

UL 73

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Motor-Operated Appliances

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UL Standard for Safety
for
Motor-Operated Appliances, UL 73

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A change is indicated by a note following the affected item. The note is preceded and followed by an asterisk.

The revisions dated November 9, 1998 include a reprinted title page (page 1) for this Standard.

The revisions dated November 9, 1998 were issued to make editorial changes.

As indicated on the title page (page 1), this UL Standard for Safety is an American National Standard. Attention is directed to the note on the title page of this Standard outlining the procedures to be followed to retain the approved text of this ANSI/UL Standard.

As indicated on the title page (page 1), this UL Standard for Safety has been adopted by the Department of Defense.

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New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

INTRODUCTION

1 Scope

1.1 These requirements cover motor-operated appliances to be employed in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements also cover small utilization appliances, such as vibrators in which motion of an operating part is produced by electrical means.

1.3 These requirements do not cover appliances rated more than 600 volts; nor do they cover appliances involving universal motors rated more than 250 volts.

1.4 These requirements do not cover equipment intended particularly for the control of electric motors; separator motors; nor electric clocks, fans, clothes dryers, washing machines, hair dryers, tools, waste disposers, dishwashers, office appliances and business equipment, refrigerators, air conditioners, vending and amusement machines, hair clippers and shavers, snow movers, automotive and garage equipment, or other motor-operated appliances that are covered by individual requirements.

1.4 revised July 2, 1998

1.5 An appliance that utilizes some other source of energy, such as gas or steam, in addition to electric energy will be investigated under these requirements and under such additional requirements as are applicable to the appliance under consideration.

1.6 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements to determine that the level of safety as originally anticipated by the intent of this standard is maintained. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard shall not be judged to comply with this standard. Where appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

1.6 revised November 9, 1998

2 Glossary

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

2.2 AUTOMATICALLY CONTROLLED APPLIANCE – An appliance is considered to be automatically controlled if:

- a) The repeated starting of the appliance, beyond one complete predetermined cycle of operation to the point where some form of limit switch opens the circuit, is independent of any manual control;
- b) During any single predetermined cycle of operation, the motor is caused to stop and restart one or more times;
- c) Upon energizing the appliance, the initial starting of the motor may be intentionally delayed beyond normal, conventional starting; or
- d) During any single predetermined cycle of operation, automatic changing of the mechanical load may reduce the motor speed sufficiently to reestablish starting-winding connections to the supply circuit.

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

2.4 LOW-VOLTAGE CIRCUIT – A circuit involving a peak open-circuit potential of not more than 42.4 volts supplied by a primary battery, by a Class 2 transformer, or by a combination of a transformer and a fixed impedance that as a unit, complies with all performance requirements for a Class 2 transformer. A circuit derived from a line-voltage circuit by connecting a resistance in series with the supply circuit as a means of limiting the voltage and current, is not considered to be a low voltage circuit.

2.5 REMOTELY CONTROLLED APPLIANCE – An appliance that is out of sight of the operator who is at the starting device.

3 Components

3.1 Except as indicated in 3.2, a component of an appliance covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the appliances covered by this standard.

3.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the appliance covered by this standard, or
- b) Is superseded by a requirement in this standard.

3.3 A component shall be used in accordance with its recognized rating established for the intended conditions of use.

3.4 Specific components are recognized as being 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 for which they have been recognized.

4 Units of Measurement

4.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

5 References

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

5.1 effective April 19, 1993

CONSTRUCTION

6 General

6.1 An appliance shall employ materials that are acceptable for the application.

7 Frame and Enclosure

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

7.2 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 be not 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 the necessary mechanical strength is provided.

7.3 An enclosure of sheet metal shall be judged with respect to its size, shape, thickness of metal, and its application, considering the intended use of the complete appliance. 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 curved or otherwise reinforced.

7.4 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) if uncoated steel, not less than 0.034 inch (0.86 mm) if galvanized steel, and not less than 0.045 inch (1.14 mm) if nonferrous.

7.5 Among the factors that shall be taken into consideration when judging a nonmetallic enclosure or an enclosure of magnesium are resistance to:

- a) Mechanical damage,
- b) Impact,
- c) Moisture-absorption,
- d) Combustion, and
- e) Distortion at temperatures to which the material may be subjected under conditions of normal or abnormal use.

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

7.7 The requirement in 7.6 will necessitate that a switch, a relay, a solenoid, or the like be individually and completely enclosed, except for terminals, unless it can be shown that malfunction of the component would not result in a risk of fire, or there are no openings in the bottom of the appliance enclosure. It will also necessitate the use of a barrier of noncombustible material:

- a) Under a motor unless:
 - 1) The structural parts of the motor or of the appliance provide the equivalent of such a barrier;
 - 2) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the appliance when the motor is energized under each of the following fault conditions:
 - i) Open main winding;
 - ii) Open starting winding;
 - iii) Starting switch short-circuited; and

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

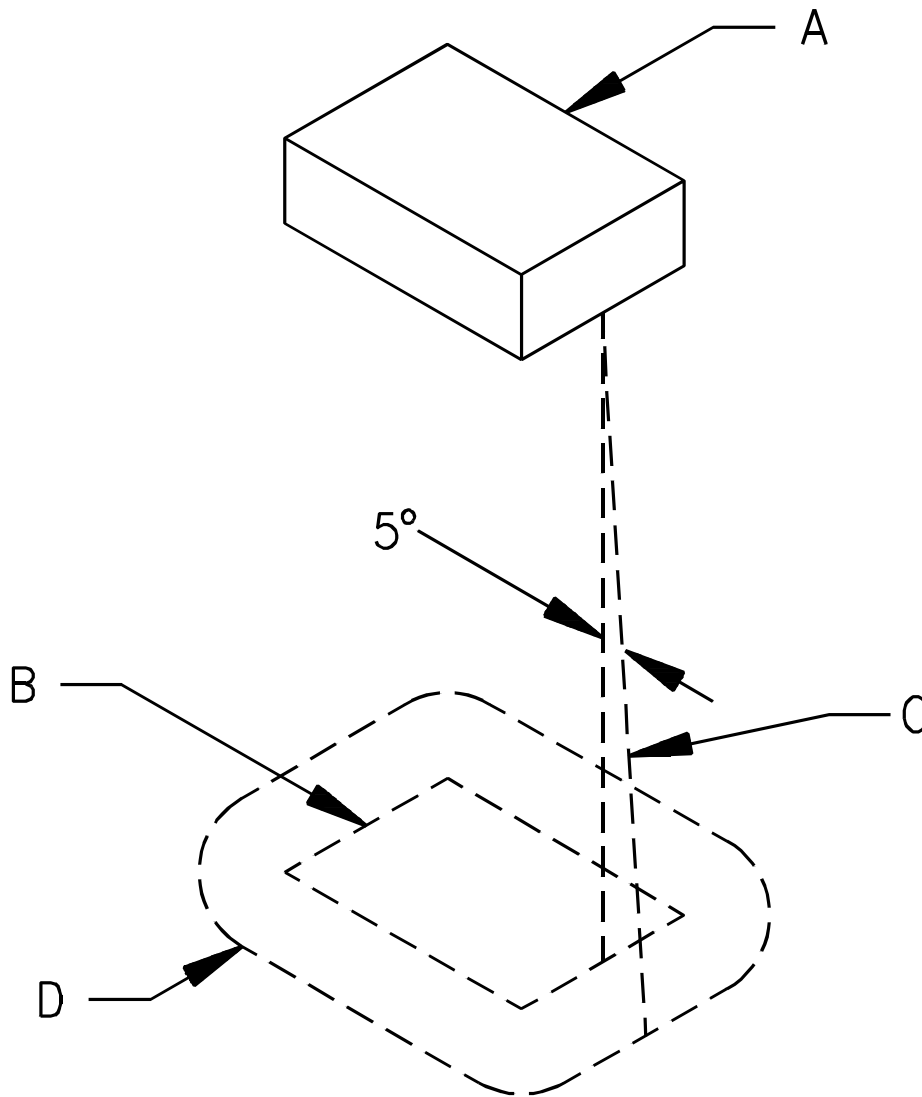
3) The motor is provided with a thermal motor protector – a protective device that is sensitive to temperature and current – that will reduce the risk of the temperature of the motor windings from exceeding 125EC (257EF) under the maximum load under which the motor will run without causing the protector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

4) The motor complies with the requirements in the Standard for Overheating Protection for Motors, UL 2111, and the temperature of the motor winding will not exceed 150EC during the first 72 hours of operation with the rotor of the motor locked.

b) Under wiring, unless it is neoprene, cross-linked polyethylene, or thermoplastic insulated.

7.8 The barrier mentioned in 7.7 shall be horizontal, shall be located as illustrated in Figure 7.1, and shall not have an area less than that described in that illustration. Openings for drainage, ventilation, and the like may be employed in the barrier, provided such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 7.1
Location and extent of barrier



SA0604-1

NOTES –

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

B – Projection of outline of component on horizontal plane.

C – Inclined line that traces out minimum area of barrier. The line is always (1) tangent to the component, (2) 5 degrees from the vertical, and (3) oriented so that the area traced out on a horizontal plane is maximum.

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

7.9 The enclosure of a gum massager or toothbrush shall be such as to reduce the risk of water from contacting uninsulated live parts when the appliance is tested as described in 45.1.1 – 45.1.3 as applicable.

7.10 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.

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

7.12 A cord-connected appliance that is provided with keyhole slots, notches, hanger holes, or the like, for hanging on a wall shall be constructed in such a manner that the hanging means is not accessible without removing the appliance from the supporting means.

7.13 To determine whether a product complies with the requirement in 7.12, any part of the enclosure or barrier that can be removed without the use of tools to gain access to the hanging means is to be removed.

7.14 An opening in the appliance provided for hanging shall be located or guarded so that a nail, hook, or the like does not displace a part that would create a risk of fire or electric shock, and does not contact one of the following:

- a) An uninsulated live part.
- b) Magnet wire.
- c) Internal wiring.
- d) Moving parts.
- e) Any other part likely to create a risk of fire or electric shock.

8 Adhesives Used to Secure Parts

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

8.2 The requirement in 8.1 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.

8.3 Whether the conditions mentioned in 8.2(a) – (d) can occur is to be considered with respect to both:

- a) A part inside the device, and
- b) A part on the outside of the device that may affect equipment in which the device is to be installed.

9 Mechanical Assembly

9.1 An appliance 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 reduce the risk of loosening.

9.2 A switch other than a through-cord switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be securely mounted and shall be prevented from turning. See 9.4.

Exception No. 1: A switch need not be prevented from turning provided:

- 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 loosen it;*
- c) *The spacings are not reduced below the minimum required values if the switch rotates; and*
- d) *The normal operation of the switch is by mechanical means rather than by direct contact by persons.*

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

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

9.4 The means for preventing the turning or shifting mentioned in 9.2 and 9.3 is to consist of more than friction between surfaces – for example, a properly applied lock washer is acceptable as the means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

10 Protection Against Corrosion

10.1 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 No. 1: Surfaces of sheet-steel and cast-iron parts within an enclosure may not be required to be protected against corrosion if the oxidation of the metal due to the exposure to air and moisture is not likely to be appreciable. The thickness of metal and temperature are also to be considered.

Exception No. 2: This requirement does not apply to bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like.

10.2 If deterioration of a liquid container provided as a part of an appliance would result in a risk of fire or electric shock, the container shall be of a material that is resistant to corrosion by the liquid intended to be used therein.

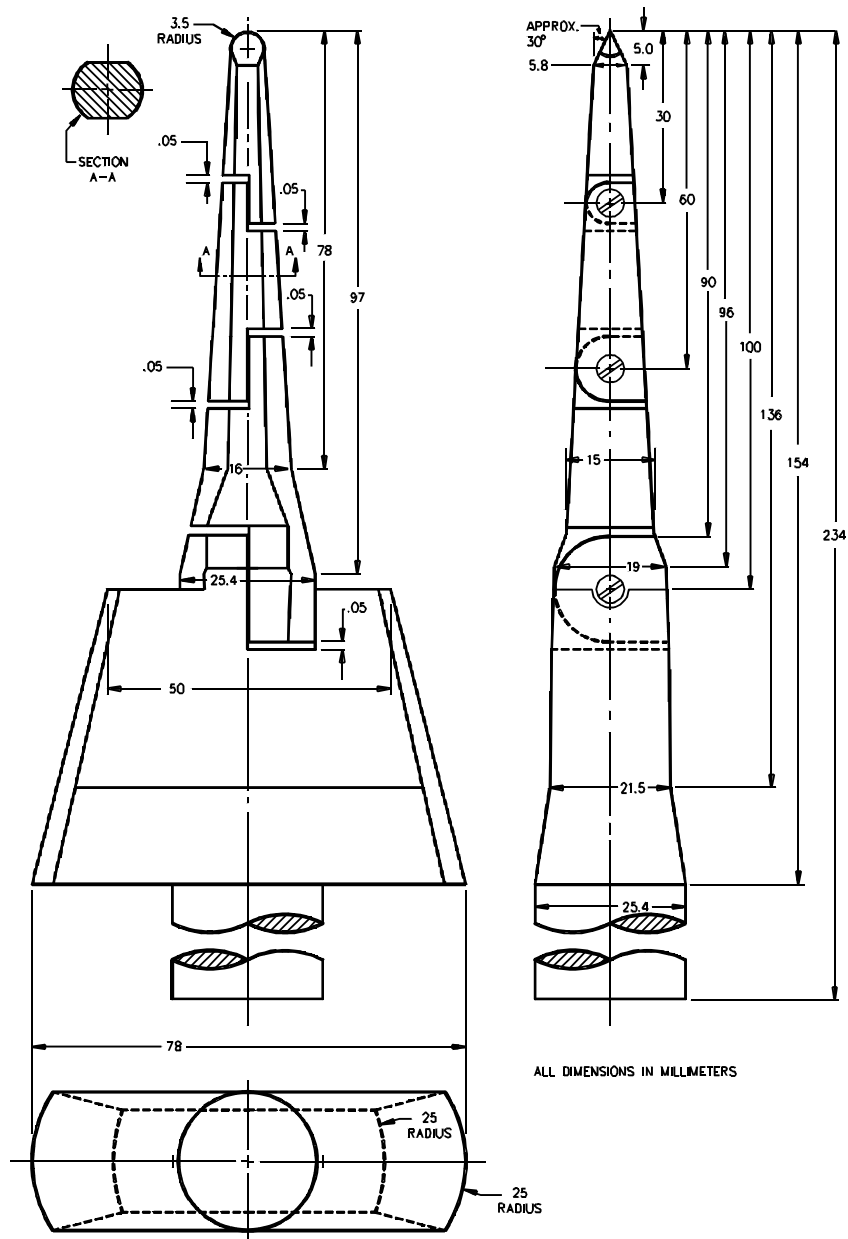
11 Accessibility of Uninsulated Live Parts and Film-Coated Wire

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

- a) For an opening that has a minor dimension (see 11.5) less than 1 inch (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 11.1.
- 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 11.1.

Exception: A motor other than one used in either a hand-held appliance or a hand-supported portion of an appliance need not comply with these requirements if it complies with the requirements in 11.2.

Figure 11.1
Articulate probe with web stop



PA100A

Table 11.1
Minimum acceptable distance from an opening to a part that
may involve a risk of electric shock

Minimum dimension ^a of opening, inches (mm) ^b		Minimum distance from opening to part, inches (mm) ^b	
3/4 ^c	(19.1)	4-1/2	(114)
1 ^c	(25.4)	6-1/2	(165)
1-1/4	(31.8)	7-1/2	(190)
1-1/2	(38.1)	12-1/2	(318)
1-7/8	(47.6)	15-1/2	(394)
2-1/8	(54.0)	17-1/2	(444)
d		30	(762)

^a See 11.5.
^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, but not more than 6 inches (152 mm).

11.2 With respect to a part or wire as mentioned in 11.1, in an integral enclosure of a motor as mentioned in the exception to 11.1:

- a) An opening that has a minor dimension (see 11.5) less than 3/4 inch (19.1 mm) is acceptable if:
- 1) Film-coated wire cannot be contacted by the probe illustrated in Figure 11.3;
 - 2) In a directly accessible motor (see 11.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 11.4; and
 - 3) In an indirectly accessible motor (see 11.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 11.2.
- b) An opening that has a minor dimension of 3/4 inch or more is acceptable if a part or wire is spaced from the opening as specified in Table 11.1.

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

11.4 The probes mentioned in 11.3 and 11.5 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.

Figure 11.2
Straight probe

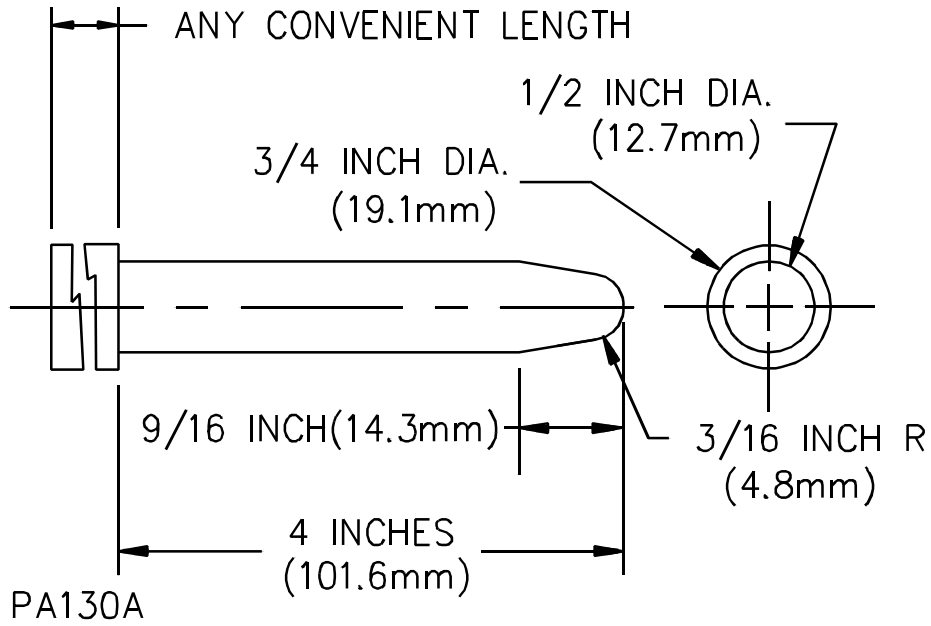


Figure 11.3
Straight probe

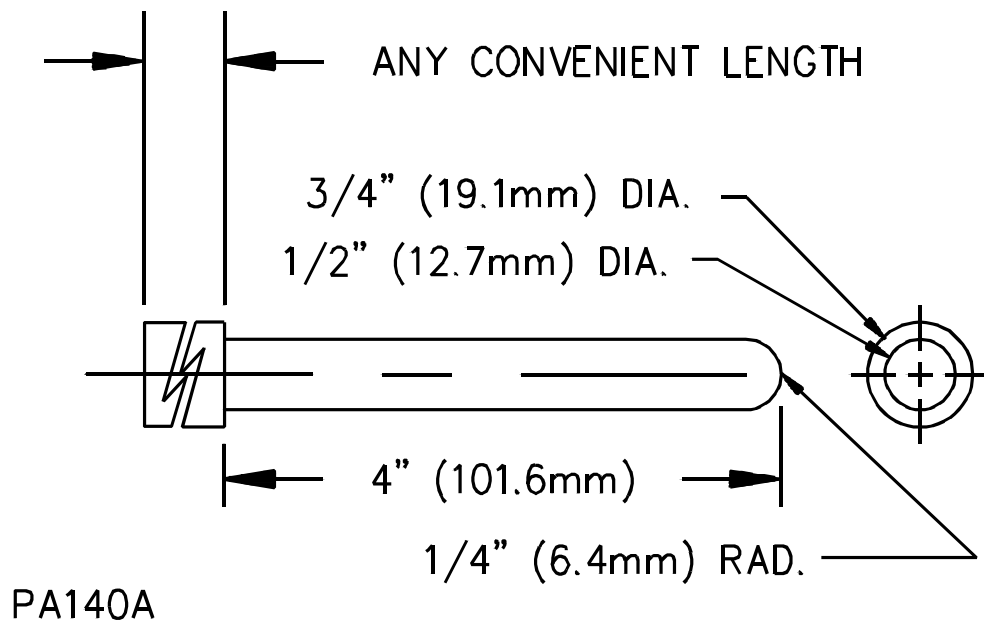
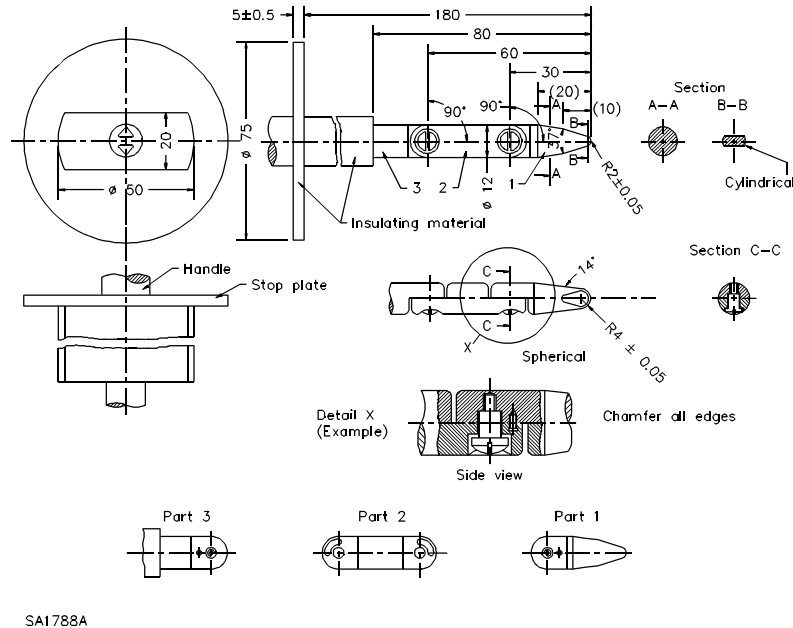


Figure 11.4
International Electrotechnical Commission (IEC)
Articulate accessibility probe with stop plate
All dimensions in millimeters
Courtesy of IEC



SA1788A

Figure 11.4 revised July 2, 1998

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

11.6 With reference to the requirements in 11.2, an indirectly accessible motor is a motor that is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, than can be opened or removed without using a tool, or that is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted. A directly accessible motor is a motor that can be contacted without opening or removing any part or that is located so as to be accessible to contact.

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

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

12 Supply Connections

12.1 Cord-Connected Appliances

12.1.1 Carbonators

12.1.1.1 A carbonator that is connected to the electrical supply by a flexible cord shall comply with the following:

- a) All waterline connections shall be by means of flexible hose or equivalent;
- b) The flexible cord shall be of Type SJT or of a Type equally servicable, shall not be longer than 10 feet (3.05 m), and shall have a grounding conductor and a grounding type attachment plug; and
- c) In addition to complying with the other applicable requirements in the standard, the wiring compartment shall be constructed and the cord attached so a permanent connection is able to be made to the power supply. The construction shall comply with the following conditions:
 - 1) The cord shall enter the wiring compartment through a 7/8-inch (22.2-mm) diameter hole that, after the cord and any bushing or fitting provided have been removed, provides an opening for attachment of a wiring system that is intended for the appliance; and
 - 2) The power-supply cord is connected to the internal wiring by a device such as a terminal block, pressure cable connector, or a similar device, that accommodates permanent wiring having an ampacity rated for the appliance, and that complies with 12.2.2 – 12.2.4.

12.1.1.1 revised July 2, 1998

12.1.2 Cords and plugs

12.1.2.1 An appliance intended to be connected to the power-supply circuit by means of a flexible cord shall be provided with a flexible cord and an attachment plug for connection to the supply circuit.

12.1.2.2 The attachment plug of an appliance intended to be connected to a nominal 120 volt circuit, and employing devices required to be connected to a specific supply conductor as specified in 20.2, 23.2, and 24.3 shall be a polarized type. The connections to the attachment plug shall be in accordance with Figure 12.1. The polarity identification of the supply cord shall be in accordance with Table 12.1A. See 56.3.3.

12.1.2.2 revised July 2, 1998

12.1.2.3 An appliance that is required to employ a polarized attachment plug as specified in 12.1.2.1, and that is provided with a separate or detachable cord set as specified in Exception No. 1 of 12.1.2.7 and 12.1.2.9 shall also employ an appliance connector of the polarized type.

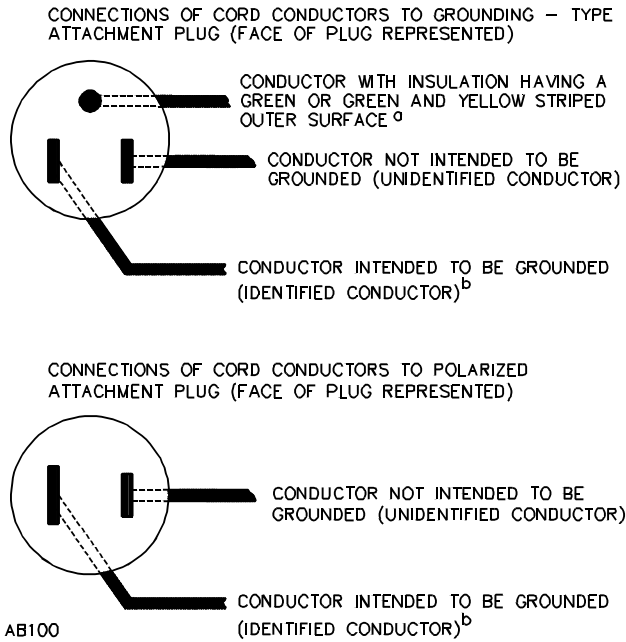
12.1.2.3 effective June 3, 1993

Table 12.1A
Polarity identification of flexible cords

Method of identification	Acceptable combinations	
	Wire intended to be grounded ^a – wire to be connected to the screw shells of lampholders	All other wires ^a
Color of braids on individual conductors	Solid white or natural gray – without tracer Color other than white, or natural gray, with tracer in braid	Solid color other than white or natural gray – without tracer Solid color other than white or natural gray – without tracer
Color of insulation on individual conductors	Solid white or natural gray ^b Light blue ^c	Solid color other than white or natural gray Solid color other than light blue, white or natural gray
Color of separators	White or natural gray ^c	Color other than white, or natural gray
Other means	Tin or other white metal on all strands of the conductor ^d	No tin or other white metal on the strands of the conductor
	A stripe, ridge, or groove on the exterior surface of the cord ^d	
^a A wire finished to show a green color with or without one or more yellow stripes or tracers is to be used only as an equipment-grounding conductor. See 18.2.1 and Figure 12.1. ^b Only for cords – other than types SP-1, SP-2, SPT-1, or SPT-2 – having no braid on any individual conductor. ^c For jacketed cords. ^d Only for types SP-1, SP-2, SPT-1, and SPT-2 cords.		

Table 12.1A effective June 3, 1993

Figure 12.1
Connections to attachment plugs



NOTES –

^a In the above illustration, the blade to which the green conductor is connected may have a U-shape instead of a circular cross section.

^b Signifies a conductor identified in accordance with Table 12.1A.

Figure 12.1 revised July 2, 1998

Table 12.1B
Cords and appliances

Table 12.1B deleted July 2, 1998

12.1.2.4 The flexible cord shall have a voltage rating not less than the rated voltage of the appliance, and shall have an ampacity that is not less than the current rating of the appliance.

12.1.2.5 *Deleted July 2, 1998*

12.1.2.6 Type SJ, SJE, SJO, SJOO, SJT, SJTO, or SJTOO cord is required when the appliance is intended for commercial or industrial use, and Type SP-2, SPE-2, or SPT-2 when the appliance is intended for household use.

12.1.2.6 revised July 2, 1998

12.1.2.7 The flexible cord shall not be less than 6 feet (1.83 m) long and shall be attached to the appliance.

Exception No. 1: An appliance that is not required to be provided with a grounding conductor may be provided with a separate cord set having means for connection to the appliance and a length of not less than 6 feet.

Exception No. 2: A cord-connected appliance that is required to be equipped with a grounding conductor may be provided with not more than 18 inches (457 mm) of permanently attached flexible cord or with a connector base if:

a) Usage of the appliance is such that it is necessary to connect it by means of an extension cord during normal operation; the manufacturer makes extension cords available; and a statement indicating the availability of such extension cords is marked on the appliance or is included in an instruction book or the like that is regularly furnished with the appliance; or

b) The manufacturer furnishes a detachable cord set, 6 feet or more long, with the appliance.

Exception No. 3: This requirement does not apply to a cord as described in 12.1.1.1(b).

Exception No. 4: A hand-supported engraver, intended for marking or etching materials, may be provided with not less than 5 feet (1.52 m) of attached flexible cord.

12.1.2.8 The length of an attached flexible cord includes the attachment plug. The length of a cord set includes the fittings.

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

12.1.2.10 The attachment plug shall have an ampacity not less than the rated current of an appliance, or the input current under maximum normal load conditions, whichever is greater, and a voltage rating equal to the rated voltage of the appliance. If an appliance can be adapted for use on two or more different values of voltage by field alteration of internal connections, the attachment plug provided with the appliance shall be acceptable for the voltage for which the appliance is connected when shipped from the factory. See 56.1.3.

12.1.2.11 A three- to two-wire, grounding-type adapter shall not be provided with an appliance if:

a) Usage of the appliance is such that it is necessary to connect it by means of an extension cord during normal operation,

b) The manufacturer makes extension cords available, and

c) A statement indicating the availability of such extension cords is marked on the appliance or is included in an instruction book or the like that is regularly furnished with the appliance.

12.1.2.12 If an appliance incorporates a disconnecting means, such as a cord connector in the supply cord between the handle and the motor, the arrangement shall be such that no live parts will be exposed under any normal conditions.

12.1.3 Strain relief

12.1.3.1 Strain relief shall be provided so that mechanical stress on a flexible cord will not be transmitted to terminals, splices, or interior wiring.

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

Exception: The auxiliary insulation may be omitted for Type SV, SVE, SVO, or SVOO cord.

12.1.3.3 A clamp of any material – metal or otherwise – is not acceptable for use on Type SPT-1, SPT-2, SVT, SVTO, or SVTOO cord.

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

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

12.1.3.4 For types of thermoplastic-insulated cord, heavier than Type SPT-1, SPT-2, SVT, SVTO, or SVTOO, a clamp may be employed and the auxiliary insulation is not required unless it is judged that the clamp may damage the cord insulation.

12.1.3.5 Means shall be provided to reduce the risk of a flexible cord from being pushed into an appliance through a cord-entry hole if such displacement may subject the cord to mechanical damage or to exposure to a temperature higher than that for which the cord is acceptable, or may reduce a spacing, such as to a metal strain-relief clamp, below the minimum acceptable value.

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

12.1.4 Bushings

12.1.4.1 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 reliably secured in place, and shall have a smooth, rounded surface against which the cord may bear.

12.1.4.2 An insulating bushing shall be provided if:

- a) Type SP-1, SPE-1, SPT-1, SP-2, SPE-2, SPT-2, or other cord lighter than Type SV or SVE is employed,
- 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 fills completely the space between the grommet and the metal in which it is mounted may be used instead of an insulating bushing.

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

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

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

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

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

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

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

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

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

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

12.2 Permanently Connected Appliances

12.2.1 General

12.2.1.1 Except as noted in 12.2.1.2, an appliance intended for permanent connection to the power supply shall have provision for connection of one of the wiring systems that would be acceptable for the appliance.

12.2.1.2 A stationary appliance may be provided with not more than 8 feet (2.44 m) of Type S, SE, SO, SOO, ST, STO, or STOO cord and an attachment plug for supply connection. The investigation of such a feature will include consideration of the utility of the appliance and the necessity of having it readily detachable from its source of supply by means of a plug.

12.2.2 Terminal compartment

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

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

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

12.2.3 Wiring terminals and leads

12.2.3.1 A permanently connected appliance shall be provided with wiring terminals for the connection of conductors having an ampacity acceptable for the appliance; or the appliance shall be provided with leads for such connection.

12.2.3.2 A field-wiring terminal is considered to be a terminal to which a wire may be connected in the field, unless the wire and, a means of making the connection – a pressure terminal connector, soldering lug, soldered loop, crimped eyelet, or the like, factory-assembled to the wire – are provided as a part of the appliance.

12.2.3.3 Wiring terminals for the supply conductors – excluding the grounding 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 (4.8 mm diameter) or larger wire-binding screw or stud-and-nut combination may be employed at a wiring terminal intended to accommodate a No. 10 AWG (5.3 mm²) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in place.

12.2.3.4 A wiring terminal shall be prevented from turning.

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

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

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

Exception No. 1: A No. 8 (4.2 mm diameter) screw or stud-and-nut combination may be used at a terminal intended only for the connection of a No. 14 AWG (2.1 mm²) conductor.

Exception No. 2: A No. 6 (3.5 mm diameter) screw may be used for the connection of a No. 16 or 18 AWG (1.3 or 0.8 mm²) conductor in a low-voltage circuit.

12.2.3.7 According to the National Electrical Code, ANSI/NFPA 70-1993, No. 14 AWG (2.1 mm²) is the smallest conductor that may be used for branch-circuit wiring, and therefore is the smallest conductor that may be anticipated at a terminal for connection of a power-supply wire.

12.2.3.8 A wire-binding screw shall thread into metal.

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

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

12.2.3.10 A terminal plate formed from stock having the thickness specified in 12.2.3.9 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

12.2.3.11 Uprturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size specified in 12.2.3.1 under the head of the screw or washer.

12.2.4 Identified terminals and leads

12.2.4.1 A permanently connected appliance rated 125 or 125/250 volts (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.

12.2.4.2 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 an attached wiring diagram.

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

13 Current-Carrying Parts

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

13.2 Ordinary iron or steel shall not be used as a current-carrying part.

Exception: Ordinary iron or steel provided with a corrosion-resistant coating may be used for a current-carrying part if acceptable in accordance with 3.1 or within a motor or associated governor.

14 Insulating Material

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

14.2 Ordinary vulcanized fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts where shrinkage, current leakage, or warpage may introduce a risk of fire or electric shock.

14.3 A thermoplastic material generally is not considered acceptable for the sole support of uninsulated live parts, but may be employed if found to have the necessary mechanical strength and rigidity, resistance to heat, resistance to flame propagation, dielectric voltage withstand, and other appropriate properties.

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

15 Internal Wiring

15.1 Mechanical Protection

15.1.1 Wiring and connections between parts of an appliance shall be protected or enclosed.

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

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

15.1.3 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure of an appliance shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which the wires may bear. A flexible cord used for external interconnection as mentioned in 15.1.1 shall be provided with strain relief and bushings in accordance with the requirements in 12.1.3.1 – 12.1.4.8, and Section 47, Strain-Relief Test, unless the construction is such that the cord will be protected from stress and motion.

15.1.4 Insulated wires may be bunched and passed through a single opening in a metal wall within the enclosure of an appliance.

15.1.5 A conductor utilizing beads for insulation shall not be employed outside an enclosure.

15.1.6 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.

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

15.1.8 Type AF wire shall not be employed in an appliance if the wire is likely to be exposed to moisture, including any condensation resulting from operation of the appliance.

Exception: Type AF wire may be employed if the appliance includes a heating element, and if the wire is subjected to a temperature of more than 80EC (176EF).

15.1.8 effective April 19, 1993

15.1.9 With reference to exposure of insulated wiring through an opening in the enclosure of an appliance, the protection of such wiring required by 15.1.1 is considered to exist if, when judged as though it were film-coated wire, the wiring would be acceptable according to 11.1 and 11.2. 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.

15.1.10 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.

15.2 Splices and Connections

15.2.1 Each splice and connection shall be mechanically secure and shall provide reliable electrical contact. 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.

15.2.2 For an appliance in which excessive vibration is likely to occur – such as a bin vibrator – the requirement in 15.2.1 will necessitate the use of lock washers or other equivalent means to reduce the risk of wire-binding screws and nuts from becoming loosened.

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

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

15.2.5 With reference to the requirements in 15.2.4, 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, and the like.

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

15.2.7 If stranded internal wiring is connected to a wire-binding screw, loose strands of wire shall be prevented from contacting other uninsulated live parts that are not always of the same polarity as the wire and from 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.

16 Separation of Circuits

16.1 Conductors of circuits operating at different potentials shall be reliably separated from each other unless they are each provided with insulation acceptable for the highest potential involved.

16.1 effective June 3, 1993

16.2 An insulated conductor shall be reliably retained so that it cannot contact an uninsulated live part of a circuit operating at a different potential.

16.2 effective June 3, 1993

16.3 In a compartment that is intended for the field installation of conductors, and that contains provision for connection of Class 2 or Class 3 circuit conductors, and Class 1, power, or lighting circuit conductors, a barrier shall be provided to separate the conductors of the different circuits, or the arrangement of the compartment shall be such that a minimum spacing of 1/4 inch (6.4 mm) can be maintained between the conductors of the different circuits including the conductors to be field installed.

16.3 effective June 3, 1993

17 Capacitors

17.1 A capacitor provided as a part of a capacitor motor and a capacitor connected across the line, such as a capacitor for radio-interference elimination or power-factor correction, shall be housed within an enclosure or container that will protect the plates against mechanical damage and that will reduce the risk of 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). Sheet metal having a thickness less than 0.026 inch (0.66 mm) is not recommended.

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 appliance and provided that such housing is acceptable for the enclosure of live parts.

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

17.3 A capacitor connected from one side of the line to the frame or enclosure of an appliance shall have a capacitance rating of not more than 0.10 microfarad. See 37.2.

17.4 An appliance that is intended to be controlled by or operated in conjunction with a capacitor or a capacitor/transformer unit shall be supplied with such capacitor or unit.

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17.5 Under both normal and abnormal conditions of use, a capacitor employing a 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.

18 Grounding

18.1 General

18.1.1 An appliance of one or more of the following types shall have provision for grounding.

- a) An appliance for use in damp or wet locations and intended to be used in other than residential occupancies.
- b) An appliance intended to be used on a circuit operating at more than 150 volts to ground – see 18.1.2.
- c) An upholstery shampooer.
- d) An insecticide sprayer.

Exception: An appliance may be provided with a double insulation system that complies with the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097 in place of a provision for grounding.

18.1.1 revised January 18, 1996

18.1.2 *18.1.2 deleted April 19, 1993*

18.1.3 With reference to 18.1.1(b), a two-wire appliance intended to operate at any potential higher than 150 volts to ground, shall be provided with means for grounding in accordance with 18.1.6 and 18.1.7 unless the marked rating on the appliance is 120/240 volts or the appliance is otherwise marked to indicate that it is to be connected to a circuit operating at 150 volts or less to ground.

18.1.4 An appliance marked as being provided with double insulation shall not be provided with a means for grounding.

18.1.5 If a grounding means is provided, whether required or not, it shall be in accordance with 18.1.6 and, if the appliance is cord-connected, shall comply with the requirements in 18.1.7. 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.

18.1.6 The following are acceptable means for grounding:

- a) In an appliance intended to be permanently connected by a metal-enclosed wiring system, a knockout or equivalent opening in the metal enclosure of the appliance.
- b) In an appliance intended to be permanently connected by a nonmetal-enclosed wiring system, such as nonmetallic-sheathed cable, an equipment grounding terminal or lead. See 18.1.11 and 56.2.3.
- c) In a cord-connected appliance, an equipment grounding conductor in the cord.

18.1.7 The grounding conductor of a supply cord shall be secured to the frame or enclosure of the appliance by means of a screw that is not likely to be removed during any servicing operation not involving the power-supply cord, or by other equivalent means. Solder alone shall not be used for securing the grounding conductor. Servicing includes repair of the appliance by qualified service personnel.

18.1.8 The grounding conductor of a cord-connected appliance shall be connected to the grounding member of an attachment plug. The grounding member shall be fixed.

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

18.1.9 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 acceptable.

18.1.10 If an appliance 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.

18.1.11 A terminal solely 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.

18.1.12 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 normal servicing of the appliance.

18.2 Grounding Identification

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

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

18.2.3 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 the like, or by a marking on a wiring diagram provided on the appliance.

19 Heating Elements

19.1 The voltage rating of a heating element employed in an appliance shall not be less than that specified in Table 19.1.

Table 19.1
Rating of heating element

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

20 Lampholders

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

20.2 The screw shall of an Edison-base lampholder in a permanently connected appliance, or an appliance 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.

21 Motors

21.1 Construction

21.1.1 A motor shall be acceptable for the application, and shall be capable of handling the maximum normal load of the appliance as described in 41.2.1.1 – 41.2.4.1 without creating a risk of fire, electric shock, or injury to persons.

21.1.2 A motor winding shall resist the absorption of moisture.

21.1.3 With reference to the requirement in 21.1.2, film-coated wire is not required to be additionally treated to resist absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials are to be provided with impregnation or otherwise treated to resist moisture absorption.

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

21.2 Brush wear out

21.2.1 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly shall be retained to the degree necessary not to cause accessible dead metal parts to become energized, and live parts to become accessible.

21.3 Overload protection

21.3.1 An appliance shall incorporate thermal or overload protection in accordance with 21.3.2 if it is intended to be permanently connected, continuous-duty, and manually started, employing a motor rated 1 horsepower (746 W output) or less, or remotely or automatically controlled.

21.3.2 Motor-overload protection required for an appliance shall consist of one of the following:

a) Thermal protection complying with the applicable requirements in the Standard for Overheating Protection for Motors, UL 2111.

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

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

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

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

Exception No. 3: A shaded-pole motor with a 2:1 or smaller ratio between locked-rotor and no-load currents and a 1-ampere 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 requirements in the Standard for Overheating Protection for Motors, UL 2111, when the motor is tested as used in the appliance under locked-rotor conditions.

c) Other protection that is shown by test to be equivalent to the protection mentioned in item (a).

Exception: A motor as described in Exception No. 2 to item (a) is not required to have running-overload protection.

21.3.2 revised November 9, 1998

21.3.3 If a requirement in this standard refers to the horsepower rating of a motor and the motor is not rated in horsepower, use is to be made of the appropriate table of the National Electrical Code, ANSI/NFPA 70-1993, that gives the relationships between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating-current motor is to be used if the appliance is marked for use on alternating current only; otherwise the table applying to direct-current motors is to be used.

21.3.4 For a multispeed motor of any of the types mentioned in 21.3.1 that employs a separate overload protective device to provide running overload protection, the requirement applies at all speeds at which the motor is intended to operate.

21.3.5 The motor of an appliance with load characteristics likely to result in an overload or stalled condition that will not be evident to the user shall incorporate thermal or overload protection in accordance with the requirements in 21.3.2.

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

21.3.7 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.

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

21.3.9 With reference to 21.3.2(c), an overload-protective device conforming with the National Electrical Code, ANSI/NFPA 70-1993, is equivalent to an overload device that is responsive to motor current and is rated or set as specified in column A of Table 21.1. When 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 higher size, rating, or setting shall be used, and shall not be more than that specified in column B of Table 21.1. For a multispeed motor, each winding connection is to be considered separately.

21.3.9 revised November 9, 1998

Table 21.1
**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 40EC or less	125	140
Any other motor	115	130

21.3.10 Motor-overload protection in which contacts control a relay coil in a motor starter shall comply with the requirements in 21.3.2.

22 Overload- or Thermal-Protective Devices

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

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

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

- a) For each separate motor or heating-element circuit supplied by insulated conductors having an ampacity at least one-third that of the protective device in the branch circuit to which the appliance will properly be connected.*
- b) For each separate motor-control circuit supplied by insulated conductors having an ampacity at least one-fifth that of the protective device in the branch circuit to which the appliance will properly be connected.*

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

Exception: The protective device need not be readily accessible provided:

- a) The appliance, with the protective device shunted out of the circuit, complies with all applicable requirements in this standard; and*
- b) The presence of the protective device would ordinarily be unknown to the user of the appliance because of its location and the omission of reference to the device in the operating instructions, circuit diagrams, and the like for the appliance.*

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

Exception: The operating handle of a circuit breaker, the operating button of a manually operable motor protector, and similar parts may project outside the appliance enclosure.

22.5 A fuseholder shall be constructed and installed so that no uninsulated live part other than the screw shell or clips will be exposed to contact by persons removing or replacing fuses.

Exception: The requirement does not apply if the presence of the protective device would ordinarily be unknown to the user of the appliance because of its location and the omission of reference to the device in the operating instructions, circuit diagrams, and the like for the appliance.

22.6 The screw shell of a plug-type fuseholder shall be connected toward the load.

23 Receptacles

23.1 A 15- or 20-ampere general-use attachment-plug receptacle in an appliance provided with a means for grounding – a permanently wired appliance or a cord-connected appliance with a grounding conductor in the cord – shall be of the grounding type. The grounding contact of the receptacle shall be electrically connected to dead metal that will be grounded when the appliance is in use.

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

23.2 effective June 3, 1993

23.3 Each circuit having an attachment-plug receptacle intended for general use shall have overcurrent protection of not more than 20 amperes provided as a part of the appliance if the overcurrent protection of the branch circuit to which the appliance will properly be connected exceeds that acceptable for the receptacles. The overcurrent protection provided shall be of the time-delay type.

23.4 A 120-volt, single-phase, 15- or 20-ampere receptacle outlet installed in an appliance intended for outdoor use shall have ground-fault circuit protection.

Exception: A cord-connected portable appliance need not comply with this requirement.

23.5 A fuseholder provided in accordance with 23.3 shall be of Type S construction or shall be of the Edison-base type with a factory-installed nonremovable adapter of Type S construction.

23.6 The face of a receptacle shall:

- a) Be flush with or project beyond a nonconductive surrounding surface, or
- b) Project at least 0.015 inch (0.38 mm) beyond a conductive surrounding surface.

24 Switches and Controls

24.1 A switch or other control device shall have a current and voltage rating not less than that of the load that it controls.

24.2 With reference to the requirement in 24.1, the current rating of a switch that controls an inductive load other than a motor, such as a transformer or an electric-discharge-lamp ballast, shall 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.

24.3 In an appliance rated 125 or 125/250 volts (3-wire) or less, a switch or an 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 an ungrounded conductor of the supply circuit.

24.3 effective June 3, 1993

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

Exception: If the appliance is marked in accordance with 56.3.1, the manually operated motor-control switch need not be provided in an appliance where the switch would be inaccessible.

24.5 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.

25 Spacings

25.1 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 25.1.

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

Exception No. 2: This requirement does not apply if a spacing complies with the requirements in 25.5.

**Table 25.1
Spacings at other than field-wiring terminals**

Potential involved, volts	Diameter of motor used in appliance			
	7 inches (178 mm) or less ^a		More than 7 inches (178 mm) ^{a,c}	
	Over surface Inch (mm)	Through air Inch (mm)	Over surface Inch (mm)	Through air Inch (mm)
0 – 125	3/32 (2.4) ^b	3/32 (2.4) ^b	1/4 (6.4) ^c	1/8 (3.2) ^c
126 – 250	3/32 (2.4)	3/32 (2.4)	1/4 (6.4) ^c	1/4 (6.4) ^c
251 – 600	1/2 (12.7) ^c	3/8 (9.5) ^c	1/2 (12.7)	3/8 (9.5) ^c

^a See 21.1.4.

^b For an appliance employing a motor rated at 1/3 horsepower (250 W output) or less, these spacings may be not less than 1/16 inch (1.6 mm).

^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.

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

25.3 In an appliance incorporating two or more motors of different sizes, the spacings in the appliance are to be investigated on the basis of the size of the largest motor in the appliance.

25.4 The spacings in a motor shall comply with the spacing requirements in the Standard for Electric Motors, UL 1004.

25.5 If an isolated dead metal part is interposed between or is in close proximity to live parts of opposite polarity, to a live part and an exposed dead metal part, or to a live part and a dead metal part that may be grounded, the spacing may be not less than 3/64 inch (1.2 mm) between the isolated dead metal part and any one of the other parts previously mentioned, provided the total spacing between the isolated dead metal part and the two other parts is not less than the value specified in Table 25.1.

25.6 An insulating lining 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 conjunction with an air spacing 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.

25.7 All uninsulated live parts connected to different – line- or low-voltage – circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirements in 25.1 and 25.9 and shall be investigated on the basis of the highest voltage involved.

25.8 The spacing between uninsulated live parts of opposite polarity and between such parts and dead metal that may be grounded in service is not specified for parts of low-voltage circuits.

25.9 The spacing between wiring terminals of opposite polarity, and between a wiring terminal and any other uninsulated metal part – dead or live – not of the same polarity, shall not be less than that specified in Table 23.2. See 12.2.3.2.

Table 25.2
Spacings at wiring terminals

Potential involved, volts	Minimum spacings, inch (mm)		
	Between wiring terminals, through air, or over surface	Between terminals and other uninsulated metal parts not always of the same polarity ^a	
		Over surface	Through air
250 or less	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, 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.

25.10 At terminal screws and studs to which connection may be made in the field by means of the wire connectors, eyelets, and the like, as described in 12.2.3.2, spacings shall not be less than those specified in Table 25.1 when such connectors, eyelets, and the like, are in such position that minimum spacings – opposite polarity and to dead metal – exist.

PROTECTION AGAINST INJURY TO PERSONS

26 General

26.1 If the operation and maintenance of an appliance by the user involves the risk of injury to persons, protection shall be provided to reduce the risk.

26.2 When investigating an appliance with respect to the requirement in 26.1, consideration shall be given to reasonably foreseeable misuse of the appliance.

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

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

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

27 Sharp Edges

27.1 An enclosure, a frame, a guard, a handle, or the like shall not be sufficiently sharp to constitute a risk of injury to persons in normal maintenance and use.

Exception: This requirement does not apply to a part or portion of a part needed to perform a working function.

28 Enclosures and Guards

28.1 The rotor of a motor, a pulley, a belt, a gear, a fan, or other moving part that could cause 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 contacted by the probe illustrated in Figure 11.1.

Exception No. 1: An opening in the integral enclosure of a motor 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 11.2.

Exception No. 2: A part or portion of a part that is necessarily exposed to perform the work function need not be enclosed but, when necessary, guarding shall be provided. See 28.4.

28.2 During the examination of an appliance to determine whether it complies with the requirements in 28.1, 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 reasons) is to be opened or removed.

Exception: A part need not be opened or removed provided the appliance is marked in accordance with 36.8.

28.3 Among the factors to be considered in judging the acceptability of an exposed moving part are:

- a) The degree of exposure necessary to perform the intended function,
- b) The sharpness of the moving part,
- c) The likelihood of unintentional contact therewith,
- d) The speed of the moving part, and
- e) The likelihood that a part of the body would be endangered or that clothing would be entangled by the moving part, resulting in a risk of injury to persons.

These factors are to be considered with respect to both intended operation of the appliance and any reasonably foreseeable misuse.

28.4 Some guards are required to be self-restoring. 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 a risk of injury to persons such as a pinch point, and the necessity for additional handling because of the increased need for servicing, such as for cleaning, unjamming, and the like; and
- f) Usage – household or commercial.

28.5 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.

28.6 If complete guarding of a moving part that could obviously cause injury to persons would defeat the utility of an appliance, a control, such as a momentary contact switch, shall be provided; and an appropriate marking shall be provided in the instruction manual warning the user of the potential risk.

28.7 A feeding mechanism, either manual or automatic, shall be constructed or guarded to reduce the likelihood or necessity of the operator's fingers being in an area that could cause injury. If the average inside diameter – one-half the sum of the maximum and minimum dimensions – of the throat of a hopper or tubular feed opening for manual feeding is not more than 2-1/2 inches (64 mm), it is considered acceptable, if the cutters are recessed below the plane of the opening.

28.8 A cutting or slicing mechanism shall be guarded.

Exception: If exposure of the blade or equivalent part is necessary for the cutting or slicing operation, guarding need not be provided.

29 Materials

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

29.2 The requirement in 29.1 applies to those portions of a part adjacent to a moving part considered to involve a risk of injury to persons.

30 Rotating or Moving Members

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

30.2 A rotating member, the breakage of which may create a risk of injury to persons, shall be constructed to reduce the likelihood of its breakage, or the release or loosening of a part that could become a risk of injury to persons.

30.3 To determine whether an appliance employing a series motor complies with the requirement in 30.2, it shall be tested as described in 30.4. A part that can become a risk of injury to persons shall not work loose.

30.4 For the test required by 30.3, an appliance employing a series motor is to be operated for 1 minute at the no-load speed resulting from application of 1.3 times rated voltage. An appliance in which the rotating load may be varied is to be tested for each condition of loading that can occur.

31 Parts Subject to Pressure

31.1 A pressure vessel having an inside diameter more than 6 inches (152 mm), subjected to a pressure more than 15 psig (102 kPa), and eligible to be covered by the National Board of Boiler and Pressure Vessel Inspectors shall be marked in accordance with the appropriate boiler and pressure vessel code symbol of the American Society of Mechanical Engineers (ASME) for a working pressure not less than the pressure determined in accordance with 31.3.

31.2 A pressure vessel, because of its application, not covered by the scope of the inspection procedure of the ASME code shall be constructed so that it will comply with requirements in 31.3.

31.3 A part or an assembly that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid, during normal or abnormal operation shall withstand a pressure equal to the highest of the following that is applicable:

- a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the assembly, but not more than five times the marked maximum supply pressure from an external source and not more than five times the pressure setting of a pressure-relief device provided as a part of the assembly.
- b) Five times the marked maximum supply pressure from an external source, unless the pressure is limited by a pressure-relief device in accordance with item (a).
- c) Five times the pressure setting of a required pressure-relief device.

- d) Five times the maximum pressure that can be developed by an air compressor that is part of the assembly unless the pressure is limited by a pressure-relief device in accordance with item (a).
- e) Five times the working pressure marked on the part.

Exception No. 1: This requirement does not apply to a section of a pressure system constructed of continuous tubing or of lengths of tubing connected by hard-soldered, brazed, or welded joints, provided the wall thickness of tubing is not less than the value specified in Table 31.1.

Exception No. 2: This requirement does not apply to a pressure vessel bearing the ASME code inspection symbol – other than the UM symbol – provided the vessel is marked with a value of working pressure not less than that to which it is subjected during normal or abnormal operation.

Table 31.1
Wall thickness for copper and steel tubing

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

31.4 If a test is necessary to determine whether a part complies with requirements in 31.3, two samples of the part are to be subjected to a hydrostatic pressure test. Each sample is to be filled with water so as to exclude air, and is to be connected to a hydraulic pump. The pressure is to be raised gradually to the specified test value, and is to be held at that value for 1 minute. The results are not acceptable if either sample bursts or leaks.

Exception: Leakage or rupture of a nonmetallic fluid transfer line and its connections, or at a gasket is acceptable if repeated tests conducted with the media they are intended to contain show no evidence of presenting a risk of injury to persons or of electric shock.

31.5 A part supported or actuated hydraulically that could result in a risk of injury to persons due to pressure loss shall comply with the requirement in 31.4 when tested at a pressure equal to five times the maximum pressure capable of being developed in the system.

32 Pressure-Relief Devices

32.1 A means for relieving pressure shall be provided for a part in which pressure might be generated by an external source of heat.

32.2 A pressure-relief device, a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent pressure-relief means may be employed to comply with the requirement in 32.1.

32.3 A pressure-relief device is considered to be a pressure-actuated valve or rupture member intended to relieve excessive pressures automatically.

32.4 There shall be no shutoff valve between the pressure-relief means and the parts that it is intended to protect.

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

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

32.7 A pressure-relief device shall:

- a) Be connected as close as possible to the pressure vessel or part of the system that it is intended to protect;
- b) Be installed so that it is readily accessible for inspection and repair, and cannot be readily rendered inoperative so that it will not perform its intended function; and
- c) Have its discharge opening located and directed so that:
 - 1) Operation of the device will not deposit moisture on bare live parts or on insulation or components detrimentally affected by moisture, and
 - 2) The likelihood of scalding persons is reduced.

32.8 A pressure-relief device having an adjustable setting is to be investigated on the basis of the maximum setting unless the adjusting means is reliably sealed at a lower setting.

32.9 The control that limits the pressure in a vessel required to have a pressure-relief device shall perform under rated load for 100,000 cycles of operation, and shall operate so that the pressure does not exceed 90 percent of the relief-device setting under any condition of normal operation.

33 Switches, Controls, and Interlocks

33.1 An appliance shall be constructed so as to reduce the likelihood of unexpected operation of any part capable of causing injury to persons.

33.2 Each function of a multiple-function appliance is to be taken into consideration in determining whether the appliance complies with the requirements in 33.1.

33.3 If, when energized, an appliance has a moving part that may cause injury to persons, a motor control switch, other than a momentary-contact switch, shall be provided on the appliance. See 36.5.

33.4 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.

33.5 The actuator of a switch may be guarded by recessing, ribs, barriers, or the like.

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

33.7 Operation of an interlock in normal use shall not inconvenience the operator so as to encourage deliberate defeat of the interlock.

33.8 An interlock shall not be capable of being defeated by materials such as wood or metal chips that could accumulate in normal use.

33.9 An interlock shall be such that it cannot be defeated readily:

- a) Without damaging the appliance,
- b) Without making wiring connections or alterations, or
- c) By using materials that are readily available.

33.10 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 33.6.

33.11 A floor- or ground-supported appliance that can travel or rotate to an extent that could result in injury to persons if left unattended shall be provided with a momentary contact switch that cannot be locked in the on position.

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

33.13 The requirement in 33.12 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.

34 Specific Appliances

34.1 A self-propelled appliance weighing more than 50 pounds (22 kg) when fully loaded shall be provided with a braking means.

35 Stability

35.1 If a portable appliance overturns when tested as described in 35.2 and 35.4, a risk of injury to persons shall not result.

Exception: An appliance that is completely hand supported in normal use need not be tested.

35.2 The appliance is not to be energized during the stability test. The test is to be conducted under conditions most likely to cause the appliance to overturn. The following conditions are to be such as to result in the least stability:

- a) Position of all doors, drawers, casters, and other movable or adjustable parts, including that of the supply cord resting on the surface supporting the appliance;
- b) Connection of or omission of any attachment made available or recommended by the manufacturer;

- c) Provision of or omission of any normal load if the appliance is intended to contain a liquid or other mechanical load; and
- d) Direction in which the appliance is tipped or the supporting surface is inclined.

35.3 In conducting the stability test, the appliance is to be:

- a) Placed on a plane inclined at an angle of 10 degrees from the horizontal; or
- b) Tipped through an angle of 10 degrees from an at rest position on a horizontal plane.

35.4 With reference to the requirement in 35.3(b), for an appliance that is constructed so that while being tipped through an angle of 10 degrees a part or surface of the appliance not normally in contact with the horizontal supporting surface touches the supporting surface before the appliance has been tipped through an angle of 10 degrees, the tipping is to be continued until the surface or plane of the surface of the appliance originally in contact with the horizontal supporting surface is at an angle of 10 degrees from the horizontal supporting surface.

35.5 An appliance not intended to move from its de-energized position to perform its intended function that, when operated, moves from its de-energized position shall be provided with an anchoring means.

36 Marking

36.1 An appliance or a separately packaged attachment having a hidden or unexpected risk of injury to persons shall be marked to inform the user of the risk.

36.1 revised January 18, 1996

36.2 A cautionary marking shall be permanent and legible and shall be located on a permanent part of the appliance. See Section 52, Permanence of Marking Test.

36.3 A cautionary marking intended to instruct the operator shall be legible and visible from the position normally assumed by the operator when starting the appliance or from the position normally assumed for the specific operation involved. Other such markings for servicing or making settings and adjustments shall be legible and visible to the individual when such work is being accomplished.

36.4 A marking intended to inform the user of a risk of injury to persons shall be prefixed by a signal word "CAUTION," "WARNING," or "DANGER." The marking shall be in letters not less than 3/32 inches (2.4 mm) high. The signal word shall be more prominent than any other required marking on the appliance.

36.5 If, when energized, an appliance has a moving part that may cause injury to persons, a switch that controls the motor that drives the part shall have a plainly marked off position.

Exception: A momentary-contact switch need not comply with this requirement.

36.6 The literature accompanying a package containing a basic appliance and attachments intended to be marketed as a complete unit shall indicate what attachments are intended for use with the basic appliance if use of such attachments may expose the user to a risk of injury.

36.7 An attachment that is packaged and marketed separately from the basic appliance and recommended by the manufacturer for use on the basic appliance shall be marked to identify the basic appliance with which it is intended to be used. The identification shall appear in at least one of the following locations:

- a) On the attachment,

- b) On the package housing the attachment,
- c) In the instruction book for the basic appliance, or
- d) In information furnished with the attachment.

36.8 An appliance having a part of an enclosure as described in the Exception to 28.2 shall be marked to indicate that such servicing is to be done with the appliance disconnected from the supply circuit.

PERFORMANCE

37 Leakage Current Test

37.1 A household or similar cord-connected appliance rated for a nominal 120-volt supply shall be tested in accordance with 37.3 – 37.7. Leakage current shall not be more than:

- a) 0.5 milliamperere for an ungrounded 2-wire appliance,
- b) 0.5 milliamperere for a grounded 3-wire portable appliance, and
- c) 0.75 milliamperere for a grounded 3-wire appliance;
 - 1) Employing a standard attachment plug rated 20 amperes or less, and
 - 2) Intended to be fastened in place or located in a dedicated space.

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

37.3 All exposed conductive surfaces are to be tested for leakage currents. If simultaneously accessible, the leakage currents from exposed conductive surfaces are to be measured to the grounded supply conductor individually as well as collectively, and from one surface to another. A part is considered to be an exposed surface unless guarded by an enclosure that complies with the requirements in Accessibility of Uninsulated Live Parts and Film-Coated Wire, Section 11. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that do not present a risk of electric shock.

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

37.5 The measurement circuit for leakage current is to be as illustrated in Figure 35.1. The measurement instrument is defined in items (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 microfarad.
- b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor.

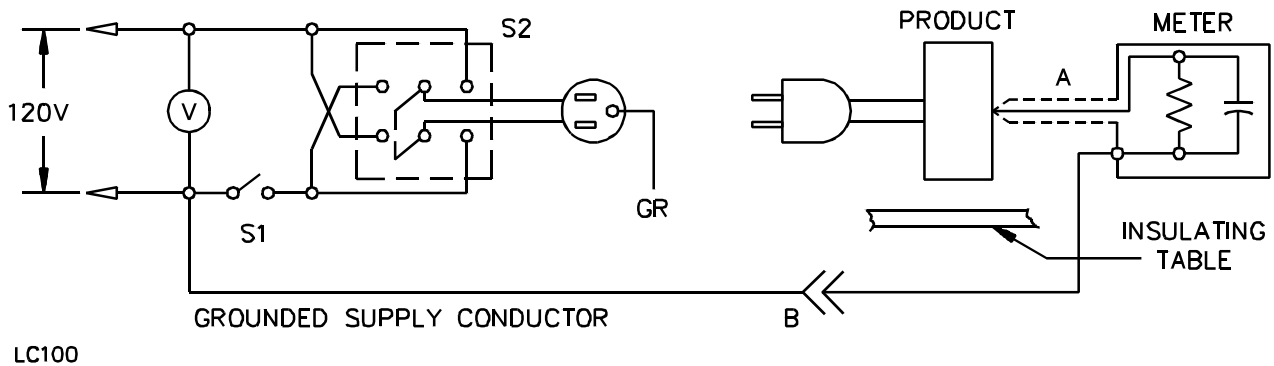
c) Over a frequency range of 0 – 100 kilohertz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 or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

37.6 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 an appliance.

37.7 A sample of the appliance is to be tested for leakage current starting with the as-received condition but with its grounding conductor, if any, open at the attachment plug. The as-received condition being without prior energization except as may occur as part of the production-line testing. The supply voltage is to be adjusted to 120 volts. The test sequence, with reference to the measuring circuit – Figure 37.1 – is to be as follows:

- a) With switch S1 open, the appliance is to be connected to the measuring circuit. Leakage current is to be measured using both positions of switch S2, and with the appliance switching devices in all their normal operating positions.
- b) Switch S1 is then to be closed energizing the appliance, and within 5 seconds, the leakage current is to be measured using both positions of switch S2 with the appliance switching devices in all their normal 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 normal temperature test.

Figure 37.1
Leakage-current measurement circuit



NOTES –

A: Probe with shielded lead.

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

Figure 37.1 revised July 2, 1998

37.8 Normally, the complete leakage current test program as covered by 37.7 is to be conducted without interruption for other tests. However, with the concurrence of those concerned, the leakage current tests may be interrupted for the purpose of conducting other nondestructive tests.

38 Leakage Current Test Following Humidity Conditioning

38.1 An appliance as described in 37.1 shall comply with the requirements for leakage current in 37.1 following exposure for 48 hours to air having a relative humidity of 88 ± 2 percent at a temperature of 32 ± 2 EC (90 ± 4 EF).

38.2 A sample of the appliance is to be heated to a temperature just above 34EC (93EF) 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 38.1. Following the conditioning and while still in the chamber, the sample is to be tested unenergized as described in 37.7(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 37.7(b) and (c). The test is to be discontinued when the leakage current stabilizes or decreases.

39 Starting Current Test

39.1 An appliance shall start and operate normally on a circuit protected by an ordinary – not time-delay – fuse having a current rating corresponding to that of the branch circuit to which the appliance should be connected. The performance is unacceptable if the fuse opens or an overload protector provided as part of the appliance trips.

Exception: The requirement concerning an ordinary fuse does not apply if:

- a) The construction of the appliance or the nature of its usage is such that it is likely to be used continually on the same branch circuit after installation,*
- b) The appliance will start and operate normally on a circuit protected by a time-delay fuse,*
- c) The appliance is marked in accordance with 56.1.8,*
- d) A household appliance would normally be used on a 15- or 20-ampere branch circuit, provided that the appliance starts and operates normally on a circuit protected by a time-delay fuse having an ampere rating corresponding to that of the branch circuit on which the appliance would normally be used.*

39.2 The appliance is to be started three times 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 appliance – and the motor is to be allowed to come to rest between successive starts.

40 Input Test

40.1 The current or wattage input to an appliance shall not be more than 110 percent of the rated value when the appliance is operated under the condition of maximum normal load as described in 41.2.1.1 – 41.2.4.1 as applicable and when connected to a supply circuit of maximum rated voltage and rated frequency.

40.2 For an appliance having a single voltage rating, such as 115 volts, maximum rated voltage is considered to be that single value of voltage. If the rating is given in terms of a range of voltages, such as 110 – 120 volts, maximum rated voltage is considered to be the highest value of the range.

41 Temperature Tests

41.1 General

41.1.1 An appliance shall be tested as described in 41.2.1.1 – 41.2.4.1 and shall not reach a temperature at any point high enough to cause a risk of fire, to damage any materials in the appliance, or to exceed the temperature rises specified in Table 41.1.

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

41.1.3 All values of temperature rise in Table 39.1 are based on an assumed ambient temperature of 25EC (77EF). Tests may be conducted at any ambient temperature within the range of 10 – 40EC (50 – 104EF).

41.1.4 For the temperature test, the voltage of a direct-current supply circuit is to be 115 volts or 230 volts, and that of an alternating-current circuit is to be 120 volts or 240 volts, depending on whether the appliance has a nominal voltage rating of 115 or 230 volts.

41.1.5 An appliance having a single frequency rating is to be tested at that frequency. An appliance rated ac/dc or dc-60 hertz is to be tested on direct current or 60-hertz alternating current, whichever results in higher temperatures. An appliance rated 25 – 60 hertz or 50 – 60 hertz is to be tested on 60-hertz alternating current.

41.1.6 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 the like. 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 41.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor.

Table 41.1
Maximum temperature rises

Material and component parts	Degrees	
	C	F
1. Capacitors:		
Electrolytic ^a	40	72
Other types ^b	65	117
2. Fuses		
A. Class G, J, L, T, and CC		
Tube	100	180
Ferrule or blade	85	153
B. Other ^h	65	117
3. Fiber employed as electrical insulation	65	117
4. At any point within a terminal box or wiring compartment of a permanently connected appliance in which power-supply conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with 56.1.1.	35	63
5. A surface upon which an appliance may be fastened in place, and surfaces that may be adjacent to the appliance when so fastened.	65	117
6. Class A insulation system on coil windings of an a-c motor having a diameter of more than 7 inches (178 mm), of a d-c 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 A insulation systems on coil windings of an a-c 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

(Continued)

Table 41.1 (Cont'd)

Material and component parts	Degrees	
	C	F
8. Class B insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 inches, of a d-c 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 B insulation system on coil windings or an a-c motor having a diameter of 7 inches or less not including a universal motor: ^{c,d}		
A. In an open motor:		
Thermocouple or resistance method	95	171
B. In a totally enclosed motor:		
Thermocouple 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 a relay, a solenoid, and the like: ^c		
Thermocouple method	85	153
Resistance method	105	189
12. Class 130 insulation systems on vibrator coils:		
Thermocouple or resistance method	95	171
13. Phenolic composition employed as electrical insulation or as a part the deterioration of which would result in a risk of fire or electric shock. ^e	125	225
14. Rubber- or thermoplastic-insulated wire and cord. ^{e,f,g}	35	63

(Continued)

Table 41.1 (Cont'd)

Material and component parts	Degrees																								
	C	F																							
16. Sealing compound	40EC (104EF) less than melting point																								
17. Varnished-cloth insulation	60	108																							
18. Wood and other combustible material	65	117																							
19. Transformers with Class 105 insulation system:																									
Thermocouple method	65	117																							
Resistance method	75	135																							
<p>^a The temperature rise on insulating material integral with the enclosure of an electrolytic capacitor that is physically integral with or attached to a motor may be not more than 65EC (117EF).</p> <p>^b A capacitor that operates at a temperature rise of more than 65EC may be judged on the basis of its marked temperature limit.</p> <p>^c At a point on the surface of a coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be higher by the following amount than the maximum specified provided that the temperature rise of the coil, as measured by the resistance method, is not more than that specified in the table.</p> <table border="1" data-bbox="552 777 1380 1092"> <thead> <tr> <th rowspan="2">Item</th> <th colspan="2">Additional temperature rises</th> </tr> <tr> <th>EC</th> <th>EF</th> </tr> </thead> <tbody> <tr> <td>Part A of item 6</td> <td>15</td> <td>27</td> </tr> <tr> <td>Part A of item 7</td> <td>5</td> <td>9</td> </tr> <tr> <td>Part A of item 8</td> <td>20</td> <td>36</td> </tr> <tr> <td>Part A of item 9</td> <td>10</td> <td>18</td> </tr> <tr> <td>10</td> <td>15</td> <td>27</td> </tr> <tr> <td>11</td> <td>15</td> <td>27</td> </tr> </tbody> </table> <p>^d See 21.1.4.</p> <p>^e The limitations 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.</p> <p>^f Rubber-insulated conductors within a Class-A-insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35EC, 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.</p>			Item	Additional temperature rises		EC	EF	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	11	15	27
Item	Additional temperature rises																								
	EC	EF																							
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																							
11	15	27																							

(Continued)

Table 41.1 (Cont'd)

^g A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60EC (140EF), 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 a higher temperature may be used at that temperature.

41.1.7 Thermocouples are to consist of wires not larger than No. 24 AWG (0.21 mm^2) and not smaller than No. 30 AWG (0.05 mm^2). Whenever referee temperature measurements by thermocouples are necessary, thermocouples consisting of No. 30 AWG iron and constantan wire and a potentiometer-type instrument are to be used. The thermocouple wire is to conform with the requirements for special thermocouples as listed in the table of limits of error of thermocouples in Temperature-Measurement Thermocouples, ANSI MC96.1-1982.

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

41.1.9 For an appliance that is obviously not intended for continuous operation, the probable intermittent or short-time operation of the appliance is to be taken into consideration when conducting the temperature test.

41.1.10 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.

41.2 Maximum normal load

41.2.1 General

41.2.1.1 In tests on an appliance, maximum normal load is considered to be the load that approximates as closely as possible the most severe conditions of normal use. It is not a deliberate overload 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 appliance. Test loads that have been found to be close approximations of the most severe conditions of normal use are described in 41.2.2.1 – 41.2.4.1 for some common appliances. However, appliances having features not contemplated in these test procedures may be tested as necessary to meet the intent of these requirements.

41.2.2 Carbonators

41.2.2.1 A carbonator is to be operated continuously, until temperatures are constant, with maximum rated carbon dioxide gas pressure – but at not less than 125 psi (861 kPa) pressure – and maximum steady water flow. The pressure and flow may be modified if maximum input occurs at other than maximum rated gas pressure and maximum steady flow.

41.2.3 Motor-operated chairs, tables, beds, lounges, and the like

41.2.3.1 These are appliances that incorporate motors for adjustment of height, position, contour, and the like; they do not include vibrating chairs, vibrating hassocks, or other appliances in which the motors impart vibratory motions. For the temperature test, a load of 200 pounds (91 kg) is to be placed on the appliance to approximate the load that would be imposed by a human body. Nine complete cycles of adjustment of

the appliance through its complete range of motion are to be performed, without pause between cycles, except that a 5-minute period is to be interposed between the third and fourth cycle and between the sixth and seventh cycles. During the 5-minute interval the motor is to be running but with the appliance not operating, if it can be so controlled; otherwise the motor is to be de-energized. If the speed of operation of the appliance can be controlled, the test is to be performed at such speed that maximum heating will result. An appliance that is capable of more than one mode of motion is to be tested for each such motion.

41.2.4 Automobile wheel balancers

41.2.4.1 The temperature test on a wheel balancer for balancing automobile – not truck – wheels is to be conducted as follows. If the control switch on the appliance is not of the momentary-contact type, the wheel balancer is to be operated continuously at no-load until constant temperatures are attained, and then is to be subjected to 10 cycles of operation while balancing wheels, with each cycle of operation consisting of 10 seconds on, 50 seconds off, 10 seconds on, and 2 minutes 50 seconds off. A wheel balancer equipped with a momentary-contact switch is to be operated with the preliminary no-load operation omitted.

42 Surface Temperature Tests

42.1 Exterior surfaces

42.1 revised January 18, 1996

42.1.1 A cord-connected appliance of the hand-supported type shall not attain a temperature of more than 125EC (257EF) on any exterior surface that may be laid on combustible material or against which combustible material may be laid, and there shall be no emission of smoke or molten material.

42.1 relocated as 42.1.1 January 18, 1996

42.1.2 To determine whether an appliance complies with the requirement in 42.1.1, the appliance is to be operated at the voltage and frequency specified in 41.1.4 and 41.1.5 until constant temperatures are attained. The appliance may be stationary during the test, and simulation of actual service conditions need not be attempted.

42.2 relocated as 42.1.2 January 18, 1996

42.2 Contact surfaces

Added 42.2 effective January 19, 1998

42.2.1 During the temperature test, the temperature of a surface that may be contacted by a user shall not be more than the applicable value specified in Table 42.1. If the test is conducted at a room temperature of other than 25EC (77EF), the results are to be corrected to that temperature.

Added 42.2.1 effective January 19, 1998

Table 42.1
Maximum surface temperatures

Location	Composition of surface ^a			
	Metal		Nonmetallic	
Handles or knobs that are grasped for lifting, carrying, or holding	50EC	(122EF)	60EC	(140EF)
Handles or knobs that are contacted but do not involve lifting, carrying, or holding	60EC	(140EF)	85EC	(185EF)
Surfaces subjected to contact during operation or user maintenance	60EC	(140EF)	85EC	(185EF)

^a A handle, knob, or the like, made of a 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, and is investigated as, a nonmetallic part.

Added Table 42.1 effective January 19, 1998

43 Dielectric Voltage-Withstand Test

43.1 An appliance shall withstand for 1 minute without breakdown the application of a 60-hertz essentially sinusoidal potential between live parts and dead metal parts with the appliance at the maximum operating temperature reached in normal use. The test potential for the primary circuit shall be:

- a) One-thousand volts for an appliance employing a motor rated 1/2 horsepower (373 W output) or less and 250 volts or less.
- b) One-thousand volts plus twice the rated voltage for:
 - 1) An appliance employing a motor rated more than 1/2 horsepower or more than 250 volts, or
 - 2) An appliance applied directly to persons – see item (c).
- c) Twenty-five hundred volts for an appliance that is applied in a wet or moist condition directly to persons.

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

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

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- b) One-thousand volts if the secondary operates at 51 – 250 volts.
- c) Five-hundred volts if the secondary operates at 50 volts or less.

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

43.3 A capacitor used for radio-interference elimination or arc suppression shall withstand for 1 minute without breakdown the application of a 60-hertz essentially sinusoidal potential between live parts of opposite polarity with the appliance at the maximum operating temperature reached in normal use. The test potential shall be:

- a) One-thousand volts for an appliance employing a motor rated 1/2 horsepower (373 W output) or less and 250 volts or less.
- b) One-thousand volts plus twice the rated voltage for:
 - 1) An appliance employing a motor rated more than 1/2 horsepower or more than 250 volts, or
 - 2) An appliance applied directly to persons.

43.4 To determine whether an appliance complies with the requirements in 43.1 – 43.3, the appliance is to be tested by means of a 500 volt-ampere 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.

43.5 With reference to the requirement in 43.4, a 500 volt-ampere or larger capacity transformer need not be used if the transformer is provided with a voltmeter to measure directly the applied output potential.

44 Continuous Operation Test

44.1 When a combination appliance not provided with a momentary contact switch is tested as described in 44.2:

- a) Neither the cheesecloth nor the tissue paper shall ignite, and
- b) The 3-ampere grounding fuse shall not open.

44.2 The appliance is to be:

- a) Placed on a white tissue paper covered softwood surface,
- b) Connected to a 120-volt or 240-volt, as applicable, 60-hertz supply circuit in series with a 20-ampere time-delay plug fuse,
- c) Draped with a double layer of cheesecloth over the whole appliance with the cloth within 1/8 inch (3.2 mm) of each opening in the enclosure, and
- d) Grounded by means of a 3-ampere nontime-delay plug fuse connected between exposed metal parts and earth ground.

The appliance is to operate continuously at no load until temperatures stabilize or burnout occurs.

45 Resistance-to-Moisture Test

45.1 General

45.1.1 A gum massager and a toothbrush shall be subjected to the exposure described in 45.1.3. Following exposure, the appliance shall comply with the requirement:

- a) In 37.1 in a repeated leakage current test, except that the test shall be discontinued when the leakage current stabilizes.
- b) In 43.1 in a repeated dielectric voltage-withstand test.

45.1.2 In addition to the requirements in 45.1.1, the test described in 45.1.3 shall not result in the entrance of water into the interior of the appliance in such a manner that it might come into contact with uninsulated live parts or film-coated wire.

45.1.3 Each of three samples of a toothbrush or gum massager is to be connected to a supply circuit as described in 41.1.4 and 41.1.5, and operated through repeated cycles of 5 minutes off and 5 minutes on for 7 hours. Following the last on period, and while still connected to the supply circuit, each sample is to be subjected to three 30-second immersions in a solution containing 1/2 gram of common table salt per liter of distilled water. The interval between immersions is to be 30 seconds. During the immersions, the sample is to be oriented to facilitate the entrance of water into the enclosure. During the intervals between immersions, the sample is to be oriented for minimum drainage. Immediately following the third immersion, the sample is to be disconnected from the supply circuit and wrapped in metal foil. The foil is to be in intimate contact with the enclosure and with all exposed metal parts, if any, during the tests required by 45.1.1. Following these tests, the samples are to be disassembled and the interior examined for the presence of water.

45.2 Flooding of live parts

45.2.1 The malfunction of a timer switch or of a float- or pressure-operated switch, or the deterioration or damage of a boot or diaphragm of rubber or similar material shall not cause flooding of the electrical components of an appliance that employs water or other electrically conductive liquid in its operation.

45.2.2 In a test to determine whether an appliance complies with the requirements in 45.2.1 with respect to deterioration or damage of a boot or diaphragm due to flexing, such component is to be removed completely and the appliance operated through one complete cycle of normal operation. If flexing is not present, but if a rubber part is subjected to hot soapy water, the material is to be investigated to determine if deterioration or damage of the part would create a risk of fire or electric shock. This investigation is to include consideration of the effects of heat, air pressure, soap solutions, and other factors contributing to the aging.

45.2.3 Infrequent motion of small amplitude, such as that experienced during normal operation by a diaphragm covering a pressure-sensitive switch, is not considered to constitute flexing.

46 Tests on Switches and Controls

46.1 A switch or other device that controls a motor of an appliance, a solenoid, a relay coil, or the like shall perform acceptably when subjected to an overload test consisting of 50 cycles of operation as described in 46.2 – 46.4 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: This requirement does not apply to a device known to be acceptable for the application.

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

46.2 Exposed dead metal parts of the appliance are to be connected to ground through a 3-ampere plug fuse, and the appliance 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.

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

46.4 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 appliance is to be connected to a supply circuit of maximum rated voltage. See 41.1.4. 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 appliance is intended for use on direct current, or on direct current as well as alternating current, the exposed dead metal parts of the appliance are to be connected so as to be positive with respect to a single-pole, current-interrupting control device.

47 Strain-Relief Test

47.1 The strain relief means provided on an attached flexible cord, when tested in accordance with 47.2, shall withstand for 1 minute without displacement a direct pull of 35 pounds (156 N) applied to the cord, with the connections within the appliance disconnected.

Exception: The pull applied to a Type TP or TPT cord is to be 20 pounds (89 N).

47.2 A 35- or 20-pound (15.9- or 9.1-kg) weight, as applicable, is to be suspended on the cord and supported by the appliance so that the strain-relief means will be stressed from any angle that the construction of the appliance 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.

48 Abnormal Operation Test

48.1 Short-circuiting either the rectifier or the capacitor of a combination consisting of a rectifier and an electrolytic capacitor shall not create a risk of fire, electric shock, or injury to persons.

49 Radiation Test

49.1 An appliance that produces radiation, such as X-rays, microwaves, ultrasonic sound, laser, ultraviolet, or infrared light, shall be investigated with respect to the effects of the radiation on users and service personnel.

50 Ozone Test

50.1 An appliance that produces ozone during normal operation shall not produce an average time weighted concentration above background in excess of 0.1 part per million, nor a transitory concentration of more than 0.3 part per million when tested as described in 50.3 – 50.6.

50.2 With reference to the requirement in 50.1, the normal functioning of electrical contact points is not considered to be capable of generating an unacceptable concentration of ozone.

50.3 Ozone concentration is to be measured at all operating positions while the appliance is located in the center of a closed room of 1000 cubic feet (28.3 m³), approximately 8 by 12 by 10 feet (2.4 by 3.7 by 3.0 m). All test room walls are to be covered with sheet polyethylene.

50.4 The room is to be maintained at a temperature of approximately 25EC (77EF) and a relative humidity of 50 percent. Prior to and immediately after the test, the ozone background level is to be measured with the appliance off. The background level average is to be calculated and subtracted from the maximum measurement during the test.

50.5 During the test, the appliance is to be operated in the same manner and for the length of time specified as for the temperature test described in Section 41. The average time weighted concentration is to be considered as the average concentration of ozone extrapolated for an 8-hour operating period.

50.6 If the appliance can be operated with any of its fans, heaters, or the like not functioning, with replaceable charges, filters, or the like removed, or with paper, fluid, or the like exhausted, the test described in 50.3 – 50.5 is to be repeated a sufficient number of times with the various components not operating or with the items removed or exhausted to determine that these conditions do not result in ozone emission exceeding that specified in 50.1.

51 Operational Test

51.1 Operation, as described in 51.2, of an appliance intended for household use shall not increase the risk of fire, electric shock, or injury to persons.

51.2 An as-received sample of the appliance is to be set up or installed in accordance with the manufacturer's instructions. The sample is to be operated in accordance with the manufacturer's instructions with respect to the intended uses of the appliance, including maintenance and cleaning recommended by the manufacturer and lack of such maintenance and cleaning; and with all accessories recommended by the manufacturer for use with the appliance. The appliance is to be manipulated as it would be in actual use, including manipulation of all controls and operation under the various loading conditions that can be expected. The appliance is to be operated for a sufficient length of time or through a sufficient number of cycles to determine that all reasonably foreseeable complications are revealed.

52 Permanence of Marking Test

52.1 A marking that is required to be permanent shall be molded, die-stamped, paint-stenciled, stamped or etched metal that is permanently secured, or indelibly stamped lettering on a pressure-sensitive label secured by adhesive that, upon investigation, is found to be acceptable for the application. Ordinary usage, handling, storage, and the like of a product are considered in the determination of the permanence of a marking.

52.2 Unless it has been investigated and found to be acceptable for the application, a pressure-sensitive label or a label that is secured by cement or adhesive and that is required to be permanent shall comply with the applicable requirements in the Standard for Marking and Labeling Systems, UL 969.

MANUFACTURING AND PRODUCTION TESTS

53 Dielectric Voltage-Withstand Test

53.1 Each appliance shall withstand without electrical breakdown, as a routine production-line test, the application of a 40 – 70 hertz potential between the primary wiring, including connected components:

- a) Accessible dead metal parts that are likely to become energized, and
- b) Accessible low-voltage metal parts, including terminals.

53.2 The production-line test shall be in accordance with either Condition A or Condition B of Table 53.1.

**Table 53.1
Production-line test conditions**

Appliance rating or application	Condition A		Condition B	
	Potential, volts	Time, seconds	Potential, volts	Time, seconds
250 volts or less with or without a motor rated 1/2 horsepower (373 W output) or less	1000	60	1200	1
Applied directly to persons	$1000 + 2V^a$	60	$1200 + 2.4V^a$	1
Rated more than 250 volts with a motor rated more than 1/2 horsepower	$1000 + 2V^a$	60	$1200 + 2.4V^a$	1
Applied in a wet or moist condition directly to persons	2500	60	3000	1
^a Maximum rated voltage.				

53.3 The appliance may be in a heated or unheated condition for the test.

53.4 The test is to be conducted when the appliance is complete – fully assembled – and with the primary switch in the on position. It is not intended that the appliance be unwired, modified, or disassembled for the test.

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

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

Exception No. 3: The test may be conducted before a solid-state component that can be damaged by the dielectric potential is electrically connected. However, a random sampling of each day's production is to be tested at the potential specified in 53.2, and the circuitry may be rearranged for the test to minimize the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

53.5 The test equipment shall include a transformer having an essentially sinusoidal output, a means of indicating the test potential, an audible or visual indicator of electrical breakdown, and either a manually reset device to restore the equipment after electrical breakdown or an automatic reject feature of any unacceptable unit.

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

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

- a) A voltmeter in the primary circuit or in a tertiary winding circuit,
- b) A selector switch marked to indicate the test potential, or
- c) A marking in a readily visible location to indicate the test potential of equipment having a single test potential output. If marking is used without an indicating voltmeter, the equipment shall include a positive means, such as a power-on lamp to indicate that the manually reset switch has been reset following a tripout.

53.8 Test equipment other than that described in 53.5 – 53.7 may be used if found to accomplish the intended factory control.

53.9 During the test, both sides of the primary circuit of the appliance are to be connected together to one terminal of the test equipment; the second test equipment terminal is to be connected to the accessible dead metal.

Exception No. 1: This requirement does not apply to a resistive-type appliance.

Exception No. 2: This requirement does not apply to an appliance utilizing a motor, relay, coil, or transformer having circuitry not subject to excessive secondary voltage buildup in case of electrical breakdown during the test.

54 Grounding Continuity Test

54.1 Each appliance that has a power-supply cord having a grounding conductor shall be tested, as a routine production-line test, to determine that grounding continuity exists between the grounding blade of the attachment plug and the accessible dead metal parts of the appliance that are likely to become energized.

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

54.3 Any indicating device, such as an ohmmeter, a battery-and-buzzer combination, or the like, may be used to determine compliance with the grounding continuity requirement in 54.1.

RATING

55 Details

55.1 An appliance shall be rated in volts, in frequency – expressed in one of the following terms: hertz, Hz, cycles-per-second, cps, cycles/second, c/s, ac-dc, or ac only and, other than as noted in 55.2, in amperes. The frequency may be expressed as ____/dc – for example, 60/dc – if a universal motor nameplate serves as the appliance rating marking. If an appliance is intended for use on a polyphase circuit, the number of phases shall be included in the rating.

55.2 Instead of the ampere rating mentioned in 55.1, an appliance may be rated in watts if the full-load power factor is 0.80 or more or if the rating of a cord-connected appliance is 50 watts or less.

MARKING

56 Details

56.1 General

56.1.1 An appliance shall be plainly and permanently marked where it will be readily visible – after installation, in the case of a permanently connected appliance – with:

- a) The manufacturer's name, trade name, or trademark, or other descriptive marking by which the organization responsible for the product may be identified,
- b) A distinctive catalog number or the equivalent,
- c) The electrical rating, and
- d) The date or other dating period of manufacture not exceeding any three consecutive months.

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

Exception No. 2: The date of manufacture may be abbreviated; or may be in a nationally accepted conventional code or in a code affirmed by the manufacturer, provided that the code does not:

- a) Repeat in less than 10 years for a household product and less than 20 years for a commercial product, and*
- b) Require reference to the production records of the manufacturer to determine when the product was manufactured.*

56.1.2 An appliance that employs a single motor as its only electrical-energy-consuming component need not show the electrical rating given on the motor nameplate elsewhere on the appliance if this nameplate is readily visible after the motor has been installed in the appliance.

56.1.3 If the motor nameplate of a dual-voltage motor is employed to give the electrical rating of the appliance as specified in 56.1.2, the appliance shall be additionally and permanently marked to indicate the particular voltage for which it is connected when shipped from the factory. If the appliance employs an attachment plug, instructions shall be provided to indicate the type of plug that should be used if the appliance is reconnected for the alternate voltage.

56.1.4 If a manufacturer produces or assembles motor-operated appliances at more than one factory, each finished appliance shall have a distinctive permanent marking by means of which it may be identified as the product of a particular factory.

56.1.5 An appliance having provisions for two or more separate connections to a branch circuit or other power-supply source shall be permanently marked with the word "CAUTION" and the following or the equivalent: "This appliance has more than one connection to the source of supply. To reduce the risk of electrical shock, disconnect all such connections before servicing." The marking shall be located at each point of connection, and shall be readily visible after installation of the appliance.

56.1.6 If the design of an appliance contemplates cleaning or servicing, such as the replacement of pilot lamps or fuses, by the user, and if such cleaning or servicing would involve the exposure of a normally enclosed or protected live part to unintentional contact, the appliance shall be plainly and permanently marked to indicate that such servicing or cleaning be done with the appliance disconnected from the supply circuit.

56.1.7 An appliance that is intended for installation in a garage or the like and that incorporates arcing or sparking parts shall be permanently marked with the following statement: "This equipment incorporates parts, such as snap switches, receptacles, and the like that tend to produce arcs or sparks and, therefore, when located in a garage, it should be in a room or enclosure provided for the purpose, or should be 18 inches (457 mm) or more above the floor."

56.1.8 An appliance that will not start and attain normal running speed when connected to a circuit protected by an ordinary – not a time-delay – fuse as described in 39.1 shall be plainly and permanently marked with the words: "If connected to a circuit protected by fuses, use time-delay fuses with this appliance," or with equivalent wording.

56.1.9 An appliance shall not be marked with a double insulation symbol – a square within a square – the words "Double Insulation," or the equivalent unless it complies with the requirements for double-insulated appliances.

56.2 Permanently connected appliances

56.2.1 If any point within a terminal box or wiring compartment of a permanently connected appliance in which the power-supply conductors are intended to be connected, including such conductors themselves, attains a temperature rise of more than 35EC (63EF) during the normal temperature test, the appliance shall be permanently marked: "For supply connection, use wires acceptable for at least ...EC (...EF)," or with an equivalent statement, and the temperature value shall be in accordance with Table 56.1. This statement shall be located at or near the point where the supply connections are to be made, and shall be clearly visible both during and after installation of the appliance.

Table 56.1
Outlet-box marking

Temperature rise attained during test in terminal box or compartment	Temperature marking
36–50EC (64 – 90EF)	75EC (167EF)
51–65EC (91 – 117EF)	90EC (194EF)

56.2.2 A permanently connected appliance having one motor and other loads or more than one motor with or without other loads shall be permanently marked in a location that will be visible when connections to the power-supply circuit are made and inspected with:

- a) The minimum supply-circuit conductor ampacity based on the maximum input in accordance with 40.1;
- b) The maximum rating of the supply-circuit overcurrent-protective device, which is not to exceed the rating of the fuse employed in the short-circuit test of the motor-overload-protective device employed in the appliance; and
- c) The type of supply-circuit overcurrent-protective device – for example, nontime delay fuse or dual-element time-delay fuse.

56.2.3 An appliance intended for permanent connection to a wiring system other than rigid metal conduit or armored cable shall be permanently marked to indicate the system or systems for which it is acceptable. The marking shall be located so that it will be visible when power-supply connections to the appliance are being made.

56.3 Cord-connected appliances

56.3.1 A cord-connected appliance that employs a motor rated more than 1/3 horsepower (250 W output) and in which the manually operated motor-control switch required by 24.4 would be inaccessible shall be permanently marked with the words: "An acceptable motor control switch shall be provided at the time of installation."

56.3.2 If an appliance is provided with a power-supply cord less than 18 inches (457 mm) long or with a motor-attachment plug in accordance with Exception No. 3 of 12.1.2.7, a statement advising of the availability of extension cords and the importance of using one of these cords shall be marked on the appliance, or shall be included in the instruction book or other literature regularly furnished with the appliance.

56.3.3 An appliance provided with a 2-blade, polarized attachment plug shall be provided with the following instructions or the equivalent: To reduce the risk of electric shock, this appliance has a polarized plug (one blade is wider than the other). This plug will fit in a polarized outlet only one way. If the plug does not fit fully in the outlet, reverse the plug. If it still does not fit, contact a qualified electrician to install the proper outlet. Do not change the plug in any way.

56.3.3 effective June 3, 1993

56.4 Carbonators

56.4.1 A carbonator shall be permanently marked to show the maximum pressure with which it is intended to be used.

56.4.2 A cord-connected carbonator shall be provided with installation instructions that:

- a) Specify the need for a grounding receptacle for connection to the supply and stress the importance of proper grounding,
- b) Inform the installer that permanent wiring is to be employed if required by local codes, and
- c) Provide instructions for conversion to permanent wiring.

56.5 Plumbing accessories

56.5.1 A plumbing accessory that has been evaluated for outdoor use shall be permanently marked "For Outdoor Use," or the equivalent.

56.6 Insect-exterminating appliances

56.6.1 An insect-exterminating appliance shall be permanently marked with the following: "CAUTION – When a flammable liquid is sprayed, there may be danger of fire or explosion, especially in a closed room."

56.7 Components

56.7.1 A heating element rated more than 1 ampere and intended to be replaceable in the field shall be permanently marked with its rating in volts and amperes or in volts and watts, or the manufacturer's part number, or other means of identification.

56.7.2 An appliance that is designed to be controlled by or operated in conjunction with a capacitor or a capacitor/transformer unit shall be supplied with such capacitor or unit. A capacitor or a unit that is not physically a part of the appliance shall be permanently marked with an identification symbol. This symbol shall also appear on the nameplate of the motor.

56.8 Venting

56.8.1 If exhaust air must be vented for proper operation of an appliance, explicit instructions shall be provided specifying:

- a) How the appliance should be vented; and
- b) That the exhaust air should not be vented into a wall, a ceiling, or a concealed space of a building.

56.8.2 With reference to the requirement in 56.8.1, the instructions may be included in an installation-instruction book, or marked on the appliance in a location that will be visible when the exhaust system is being installed.

56.8.3 An appliance that includes an isolated ground receptacle shall be permanently marked in a location that will be visible to the installing electrician at the field wiring connection compartment with the following or the equivalent: "Notice – This appliance has an isolated ground receptacle. Provide a separate ground for the receptacle in addition to the equipment ground."

56.8.3 effective June 3, 1993

PROTECTION FROM CONTAMINATION

57 Scope

57.1 Sections 58 – 60 cover requirements to avoid contamination of carbonated beverages by copper salts.

58 Construction

58.1 The carbonator tank or other vessels or tubing that may contain carbonated water shall not be made of copper-bearing materials.

58.2 To reduce the risk of backflow of carbonated water into the water line, the point of connection of the water supply shall be provided with:

- a) A double check valve,
- b) Two single check valves, or
- c) A single check valve together with a device in the input line to vent carbon dioxide to the atmosphere.

58.3 A water input connection that is not provided with a carbon dioxide vent device shall be provided with a screen of not less than 100 mesh to the square inch in the water supply connection immediately ahead of the check valves to reduce the possibility of fouling the valves. The screen shall be removable for cleaning or replacement.

58.4 If the reliability of a check valve has not previously been determined, it shall be subjected to the test described in Section 59, Performance.

59 Performance

59.1 A check valve shall not leak when subjected to a reverse pressure of:

- a) 15 – 20 psi (120±18 kPa) minimum, and
- b) 200 psi (1.38 MPa) maximum.

59.2 Three samples of the valves are to be subjected to a reverse hydrostatic pressure. The valves shall effectively close at a pressure between 15 and 20 psi (102 and 138 kPa) and shall withstand a pressure of 200 psi (1.38 MPa) for 1 hour without leaking enough water to wet paper located beneath the valve assembly.

60 Marking

60.1 A carbonator shall be marked at a point close to the output connection with the word "WARNING" and the following or the equivalent: "To avoid contamination of potable liquids, do not connect copper tubing or fittings between this point and points of delivery." The word "WARNING" shall be in letters at least 1/4 inch (6.4 mm) high and the rest of the letters in the marking at least 1/8 inch (3.2 mm) high. The entire marking shall be durable and permanent.

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APPENDIX A**Standards for Components**

Standards under which components of the products covered by this standard are evaluated include the following:

Title of Standard – UL Standard Designation

Attachment Plugs and Receptacles – UL 498
Cord Sets and Power-Supply Cords – UL 817
Determination of Sharpness of Edges on Equipment – UL 1439
Double Insulation Systems for Use in Electrical Equipment – UL 1097
Fans, Electric – UL 507
Fuseholders – UL 512
Fuses for Supplementary Overcurrent Protection – UL 198G
Lampholders, Edison-Base – UL 496
Marking and Labeling Systems – UL 969
Motors, Electric – UL 1004
Motors, Overheating Protection for – UL 2111
Plastic Materials for Parts in Devices and Appliances – Tests for Flammability of – UL 94
Printed-Wiring Boards – UL 796
Switches, Clock-Operated – UL 917
Switches, General-Use Snap – UL 20
Switches, Special-Use – UL 1054
Tape, Electrical Insulating – UL 510
Temperature-Indicating and -Regulating Equipment – UL 873
Thermal Cutoffs for Use in Electrical Appliances and Components – UL 1020
Wire Connectors and Soldering Lugs for Use with Copper Conductors – UL 486A
Wire Connectors for Use with Aluminum Conductors – UL 486B
Wire, Flexible Cord and Fixture – UL 62
Wires and Cables, Rubber-Insulated – UL 44
Wires and Cables, Thermoplastic-Insulated – UL 83

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