UL 1594

STANDARD FOR SAFETY

Sewing and Cutting Machines

UL Standard for Safety for Sewing and Cutting Machines, UL 1594

Fourth Edition, Dated April 18, 2008

Summary of Topics

This revision to UL 1594 dated September 21, 2021 includes the following changes in requirements:

– Revisions to Paragraph 59.9 to clarify instructions provided in electronic format

– Addition of Requirements for Appliances Incorporating Lasers, New Section 24A

– Addition of Requirements for Appliances Incorporating Button Batteries, New Section 24B

– Revisions to Relocate Component Standard References from Appendix A to the Body of the Standard; 2.1, 3.1.1 – 3.1.3, 3.2.1 – 3.2.7, Section 4A, 13.2.6, 13.4.1 – 13.4.3, Section 14, 17.3.1 – 17.3.10, Table 17.1, 18.1, Section 20, 21.2, 21.5, 29.5, 29.14, 44.2.1, Section 46, 58.1.2

– Revisions to Relocate Marking Requirements from Section 33 to Section 58; 58.1.6 – 58.1.9, 58.1A.1 – 58.1A.7, 59.3, 59.10

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated January 29, 2021 and August 20, 2021.

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1

UL 1594

Standard for Sewing and Cutting Machines

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Second Edition – January, 1995
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Fourth Edition

April 18, 2008

This UL Standard for Safety consists of the Fourth Edition including revisions through September 21, 2021.

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.

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION

PROTECTION AGAINST INJURY TO PERSONS

PERFORMANCE

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements cover both household and industrial sewing and cutting machines to be employed in accordance with the National Electrical Code.

1.2 These requirements also cover small utilization products, such as vibrator-powered scissors where motion of an operating part is produced by electrical means.

1.3 These requirements do not cover equipment rated more than 600 V; nor do they cover products involving universal motors rated more than 250 V.

1.4 These requirements also cover textile equipment for use in ordinary locations but do not cover equipment intended for use in hazardous locations such as certain textile processing equipment, and yarn handling equipment.

2 General

2.1 Components

2.1.1 *Deleted*

2.1.2 *Deleted*

2.1.3 *Deleted*

2.1.4 *Deleted*

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 otherwise indicated, all voltage and current values mentioned in this Standard are root-mean-square.

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.

3.1.1 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).

3.1.2 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.

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

3.2 AUTOMATICALLY CONTROLLED PRODUCT – A product is determined to be automatically controlled if it complies with one or more of the following conditions:

a) The repeated starting of the product is independent of any manual control after one complete cycle of operation, after which some form of limit device opens the circuit.

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

c) When the product is energized, the initial starting of the motor may be intentionally delayed beyond intended, conventional starting.

d) For a product employing a motor with a separate starting winding, during any single predetermined cycle of operation, automatic changing of the mechanical load reduces the motor speed sufficiently to reestablish starting-winding connections to the supply circuit.

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

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

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

3.2.4 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.

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

3.2.6 CONTROL, OPERATING – A device or assembly of devices, the operation of which starts or regulates the appliance during normal operation. Operating controls are also referred to as ″regulating controls″.

3.2.7 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. Protective controls are also referred to as ″limiting controls″ and ″safety controls″.

3.3 DEAD METAL PART – A metal or other electrically conductive part, accessible or inaccessible, that is not conductively connected to a live part.

3.4 FIRMWARE – Computer program contained permanently in a hardware device as read-only memory.

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

3.6 HAND-SUPPORTED PRODUCT – A product such as an electric scissor, that is physically supported by any part of the user during the performance of its intended functions.

3.7 ISOLATING TRANSFORMER – A transformer having one or more output windings electrically insulated from all other windings.

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

3.9 LIVE PART – A part energized with respect to earth or energized with respect to some other part.

3.10 LOW-VOLTAGE CIRCUIT – A circuit involving a peak open-circuit potential of not more than 42.4 V supplied by a primary battery; a Class 2 transformer; or a combination of an isolation 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.

3.11 PORTABLE – Capable of being carried or conveyed.

3.12 REMOTELY CONTROLLED PRODUCT – A product that is out of view of the operator at the starting device.

3.13 SEWING MACHINE TRANSMITTER – A motor, provided with either a mechanically or electrically operated clutch assembly, used to provide rotary drive for an industrial sewing machine.

CONSTRUCTION

4 General

4.1 A product shall employ materials that are acceptable for the particular use, and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

4A Components

4A.1 General

4A.1.1 Except as indicated in 4A.1.2, a component of a product covered by this standard shall:

a) Comply with the requirements for that component as indicated in 4A.2 – 4A.19;

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

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

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

e) Not contain mercury.

4A.1.2 A component 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 standard, or

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

4A.1.3 A component that complies with a UL component standard other than those specified in 4A.2 – 4A.19 is acceptable if:

a) The component also complies with the applicable component standard specified in 4A.2 – 4A.19; or

b) The component standard:

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

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

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

4A.1.4 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.

4A.1.5 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. However, 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 UL standard(s) need not be applied.

4A.1.6 A component not anticipated by the requirements of this standard, not specifically covered by the component standards in 4A.2 – 4A.19, 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 4A.1.1 (b) – (e).

4A.1.7 With regard to a component being additionally investigated, reference to construction and performance requirements in another UL end product standard is appropriate where that standard anticipates normal and abnormal use conditions consistent with the application of UL 1594.

4A.1.8 Unless otherwise specified, components that do not present a risk of electric shock, fire or injury to persons, such as connectors in a low-voltage circuit, are not required to meet the specified component standards.

4A.2 Attachment plugs, receptacles, connectors, and terminals

4A.2.1 Except for attachment plugs and appliance couplers integral to cord sets or power supply cords investigated in accordance with the Standard for Cord Sets and Power-Supply Cords, UL 817, 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 or the Standard for Appliance Couplers for Household and Similar General Purposes – Part 1: General Requirements, UL 60320-1.

4A.2.2 Quick-connect terminals, both connectors and tabs, shall comply with the Standard for Electrical Quick-Connect Terminals, UL 310, and shall be suitable for the wire size, type (solid or stranded), conductor material (copper or aluminum) and the number of conductors terminated. If insulated, the rated voltage and temperature shall be suitable for the intended use. Quick-connect terminals shall be applied per the installation instructions of the quick-connect terminal manufacturer.

4A.2.3 Single and multipole connectors for use in data, signal, control and power applications within the appliance 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.

4A.2.4 Wire connectors shall comply with the Standard for Wiring Connectors, UL 486A-486B.

4A.2.5 Splicing wire connectors shall comply with the Standard for Splicing Wiring Connectors, UL 486C.

4A.2.6 Multipole 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 2549. See 4A.2.9.

4A.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.

4A.2.8 Terminal blocks shall comply with the Standard for Terminal Blocks, UL 1059, and if applicable, be suitably rated for field wiring.

4A.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.

4A.3 Batteries, battery chargers and power supplies

4A.3.1 Rechargeable lithium ion (Li-ion) batteries shall comply with the Standard for:

a) Household and Commercial Batteries, UL 2054; or

b) Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made From Them, for Use in Portable Applications – Part 2: Lithium Systems, UL 62133-2.

4A.3.2 A Class 2 or limited power source (LPS) battery charger or power supply shall comply with the Standard for:

a) Class 2 Power Units, UL 1310;

b) Household and Similar Electrical Appliances, Part 2-29: Particular Requirements for Battery Chargers, UL 60335-2-29;

c) Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1; or

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

4A.3.3 A non-Class 2 battery charger or power supply shall comply with the Standard for:

a) Power Units Other Than Class 2, UL 1012;

b) Household and Similar Electrical Appliances, Part 2-29: Particular Requirements for Battery Chargers, UL 60335-2-29;

c) Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1; or

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

4A.4 Boxes and raceways

4A.4.1 Electrical boxes and the associated bushings and fittings, and raceways, of the types specified in Chapter 3 of the National Electrical Code, ANSI/NFPA 70 and that comply with the relevant UL standard (such as the Standard for Metallic Outlet Boxes, UL 514A, the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers, UL 514C, the Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D) and 4A.1 are considered to comply with the requirements of this Standard.

4A.5 Capacitors and filters

4A.5.1 Capacitors connected between the ungrounded and grounded conductors (across the line) or from one of these conductors to accessible dead metal of the appliance shall comply with:

a) The Standard for Electromagnetic Interference Filters, UL 1283; or

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

4A.5.2 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 overall enclosure or container, that will not permit the emission of flame or molten material resulting from malfunction or breakdown of the capacitor. 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).

Exception: The individual container of a capacitor may be of sheet metal less than 0.020 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.

4A.5.3 Electromagnetic interference filters with integral enclosures that comply with the Standard for Electromagnetic Interference Filters, UL 1283, are considered to fulfill the requirements of 4A.5.2.

4A.5.4 If malfunction or breakdown of a capacitor that is not a part of a capacitor motor or a capacitor-start motor is connected in a product that is intended to be automatically or remotely controlled, would result in a risk of fire, electric shock, or injury to persons, thermal or overcurrent protection shall be provided in the product.

4A.5.5 A capacitor connected from either side of the line to the frame or enclosure of a product shall have a capacitance rating of not more than 0.10 mF.

4A.5.6 A product that is constructed to be controlled or operated in conjunction with a capacitor or a capacitor/transformer unit shall be supplied with such capacitor or unit.

4A.5.7 The materials and construction of a capacitor or its enclosure within a product, including a means for venting, shall be such that no hazardous pressures can develop in the capacitor as a result of a short circuit in the capacitor or the circuit in which it is connected.

4A.5.8 The voltage rating of a capacitor other than a motor-starting or motor-running capacitor shall be equal to or exceed the maximum steady-state potential to which the capacitor is subjected during operation at rated voltage or user servicing of the product.

4A.5.9 Under both normal and abnormal conditions of use, a capacitor employing a liquid dielectric medium more combustible than askarel shall not cause a risk of electric shock or fire and shall be protected against expulsion of the dielectric medium. A capacitor complying with the Standard for Capacitors, UL 810, is considered to fulfill this requirement.

4A.6 Controls

4A.6.1 Auxiliary controls

4A.6.1.1 Auxiliary controls shall be evaluated using the applicable requirements of this standard or the Standard for Automatic Electrical Controls; Part 1: General Requirements, UL 60730-1 and any applicable UL 60730 Part 2 standard.

4A.6.1.2 A control regulating the motor speed, stitch selection, stitch length or width, thread tension and any other control not relied upon for compliance with this standard shall be evaluated as an auxiliary control.

4A.6.2 Operating controls

4A.6.2.1 Operating (regulating) controls shall comply with this standard or the Standard for Automatic Electrical Controls; Part 1: General Requirements, UL 60730-1 and any applicable UL 60730 Part 2 standard, unless otherwise specified, as follows:

a) Manual and automatic controls in a line voltage circuit making or breaking a load shall be tested for 6,000 cycles under maximum normal load conditions and 50 cycles under overload conditions, including locked rotor conditions if controlling a motor;

b) The Overvoltage Category shall be as specified in Table 23.2;

c) The Pollution Degree is considered to be Pollution Degree 2 unless the control is located in an area protected against deposition of dirt (Pollution Degree 1) or in an area where conductive pollution is present (Pollution Degree 3) as specified in Table 23.1.

4A.6.2.2 A control limiting the operating time during normal operation or starting or stopping the motor, except when serving as an interlock required for compliance with this standard, shall be evaluated as an operating control.

4A.6.3 Protective controls

4A.6.3.1 Protective (limiting) controls shall comply with the Standard for Automatic Electrical Controls; Part 1: General Requirements, UL 60730-1 and any applicable UL 60730 Part 2 standard, unless otherwise specified, as follows:

a) Manual and automatic controls acting as an interlock or disconnecting the load when abnormal conditions are detected shall be tested for 100,000 cycles under maximum normal load conditions;

b) The Overvoltage Category shall be as specified in Table 23.2;

c) The Pollution Degree is considered to be Pollution Degree 2 unless the control is located in an area protected against deposition of dirt (Pollution Degree 1) or in an area where conductive pollution is present (Pollution Degree 3) as specified in Table 23.1;

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

e) Power Supply Voltage Dips, Variation and Interruptions within a temperature range of 50°F(10°C) and the maximum ambient temperature determined by conducting the Normal Temperature Test, Section 39;

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

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

h) Electrostatic discharge test;

i) 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;

j) Thermal Cycling test of clause H.17.1.4.2 of UL 60730-1 shall be conducted on protective devices intended for other than outdoor use at ambient temperatures of 32.0 ±3.6°F (0 ±2°C) and 104 ±3.6°F (40.0 ±2°C). For protective devices intended for outdoor use, the test shall be conducted at ambient temperatures of minus 31.0 ±3.6°F (minus 35.0 ±2°C) and 104 ±3.6°F (40.0 ±2°C). If the maximum ambient temperature of the control is determined to exceed the specified upper limit of the ambient temperature by conducting the Normal Temperature Test, Section 39, this higher ambient temperature shall be used. The test shall be conducted for 14 days; and

k) Overload shall be conducted based on the maximum declared ambient temperature (T_{max}) or as determined by conducting the Normal Temperature Test, Section 39;

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

4A.6.3.2 The following functions shall be evaluated as protective control functions:

a) Serving as motor overload protection required in accordance with 4A.13.4 (See also 4A.6.4);

b) Limiting the operating time under abnormal operating conditions and relied upon for compliance with the standard;

c) Detecting abnormal temperatures or currents and automatically disconnecting the motor or circuit during an abnormal operating condition and relied upon for compliance with this standard; or

d) Serving as an interlock relied upon for compliance with this standard.

4A.6.4 Motor controls

4A.6.4.1 A control used to regulate or control a motor of a sewing machine transmitter, including motor overload protection, shall comply with this standard, if acting as an auxiliary or operating control, or one of the following standards:

a) The Standard for Industrial Control Equipment, UL 508;

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

c) The Standard for Automatic Electrical Controls; Part 1: General Requirements, UL 60730-1 and if applicable, the Standard for Automatic Electrical Controls; Part 2-2: Particular Requirements for Thermal Motor Protectors (See also 4A.13.4).

4A.6.5 Temperature controls

4A.6.5.1 A temperature positive temperature coefficient (PTC) or a negative temperature coefficient (NTC) thermistor, that performs the same function as an operating or protective control shall comply with the Standard for Thermistor-Type Devices, UL 1434 or the Standard for Automatic Electrical Controls; Part 1: General Requirements, UL 60730-1 and, if applicable, the Standard for Automatic Electrical Controls; Part 2-9: Particular Requirements for Temperature Sensing Controls, UL 60730-2-9.

4A.6.5.2 A thermal link shall comply with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691.

4A.7 Cords, cables, and internal wiring

4A.7.1 A cord set or power supply cord shall comply with the Standard for Cord Sets and Power Supply Cords, UL 817.

4A.7.2 Flexible cords and cables shall comply with the Standard for Flexible Cords and Cables, UL 62. Flexible cord and cables are considered to fulfill this requirement when pre-assembled in a cord set or power supply cord complying with the Standard for Cord Sets and Power Supply Cords, UL 817.

4A.7.3 Internal wiring composed of insulated conductors, except those located in a low-voltage circuit not involving a risk of fire or personal injury, shall comply with one of the following:

a) The Standard for Appliance Wiring Material, UL 758;

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

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

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

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

4A.8 Cord reels

4A.8.1 An automatic cord reel shall comply with special use cord reel requirements of the Standard for Cord Reels, UL 355.

4A.9 Film-coated wire (magnet wire)

4A.9.1 The component requirements for film coated wire and Class 105 (A) insulation systems are not specified.

4A.9.2 Film-coated wire in intimate combination with one or more insulators, and incorporated in an insulation system rated Class 120 (E) or higher, shall comply with the magnet wire requirements in the Standard for Systems of Insulating Materials – General, UL 1446.

4A.10 Insulation systems

4A.10.1 Materials used in an insulation system, including film-coated wire, operating above Class 105 (A) temperatures shall comply with the Standard for Systems of Insulating Materials – General, UL 1446.

4A.10.2 All insulation systems employing integral ground insulation (epoxy coating) shall comply with the requirements specified in the Standard for Systems of Insulating Materials – General, UL 1446.

4A.10.3 Motors that are provided with thermoplastic coil forms or thermoplastic insulating material shall comply with the requirements in the Standard for Polymeric Materials – Coil Forms, UL 1692. Motors with insulation systems above Class 105 (A) complying with the Standard for Systems of Insulating Materials – General, UL 1446, are considered to comply with this requirement.

4A.11 Light sources and associated components

4A.11.1 Lampholders and indicating lamps shall comply with the Standard for Lampholders, UL 496.

4A.11.2 Lighting ballasts shall comply with one of the following:

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

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

Exception: Ballasts for other light sources shall comply with the applicable UL standard(s).

4A.12 Marking and labeling systems

4A.12.1 A marking and labeling system shall comply with the Standard for Marking and Labeling Systems, UL 969.

4A.13 Motors and motor overload protection

4A.13.1 General

4A.13.1.1 General-purpose type motors having a NEMA frame size shall comply with the requirements specified in 4A.13.2. 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).

4A.13.1.2 Motors not enclosed, or partially enclosed, by the end-product enclosure shall comply with the requirements specified in 4A.13.2.

4A.13.1.3 Component type motors completely enclosed within the end-product enclosure shall comply with the requirements specified in 4A.13.2 or 4A.13.3.

4A.13.1.4 Motors located in a low voltage circuit are evaluated for the risk of fire and personal injury in accordance with the applicable requirements of this standard.

4A.13.2 General-purpose type motors

4A.13.2.1 A general-purpose type motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

4A.13.3 Component type motors

4A.13.3.1 Component type motors shall comply with either 4A.13.3.2 or 4A.13.3.3.

4A.13.3.2 The motor shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 except as noted in Table 4A.1.

Table 4A.1
Superseded requirements

UL 1004-1 requirements	Superseded by UL 1594 requirements
Current and Horsepower Relation, Section 6	17.3.4
Solid-State Controls, 7.1	4A.6
Non-metallic enclosure thermal aging, 9.1.4	5.3
Motor enclosure, 9.2 – 9.4	Section 5
Grounding, Sections 10 and 11	Section 15
Ventilation Openings, Section 12	Section 9
Accessibility of Uninsulated Live Parts, Film-Coated Wire, and Moving Parts, Section 13	Section 9
Protection Against Corrosion, Section 14	Section 8
Cord-Connected Motors, Section 15	10.1
Factory Wiring Terminals and Leads, Section 17	Section 13
Electrical Insulation, Section 22	Section 12
Available fault current ratings for motor start and running capacitors, Clause 26.6: not applicable for cord and plug connected appliances.	4A.5
Switch, Section 27 is not applicable to centrifugal starting switches	Section 29
Non-Metallic Functional Parts, Section 28	Sections 5, 12, 17
With the exception of Sections 35 and 40 (Resilient Elastomer Mounting and Electrolytic Capacitor Tests, respectively), the performance tests of UL 1004-1 are not applicable.	All applicable performance tests.
Only the following marking requirements specified in 44.1 of UL 1004-1 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.	58.1

4A.13.3.3 The motor shall comply with the component requirements in Components, Section 4A, the following construction requirements, and the performance requirements (when tested in conjunction with the end-product), of this standard, as applicable:

a) Protection Against Corrosion, Section 8.

b) Terminal Compartment, Section 10 (10.2.2).

c) Insulating Materials, Section 12.

d) Internal Wiring, Section 13.

e) Grounding, Section 15.

f) Motors, Section 17.

g) Spacings, Section 22.

4A.13.4 Motor overload protection

4A.13.4.1 A product shall incorporate thermal or overload protection in accordance with 4A.13.4.2 if it is intended to be:

a) Permanently connected, continuous-duty, and manually started, employing a motor rated 1 horsepower (746 W output) or less or

b) Remotely or automatically controlled.

4A.13.4.2 Motor-overload protection required for a product shall consist of one of the following:

a) Thermal protection complying with the applicable requirements in the Standard for Thermally Protected Motors, UL 1004-3.

Exception No. 1: The test on a manually reset device is to be continued for four operations of the protective device, with the device being reset as quickly as possible after it has opened.

Exception No. 2: A motor intended to move air only by means of an air-moving fan that is integrally attached, keyed, or otherwise fixed to the motor shaft is considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

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

b) Impedance protection complying with the Standard for Impedance Protected Motors, UL 1004-2, when the motor is tested as used in the product under stalled rotor conditions.

c) Electronic protection complying with the Standard for Electronically Protected Motors, UL 1004-7 or, alternatively for sewing machine transmitters, the Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy, UL 61800-5-1.

d) Other protection that is shown by test to be equivalent to the protection as specified in (a).

4A.13.4.3 For a multispeed motor of any of the types mentioned in 4A.13.4.1 that employs a separate overcurrent-protective device to provide running-overcurrent protection, the requirement in that paragraph applies at all speeds at which the motor is intended to operate.

4A.13.4.4 If a requirement in this standard refers to the horsepower rating of a motor and the motor is not rated in horsepower, use is to be made of the appropriate table of the National Electrical Code, ANSI/NFPA 70, that gives the relationships between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating-current motor is to be used if the product is marked for use on alternating current only; otherwise the table applying to direct-current motors is to be used.

4A.13.4.5 The motor product with load characteristics likely to result in overload or stalled condition that will not be evident to the user, shall incorporate thermal or overload protection in accordance with 4A.13.4.2.

4A.13.4.6 The functioning motor-protective device provided as part of a product, whether such device is required or not, shall not result in a risk of fire or injury to persons.

4A.13.4.7 Overload devices employed for running overload protection, other than those that are inherent in a motor, shall be located in at least one ungrounded conductor of a single-phase supply system and in each ungrounded conductor of a 3-phase supply system.

4A.13.4.8 Fuses employed for motor-running overload protection shall be located in each ungrounded conductor; and in each phase of a 3-phase, 3-wire, alternating-current motor.

4A.13.4.9 With reference to 4A.13.4.2(d), an overload-protective device conforming with the National Electrical Code, ANSI/NFPA 70 is considered to be an overload device that is responsive to motor current and is rated or set as specified in Column A of Table Table 4A.2. If the rating of the motor-running overload protection determined in accordance with the foregoing does not correspond to a standard size or rating of a fuse, nonadjustable circuit breaker, thermal cutout, thermal relay, or heating element of a thermal-trip motor switch, the next highest size, rating, or setting may be used, but may not be more than that specified in Column B of Table 4A.2. For a multispeed motor, each winding connection is to be considered separately.

Table 4A.2
Maximum rating or setting of overload-protective device

Type of motor	Ampere rating of device as a percentage of motor full-load current rating	
	A	B
Motor with marked service factor of 1.15 or more	125	140
Motor with marked temperature rise of 40°C (72°F) or less	125	140
Any other motor	115	130

4A.13.4.10 Motor-overload protection in which contacts control a relay coil in a motor starter shall comply with the requirements in 4A.13.4.2.

4A.14 Overcurrent protection

4A.14.1 Fuses shall comply with the Standard for Low-Voltage Fuses – Part 1: General Requirements, UL 248-1; and the applicable UL 248 Part X (e.g. UL 248-5). Defined use fuses that comply with UL 248-1 and another applicable UL standard for fuses are considered to comply with this requirement.

4A.14.2 Fuseholders shall comply with the Standard for Fuseholders – Part 1: General Requirements, UL 4248-1, and the applicable Part X (e.g. UL 4248-9).

4A.14.3 Circuit breakers shall comply with the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489. However, circuit breakers used in telecommunications circuitry shall comply with the Standard for Circuit Breakers For Use in Communications Equipment, UL 489A.

4A.14.4 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.

4A.14.5 Supplementary protectors shall comply with the Standard for Supplementary Protectors for Use in Electrical Equipment, UL 1077.

4A.14.6 Fusing resistors shall comply with the Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances, UL 1412.

4A.15 Printed wiring boards

4A.15.1 Printed-wiring boards used in secondary circuits not complying with 21.2 or 21.3, and primary circuits, shall comply with the Standard for Printed-Wiring Boards, UL 796, including the requirements for direct support of live parts.

4A.15.2 A printed-wiring board shall have a minimum flame classification of V-2.

Exception: A printed-wiring board located in a secondary circuit that complies with the requirements for Class 2 or limited voltage/current circuits as described in 21.2 or 21.3 may have a minimum flame Class of HB.

4A.15.3 Printed circuit boards used in Class 2 or limited voltage/current secondary circuits complying with 21.2 or 21.3 where deterioration or breakage of the bond between the conductor and the base material does not result in a risk of fire, electric shock, or increase in the risk of injury to persons are considered to be acceptable for the application without further investigation.

4A.16 Semiconductors, contactors, relays and small electrical and electronic components

4A.16.1 A power switching semiconductor device that is relied upon to provide isolation to ground or accessible metal parts shall comply with the Standard for Electrically Isolated Semiconductor Devices, UL 1557.

4A.16.2 An optical isolator that is relied upon to provide isolation between primary and secondary circuits or between other circuits as required by this standard shall comply with the Standard for Safety for Optical Isolators, UL 1577.

4A.16.3 Contactors and relays shall comply with:

a) The Standard for Industrial Control Equipment, UL 508;

b) The Standard for Low-Voltage Switchgear and Controlgear – Part 1: General Rules, UL 60947-1, with the Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1; or

c) The Standard for Automatic Electrical Controls – Part 1: General Requirements, UL 60730-1, and, where applicable, the relevant Part 2 standard from the UL 60730 series.

4A.17 Supplemental insulation, insulating bushings, and assembly aids

4A.17.1 The requirements for supplemental insulation (e.g. tape, sleeving or tubing) are not specified unless the insulation or device is required to comply with a performance requirement of this standard. In such cases the insulation or device shall comply with the following applicable standards:

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; or

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

4A.17.2 Wire positioning devices necessary for compliance with this standard shall comply with the Standard for Positioning Devices, UL 1565.

4A.17.3 Insulating bushings shall comply with the Standard for Insulating Bushings, UL 635 and be suitable for the application with respect to the hole size and shape, maximum use temperature and wire size or type. To determine if the hole size and shape is suitable for the bushing, the applicable test(s) specified in this standard (e.g. Strain Relief Test, Push-Back Relief Test, Strain Relief Following Mold Stress) shall be conducted.

4A.18 Switches

4A.18.1 Switches shall comply with one of the following, as applicable:

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

b) The Standard for General-Use Snap Switches, UL 20.

4A.18.2 Clock-operated switches, and time switches, including timers, shall comply with one of the following:

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

b) The Standard for Automatic Electrical Controls; Part 1: General Requirements, UL 60730-1; and the Standard for Automatic Electrical Controls for Household and Similar Use; Part 2: Particular Requirements for Timers and Time Switches, UL 60730-2-7. See also 4A.6.

4A.18.3 A switch or other control device shall have a current and voltage rating not less than that of the load it controls and shall be evaluated for at least 6000 cycles of operation. However, an interlock switch required for compliance with this standard shall be evaluated for at least 100,000 cycles or operation.

4A.18.4 With reference to the requirement in 4A.18.4, 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 not be 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.

4A.18.5 In a permanently-connected product rated 125 or 125/250 V (3-wire) or less, no switch or overcurrent-protective device of the single-pole type other than an automatic control without a marked off position shall be electrically connected to a terminal or lead intended for connection to the grounded conductor of the supply circuit.

4A.18.6 A manually operated motor-control switch shall be provided in a cord-connected product that employs a motor rated more than 1/3 horsepower (250 W).

4A.18.7 A switch that controls a medium-base lampholder of other than a pilot or indicating light shall be acceptable for use with tungsten-filament lamps.

4A.19 Transformers

4A.19.1 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.

4A.19.2 Class 2 and Class 3 transformers, other than those located in a low voltage circuit, 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.

4A.19.3 A transformer used in a circuit involving an audio or video component, shall comply with the Standard for Transformers and Motor Transformers for Use in Audio-, Radio-, and Television-Type Appliances, UL 1411.

4A.19.4 An isolating transformer as specified in 21.1 shall comply with the requirements in above standards, as applicable, including those for providing isolation between the primary and secondary circuits or with the requirements for isolating transformers within the power supply standards specified in 4A.3.2 or 4A.3.3.

5 Frame and Enclosure

5.1 General

5.1.1 A product shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses that it is likely to be subjected to under normal and foreseeable abnormal conditions.

5.1.2 The enclosure of a remotely or automatically controlled product shall be so constructed as to prevent molten metal, burning insulation, flaming particles, or similar materials from falling on combustible materials, including the surface upon which the product is supported.

5.1.3 A door or a cover of an enclosure that provides access to any overload-protective device that requires resetting or renewal shall be hinged or otherwise attached in an equivalent manner.

5.1.4 Means shall be provided for holding the door or cover over a fuseholder in a closed position.

5.2 Cast and sheet metal

5.2.1 For unreinforced, flat surfaces in general, cast metal shall not be less than 1/8 inch (3.2 mm) thick, except that malleable iron may not be less than 3/32 inch (2.4 mm) and die-cast metal may be not less than 5/64 inch (2.0 mm) thick. Corresponding thicknesses of not less than 3/32, 1/16 (1.6 mm), and 3/64 inch (1.2 mm), respectively, may be acceptable if the surface under consideration is curved, ribbed, or otherwise reinforced, or if the shape or size, or both, of the surface is such that adequate mechanical strength is provided.

5.2.2 An enclosure of sheet metal is to be judged with respect to its size, shape, thickness of metal, and its application, considering the intended use of the complete product. The use of sheet steel having a thickness of less than 0.026 inch (0.66 mm) if uncoated or 0.029 inch (0.74 mm) if galvanized or of nonferrous sheet metal having a thickness of less than 0.036 inch (0.91 mm) is not recommended, except for relatively small areas or for surfaces that are covered or otherwise reinforced.

5.2.3 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 inch (0.81 mm) for uncoated steel, not less than 0.034 inch (0.86 mm) for galvanized steel, and not less than 0.045 inch (1.14 mm) for nonferrous metal.

5.3 Polymeric enclosures

5.3.1 Enclosures of polymeric material shall comply with the requirements for enclosures contained in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: The ball impact test for portable table top or counter supported products shall be conducted using a 3 ft·lbf (4.07 J) impact.

Exception No. 2: A polymeric material having a volume resistivity lower than that required by the section for volume resistivity of UL 746C may only be used if, with the enclosure considered to be a dead metal part, the product complies with the requirements for spacings in Spacings, Section 22.

Exception No. 3: For the impact tests specified in UL 746C:

a) Each surface that is likely to be exposed to abuse during normal use is to be tested, but no more than 3 impacts are to be applied to any one sample;

b) In lieu of the requirements for dielectric voltage-withstand, the requirements for accessibility in Accessibility of Uninsulated Live Parts and Magnet Wire, Section 9, shall be applied after the impact test.

Exception No. 4: For the mold stress-relief distortion conditioning requirements specified in UL 746C, the requirement that specify conditioning results shall not cause interference with the intended operation or servicing of the equipment, is not applicable.

Exception No. 5: For the abnormal operation requirements specified in UL 746C:

a) Cheesecloth is not required to be applied.

b) There shall be no ignition of the enclosure material, exposure of live part, nor glowing or flaming of the material upon which the product is placed as a result of emission of flame through other than existing openings.

6 Adhesives Used to Secure Parts

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

6.2 The requirement in 6.1 also applies to an adhesive used to secure a conductive part, including a nameplate, that may, if loosened or dislodged:

a) Energize an accessible dead metal part,

b) Make a live part accessible,

c) Reduce spacings below the minimum acceptable values, or

d) Short circuit live parts.

7 Mechanical Assembly

7.1 A product shall be assembled so that it will not be adversely affected by the vibration of normal operation. Brush caps shall be tightly threaded or otherwise constructed to be kept from loosening.

7.2 A switch other than a through-cord switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be mounted securely and shall be kept from turning. See 7.4.

Exception No. 1: A switch is not required to be kept from turning if all four of the following conditions are met:

a) The switch is of a 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 normal operation of the switch.

b) The means for mounting the switch makes it unlikely that operation of the switch will cause it to loosen.

c) The spacings are not reduced below the minimum required values if the switch rotates.

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

Exception No. 2: A nonserviceable lamp such as a neon light in which the lamp is sealed in a nonremovable jewel, is not required to be kept from turning if rotation does not reduce spacings below the minimum required values.

7.3 Uninsulated live parts shall be secured to the base or mounting surface so that they will be kept from turning or shifting in position, if such motion results in a reduction of spacings below the minimum acceptable values.

7.4 The means used to keep the parts mentioned in 7.2 and 7.3 from turning or shifting is to consist of more than friction between surfaces. For example, a properly applied lock washer is acceptable as the means for keeping a small stem-mounted switch, or other device having a single-hole mounting means, from turning.

8 Protection Against Corrosion

8.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means, if corrosion of such unprotected parts would be likely to result in a risk of fire, electric shock, or injury to persons.

Exception: Bearings, laminations, or small parts of iron or steel, such as washers, screws, and similar parts are not required to comply with this requirement.

9 Accessibility of Uninsulated Live Parts and Magnet Wire

9.1 General

9.1.1 The requirements in 9.1.2 – 9.2.3 shall apply to uninsulated live parts and magnet wire in circuits other than Class 2 and limited voltage/current circuits as described in 21.2 and 21.3.

9.1.2 To reduce the likelihood of unintentional contact that may involve a risk of electric shock, an uninsulated live part or magnet wire shall comply with either (a) or (b).

a) For an opening that has a minor dimension (see 9.1.6) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 9.1.

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 9.1.

Exception: A motor used in an appliance intended for commercial use other than one used in either a hand-held product or a hand-supported portion of a product is not required to comply with these requirements if it complies with the requirements in 9.1.3.

Table 9.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

Minor dimension of opening,[a]		Minimum distance from opening to part,	
inches[b]	(mm[b])	inches[b]	(mm[b])
3/4	(19.1)	4-1/2	(114.0)
1[c]	(25.4)	6-1/2	(165.0)
1-1/4	(31.8)	7-1/2	(190.0)
1-1/2	(38.1)	12-1/2	(318.0)
1-7/8	(47.6)	15-1/2	(394.0)
2-1/8	(54.0)	17-1/2	(444.0)
d	d	30	(762.0)

[a] See 9.1.6

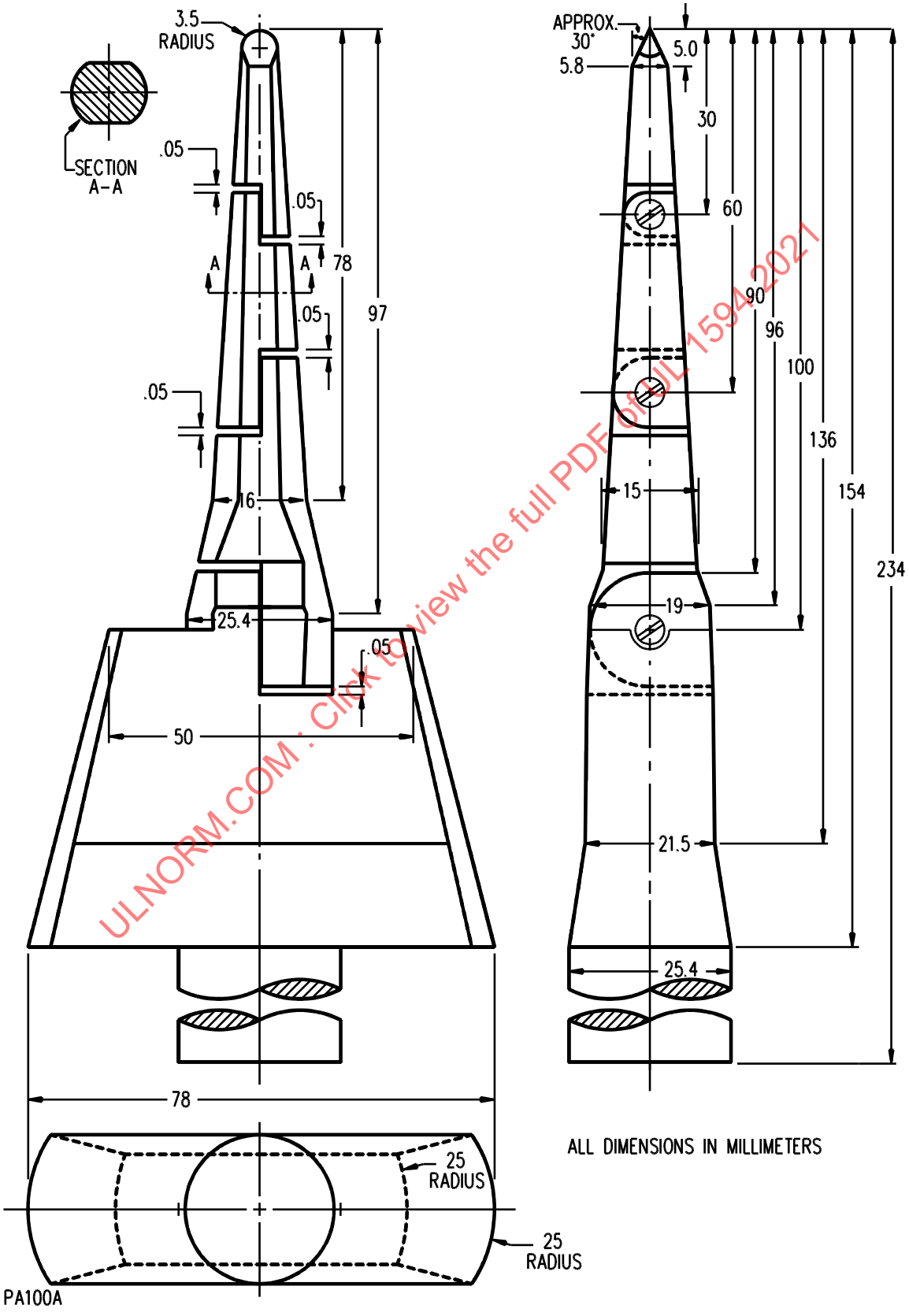
[b] Between 3/4 and 2-1/8 inches, interpolation is to be used to determine a value between values specified in the table.

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

[d] More than 2-1/8 inches (54.0 mm), but not more than 6 inches (152.0 mm).

Figure 9.1

Articulate probe with web stop



9.1.3 With respect to a part or wire as mentioned in 9.1.2, in an integral enclosure of a motor as mentioned in the Exception to 9.1.2:

a) An opening that has a minor dimension (see 9.1.6) less than 3/4 inch (19.1 mm) is acceptable if:

1) Magnet wire cannot be contacted by the probe illustrated in Figure 9.2

2) An uninsulated live part cannot be contacted by the probe illustrated in Figure 9.3.

b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 9.1.

Figure 9.2

Straight probe

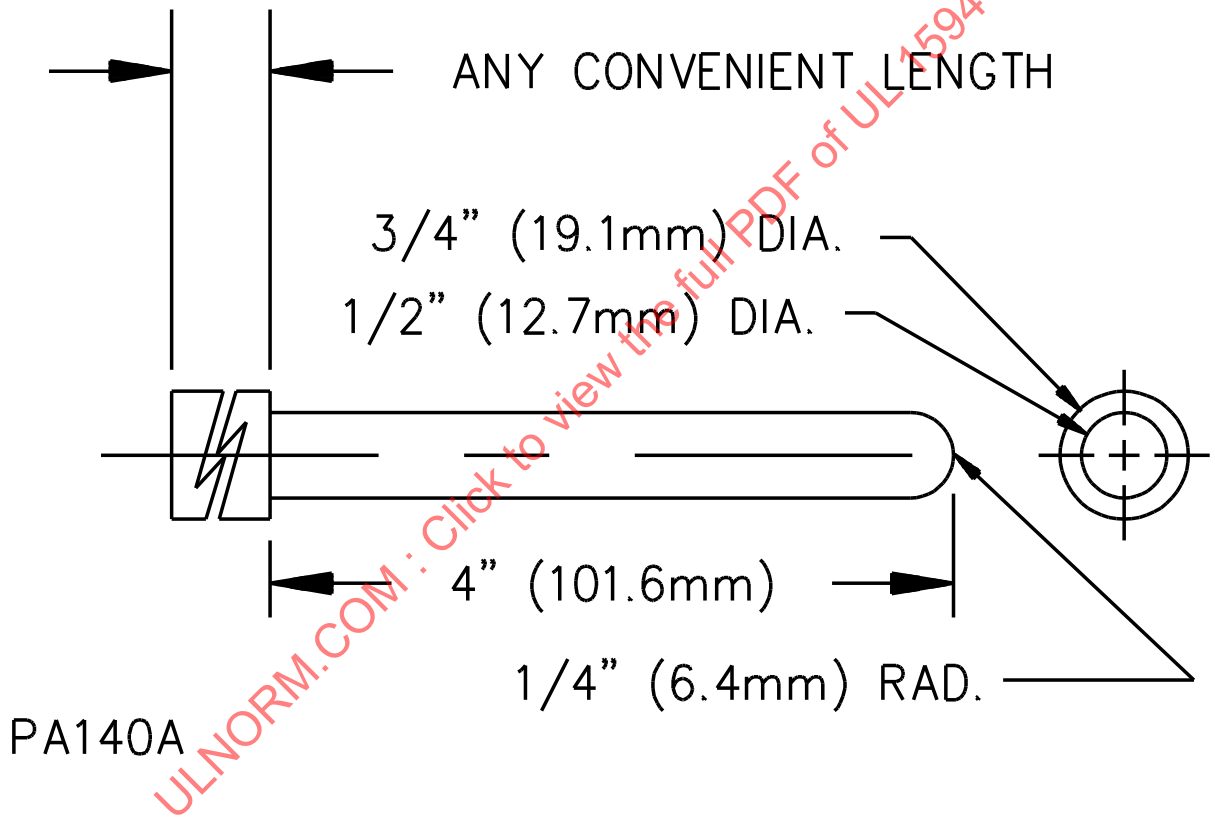
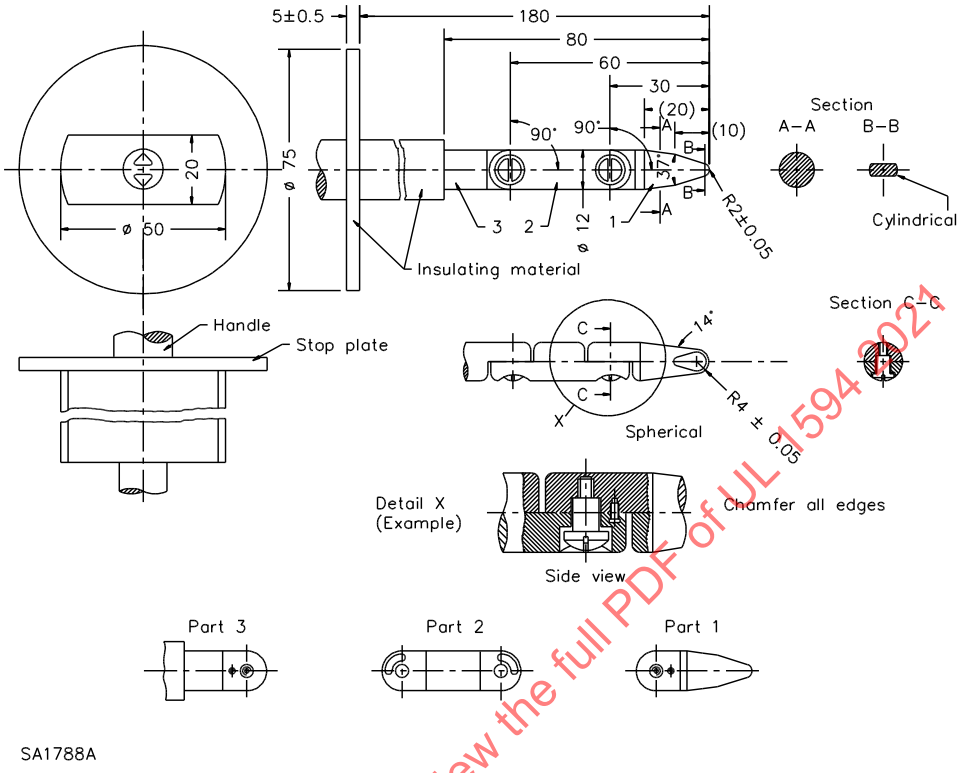


Figure 9.3

Articulate probe with stop plate



NOTE – All dimensions in millimeters

9.1.4 The probes mentioned in 9.1.2 and 9.1.3 and illustrated in Figure 9.1 – Figure 9.3 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 9.1 and Figure 9.3 shall be applied in any possible configuration; and, if required, the configuration shall be changed after insertion through the opening.

9.1.5 The probes mentioned in 9.1.2 and 9.1.3 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; they shall be applied with the minimum force necessary to determine accessibility.

9.1.6 With reference to the requirements in 9.1.2 and 9.1.3, 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.

9.1.7 During the examination of a product to determine whether it complies with the requirements in 9.1.2 or 9.1.3, a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

9.1.8 With reference to the requirements in 9.1.2 and 9.1.3, insulated brush caps are not required to be additionally enclosed.

9.2 Accessibility of parts requiring servicing

9.2.1 For routine operator servicing or adjustment, a fuseholder, or a circuit breaker shall be constructed and installed so that a person servicing the fuse, or the circuit breaker will not come in contact with an uninsulated live part.

9.2.2 A door or a cover that is accessible from outside the enclosure shall be hinged or otherwise permanently attached to the product if it gives access to any overload-protective device other than a type that does not require an additional enclosure.

9.2.3 Means shall be provided for holding the door or the cover over a fuseholder in a closed position.

10 Supply Connections

10.1 Cord-connected products

10.1.1 Cords and plugs

10.1.1.1 A product intended to be connected to the power-supply circuit by means of a power-supply cord shall be provided with a flexible cord and an attachment plug acceptable for the connection.

10.1.1.2 The power-supply cord shall have a voltage rating not less than the rated voltage of the product, and shall have an ampacity that is not less than the current input to the product as measured during the input test or the rating of the product, whichever is higher.

10.1.1.3 The power-supply cord shall be as specified in Table 10.1, or shall be of a type at least equally serviceable for the application.

Table 10.1
Cords for products

Product	Types of cord
Cloth-cutting machines:	
Household (includes scissors)	SP-2, SPT-2, SPE-2, SV, SVE, SVT
Commercial	SJ, SJT, SJE
Commercial textile equipment	S, ST, SE
Knitting machines:	
Household	SP-2, SPT-2, SPE-2, SV, SVE, SVT
Commercial	S, ST, SE
Sewing machines:	
Household	SP-2, SPT-2, SPE-2, SV, SVE, SVT
Transmitters	S, ST, SE

10.1.1.4 For a product not specifically mentioned in Table 10.1, Type SJ, SJT, or equivalent cord is ordinarily required if the product is intended for commercial use, and Type SP-1, SPT-1 or equivalent if the product is intended for household use.

10.1.1.5 The power-supply cord shall not be less than 5 feet (1.52 m) long.

10.1.1.6 The length of an attached power-supply cord includes the attachment plug. The length of a cord set includes the attachment plug and cord-connector body.

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

10.1.1.8 The attachment cap shall have an ampacity not less than the current input to the product as measured during the input test or the rating of the product, whichever is higher, and a voltage rating equal to the rated voltage of the product. If a product is acceptable for adaptation for use on two or more different values of voltage by field alteration of internal connections, the attachment plug provided with the product shall be acceptable for the voltage for which the product is intended to be connected when shipped from the factory. See 58.1.4.

10.1.1.9 A 3- to 2-wire, grounding-type adapter shall not be provided with a product.

10.1.1.10 A product provided with special-use pin terminals shall be constructed so that no live parts will be exposed to unintentional contact either during or after placement of an intended plug on the pins in the intended manner.

10.1.1.11 With reference to 10.1.1.10 a pin guard shall be provided such that:

a) A flat straight edge placed in any position, across and in contact with edges of the plug opening without the plug in place, will not contact any current-carrying pin and

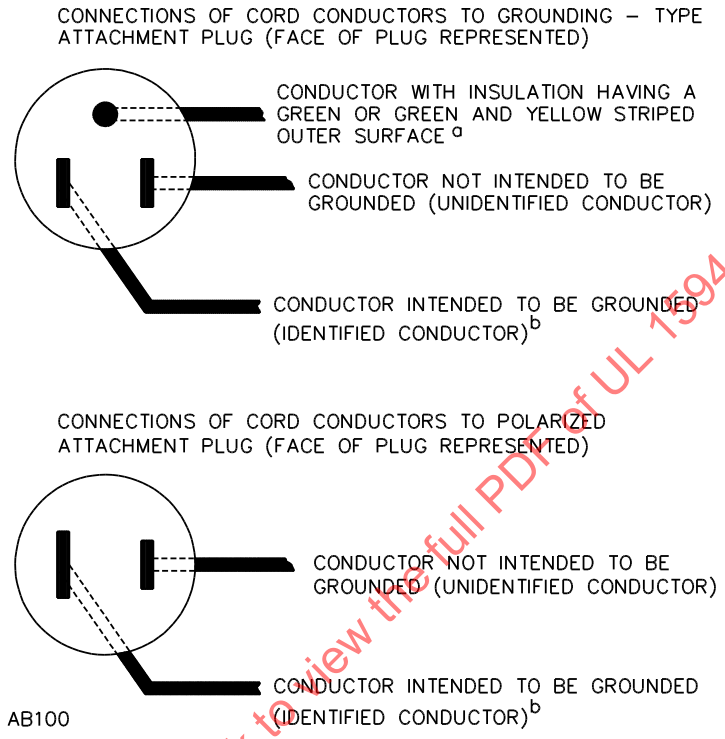
b) The probe illustrated in Figure 9.1 will not contact any current carrying pin when the probe is inserted through any opening created by aligning the plug with its face in the plane perpendicular to the axis of, and tangent to the end of the farthest projecting current-carrying pin.

10.1.1.12 A product intended for connection to a nominal 120 V circuit, and provided with a manually operated, line-connected, single-pole switch for appliance on-off operation, an Edison base lampholder, or a 15- or 20-ampere receptacle shall have a polarized attachment plug (2-blade polarized or 3 wire-

grounding). The connections to the attachment plug shall be in accordance with Figure 10.1 and Table 10.2.

Figure 10.1

Connections to attachment plugs



[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 10.2.

Table 10.2
Polarity identification of flexible cords

Method of identification	Acceptable combinations	
	Conductor intended to be grounded[a,b]	All other conductors[a]
Color of braids on individual conductors	Solid white or gray – without tracer	Solid color other than white or gray – without tracer
	Color other than white or gray, with tracer in braid	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	Solid white or gray[c]	Solid color other than white or gray
	Solid light blue[d]	Solid color other than light blue, white, or gray.
Color of separators	White or gray[e]	Color other than white or gray
Other means	Tin or other white metallic coating on all strands of the conductor[e]	No tin or other white metallic coating on the strands of the conductor
	A stripe, ridge, or groove on the exterior surface of the cord[e]	

Table 10.2 Continued on Next Page

Table 10.2 Continued

Method of identification	Acceptable combinations	
	Conductor intended to be grounded[a,b]	All other conductors[a]

[a] A conductor finished to show a green color with or without one or more yellow stripes or tracers is to be used only as an equipment grounding conductor. See 10.1.1.12 and Figure 10.1.

[b] The grounded (identified) conductor is the neutral supply conductor.

[c] Only for cords – other than Type SP-2 or SPT-2 – having no braid on any individual conductor.

[d] For jacketed cord.

[e] Only for Type SP-2 and SPT-2 cords.

10.1.1.13 A product rated 120 V shall have the circuit conductors in the flexible cord connected to the plug and to the wiring in the product so that any of the following devices used in the primary circuit are connected in an ungrounded side of the line: the center contact of an Edison-base lampholder, a single-pole switch, a fuseholder, any other single-pole overcurrent protective device, and an automatic control with a marked off position.

10.1.1.14 A product not intended to be moved during use may be provided with not more than 8 feet (2.44 m) of Type S, SO, ST, or STO cord and an attachment plug for supply connection. The investigation of such a feature will include consideration of the utility of the product and the necessity of having it readily detachable from its source of supply by means of a plug.

10.1.2 Strain relief

10.1.2.1 Strain relief shall be provided so that mechanical stress, including a rotational stress, on any external cord will not be transmitted to terminals, splices, or interior wiring. The strain relief shall comply with the requirements of the Strain Relief Test, Section 42.

10.1.2.2 A metal strain-relief clamp or band used with Type SP-2 or lighter general-use rubber-insulated cord shall be provided with auxiliary insulation over the cord for mechanical protection.

10.1.2.3 A clamp of any material is not acceptable for use on Type SVT, SVE, SVTO, SPE-2, or SPT-2 cord.

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

Exception No. 2: A clamp that has been investigated and found to be acceptable is not required to comply with this requirement. See 42.3.

10.1.2.4 For types of thermoplastic-insulated cord, heavier than Type SPT-2, SPE-2, SVE, SVT or SVTO, a clamp may be employed without auxiliary insulation if it is determined that the design of the clamp will not damage the cord insulation.

10.1.2.5 Means shall be provided to prevent a flexible cord from being pushed into a product through a cord-entry hole when such displacement:

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

b) Reduces a spacing, such as to a metal strain-relief clamp, below the minimum values specified in 22.1.

See the Push-Back Relief Test, Section 43.

10.1.2.6 If a knot in a flexible cord serves as strain relief, the surface that the knot may contact shall be free from sharp edges, burrs, fins, and other projections likely to damage the cord.

10.1.3 Bushings

10.1.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be substantial, reliably secured in place, and shall have a smooth, well-rounded surface that the cord may bear against.

10.1.3.2 The insulating bushing shall be provided if;

a) Type SP-2, SPE-2, SPT-2, or other cord lighter than Type SV is used,

b) The wall or barrier is of metal, or

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

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

10.1.3.3 A cord hole in wood, porcelain, phenolic composition, or other nonconducting material having a smooth, rounded surface is considered to be equivalent to a bushing.

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

10.1.3.5 A vulcanized fiber bushing shall not be less than 3/64 inch (1.2 mm) thick and so formed and secured in place that it will not be adversely affected by conditions of ordinary moisture.

10.1.3.6 A separate soft-rubber, neoprene, or polyvinyl chloride bushing shall not be employed in the product.

Exception No. 1: 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 3/64 inch (1.2 mm) thick and

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

Exception No. 2: 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 one of these materials is used anywhere in the product, the edges of the hole in which the bushing is mounted are to be smooth and free from burrs, fins, and similar hazards.

10.1.3.7 At any point in a product, a bushing integrally molded of the same material as the supply cord is acceptable on a Type SP-2, SPE-2, SPT-2 or heavier cord if the built-up section is not less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

10.2 Permanently-connected products

10.2.1 General

10.2.1.1 Except as noted in 10.1.1.14 a product intended for permanent connection to a power supply shall have provision for connection of one of the wiring systems that would be acceptable for the product.

10.2.2 Terminal compartment

10.2.2.1 A terminal box or compartment shall be provided on all products intended to be permanently connected and located so that the connections may be readily inspected after the product is installed without moving the product. Electrical components shall not be mounted on the door or cover of the terminal box or compartment.

10.2.2.2 A wiring space or compartment intended to enclose wires shall be free of any sharp edge, burr, fin, moving part, or similar hazards, that may abrade the insulation on conductors or otherwise damage the wires.

10.2.2.3 A terminal compartment intended for connection of a supply raceway shall be attached to the product so as to be keep it from turning.

10.2.2.4 If it is intended that supply connections be made directly to a motor, the terminal compartment on the motor shall comply with the requirements for terminal compartments in the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

10.2.3 Wiring terminals and leads

10.2.3.1 A product intended to be permanently connected shall be provided with wiring terminals for the connection of conductors having an ampacity acceptable for the product.

10.2.3.2 A field-wiring terminal is a terminal to which a wire is intended to be connected in the field, unless the wire and a means of making the connection such as a pressure wire connector, soldering lug, soldered loop, or crimped eyelet factory-assembled to the wire, are provided as a part of the product.

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

Exception No. 1: A soldering lug may be used.

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

Exception No. 3: A No. 8 screw or stud-and-nut combination may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

10.2.3.4 A wiring terminal shall be kept from turning.

10.2.3.5 The free length of a lead inside an outlet box or wiring compartment shall be 6 inches (152.4 mm) or more if the lead is intended for field connection to an external circuit. The leads provided for connection to the branch-circuit supply shall have an ampacity rating not less than that of a conductor of the next smaller size than that acceptable for the rating of the product.

Exception: The lead may be less than 6 inches long if the use of a longer lead might result in a risk of fire or electric shock.

10.2.3.6 A wire-binding screw shall thread into metal.

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

Exception: A plate not less than 0.030 inch (0.76 mm) thick, is acceptable if the tapped threads have adequate mechanical strength.

10.2.3.8 A terminal plate formed from stock having the thickness specified in 10.2.3.7 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

10.2.3.9 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size specified in 10.2.3.1 under the head of the screw or washer.

10.2.4 Identified terminals and leads

10.2.4.1 A product intended to be permanently connected rated 125 or 125/250 V (3-wire) or less and employing a lampholder of the Edison-screw-shell type, or a single-pole switch or overcurrent-protective device other than an automatic control without a marked off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit.

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

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

10.2.4.4 Wiring compartments or the equivalent for field-wiring terminals of low-voltage circuits shall be separate from wiring compartments for other terminals.

11 Current-Carrying Parts

11.1 A current-carrying part shall be of silver, stainless steel, copper, a copper alloy, or other similar metal.

11.2 Iron or steel shall not be used as a current-carrying part.

Exception: Iron or steel provided with a corrosion-resistant coating may be used for a current-carrying part;

a) If acceptable in accordance with 2.1.1 – 2.1.4; or

b) Within a motor or associated governor.

12 Insulating Materials

12.1 Material used for mounting an uninsulated live part or as electrical insulation shall comply with the requirements for direct support materials described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

12.2 Vulcanized fiber minimum 1/32 inch (0.8 mm) thick may be used for insulating bushings, washers, separators, and barriers, but not as the direct support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

12.3 Small molded parts, such as brush caps, shall be constructed to have the necessary mechanical strength and rigidity to withstand the stresses of actual service. Brush caps shall be secured or located so that they are protected from mechanical damage that might result during intended use.

13 Internal Wiring

13.1 Mechanical protection

13.1.1 Wiring and connections between parts of a product shall be enclosed or otherwise protected.

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

13.1.2 Wires within an enclosure, a compartment, a raceway, or similar area shall be routed or otherwise protected so that damage to conductor insulation cannot result from contact with any rough, sharp, or moving part.

13.1.3 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure of a product shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces.

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

13.1.5 Internal wiring shall consist of wires of a type or types that are acceptable for the application, when considered with respect to the temperature and voltage to which the wiring is likely to be subjected and with respect to its exposure to oil, grease, or other conditions of service to which it is likely to be subjected.

13.1.6 Thermoplastic-insulated, neoprene-insulated, or rubber-insulated wire used for internal wiring of a commercial-or industrial-type sewing or cutting machine shall be standard building wire or appliance wiring material and shall comply with Table 13.1.

Exception: Wiring used in the electronic portions of these products is not required to comply with this requirement.

Table 13.1
Characteristics of internal wiring

Insulation	Nominal wall thickness of insulation, inch	(mm)	Braid jacket required	Nominal thickness of braid or jacket, inch	(mm)
Thermoplastic or neoprene	0.030[a]	(0.76)	No[a]		
Rubber	0.030[b]	(0.76)	Yes[b]	0.015	(0.38)
Cross-linked synthetic polymer or teflon	0.015	(0.38)	No		

[a] The wall thickness may not be less than 0.015 inch (0.38 mm) if the wire is provided with a braid or jacket not less than 0.015 inch thick.

[b] For heat-resistant rubber (other than a silicone type), the wall thickness is to be not less than 3/64 inch (1.2 mm) and no braid is required.

13.1.7 With reference to exposure of insulated wiring through an opening in the enclosure of a product, the protection of such wiring required by 13.1.1 is considered to exist if, when judged as though it were enameled wire, the wiring would be acceptable according to 9.1.4 – 9.1.6. Internal wiring not so protected may be accepted if it is secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

13.1.8 Wiring that may be located in proximity to combustible material or may be subjected to mechanical damage shall be in armored cable, rigid metal conduit, electrical metallic tubing, metal raceway, or be otherwise equivalently protected.

13.2 Splices and connections

13.2.1 Each splice and connection shall be mechanically secure and shall provide reliable electrical contact. For a product where excessive vibration is likely to occur, this will necessitate the use of lock washers or other equivalent means to keep wire-binding screws and nuts from becoming loosened.

13.2.2 A soldered connection shall be mechanically secured before being soldered if breaking or loosening of the connection may result in a risk of fire or electric shock.

13.2.3 A splice shall be provided with insulation equivalent to that of the wires involved.

13.2.4 Aluminum conductors, insulated or uninsulated, such as for internal connection between current-carrying parts or as motor windings, shall be terminated at the point of connection by a method acceptable for the combination of metals involved. A wire-binding screw or a pressure-wire connector used as a terminating device shall be acceptable for use with aluminum under the conditions involved – for example, temperature, heat cycling, vibration, or similar conditions.

13.2.5 If stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall be kept from contacting other uninsulated live parts and contacting 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 other reliable means.

13.2.6 *Deleted*

13.3 Secondary circuits

13.3.1 Wiring in secondary circuits is judged under the requirements for line-voltage circuits.

Exception: Wiring located in Class 2 or limited voltage/current secondary circuits as described in 21.2 or 21.3, is not required to comply with this requirement.

13.4 Printed-wiring boards

13.4.1 *Relocated to 4A.15.1*

13.4.2 *Relocated to 4A.15.2*

13.4.3 *Relocated to 4A.15.3*

13.5 Separation of circuits

13.5.1 Conductors shall be segregated or separated by barriers from:

a) Each other if used in different internal wiring circuits and

b) Uninsulated live parts connected to different circuits.

Exception: Conductors provided with insulation acceptable for the highest voltage involved are not required to comply with (a).

13.5.2 Segregation of conductors may be accomplished by barriers, routing, or equivalent means.

13.5.3 Wires and cables that are part of the circuits covered in 21.1 shall be provided with strain relief in accordance with 10.1.2.1 – 10.1.2.6, if stresses on wire or cable could cause the internal wiring of the circuits to contact parts or wiring of other circuits. Separation of circuits must also be maintained between low-voltage limited energy circuits, Class 2 circuits, and limited voltage/current circuits.

14 Capacitors

14.1 *Relocated to 4A.5.2*

14.2 *Relocated to 4A.5.4*

14.3 *Relocated to 4A.5.5*

14.4 *Relocated to 4A.5.6*

14.5 *Relocated to 4A.5.7*

14.6 *Relocated to 4A.5.8*

14.7 *Relocated to 4A.5.9*

14.8 *Relocated to 4A.5.9*

15 Grounding

15.1 General

15.1.1 A product of one or more of the following types shall have provision for grounding:

a) A non-residential use cord-connected product;

b) A product intended to be used on a circuit operating at more than 150 V to ground – see 15.1.2;

c) A product intended to be permanently connected.

Exception: A product may be provided with a system of double insulation in lieu of grounding.

15.1.2 With reference to 15.1.1(b), a 2-wire product intended to operate at any potential greater than 150 V, is to be provided with means for grounding in accordance with 15.1.5 and 15.1.6 unless the marked rating on the product is 120/240 V or the product is otherwise marked to indicate that it is to be connected to a circuit operating at 150 V or less to ground.

15.1.3 A product marked as double insulated shall not be provided with a means for grounding and shall comply with the requirements of the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

Exception: In measuring leakage current, thermal stabilization is to be obtained by continuous operation under no load conditions.

15.1.4 If a grounding means is provided, whether required or not, it shall be in accordance with 15.1.5 and if the product is cord connected shall comply with the requirements in 15.1.6. All exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during any user servicing operation and are likely to become energized shall be reliably connected to the means for grounding.

15.1.5 The following are acceptable means for grounding:

a) In a product intended to be permanently connected by a metal-enclosed wiring system, a knockout or equivalent opening in the metal enclosure of the product.

b) In a product intended to be permanently connected by a nonmetal-enclosed wiring system, such as a nonmetallic-sheathed cable, an equipment-grounding terminal or lead. See 15.1.10.

c) An equipment-grounding conductor in the cord of a cord-connected product.

15.1.6 The grounding conductor of a supply cord shall be secured to the frame or enclosure of the product by means of a screw that does not have to be removed during any servicing operation not involving the power-supply cord, or by other equivalent means. Sheet-metal screws shall not be used to connect the equipment grounding conductor and bonding jumper to the enclosures or frame. 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.

15.1.7 The grounding conductor of a cord-connected product shall be connected to the grounding member of an attachment plug.

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

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

15.1.9 If a product is intended to be grounded and is provided with means for separate connection to more than one power supply, each such connection shall be provided with a means for grounding.

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

15.1.11 A wire-binding screw or pressure-wire connector intended for the connection of an equipment-grounding conductor shall be located so that it is unlikely to be removed during servicing of the product.

15.2 Grounding identification

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

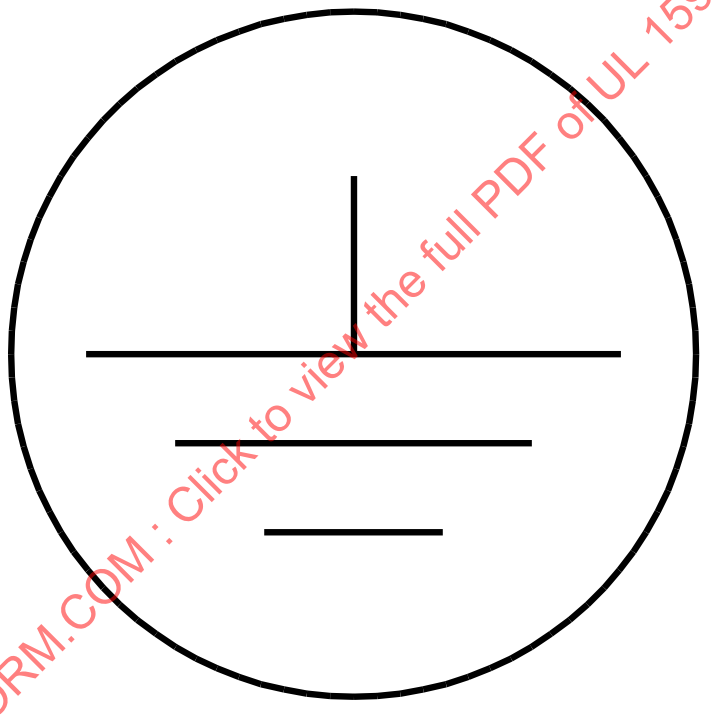
15.2.2 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal or slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked "G," "GR," "Ground," "Grounding," or similar markings, or by a marking on a wiring diagram provided on the product.

15.2.3 The surface of the insulation of a grounding conductor of a flexible cord shall be green with or without one or more yellow stripes.

15.2.4 The grounding symbol illustrated in Figure 15.1 may be provided on or adjacent to the grounding terminal or on a wiring diagram provided on the product. The symbol may be used in addition to or in place of the grounding identification required by 15.2.2.

Figure 15.1

Grounding Symbol



16 Lampholders

16.1 A lampholder for a sewing machine light – such as a 6 V lamp – shall not be tapped across a part of a motor winding if the motor is rated more than 150 V.

Exception: The motor rating may be more than 150 V but not more than 250 V if the product has a marked rating of 125/250 V, or is marked "Do not connect to a circuit operating at more than 150 V to ground" or equivalent.

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

17 Motors

17.1 Construction

17.1.1 A motor shall be capable of handling the maximum normal load of the product as described in 39.2.1.1 – 39.2.6.1 without creating a risk of fire, electric shock, or injury to persons.

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

17.2 Brush wearout

17.2.1 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its intended function – the brush, spring, and other parts of the assembly will be retained to the degree necessary not to cause:

a) Accessible dead metal parts to become energized and

b) Live parts to become accessible.

17.3 Overload protection

17.3.1 *Relocated to 4A.13.4.1*

17.3.2 *Relocated to 4A.13.4.2*

17.3.3 *Relocated to 4A.13.4.3*

17.3.4 *Relocated to 4A.13.4.4*

17.3.5 *Relocated to 4A.13.4.5*

17.3.6 *Relocated to 4A.13.4.6*

17.3.7 *Relocated to 4A.13.4.7*

17.3.8 *Relocated to 4A.13.4.8*

17.3.9 *Relocated to 4A.13.4.9*

Table 17.1
Maximum rating or setting of overload-protective device

Relocated to Table 4A.1

17.3.10 *Relocated to 4A.13.4.10*

18 Overload- or Thermal-Protective Devices

18.1 *Deleted*

18.2 A protective device shall be inaccessible from outside the product.

Exception No. 1: The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts may project outside the product enclosure.

Exception No. 2: The product, with the protective device shunted out of the circuit, complies with all applicable requirements in this standard.

18.3 If a circuit breaker handle is operated vertically rather than rotationally or horizontally, the up position shall be the on position. See also 58.1.12.

Exception: A switching device having more than one on position such as a transfer switch or a double throw switch is not required to comply with this requirement.

18.4 A fuseholder shall be constructed and installed so that uninsulated live parts will not be exposed to contact by persons removing or replacing a fuse.

Exception: The requirement does not apply if the product is marked in accordance with 58.1.9.

18.5 The screw shell of a plug-type fuseholder and the side terminal of an extractor-type fuseholder shall be connected to the load side of the circuit.

19 Receptacles

19.1 A 15 or 20 A general-use attachment-plug receptacle in a product provided with a means for grounding shall be of the grounding type.

19.2 The grounding contact of the receptacle shall be electrically connected to dead metal that is intended to be grounded.

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

19.4 A receptacle provided for the connection of a sewing machine light shall not be tapped across a motor winding and shall be:

a) A general-purpose receptacle having an ANSI configuration with a voltage rating equal to the nominal voltage supplied to the receptacle or

b) A receptacle having a special-purpose configuration with an adjacent marking specifying the voltage supplied to the receptacle.

19.5 The face of a receptacle shall:

a) Be flush with or project above a nonconductive surrounding surface or

b) Project at least 0.015 inch (0.38 mm) above a conductive surrounding surface.

20 Switches and Controls

20.1 *Revised and relocated to 4A.18.3 and 29.14*

20.2 *Relocated to 4A.18.4*

20.3 *Relocated to 4A.18.5*

20.4 *Relocated to 4A.18.6*

20.5 *Relocated to 4A.18.7*

20.6

21 Secondary Circuits

21.1 Secondary circuits supplied by an isolating transformer, or a power supply that includes an isolating transformer, may be classified as one of the following:

a) Class 2 circuit as described in 21.2.

b) Limited voltage/current circuit as described in 21.3.

c) Low voltage limited energy circuit as described in 21.4.

21.2 A Class 2 circuit shall be supplied by a:

a) Class 2 transformer complying with the requirements in 4A.19.3, or

b) Class 2 power supply complying with the requirements in 4A.15.1.

21.3 A limited voltage/current circuit shall meet the following:

a) The open circuit potential does not exceed 42.4 V peak (30 Vrms),

b) The current is limited by a fuse in the low voltage circuit rated at not more than the values specified in Table 21.1, and

c) The transformer/fuse combination complies with the requirements of 44.4.1 – 44.4.5.

d) See also 18.2.

Table 21.1
Fuse rating

Open-circuit potential,		Current rating,
volts peak	(RMS)	amperes
0 – 21.2	0 – 15	5
21.3 – 42.4	15.1 – 30	3.2

21.4 A low voltage limited energy circuit shall meet the following:

a) The open circuit potential does not exceed 42.4 V peak (30 Vrms), and

b) The maximum power available does not exceed 200 VA.

21.5 *Deleted*

21.6 The voltage limit specified in 21.3(a) and 21.4(a) and power limit specified in 21.4(b) are measured as follows:

a) The product is connected to a supply as indicated in 34.1 and all loads are disconnected for the circuit under test.

b) Only one secondary circuit of a multiple secondary transformer is tested at a time and all other secondaries not under test are loaded as intended. The voltage and volt-ampere capacity measurements are made directly across the secondary output terminals of the transformer. When a tapped transformer winding is used to supply a full-wave rectifier, the measurements are made form either end of the winding to the tap. When the transformer is used as part of a switching-type power supply, the voltage and volt-ampere capacity measurements are made after the transformer secondary winding rectification means.

c) For the power measurement, a variable resistive load is connected across the source of the secondary. The voltage and current are measured while varying the resistive load from open circuit to short circuit in 1-1/2 to 2-1/2 minutes. The maximum available volt-ampere capacity is then calculated by multiplying the simultaneously measured values of secondary voltage and secondary current.

22 Spacings

22.1 Other than at wiring terminals, the spacing 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 that may be grounded shall not be less than the value specified in Table 22.1.

Exception No. 1: The inherent spacings of a component – such as a snap switch – are to be evaluated by the requirements for that component.

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

Exception No. 3: This requirement does not apply if a spacing complies with the requirements in 22.6.

Table 22.1
Spacings at other than field-wiring terminals and motors

Potential involved, volts	Diameter and Hp of motor used in appliance											
	7 inches (178 mm)[a] or less, 1/3 Hp or less				7 inches (178 mm)[a] or less, greater than 1/3 Hp				More than 7 inches (178 mm)[a], any Hp			
	Over surface,		Through air,		Over surface,		Through air,		Over surface,		Through air,	
	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
0 – 50[b]	3/64	1.2	3/64	1.2	3/64	1.2	3/64	1.2	3/64	1.2	3/64	1.2
51 – 125	1/16	1.6	1/16	1.6	3/32	2.4	3/32	2.4	1/4	6.4[c]	1/8	3.2[c]
126 – 250	3/32	2.4	3/32	2.4	3/32	2.4	3/32	2.4	1/4	6.4[c]	1/4	6.4[c]
251 – 600	3/8	9.5[c]	3/8	9.5[c]	1/2	12.7[c]	3/8	9.5[c]	1/2	12.7[c]	3/8	9.5[c]

[a] See 17.1.2

[b] Does not apply to circuits as described in 21.1

[c] Film-coated wire is considered to be an uninsulated live part. However, a spacing of not less than 3/32 inch (2.4 mm) 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.

22.2 If an uninsulated live part is not 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 required minimum spacing will be maintained.

22.3 In a product incorporating two or more motors of different sizes, the spacings in the product are to be investigated on the basis of the size of the largest motor in the product.

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

22.5 Any uninsulated conductor of the rotor circuit is regarded as a dead metal part with respect to the stator circuit, and the appropriate spacing is required between uninsulated stator and rotor conductors.

22.6 If an isolated dead metal part is interposed between or is in close proximity to live parts of opposite polarity, a live part and an exposed dead metal part, or a live part and a dead metal part that may be grounded, the spacing may not be 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 value specified in Table 22.1.

22.7 An insulating liner or barrier of vulcanized fiber or similar materials employed where spacing would otherwise be insufficient shall not be less than 1/32 inch (0.8 mm) thick, and shall be so located or of such material that it will not be adversely affected by arcing.

Exception No. 1: Vulcanized fiber not less than 1/64 inch (0.4 mm) thick may be used in addition to an air space of not less than 50 percent of the spacing required for air alone.

Exception No. 2: Thinner insulating material may be used, if upon investigation, it is found to be acceptable for the application.

22.8 All uninsulated live parts connected to different circuits – such as line or low voltage types – shall be spaced from one another in accordance with the requirements for parts of opposite polarity as specified in 22.1 and 22.9, and shall be investigated on the basis of the highest voltage.

22.9 The spacing between wiring terminals of opposite-polarity, and the spacing between a wiring terminal and any other uninsulated metal part not of the same polarity, shall not be less than that specified in Table 22.2. See 10.2.3.2.

Table 22.2
Spacings at field-wiring terminals

Potential involved	Minimum spacings					
	Between wiring terminals through air or over surface,		Between terminals and other uninsulated metal parts not of the same polarity[a]			
			Over surface,		Through air,	
volts	inch	(mm)	inch	(mm)	inch	(mm)
0 – 50[c]	1/8	3.2	1/8	3.2	1/8	3.2
51 – 250	1/4	6.4	1/4	6.4	1/4	6.4
More than 250	1/2	12.7[b]	1/2	12.7[b]	3/8	9.5

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

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

[c] Does not apply to circuits as described in 21.1.

22.10 If a compartment intended for the field installation of conductors contains provision for connection of Class 2 or Class 3 circuit conductors, and Class 1, power, or lighting circuit conductors, the Class 2 or

Class 3 conductors shall be separated from Class 1, power, or lighting circuit conductors by a barrier or a minimum through air or over surface spacing of 1/4 inch (6.4 mm).

22.11 Reduced spacings are acceptable between traces of a printed-wiring board in circuits that:

a) Are located on a portion of the printed-wiring board provided with a conformal coating which complies with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or

b) Are connected to the load side of a resistor such that a short circuit at that point does not result in the wattage rating of the resistor being exceeded.

22.12 The spacings of circuits as described in 22.11(a) are to be judged on the basis of the Dielectric Voltage-Withstand Test described in 40.3.1 and 40.4.1.

22.13 For a capacitor using 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 between a terminal of the capacitor, including an assembled wire connector, and:

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

b) An uninsulated live part of opposite polarity or an uninsulated noncurrent-carrying metal part that is either accessible or grounded shall not be less than the sum of the appropriate value from Table 22.1 and 1/2 inch.

23 Alternate Spacings – Clearances and Creepage Distances

23.1 As an alternative to the specified spacing requirements in Spacings, Section 22, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, may be used. These alternative spacing requirements shall not be used for spacings between field wiring terminals, between uninsulated live parts and a metal enclosure, or spacings in a motor (See 22.4). In determining the pollution degree and overvoltage category, the end-use application is to be considered and may modify those characteristics given in 23.2 – 23.5.

23.2 When applying specific requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, it is anticipated that the degrees of pollution expected or controlled will be as indicated in Table 23.1. Household sewing and cutting machines are generally considered Pollution Degree 2. Commercials sewing and cutting machines are generally considered Pollution Degree 3.

Table 23.1
Degrees of Pollution

Equipment	Pollution degree
Hermetically sealed or encapsulated equipment or printed wiring boards with protective coating.[a]	1
Equipment for ordinary locations and indoor use, such as residential controls, commercial controls for use in a clean environment, nonsafety controls for installation on or in machines.	2
All safety or limit controls, equipment of outdoor use, and equipment influenced by surrounding environment, such as industrial controls, refrigeration controls, and water heater controls.	3
[a] Tested in accordance with the protective coating test in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.	

23.3 When applying specific requirements in UL 840, it is anticipated that the equipment will be identified by overvoltage categories as indicated in Table 23.2.

Table 23.2
Overvoltage categories

Equipment	Overvoltage category
Intended for fixed wiring connection	III
Portable and stationary cord-connected	II
Power-limited and safety[a] low voltage	I
[a] Applicable to low-voltage circuits if a short circuit between the parts involved may result in operation of the controlled equipment that owuld increase the likelihood of a risk of fire or electric shock.	

23.4 In order to evaluate clearances where the levels of overvoltage are controlled, control of overvoltage shall be achieved by providing an overvoltage device or system as an integral part of the product. The equipment shall be evaluated for the rated impulse withstand voltage specified in UL 840.

23.5 Printed wiring boards constructed of Types XXXP, XXXPC, G-10, FR-2, FR-3, FR-4, FR-5, CEM-1, CEM-3, GPO-2, or GPO-3 industrial laminates in accordance with the Standard for Polymeric Material – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, are considered to have a minimum comparative tracking index of 100 without further investigation.

PROTECTION AGAINST INJURY TO PERSONS

24 General

24.1 If the operation and maintenance of a product by the user involves the risk of injury to persons, protection shall be provided to minimize the risk.

24.2 When evaluating a product with respect to the requirement in 24.1, consideration shall be given to reasonably foreseeable misuse of the product.

24.3 A functional attachment that is made available or recommended by the manufacturer for use with the basic product shall be included in the evaluation of the product. Unless the manufacturer recommends the use of two or more attachments at the same time, only one attachment at a time is to be evaluated with the product.

Exception: Attachments such as buttonhole attachments, seam guides, presser feet or similar attachments, for use with sewing machines are not included.

24.4 The acceptability of a guard, a safety release, an interlock, and the like, and whether such a device is required are to be determined from an investigation of the complete product, its operating characteristics, and the likelihood of a risk of injury to persons. The investigation is to include consideration of the results of the introduction of a breakdown or malfunction of any one component; but not more than one component at a time. If the investigation shows that breakdown or malfunction of a particular component can result in a risk of injury to persons, that component is to be investigated for reliability.

24.5 A single malfunction (short or open) of a circuit component shall not result in unexpected operation or loss of off control of the product if such operation could result in an increased risk of injury to persons. Compliance is determined by subjecting the appliance to the abnormal operation test described in 44.2.1.

Exception: A sewing machine in which the front toe of the presser foot is bent upward a minimum 15/64 inch (6 mm), or which has equivalent guarding such as a wire guard, is considered as having suitable means to reduce the risk of injury when feeding material in the event of loss of off control.

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

24A Lasers

24A.1 A product employing a laser falling within the scope of the Code of Federal Regulations (CFR), Title 21, Part 1040 shall be compliant with the regulation.

24A.2 With reference to 24A.1, compliance of laser products with the Code of Federal Regulations (CFR), Title 21, Part 1040, shall be determined by:

a) Determining the Class of the laser product and the Class of the radiation emitted by the laser product (as defined in the CFR) from the manufacturer's Center for Devices and Radiological Health (CDRH) product report;

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

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

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

e) Verifying that the manufacturer's safety instructions required by the CFR are provided with the laser product (as defined in the CFR).

24B Button Batteries

24B.1 To reduce the risk of injury due to battery ingestion, the battery compartment of an appliance or any accessory, such as a wireless control, incorporating one or more coin cell batteries of lithium technologies shall comply with the Standard for Products Incorporating Button or Coin Cell Batteries of Lithium Technologies, UL 4200A, if the appliance or any accessory:

a) Is intended for use with one or more single cell batteries having a diameter of 32 mm (1.25 in) or less where the cell diameter is greater than its height; and

b) The appliance is intended for household use.

25 Sharp Edges

25.1 An enclosure, a frame, a guard, a handle, or similar part shall not be so sharp as to constitute a risk of injury to persons during intended maintenance and use.

Exception: A part or portion of a part needed to perform a working function is not required to comply with this requirement.

26 Enclosures and Guards

26.1 The rotor of a motor, a pulley, a belt, a gear, a fan, or other moving part that could result in a risk of injury to persons shall be enclosed or provided with other means to reduce the likelihood of unintentional contact, and such a part shall not be able to be contacted by the probe illustrated in Figure 9.1.

Exception No. 1: An opening in the integral enclosure of a motor used in an appliance intended for commercial use, that is not used in either a hand-held appliance or a hand-supported portion of an appliance, is acceptable if a moving part cannot be contacted by the probe illustrated in Figure 9.3.

Exception No. 2: A moving part or portion of a moving part that is necessarily exposed to perform the work function is not required to be enclosed but, when necessary, guarding shall be provided. See 26.4 for features of guards that should be considered.

Exception No. 3: Moving parts on the underside of a bed type machine are not required to be enclosed provided the appliance is marked in accordance with 58.1.8 and has information in the operating instructions in accordance with 60.6.

26.2 During the examination of an appliance to determine whether it complies with the requirements in 26.1, a part of the enclosure that may be removed without the use of a tool (to attach an accessory, to make an operating adjustment, or for other such reasons), is to be opened or removed.

Exception: A part is not required to be opened or removed provided the appliance is marked in accordance with 58.1.7.

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

26.4 Some guards are required to be of the self-restoring type. Other features of guards that are to be considered include:

a) Removability without the use of a tool;

b) Removability for servicing;

c) Strength and rigidity;

d) Completeness;

e) Creation of additional risk of injury to persons such as pinch points, and the necessity for additional handling because of the increased need for servicing, such as for cleaning, unjamming, and similar services; and

f) Usage – household or commercial.

26.5 An enclosure or guard over a rotating part shall retain a part that, because of breakage or other reasons, may become loose or may separate from a rotating part, and retain a foreign object that may be struck and propelled by the rotating part.

26.6 If complete guarding of a moving part that could obviously cause injury to persons would defeat the utility of a product, such as the cutting blades of scissors,

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

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

27 Materials

27.1 The material of a part – such as an enclosure, a frame, a guard, or a similar part, the breakage or deterioration of which might result in a risk of injury to persons – shall have such properties as to meet the demand of expected loading conditions.

27.2 The requirement in 27.1 applies to those portions of a part adjacent to a moving part considered to involve a risk of injury to persons.

28 Rotating or Moving Parts

28.1 A rotating or moving part, that could create a risk of injury to persons if it became disengaged, shall be provided with a means to retain the part in place under conditions of use.

28.2 A rotating part whose breakage might create a risk of injury to persons shall be constructed so as to reduce the likelihood of breakage, or the release or loosening of a part that could become a risk of injury to persons.

28.3 To determine whether a product employing a series motor complies with the requirement in 28.2, it is to be tested as described in 47.1.

29 Switches, Controls, and Interlocks

29.1 A product shall be constructed so as to reduce the risk of unintentional operation of any parts capable of causing injury to persons.

29.2 Each function of a multiple-function product is to be taken into consideration in determining whether the product complies with the requirements in 29.1.

29.3 A sewing machine or a product having a moving part on the product that may cause a risk of injury to persons when energized shall have a motor control switch that has a marked "off" position. A foot controller is not considered to be the on/off motor control switch. See 58.1.12 and 63.3.

Exception: A momentary contact switch is not required to be marked.

29.4 A sewing machine shall not have a through-cord switch.

29.5 If unintentional operation of a switch can result in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such operation is unlikely. If a switch is operated vertically rather than rotationally or horizontally, the up position shall be the ON position. See also 58.1.12.

29.6 The actuator of a switch may be guarded by recessing, ribs, barriers, or similar construction.

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

29.8 The requirement in 29.7 will necessitate the use of an interlock if moving parts or the like could result in a risk of injury to persons upon the automatic starting or restarting of the motor.

29.9 The actuator of an interlock switch shall be located so that unintentional operation is unlikely. See 29.6.

29.10 Operation of an interlock during intended use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock.

29.11 An interlock shall not be capable of being defeated by materials such as chips, dust, lint or particles that could accumulate during intended use.

29.12 An interlock shall be such that it cannot be defeated readily

a) Without damaging the product or

b) Without making wiring connections or alterations.

29.13 If an interlock is actuated by movement of a guard, the arrangement shall be such that the guard is in place when the interlock is in the position that permits operation of the parts being guarded. With the guard removed, the interlock shall comply with the requirements in 29.9.

29.14 Revised and relocated to 4A.18.3

30 Stability

30.1 A portable product shall not overturn when tested as described in the Stability Test, Section 48.

Exception: A product that is completely hand supported during intended use is not required to be tested.

30.2 A product – not intended to move when performing its intended function – that moves from its de-energized position when operated shall be provided with an anchoring means.

31 Strength of Mounting

31.1 The sewing machine mounting surface of a sewing table shall withstand the loading test described in 49.1 without damage.

31.2 The mounting means provided on a product intended to be mounted on a structure, such as under a table, shall withstand the loading test described in 49.2 without evidence of damage to the brackets, the mounting surface, or that portion of the enclosure or part to which the bracket is attached.

32 Strength of Handles

32.1 A handle used to support or carry a product shall withstand the loading test described in 50.1 without damage to the handle, its securing means, or that portion of the enclosure to which the handle is attached.

33 Markings

33.1 *Relocated to 58.1.2*

33.2 *Relocated to 58.1A.1*

33.3 *Relocated to 58.1A.2*

33.4 *Relocated to 58.1A.3*

33.5 *Relocated to 59.10*

33.6 If an attachment is packaged and marketed separately from the basic product and recommended for use with it by the manufacturer of the basic product, it shall have an assigned catalog number (or equivalent). Also, information packaged with the basic product shall identify by catalog number the attachments which are intended for use with the basic product, or the catalog number of the basic product with which the attachment is intended to be used shall appear in at least one of the following locations:

a) On the attachment,

b) On the package housing the attachment, or

c) On information furnished with the attachment.

PERFORMANCE

34 General

34.1 All tests are to be conducted with the product connected to a supply circuit of rated frequency. The voltage of the supply circuit is to be:

a) 120 V if the product is rated from 105 V up to and including 120 V,

b) 240 V if the product is rated from 210 V up to and including 240 V, or

c) The maximum rated voltage if the product is rated other than as mentioned in (a) and (b),

d) A product rated 50 – 60 Hz is to be tested at 60 Hz.

35 Leakage Current Test

35.1 The leakage current of a single-phase cord-connected product rated 250 V or less, when tested in accordance with 35.3 – 35.11, shall not be more than:

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

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

c) 0.75 mA for any other grounded (3-wire) product.

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

35.3 The leakage currents from exposed conductive surfaces are to be measured to the grounded supply conductor, both individually and collectively, and if simultaneously accessible from one surface to another.

Exception: These measurements do not apply to terminals operating at less than 42.4 V peak (30 V rms).

35.4 A part is considered to be an exposed surface unless guarded by an enclosure that complies with the requirements in 9.1.1 – 9.1.5.

35.5 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.

35.6 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 metal foil having an area of 3.94 by 7.87 inches (10 by 20 cm) in contact with the surface. If the surface is less than 3.94 by 7.87 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.

35.7 The measurement circuit for leakage current is to be as illustrated in Figure 35.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

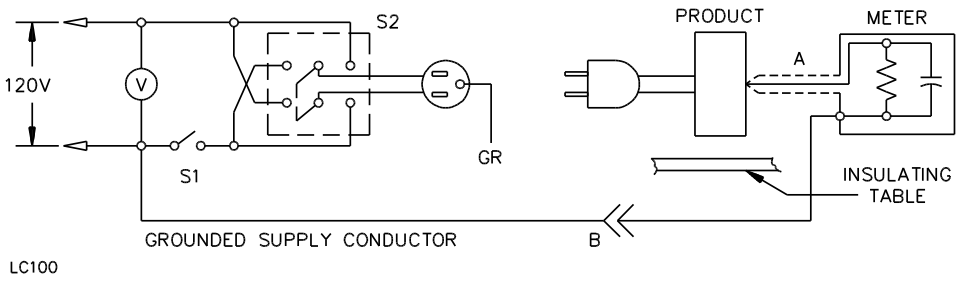
a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 µF.

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

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

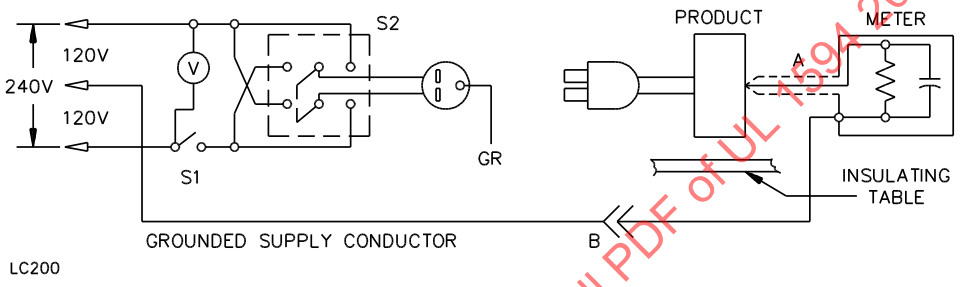
Figure 35.1

Leakage current measurement circuit



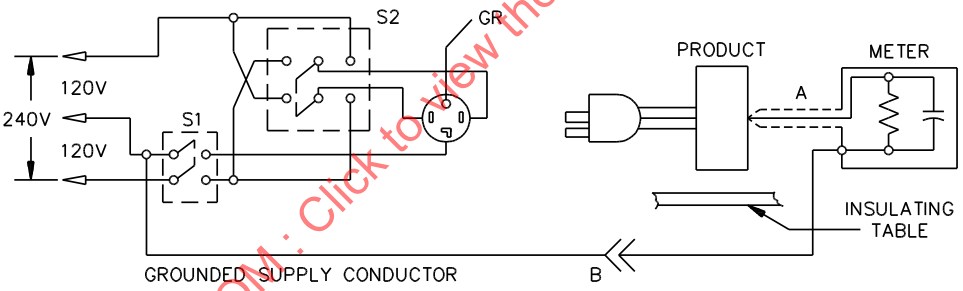
LC100

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



LC200

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



LC300

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

a) Probe with a shielded lead.

b) Separated and used as a clip when measuring currents from one part of a product to another.

35.8 The meter is to be connected to the accessible part and the grounded supply conductor unless the meter is being used to measure leakage between two parts of a product.

35.9 A sample product is to be prepared for leakage current measurement as follows:

a) The sample is to be representative of the wiring methods, routing, components, component location and installation, and similar specifications, of a production unit.

b) The grounding conductor is to be open at the attachment plug and the sample is to be isolated from ground.

c) The sample is to be tested in the as-received condition.

d) The test is to be conducted at room ambient temperature and humidity.

e) The supply voltage is to be adjusted to rated voltage.

35.10 The test sample is to be arranged so that all parallel ground paths will be eliminated.

35.11 The leakage current test sequence, with reference to the measuring circuit, Figure 35.1, 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 to be obtained by operation as in the temperature test.

36 Leakage Current Following Humidity Conditioning

36.1 A product, as described in 35.1, shall comply with the requirements for leakage current in 35.1 following exposure for 48 hours to air having a relative humidity of 88 ±2 percent at the temperature of 32 ±2°C (90 ±4°F).

36.2 To determine whether a product complies with the requirement in 36.1, a sample of the product is to be heated to a temperature just above 34°C (93°F) to reduce the likelihood of condensation of moisture during conditioning. The heated sample is to be placed in the humidity chamber and conditioned for 48 hours under the conditions specified in 36.1. Following the conditioning and while still in the chamber, the sample is to be tested unenergized as described in 35.11(a). Either while the sample is still in the humidity chamber or immediately after it has been removed from the chamber, the sample is to be energized and tested as described in 35.11 (b) or (c). The test is to be discontinued when the leakage current stabilizes or decreases.

37 Starting Current Test

37.1 A product shall start and continue to operate on a test circuit protected by a nontime-delay fuse that has a current rating corresponding to that of the branch circuit to which the product is intended to be connected. The performance is unacceptable if the fuse opens the circuit.

Exception No. 1: A time delay fuse may be used if all of the following conditions are met:

a) The construction of the product or its intended use is such that it is likely to be used only on the same branch circuit after installation,

b) The product will start and continue to operate on a circuit protected by a time-delay fuse, and

c) The product is marked in accordance with 58.1.10.

Exception No. 2: The requirement for a nontime delay fuse does not apply to a household product that is intended to be used on a 15 or 20 A branch circuit, provided that the product starts and continues to operate on a circuit protected by a time delay fuse having an ampere rating corresponding to that of the branch circuit on which the product is intended to be used.

37.2 In a test to determine whether a product complies with the requirement in 37.1, 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 normal operation – the beginning of the normal operating cycle, in the case of an automatic product – and the motor is to be allowed to come to rest between successive starts.

38 Input Test

38.1 The current or wattage input to a product shall not be more than 110 percent of the rated value when the product is operated under the condition of maximum normal load as described in 39.2.1.1 – 39.2.6.1 as applicable, and when connected to a supply circuit as described in General, Section 34.

39 Normal Temperature Test

39.1 General

39.1.1 A product, shall be tested as described in 39.2.1.1 – 39.2.6.1, and shall not reach a temperature at any point high enough to cause a risk of fire, to damage any materials in the product, or to exceed the temperature rises specified in Table 39.1.

Table 39.1
Maximum temperature rises

	Materials and component parts	°C	(°F)
1.	Capacitors:		
	Electrolytic[a]	40	72
	Other types[b]	65	117
2.	Fuses:		
	a) Class G, J, T, L and CC:	65	117
	Tube	100	180
	Ferrule or blade	85	153
	b) Others[h]	65	117
3.	Fiber employed as electrical insulation	65	117
4.	At any point within a terminal box or wiring compartment of a product intended to be permanently connected in which power-supply conductors are to be connected, including such conductors themselves, unless the product is marked in accordance with 58.2.1.	35	63

Table 39.1 Continued on Next Page

Table 39.1 Continued

Materials and component parts	°C	(°F)
5. A surface upon which a product may be mounted in service, and surfaces which may be adjacent to the product when so mounted	65	117
6. Class 105 insulation system on coil windings of an AC motor having a diameter of more than 7 inches (178 mm), of a DC motor, and of a universal motor:[c,d]		
a) In an open motor:		
Thermocouple method	65	117
Resistance method	75	135
b) In a totally enclosed motor:		
Thermocouple method	70	126
Resistance method	80	144
7. Class 105 insulation systems on coil windings of an AC motor having a diameter of 7 inches or less, not including a universal motor, and on a vibrator coil:[c,d]		
a) In an open motor and on a vibrator coil:		
Thermocouple or resistance method	75	135
b) In a totally enclosed motor:		
Thermocouple or resistance method	80	144
8. Class 130 insulation systems on coil windings of an AC motor having a frame diameter of more than 7 inches of a DC motor, and of a universal motor:[c,d]		
a) In an open motor:		
Thermocouple method	85	153
Resistance method	95	171
b) In a totally enclosed motor:		
Thermocouple method	90	162
Resistance method	100	180
9. Class 130 insulation systems on coil windings of an AC motor having a diameter of 7 inches or less, not including a universal motor:[c,d]		
a) In an open motor:		
Thermocouple method or resistance method	95	171
b) In a totally enclosed motor:		
Thermocouple method or resistance method	100	180
10. Class 105 insulation systems on windings of a relay, a solenoid, and the like:[c]		
Thermocouple method	65	117
Resistance method	85	153
11. Class 130 insulation systems on windings of relays, solenoids, and the like:		
Thermocouple method	85	153
Resistance method	105	189
12. Class 130 insulation systems of windings of vibrator coils:		
Thermocouple method or resistance method	95	171

Table 39.1 Continued on Next Page

Table 39.1 Continued

Materials and component parts		°C	(°F)
13.	Molded phenolic[e]	125	225
14.	Rubber- or thermoplastic-insulated wire and cord:[e,f,g]	35	63
15.	Sealing compound	40°C (104°F) less than the melting point	
16.	Varnished-cloth insulation	60	72
17.	Wood and other combustible materials	65	117
18.	Uninsulated copper conductors:[i]		
	a) Tinned or bare strands having:		
	1. A diameter less than 0.015 inch (0.38 mm) or a noncircular cross-sectional area having a perimeter less than the circumference of a 0.015 inch diameter circle.	125	225
	2. A diameter of 0.015 inch or more or a noncircular cross-sectional area having a perimeter equal to or greater than the circumference of a 0.015 inch diameter circle.	175	315
	b) Plated with nickel, gold, silver or a combination of these metals	225	405

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

[b] 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.

[c] At a point on surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be higher by the following amount than the maximum indicated provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.

Item	Additional temperature rise,	
	°C	(°F)
Part A of item 6	15	(27)
Part A of item 7	5	(9)
Part A of item 8	20	(36)
Part A of item 9	10	(18)
10	15	(27)

[d] See 17.1.2.

[e] The limitation on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been investigated and found acceptable for use at higher temperatures.

[f] Rubber-insulated conductors within a Class 105-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 employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.

[g] 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 strength is employed on the individual conductors of the cord to protect the conductor insulation against deterioration.

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

[i] These temperature limitations are supplemental to any other temperature limitations for the conductor insulation, sleeving, coil winding, or similar part.

39.1.2 When tested in accordance with 39.2.1.1 – 39.2.6.1, the temperature of the surfaces in Table 39.2 shall not exceed the values in Table 39.2. If the test is conducted at room temperature of other than 25°C (77°F), the results are to be adjusted to an ambient temperature of 25°C (by adding the appropriate variation between 25°C and the ambient).

Table 39.2
Maximum surface temperatures

Location	Composition of surface[a,b]			
	Metallic,		Nonmetallic,	
	°C	(°F)	°C	(°F)
1. Handles or knobs that are grasped for lifting, carrying, or holding[c]	50	(122)	60	(140)
2. Handles or knobs that may be contacted, but do not involve lifting, carrying, or holding, and other surfaces subject to contact during normal operation or user maintenance[d]	60	(140)	85	(185)

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

[b] The maximum surface temperatures do not apply to the surface of a light bulb that is not likely to be contacted during normal operation of the unit.

[c] The maximum surface temperatures specified in item 1 shall apply to all portions of a foot controller.

[d] The maximum surface temperatures specified in item 2 shall apply to all accessible surfaces of a lamp cover.

39.1.3 A thermal- or overload-protective device shall not open the circuit during the temperature test.

39.1.4 All values of temperature rise in Table 39.1 are based upon 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).

39.1.5 Temperatures are to be measured by means of thermocouples and a suitable temperature indicating instrument. Thermocouples are to consist of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2). Whenever referee temperature measurements by thermocouples are necessary, thermocouples consisting of 30 AWG iron and constant wire and a potentiometer-type instrument are to be used. The thermocouple wire is to comply with the requirements for Special Tolerances thermocouples as listed in the Tolerances on Initial Values of EMF versus Temperature tables in the Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples, ANSI/ASTM E230/E230M.

39.1.6 Ordinarily, coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices – for example, a coil immersed in sealing compound – or unless the coil wrap includes thermal insulation or more than two layers – 1/32 inch (0.8 mm) maximum – of cotton, paper, rayon, or similar materials. For a thermocouple-measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less – items 7 and 9 in Table 39.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor.

39.1.7 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.

39.1.8 For a product that is not intended for continuous operation, the probable intermittent or short-time operation of the product is to be taken into consideration when conducting the temperature test.

39.1.9 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.

39.2 Maximum normal load

39.2.1 General

39.2.1.1 In tests on a product, maximum normal 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 normal use are described in the following paragraphs for some common products. However, products having features not contemplated in these test procedures may be tested as necessary to meet the intent of these requirements.

39.2.2 Motor-operated sewing tables

39.2.2.1 These are products that incorporate motors for adjustment of the sewing machine height, position and the like. For the temperature test a load equal to the marked rated value of load, 35 lbs (15.9 kg) minimum is to be placed on the product to approximate the load that would be imposed by the sewing machine. Four complete cycles of adjustment of the product through its complete range of motion are to be performed, with a one minute pause between cycles. During the one minute interval the motor is to be running but with the product not operating, if it can be so controlled, otherwise the motor is to be de-energized. If the speed of operation of the product can be controlled, the test is to be performed at such speed that maximum heating will result. A product that is capable of more than one mode of motion is to be tested for each such motion.

39.2.3 Sewing machine speed controllers

39.2.3.1 A speed controller intended to be marketed separately from a sewing machine is to be operated in cycles of 1 minute on and 1 minute off until constant temperatures are attained. The test is to be conducted with the controller connected to a variable resistance load. The load is to be adjusted to draw the rated current of the controller, with the controller set for maximum speed. The test is to be repeated with the control device adjusted to result in the maximum wattage dissipation and operated for 15 cycles.

39.2.4 Commercial sewing machine transmitters

39.2.4.1 Commercial sewing machine transmitters are to be operated at rated current until thermal equilibrium. If a means for connection of a low-voltage light is provided a lamp of rated wattage, or an equivalent resistive load shall be connected per the manufacturer's instructions.

39.2.5 Household sewing machines

39.2.5.1 A household sewing machine is to be operated in cycles of 1 minute on and 1 minute off until constant temperatures are attained, with the motor operating at a speed during the on period so that the wattage dissipation in the motor is maximum. The test is to be repeated, at low speed with the speed-control device adjusted to result in maximum wattage dissipation in the speed-control unit during the on interval. The low speed test is to be conducted for 15 cycles. Both tests are to be conducted without thread and fabric, and with the presser foot in the up position.

39.2.5.2 For a product employing an electronic speed controller, low speed operation is to be conducted with the controller adjusted to the lowest possible speed.

39.2.6 Commercial cloth-cutting machines and vibrator-powered scissors

39.2.6.1 Commercial cloth-cutting machines and vibrator-powered scissors are to be continuously operated at no load.

40 Dielectric Voltage-Withstand Test

40.1 General

40.1.1 While at maximum normal operating temperature, a product shall withstand for 1 minute without breakdown the application of a 60 Hz essentially sinusoidal potential:

a) Between live parts and dead metal parts.

b) Between primary circuits and low voltage circuits.

c) Between terminals of opposite polarity of an across the line capacitor. The capacitor is to be disconnected from the circuit for this test.

40.1.2 To determine whether a product complies with the requirements in 40.1.1 a product is to be tested by means of a 500 VA or larger transformer, having an output voltage that is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test value is reached and is to be held at that value for 1 minute. The increase in the applied potential is to be at a substantially uniform rate and as rapid as consistent with its value being correctly indicated by a voltmeter.

40.2 Primary circuits

40.2.1 The test potential for primary circuits shall be:

a) 1000 V for a product employing a motor rated 1/2 hp (373 W) or less and 250 V or less.

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

c) 1000 V, or 1000 V plus twice the 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. To distinguish between capacitor leakage and breakdown currents, the test instrument may use a direct-current potential at 1.414 times the required alternating-current potential.

40.3 Secondary circuits

40.3.1 The test potential for the secondary circuit of an appliance employing a transformer or autotransformer shall be:

a) 1000 V plus twice the operating voltage if the secondary operates at 251 – 600 V.

b) 1000 V if the secondary operates at 51 – 250 V.

c) 500 V if the secondary operates at 50 V or less.

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

40.4 Printed-wiring assemblies

40.4.1 Printed-wiring assemblies with reduced spacings as described in 22.11(a) shall withstand without breakdown for 1 minute, between printed-wiring traces of opposite polarity, the application of a potential as indicated in Secondary Circuits, Section 40.3.

40.4.2 With the concurrence of those concerned, components are not required to be provided on the printed-wiring board subjected to the test outlined in 40.4.1 as it is a test of adequate spacings of the printed foil pattern. Boards submitted for test shall have been subjected to the production-soldering process.

41 Switches and Controls Test

41.1 A switch or other device that controls a motor of a product, or that controls a solenoid, a relay coil, or similar part shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation as described in 41.2 – 41.4 as applicable. There shall be 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 shall not open.

Exception No. 1: A device investigated and found to be acceptable for the application is not required to comply with this requirement.

Exception No. 2: A device interlocked so that it does not break the locked-rotor motor current is not required to comply with this requirement.

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 A 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, except that a faster rate of operation may be employed if agreeable to those concerned.

41.3 When testing a switch or other control device that controls a solenoid, a relay coil or similar part, 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 during servicing.

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 as described in General, Section 34. 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 Strain Relief Test

42.1 The strain relief means provided on an attached flexible cord shall withstand for 1 minute without displacement a direct pull of 35 lbf (156 N) applied to the cord, with the connections within the product disconnected, when tested in accordance with 42.2.

42.2 A 35 lb (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 that the construction of the product permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have resulted on the connections.

42.3 For the investigation mentioned in Exception No. 2 to 10.1.2.3, six samples of the clamp that have been secured to the cord in the intended manner are to be used. Three unconditioned samples are to be subjected to the dielectric voltage-withstand test described in 40.1.1 and the strain-relief tests. The other three samples are to be conditioned for 168 hours in an air oven. The oven temperature is to be 10°C (18°F) higher than the temperature measured on of the insulation of the cord at the strain relief during the temperature test, but not less than 70°C (158°F). The samples are to comply with the dielectric voltage-

withstand test requirements in 40.1.1, the value of applied potential being based on the rating of the motor. The potential is to be applied between conductors, and if the clamp is metal, the potential is to be applied between the clamp and all conductors spliced together. After cooling to room temperature, the conditioned samples are to comply with the strain relief test in 42.1.

43 Push-Back Relief Test

43.1 To determine compliance with 10.1.2.5, a product shall be tested in accordance with 43.2 without occurrence of any of the conditions specified in 10.1.2.5 (a) and (b).

43.2 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).

44 Abnormal Operation Tests

44.1 General

44.1.1 For abnormal operation tests, the product is to be connected to a supply circuit as described in 34.1 and protected by a 30 A non-time delay fuse and placed on a white tissue paper covered softwood surface.

44.1.2 A single layer of cheesecloth is to be draped loosely over the entire product.

44.1.3 A part of the product subject to removal during user servicing can be omitted if it is not necessary for the functioning of the product, not exposed to view during normal operation, or not captivated.

44.1.4 Exposed dead metal parts are to be connected to earth ground through a 3 A 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.

44.1.5 Operation under abnormal conditions shall not result in a risk of fire or electric shock. A risk of fire or electric shock is considered to exist if the test results in any of the following:

a) The single layer of cheesecloth glows or flames.

b) The tissue paper glows or flames.

c) The 3 A fuse connected to earth ground opens.

d) Any opening is developed in the overall enclosure that is larger than those permitted by accessibility requirements as covered by 9.1.2 and 9.1.3, as applicable.

e) There is failure to comply with the dielectric voltage-withstand tests described in 40.1.1.

44.2 Electronic components

44.2.1 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 or electric shock (see 44.1.5), or increased risk of personal injury (see 24.5). 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 shall be open- or short-circuited.

Exception No. 1: 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, shock, or personal injury.

Exception No. 2: Electronic components in secondary circuits complying with Section 21, are not required to be evaluated for risk of fire or electric shock.

Exception No. 3: An electronic circuit evaluated to the standards specified in 4A.6 is considered to comply with this requirement with respect to risk of fire and electric shock, unless otherwise indicated. If the circuit has also been evaluated as a protective circuit with respect to the risk of injury in the end-product, it is also considered to comply with this requirement with respect to the risk of personal injury.

44.2.2 When the circuit is interrupted by the opening of a component or protective device, the test is to be repeated 2 additional times, using new components when necessary.

44.2.3 The dielectric voltage-withstand test described in 44.1.5(e) shall be conducted only after the last abnormal operation test unless it is necessary to replace components after conducting the other tests.

44.3 Resistance speed controllers

44.3.1 For a resistance speed controller such as a carbon pile or nichrome wire type, continuous operation at maximum power dissipation shall not result in an increased risk of fire or electric shock.

44.3.2 To determine compliance with 44.3.1, the controller shall be placed on a soft wood surface covered with two layers of tissue paper. The controller is to be draped with a single layer of cheesecloth, adjusted for maximum power dissipation and operated until the ultimate result is known or 7 hours has elapsed. In most cases, continuous operation will be necessary for thermal stabilization to occur.

Exception: If operation at maximum power dissipation causes interruption of an overcurrent device or other conditions which prevent the controller from operating, the controller is to be additionally operated at the highest power dissipation that allows operation until thermal stabilization or 7 hours has elapsed.

44.3.3 There shall be no charring or glowing of the tissue paper nor ignition of the cheesecloth as a result of this test.

44.3.4 Following this test, the controller, while still hot, shall comply with the dielectric voltage-withstand test described in 40.1.1.

44.4 Transformers

44.4.1 A transformer-fuse combination, as mentioned in 21.1(b), shall be operated continuously with the applicable overload conditions as follows:

a) Each secondary winding/fuse combination shall be separately short-circuited for 7 hours, or until ultimate results are known.

b) Each secondary winding, without a fuse, shall be separately overloaded to the following percentages of the rating of the overcurrent protective device for the time indicated.

110-percent current, hours	135-percent current, minutes	200-percent current, minutes
7	60	2