminal device, such as a transistor, SCR, triac, or an integrated circuit device, any combination of terminals taken two at a time is to be open- or short-circuited.

Exception: Abnormal operation testing of multiple terminal circuit devices may be reduced if it can be determined by circuit analysis that an open- or short-circuit of the terminal(s) is not likely to result in a risk of fire, electric shock, or injury to persons.

40.2.2 The test potential described in the Dielectric Voltage-Withstand Test, Section 34, need be conducted only after the last abnormal operation test unless it is necessary to replace components after conducting the other tests.

41 Overload Test

41.1 A switch or other device that controls a motor of a product, or that controls a coil (transformer, relay, or solenoid) shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation as described in 41.2 – 41.4 as applicable. Results are acceptable if there is no electrical or mechanical malfunction or breakdown of the device or undue burning or pitting of the contacts, and the fuse in the grounding connection does not open.

Exception No. 1: A device known to be acceptable for the application need not be tested for overload.

Exception No. 2: A device interlocked so that it will never break the locked-rotor motor current need not be tested for overload.

41.2 In a test to determine whether the switch or other control device complies with the requirement in 41.1, exposed dead metal parts of the product are to be connected to ground through a 3-ampere plug fuse, and the product is to be connected to a grounded supply circuit of rated frequency. During the test the device is to be operated at a rate of not more than 10 cycles per minute.

Exception: A faster rate of operation may be used if agreeable to those concerned.

41.3 When testing a switch or other control device that controls a solenoid, a relay coil, or the like, the product is to be connected to a supply circuit of rated frequency and 110 percent of maximum rated voltage. The load on the device being tested is to be the same as that which it is intended to control in intended service.

41.4 When testing a switch or other control device that controls a motor, the rotor of the motor is to be locked in position and the product is to be connected to a supply circuit of maximum rated voltage as described in 33.1.8. The connection is to be such that any single-pole, current-interrupting device will be located in the ungrounded conductor of the supply circuit. If the product is intended for use on direct current, or on direct current as well as alternating current, the exposed dead metal parts of the product are to be connected so as to be positive with respect to a single-pole, current-interrupting control device.

42 Permanence of Marking Test

42.1 General

42.1.1 After being subjected to the conditions described in 42.2.1 – 42.3.1, a pressure-sensitive label or a label secured by cement or adhesive is considered to be permanent if, immediately following removal from each test medium, and after being exposed to room temperature for 24 hours following removal from each medium:

a) Each sample demonstrates good adhesion and the edges are not curled.

b) The label resists defacement or removal as demonstrated by scraping across the test panel with a flat metal blade 1/32 inch (0.8 mm) thick, held at right angles to the test panel.

c) The printing is legible and is not defaced by rubbing with thumb or finger pressure.

42.2 Oven-aging test

42.2.1 Three samples of the label applied to test surfaces as in the intended application are to be conditioned for 240 hours in an air oven maintained at the temperature specified in the Standard for Marking and Labeling Systems, UL 969.

42.2.2 Samples of the label applied to test surfaces as in the intended application are to be placed in a controlled atmosphere maintained at 23.0 ±2.0°C (73 ±4°F) with a 50 ±5 percent relative humidity for 24 hours. Three samples are then to be immersed in water and, if the marking is on a surface through which oil holes or tubes extend or that may otherwise be subject to contact by oil in intended use, three samples are to be immersed in oil at a temperature of 21.0 ±2.0°C (70 ±4°F) for 48 hours in each case.

42.3 Standard-atmosphere test

42.3.1 Three samples of the label applied to test surfaces as in the intended application are to be conditioned for 72 hours in a controlled atmosphere maintained at 23 ±2°C (73 ±4°F) with a 50 ±5 percent relative humidity.

MANUFACTURING AND PRODUCTION TESTS

43 Production-Line Dielectric Voltage-Withstand Test

43.1 Each product shall withstand without dielectric breakdown, as a routine production-line test, the application of a potential at a frequency within the range of 40 – 70 hertz between:

a) The primary wiring, including connected components, and accessible dead metal parts that are likely to become energized and

b) Primary wiring and accessible low-voltage (42.4 volts peak or less) metal parts, including terminals.

43.2 The production-line test shall be in accordance with either Condition A or Condition B of Table 43.1.

Table 43.1
Production-line test conditions

Appliance rating	Condition A		Condition B	
	Potential, volts	Time, seconds	Potential, volts	Time, seconds
250 volts or less with or without a motor rated 1/2 horsepower (373 watts) or less	1000	60	1200	1
Rated more than 250 volts or with a motor rated more than 1/2 horsepower	1000 + 2V[a]	60	1200 + 2.4V[a]	1

[a] Maximum rated voltage.

43.3 The product may be in a heated or unheated condition for the test.

43.4 The test is to be conducted when the product is fully assembled. It is not intended that the product be unwired, modified, or disassembled for the test.

Exception No. 1: A part such as a snap cover or a friction-fit knob that would interfere with the performance of the test need not be in place.

Exception No. 2: The test may be performed before final assembly if the test represents that for the completed product.

43.5 With reference to 43.4, a product using a solid-state component that is not relied upon to reduce the risk of electric shock and that can be damaged by the dielectric potential may be tested before the component is electrically connected, provided that a random sampling of daily production is tested at the potential specified in Table 43.1. The circuitry may be rearranged for the test to reduce the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

43.6 The test equipment is to include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visible indicator of dielectric breakdown, and either a manually reset device to restore the equipment after dielectric breakdown or an automatic feature that rejects any unacceptable unit.

43.7 If the output of the test equipment transformer is less than 500 volt-amperes, the equipment is to include a voltmeter in the output circuit to directly indicate the test potential.

43.8 If the output of the test equipment transformer is 500 volt-amperes or more, the test potential may be indicated by:

a) A voltmeter in the primary circuit or in a tertiary winding circuit;

b) A selector switch marked to indicate the test potential; or

c) A marking in a readily visible location to indicate the test potential of equipment having a single test potential output.

If a marking is used without an indicating voltmeter, the equipment shall include a positive means, such as an indicator lamp, to indicate that the manually reset switch has been reset following a dielectric breakdown.

43.9 Test equipment other than that described in 43.6 – 43.8 may be used if found to accomplish the intended factory control.

43.10 During the test, the primary switch is to be in the on position, both sides of the primary circuit of the product are to be connected together and to one terminal of the test equipment, and the second test-equipment terminal is to be connected to the accessible dead metal.

Exception No. 1: A product (resistive, high-impedance winding, or the like) having circuitry not subject to excessive secondary-voltage buildup in case of electrical breakdown during the test may be tested with:

a) A single-pole primary switch, if used, in the off position; or

b) Only one side of the primary circuit connected to the test equipment when the primary switch is in the on position, or when a primary switch is not used.

Exception No. 2: The primary switch is not required to be in the on position if the testing means applies full test potential between primary wiring and dead metal parts with the switch not in the on position.

44 Production-Line Grounding Continuity Test

44.1 Each cord-connected appliance having provision for grounding shall be tested, as a routine production-line test, to determine that grounding continuity exists between the grounding blade of the attachment plug and the accessible dead metal parts of the product that are likely to become energized.

44.2 Only a single test need be conducted if the accessible metal selected is conductively connected by construction to all other accessible metal.

44.3 Any acceptable indicating device, such as an ohmmeter, a battery-and-buzzer combination, or the like, may be used to determine whether a product complies with the requirement in 44.1.

MARKINGS

45 General

45.1 A floor finishing machine shall be legibly and permanently marked with the manufacturer's name, trade name, or trademark, the date or other dating period of manufacture not exceeding any three consecutive months, a distinctive catalog or model number or the equivalent, and the electrical rating. The electrical rating shall include the voltage, frequency, and input in amperes or watts. The marking shall also include the ampere rating unless the full load power factor is 80 percent or more or unless the machine is rated 50 watts or less. The number of phases shall be indicated if the machine is for use on a polyphase circuit.

Exception No. 1: The manufacturer's identification may be in a traceable code when the machine is identified by the brand or trademark owned by a private labeler.

Exception No. 2: The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer, provided that the code: