UL 1450

STANDARD FOR SAFETY

Motor-Operated Air Compressors, Vacuum Pumps, and Painting Equipment

UL Standard for Safety for Motor-Operated Air Compressors, Vacuum Pumps, and Painting Equipment, UL 1450

Fourth Edition, Dated May 5, 2010

Summary of Topics

The revisions to ANSI/UL 1450 dated May 27, 2021 include the following changes in requirements:

– Revision of Cord Tag Requirements; 56.2

– Update of Standard Reference For Ultraviolet Light Test; SA10.9.1 and SA10.9.2

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

The revised requirements are substantially in accordance with Proposal(s) on this subject dated April 9, 2021.

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

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INTRODUCTION

1 Scope

1.1 These requirements cover household and commercial air compressors, vacuum pumps, inflators (both compressor-type and blower-type inflators), paint sprayers, paint mixers, and paint pigment dispensers intended for indoor or outdoor use or both in accordance with the National Electrical Code, ANSI/NFPA 70. These requirements also cover motor-operated air compressors intended for use with sprinkler systems in accordance with the Standard for Installation of Sprinkler Systems, NFPA 13, and the National Electrical Code, ANSI/NFPA 70.

1.2 These requirements do not cover products:

a) Rated more than 600 V,

b) Employing a universal motor rated more than 250 V, or

c) Intended for installation and use in a hazardous location.

1.3 These requirements do not cover medical and dental products; products intended to be used in heating, air conditioning, or refrigeration systems; paint heaters; electrostatic paint spraying products; or other products covered by separate requirements.

1.4 These requirements do not cover pneumatic tools and accessories that are covered by the Outline for Investigation for Portable Pneumatic Tools, Subject 7700-1.

1.5 These requirements do not cover industrial compressors that are primarily supplied to an individual customer specification with regard to pressure, flow, electrical supply, or optional equipment.

2 Glossary

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

2.2 AUTOMATICALLY CONTROLLED PRODUCT – A product is considered to be automatically controlled under any one or more of the following conditions if:

a) The repeated starting of the product, 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 product, the initial starting of the motor may be intentionally delayed beyond normal, conventional starting.

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 EQUIPMENT, FIXED – Equipment that is intended for permanent connection to the electrical supply. This type of equipment may be physically secured to the supporting surface.

2.4 EQUIPMENT, MOVABLE – Cord-connected equipment that is intended to be moved from location to location during and in between performing its intended function. This type of equipment is not supported by the user, but supported by the ground or by other supporting surface during use.

2.5 EQUIPMENT, STATIONARY – Equipment that is cord-connected, but is not required to be moved from its original location during or in between performing its intended function.

2.6 FLASH POINT – The minimum temperature of a liquid at which vapor is evolved in sufficient quantity to form a flammable mixture with the air near the surface of the liquid or within the test vessel.

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

2.8 HAND-HELD HIGH-PRESSURE PAINT SPRAYER – A movable spraying system intended to be held in the hand during normal use that consists of a paint reservoir integral to the spray gun and pump assembly that operates at a pressure of 360 psi (2482 kPa) or greater at the spray tip.

2.9 HAND-SUPPORTED PRODUCT – A product that is physically supported by any part of the body of the user during the performance of its intended electrically-operated functions, such as a portable paint sprayer with an integral motor.

2.10 HIGH-PRESSURE AIRLESS PAINT SPRAYER – A spraying system employing a separate high-pressure liquid pump assembly connected by a high-pressure liquid hose to a spray gun that operates at a pressure of 360 psi (2482 kPa) or greater.

2.11 HIGH-PRESSURE PAINT SPRAYING PRODUCT – A term that applies to both a hand-held high-pressure paint sprayer and a high-pressure airless paint sprayer.

2.12 HOUSEHOLD-USE PRODUCT – A product that complies with Household Type Products, Section 64.4, and has an instruction manual that complies with 66.6.

2.13 INDOOR-USE PRODUCT – A product marked in accordance with 65.14 that is intended to be used in an indoor location and where wet contact is not likely to occur.

2.14 INFLATOR – A type of device that falls under one of the following two categories:

a) Blower-Type Inflator – An inflator product where the primary method to provide the inflation function is to generate air movement by rotation of an impeller or blade configuration in order to blow air out of the inflator outlet and into the inflatable product. These types are used to inflate low pressure objects, such as air mattresses and pool toys, and they do not contain any type of pressurized vessel.

b) Compressor-Type Inflator – An inflator product where the primary method to provide the inflation function is to compress air in order to cause air movement through pressure differentials, thereby forcing air from the inflator outlet into the inflatable product. These types are used to inflate objects such as automobile tires and may or may not contain a pressurized vessel.

2.15 LINEAR COMPRESS OR VACUUM PUMP – A nontank type compressor or vacuum pump that employs a diaphragm pump actuated by a moving member located between two coil assemblies rather than a standard motor operated piston, for example, style pump.

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

2.17 LOWER FLAMMABLE LIMIT (LFL) – The minimum concentration of a gas in air that, if ignited, will propagate flame throughout the gas-air mixture independently of continued application of the source of ignition; expressed as a percent by volume of gas in air.

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

2.18.1 LOW-VOLTAGE, LIMITED-ENERGY CIRCUIT – A circuit involving a potential of not more than 42.4 volts peak or 60 V dc with limited energy as described in Low Voltage Limited Energy Circuits, Section 27B.

2.19 OCCASIONAL OUTDOOR-USE PRODUCT – A product that is able to be used outdoors and be stored within a garage. These products are not intended to be exposed to rain and are marked in accordance with 65.13.

2.20 OUTDOOR-USE PRODUCT – A product that is intended for use in locations exposed to weather including partially protected locations under canopies, roofed open porches, barns, and similar locations that may be damp or wet.

2.20.1 PORTABLE PRODUCT – A product that is easily carried or moved from one place to another in normal use.

2.21 REMOTELY CONTROLLED PRODUCT – A product 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 a product 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 products covered by this standard.

3.2 A component is not required to comply with a specific requirement that:

a) Involves a feature or characteristic not required in the application of the component in the product 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 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 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

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.

6 Attachments

6.1 *Deleted November 1, 2013*

7 Instructions Provided with the Product

7.1 A copy of the operating, user-maintenance, and other instructions intended to accompany a product as produced shall be used as a guide in the examination and test of the product. For this purpose, a final printed copy is not required.

7.2 The instructions shall include such directions and information as deemed by the organization responsible for the product to be necessary to cover the operation, intended use, and maintenance of the product, and shall comply with the requirements for instruction manuals in Sections 66 – 70.

7.3 A tank-type compressor that does not employ a pressure vessel marked with the code "U" or "UM" of the American Society of Mechanical Engineers (ASME) shall comply with the requirements in 66.7.

CONSTRUCTION

8 General

8.1 A product shall employ materials found by investigation to be acceptable for the intended application.

8.2 An air compressor categorized as household use only in accordance with 2.12 shall not be rated more than 3 hp (2.25 kW output) or more than 150 psi (1034 kPa) and shall comply with 66.7.

8.3 A motor-operated air compressor intended for use with sprinkler systems shall be provided with a means to be permanently connected to a wiring system.

8.4 A nitrogen generator that is intended to remove oxygen from air within an enclosure, such as a control panel, a means shall be provided to prevent the creation of an enriched oxygen concentration within the enclosure such as the use of a ventilation fan or external discharge port.

9 Enclosure

9.1 A product 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 resulting in a 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 defects.

9.2 Cast and sheet-metal portions of an enclosure shall not be thinner than the applicable values specified in Table 9.1.

Exception No. 1: An enclosure investigated and judged acceptable with respect to the factors mentioned in 9.3 and any additional requirements applicable to the product under investigation.

Exception No. 2: For blower-type inflators, a small area or surface that is curved or otherwise reinforced to provide equivalent mechanical strength is not required to comply with the specifications in the first column of thicknesses in Table 9.1.

9.3 Among the factors that shall be considered when judging the acceptability of a nonmetallic enclosure or an enclosure of magnesium are:

a) Mechanical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Flammability, and

e) Resistance to distortion at temperatures to which the material may be subjected under conditions of normal or abnormal usage.

9.4 An enclosure of polymeric material shall comply with the applicable requirements for products that are not categorized as household use only as contained in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: An attended, intermittent duty portable product can be evaluated for compliance with the household use requirements of UL 746C if it is marked in accordance with 64.4.1, 64.4.2, and 66.6. A tank-type compressor with an automatic pressure-regulating control is not considered to be an attended, intermittent duty product.

Exception No. 2: A blower-type inflator intended for indoor, residential use only, may be evaluated for compliance with the household use requirements of UL 746C when the product is marked in accordance with 64.4.1 and 64.4.2, and the instruction manual complies with 66.6.

9.4.1 Enclosures of components in a Class 2, Limited Power Source (LPS), or Low Voltage Limited Energy (LVLE) circuit shall have a flammability rating of HB minimum.

9.5 An enclosure of polymeric material shall be subjected to the Resistance to Impact Test described in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C before and after cold conditioning at minus 35°C ±2°C (minus 31°F ±3.6°F) for 3 hours. For products marked in accordance with 65.13, the Ultraviolet Light Exposure requirements are not applicable and the cold conditioning shall be at 0°C ±2°C (32°F ±3.6°F) for 3 hours. After each test, the enclosure shall comply with 9.1.

Exception: A product marked in accordance with 65.14 is not required to be subjected to the cold conditioning.

9.6 The enclosure of a remotely or automatically controlled product shall prevent molten metal, burning insulation, flaming particles, or the like from falling on flammable materials, including the surface upon which the product is supported.

Table 9.1
Thickness of enclosure metal

Metal	Minimum thickness, in (mm)				
	At a small flat, unreinforced surface and at a surface of a shape or size to provide mechanical strength		At a surface to which a wiring system is to be connected in the field	At a relatively large unreinforced flat surface	
Die-cast metal	3/64	(1.2)	–	5/64	(2.0)
Cast malleable iron	1/16	(1.6)	–	3/32	(2.4)
Other cast metal	3/32	(2.4)	–	1/8	(3.2)

Table 9.1 Continued on Next Page

Table 9.1 Continued

Metal	Minimum thickness, in (mm)					
	At a small flat, unreinforced surface and at a surface of a shape or size to provide mechanical strength		At a surface to which a wiring system is to be connected in the field		At a relatively large unreinforced flat surface	
Uncoated sheet steel	0.026	(0.66)	0.032	(0.81)	0.026	(0.66)
Galvanized sheet steel	0.029	(0.74)	0.034	(0.86)	0.029	(0.74)
Nonferrous sheet metal	0.036	(0.91)	0.045	(1.14)	0.036	(0.91)

9.7 The requirement in 9.6 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 product enclosure. It will also necessitate the use of a barrier of nonflammable material:

a) Under a motor unless:

1) The structural parts of the motor or of the product 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 product 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 prevent the temperature of the motor windings from exceeding 125°C (257°F) under the maximum load under which the motor will run without causing the protector to cycle and from exceeding 150°C (302°F) with the rotor of the motor locked;

4) The motor complies with the requirements for impedance-protected motors in either the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Impedance Protected Motors, UL 1004-2, and the temperature of the motor winding will not exceed 150°C (302°F) during the first 72 h of operation with the rotor of the motor locked; or

5) A vertically mounted motor is supplied with a metal screen on the end bell having a mesh with nominal openings not greater than 0.079 in (2 mm) between center lines and with wire diameters of not less than 0.018 in (0.45 mm) or if the motor complies with the Flammability Tests For The Bottom Of A Fire Enclosure in the Standard for Safety For Audio/video, Information And Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

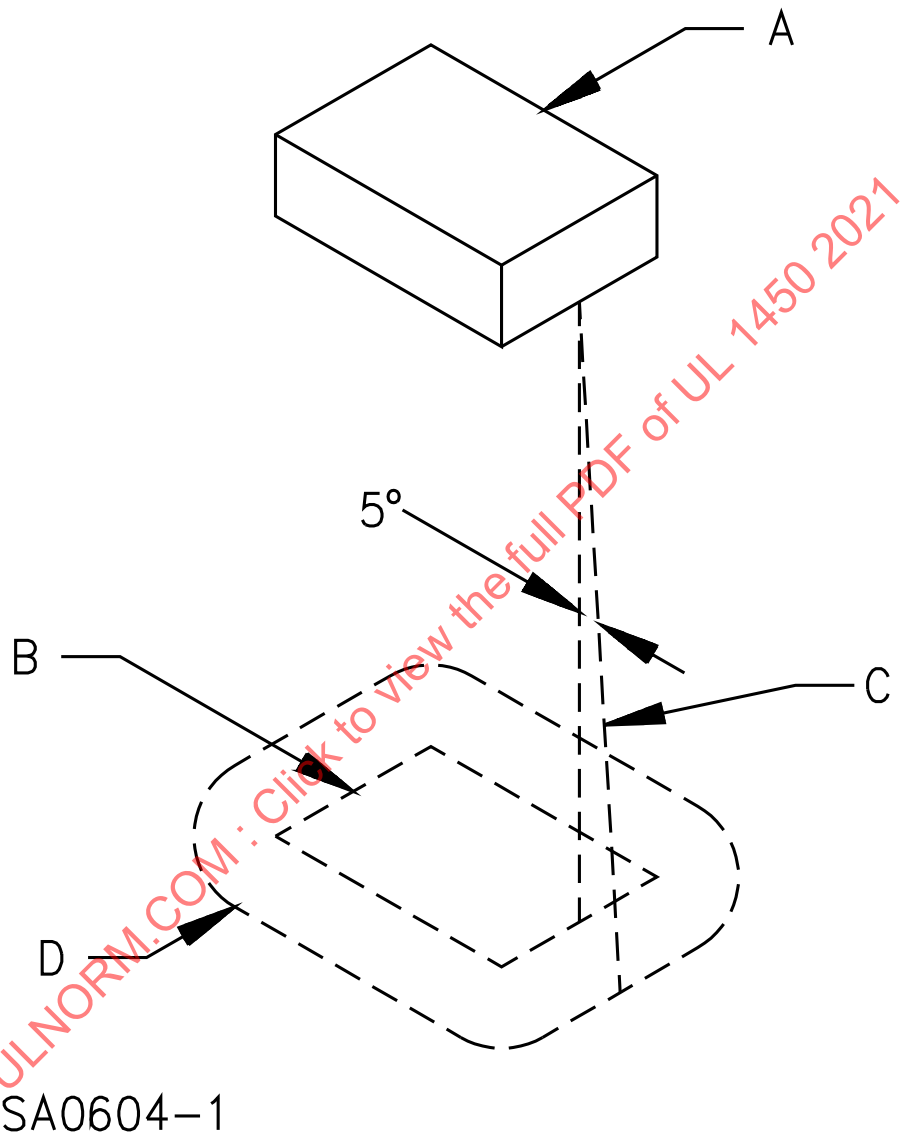
b) Under wiring, unless the wire is marked VW-1.

9.8 The barrier mentioned in 9.7 shall be horizontal, shall be located as indicated in Figure 9.1, 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 flammable material.

Figure 9.1

Location and extent of barrier



NOTES –

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

B – Projection of outline of component on horizontal plane.

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

1) tangent to the component,

2) 5 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.

9.9 A paint sprayer or compressor shall be constructed so that the accumulation of paint on any uninsulated live part is unlikely when tested as described in Section 50, Paint Entry Test.

Exception No. 1: A paint sprayer having a separate compressor or pump, a hose at least 6 ft (1.83 m) long, and a maximum paint capacity of 6 fluid ounces (186 mL) need not be tested.

Exception No. 2: A compressor, including a tank-type compressor, that:

a) Is provided with a hose at least 15 ft (9.57 m) long and is marked in accordance with 64.1.11; or

b) Either cannot be carried in one hand during use, or weighs 20 lb (9.07 kg) or more and is marked in accordance with 64.1.10, need not be tested.

9.10 In determining whether a paint sprayer or compressor is capable of being carried in one hand as mentioned in Exception No. 2 to 9.9, consideration shall be given to such factors as the weight of the compressor, the number and location of handles, and the like.

9.11 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.

9.12 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.

10 Mechanical Assembly

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

10.2 A switch other than a through-cord switch, a lampholder, an attachment-plug receptacle, a motor-attachment plug, or similar component shall be mounted securely and shall be prevented from turning. See 10.4.

Exception No. 1: A switch need not be prevented from turning if all four of the following conditions are met:

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

b) The means for mounting the switch make 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 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 or shifting in position, if such motion may result in a reduction of spacings below the minimum acceptable values.

10.3 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 required values.

10.4 The means for preventing the turning or shifting mentioned in 10.2 and 10.3 shall 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.

11 Protection Against Corrosion

11.1 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: Bearings, laminations, or minor parts of iron or steel, such as washers, screws, and the like.

11.2 If deterioration of a liquid container provided as a part of a product 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.

12 Accessibility of Uninsulated Live Parts and Film-Coated Wire

12.1 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 (a) or (b).

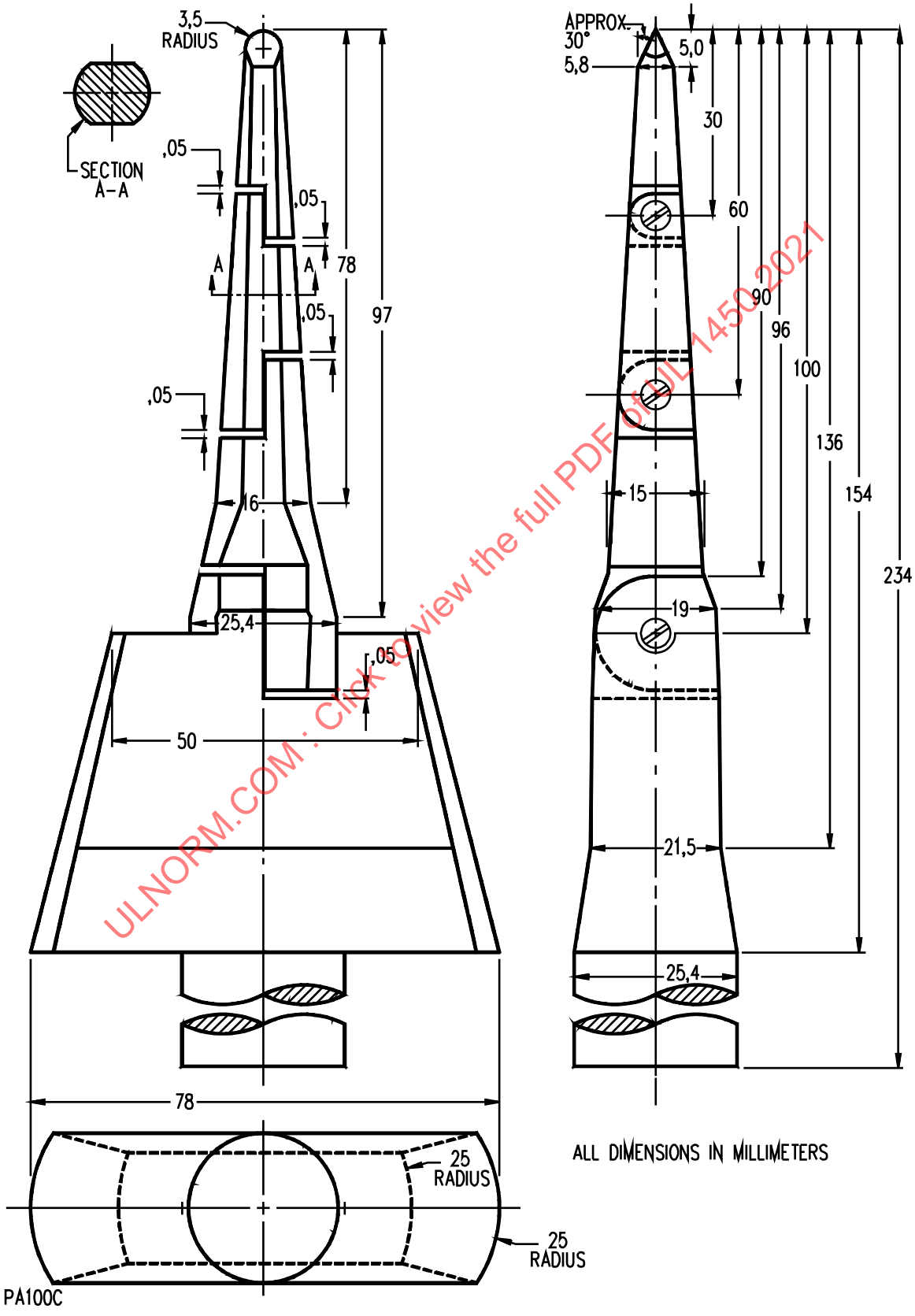
a) For an opening that has a minor or dimension (see 12.5) less than 1 in (25.4 mm), such a part or wire shall not be contacted by the probe illustrated in Figure 12.1.

b) For an opening that has a minor dimension of 1 in or more, such a part or wire shall be spaced from the opening as specified in Table 12.1.

Exception: A motor other than one used in either a hand-held product or a hand-supported portion of a product need not comply with these requirements if it complies with the requirements in 12.2.

Figure 12.1

Articulate probe with web stop



12.2 With respect to a part or wire as mentioned in 12.1 in an integral enclosure of a motor as mentioned in the Exception to 12.1:

a) An opening that has a minor dimension (see 12.5) less than 3/4 in (19.1 mm) is acceptable if:

1) Film-coated wire cannot be contacted by the probe illustrated in Figure 12.3;

2) In a directly accessible motor (see 12.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 12.4; and

3) In an indirectly accessible motor (see 12.6), an uninsulated live part cannot be contacted by the probe illustrated in Figure 12.2.

b) An opening that has a minor dimension of 3/4 in or more is acceptable if a part or wire is spaced from the opening as specified in Table 12.1.

Table 12.1
Minimum acceptable distance from an opening to a part that may involve a risk of electric shock

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

[a] See 12.5.
[b] Between 3/4 in and 2-1/8 in, interpolation is to be used to determine a value between values specified in the table.
[c] A dimension less than 1 in applies to a motor only.
[d] More than 2-1/8 in, but not more than 6 in (152.0 mm).

Figure 12.2

Rigid probe

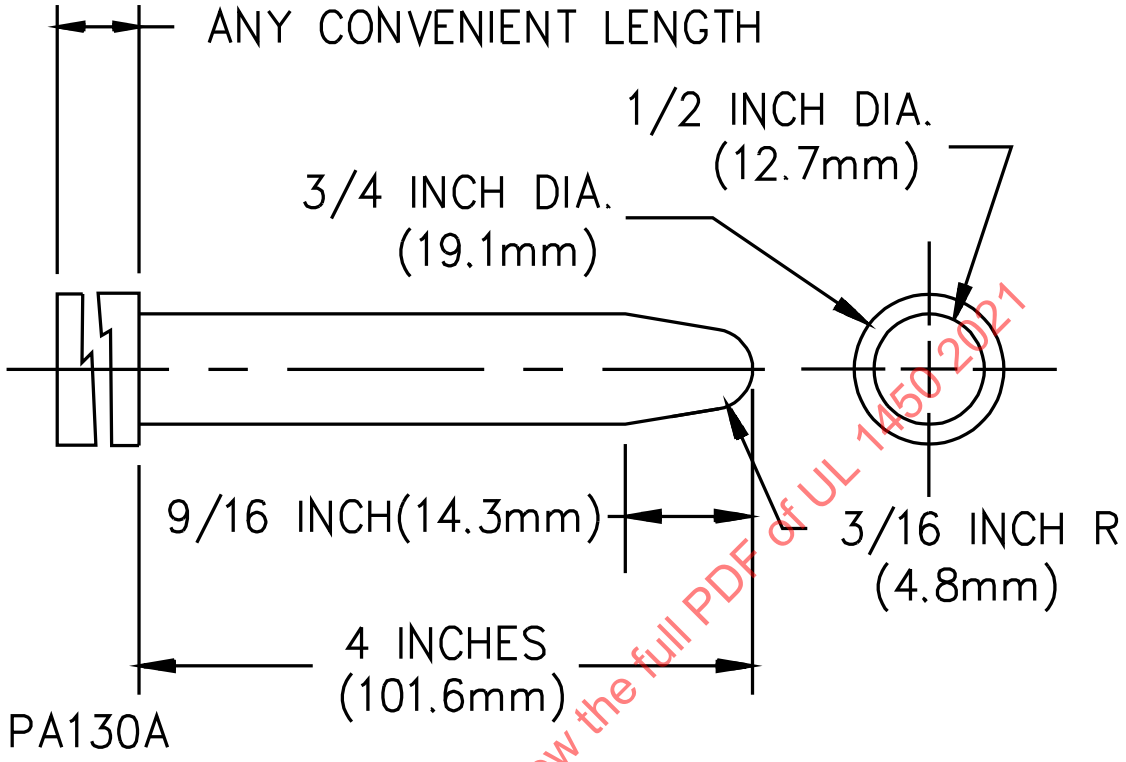


Figure 12.3

Probe for film-coated wire

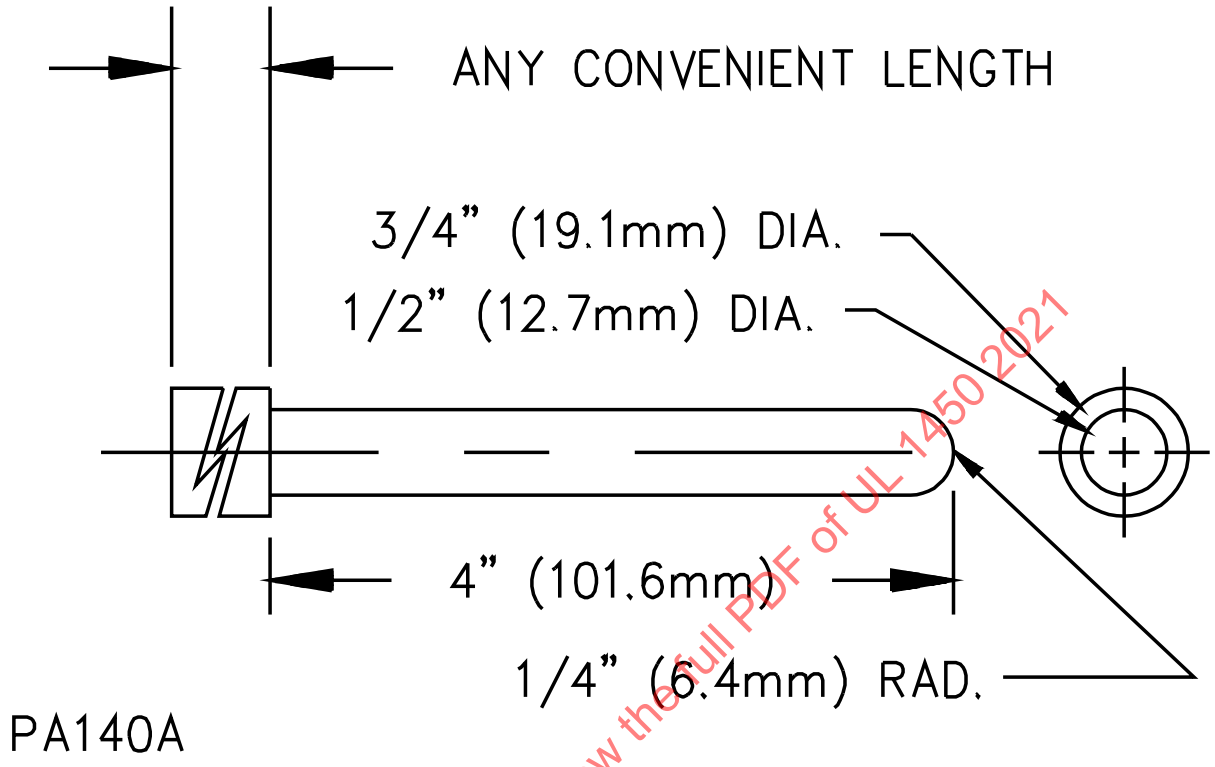
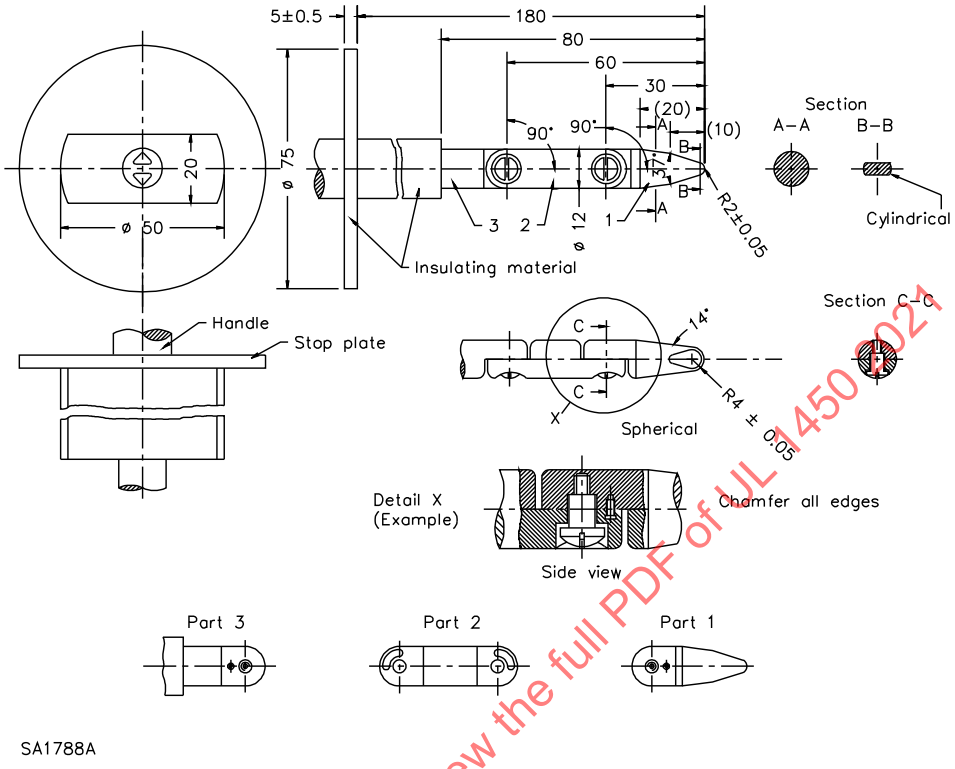


Figure 12.4

International Electrotechnical Commission (IEC) articulate accessibility probe with stop plate



12.3 The probes mentioned in 12.1 and 12.2 and illustrated in Figure 12.1 – Figure 12.4 shall be applied to any depth that the opening will permit, and shall be rotated or angled before, during, and after insertion through the opening to any position that is necessary to examine the enclosure. The probes illustrated in Figure 12.1 and Figure 12.4 shall be applied in any possible configuration; and if necessary, the configuration shall be changed after insertion through the opening.

12.4 The probes illustrated in Figure 12.1 – Figure 12.4 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.

12.5 With reference to the requirements in 12.1 and 12.2, 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.

12.6 With reference to the requirements in 12.2,

a) An indirectly accessible motor is a motor:

1) That is accessible only by opening or removing a part of the outer enclosure, such as a guard or panel, that can be opened or removed without using a tool, or

2) That is located at such a height or is otherwise guarded or enclosed so that it is unlikely to be contacted.

b) A directly accessible motor is a motor:

1) That can be contacted without opening or removing any part, or

2) That is located so as to be accessible to contact.

12.7 During the examination of a product to determine whether it complies with the requirements in 12.1 or 12.2, a part of the enclosure that may be opened or removed by the user without using a tool (to attach an accessory, to make an operating adjustment, or for other reasons) is to be opened or removed.

13 Supply Connections

13.1 Cord-connected products

13.1.1 A product 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.

13.1.2 The attachment plug of a product intended to be connected to a nominal 120 V circuit, and using devices required to be connected to a specific supply conductor as specified in 13.4.17, 25.2, and 26.3 shall be a polarized type. The connections to the attachment plug shall be in accordance with Figure 13.1. The polarity identification of the supply cord shall be in accordance with Table 13.1. See 67.6.

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

13.1.4 Type SJ, SJT, SJO, SJOO, SJTO, or SJTOO flexible cord, or a type at least equally serviceable for the application, shall be employed for the following products.

a) A compressor (including an inflator) or paint pump having a motor rated 3 hp (2.2 kW output) or less.

b) A vacuum pump.

c) A hand-held sprayer.

d) A paint mixer and pigment dispenser.

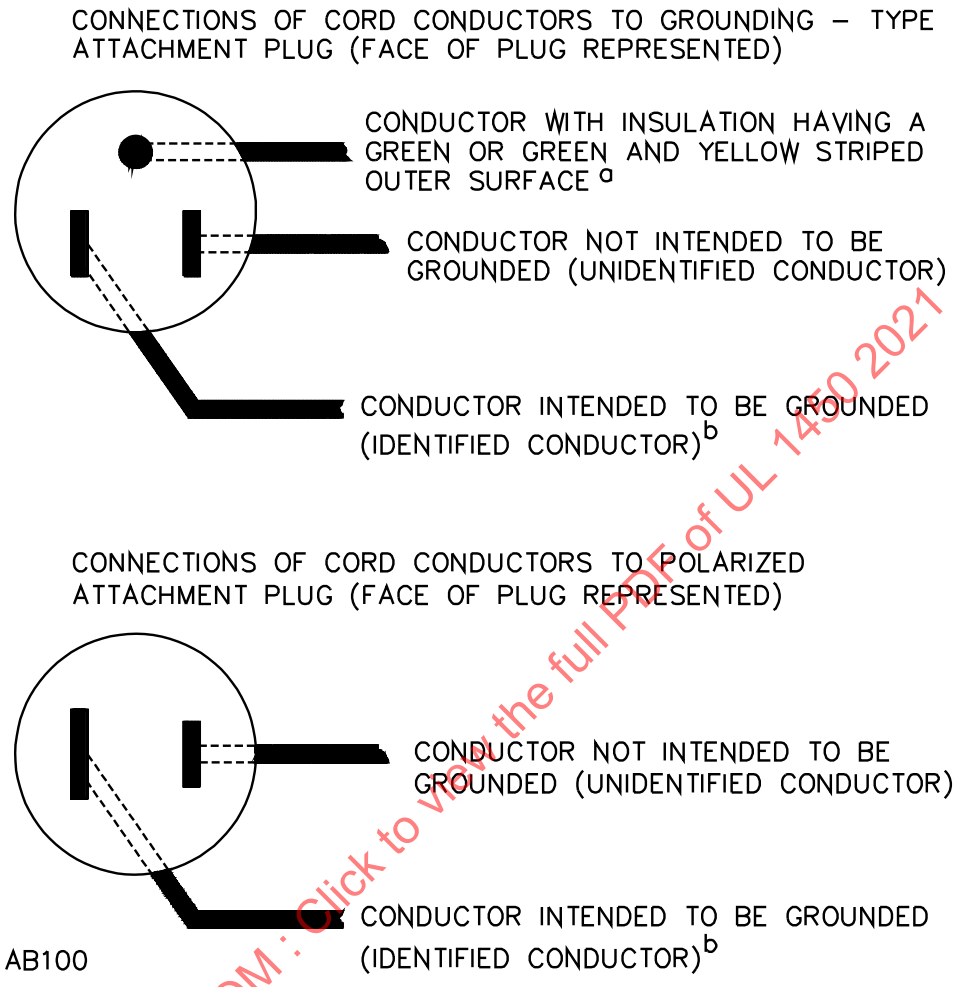
Exception: A blower type inflator intended for indoor, residential use only, may employ any of the cord types specified above or it may employ an SPT-2 type cord.

13.1.5 A compressor or paint pump having a motor rated more than 3 hp (2.2 kW output), a tank larger than 30 gal (113.4 L), or having any marking indicating a rating of more than 3 hp, shall employ Type SO, SOO, ST, STO, or STOO flexible cord or a type at least equally serviceable for the application.

13.1.6 A cord or cord set employed on a compressor or sprayer intended for outdoor use and not marked in accordance with 65.13 shall be marked "W" or "W-A."

Figure 13.1

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 13.1.

Table 13.1
Polarity identification of flexible cords

Method of identification	Acceptable combinations	
	Wire intended to be grounded[a] wire connected to the screw shells of lampholders	**All other wires[a]**
Color of braids on individual conductors	Solid white or gray – without tracer	Solid color other than white or gray – without tracer
	Color other than white or gray, with tracer in braid	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	Solid white or gray[b]	Solid color other than white or gray
	Light blue[c]	Solid color other than light blue, white, or gray
Color of separators	White or gray[d]	Color other than white or 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 20.2.1 and Figure 13.1.

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

[c] For jacketed cords.

[d] Only for Type SPT-2 cord.

13.1.7 The flexible cord may be attached permanently to a product or may be in the form of a separate cord set with means for connection to the product.

13.1.8 An attached flexible cord provided with the product shall comply with one of the following, as applicable:

a) Stationary equipment shall be provided with an attached flexible cord at least 6 ft (1.8 m) long including the attachment plug.

b) Movable, hand-held, hand-guided, and hand-supported equipment shall be provided with an attached flexible cord at least 6 ft (1.8 m) long or 18 in (457 mm) long or less including the attachment plug.

13.1.9 With reference to 13.1.8, for all product types that are acceptable for use with an 18 in (457 mm) or less flexible cord, an acceptable extension cord shall be provided with the product, or shall be marked in accordance with 64.3.1, or the instructions shall contain statements for the selection of the correct extension cord type in accordance with 67.3.

13.1.10 If a product incorporates a disconnecting means, such as a cord connector in the supply cord between parts of the product, the arrangement shall be such that no live parts will be exposed under any normal conditions.

13.1.11 A product intended for use with a detachable cord set and a product that employs three or more pin terminals intended for use with an attachment plug that covers all the pins shall have terminals spaced so they will not accommodate a two-pin flatiron or appliance plug or a two-pin cord-connector body. An acceptable plug or connector shall be one that cannot be improperly connected to the terminals.

13.1.12 A product that is required to use a polarized attachment plug as specified in 13.1.2, and that is provided with a separate or detachable cord-set as specified in 13.1.7 and the Exception to 13.1.8 shall also use an appliance connector of the polarized type.

13.1.13 The attachment plug shall have an ampacity not less than the rated current of the product or the actual current measured during the Input Test, Section 45, whichever is greater, and a voltage rating equal to the rated voltage of the product. If a product is adaptable for use on two or more different values of voltage by field alteration of internal connections, the attachment plug provided with the product shall be acceptable for the voltage for which the product is connected when shipped from the factory.

13.1.14 The power-supply cord of a product shall exit the enclosure in an area that is not in close proximity to a hot spot or moving part, such as a compressor head, blade, belt, or rotating part.

13.2 Strain relief

13.2.1 Strain relief shall be provided so that mechanical stress on a flexible cord, flexible conduit, or armored cable will not be transmitted to terminals, splices, or interior wiring. See Section 52, Strain Relief Test.

13.2.2 Means shall be provided to prevent a flexible cord from being pushed into a product through a cord-entry hole if such displacement may subject the cord to mechanical damage or 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, or damage to the internal connections or components. Compliance is to be checked by the Push-Back Strain Relief Test, Section 53.

13.2.3 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.

13.3 Bushings

13.3.1 At a point where a flexible cord passes through an opening in a wall, barrier, or enclosure, there shall be a bushing or the equivalent that shall be substantial, reliably secured in place, and shall have a smooth, well-rounded surface against which the cord may bear. The bushing or equivalent may be of metal or may be an insulating bushing that complies with the requirements in 13.3.2 – 13.3.9.

13.3.2 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.

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

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

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

13.3.6 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 in (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.

13.3.7 A bushing of any of the materials specified in 13.3.6 may be employed at any point in a product if used in conjunction with a type of cord for which an insulating bushing is not required. If a bushing of one of these materials is used anywhere in the product, the edges of the hole in which the bushing is mounted are to be smooth and free from burrs, fins, and the like.

13.3.8 At any point in a product, a bushing of the same material as, and molded integrally with, the supply cord is acceptable if the built-up section is not less than 1/16 in (1.6 mm) thick at the point where the cord passes through the enclosure.

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

13.4 Permanently connected products

13.4.1 A permanently connected product shall have provision for connection to a wiring system.

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

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

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

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

13.4.6 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 product.

13.4.7 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 wire binding screw may be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in place.

13.4.8 A wiring terminal shall be prevented from turning.

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

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

13.4.10 A wire-binding screw at a wiring terminal shall not be smaller than No. 10.

Exception No. 1: A No. 8 screw may be used at a terminal intended only for the connection of a 14 AWG (2.1 mm^2) conductor.

Exception No. 2: A No. 6 screw may be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) conductor. See 13.4.16.

13.4.11 According to the National Electrical Code, ANSI/NFPA 70, 14 AWG (2.1 mm^2) 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.

13.4.12 A wire-binding screw shall thread into metal.

13.4.13 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 in (1.27 mm) thick and, except as indicated in 13.4.14, shall not have less than two full threads in the metal.

13.4.14 Two full threads are not required if fewer threads result in a secure connection in which the threads will not strip upon the application of a 20 lbf-in (2.26 N·m) tightening torque.

13.4.15 A terminal plate formed from stock having the thickness specified in 13.4.13 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

13.4.16 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size specified in 13.4.5 under the head of the screw or washer.

13.4.17 A permanently connected product rated 125 V or less, or 125/250 V (3-wire) or less, and employing a lampholder of the Edison-screw-shell type, or a single-pole switch or overcurrent-protective device other than an automatic control without a marked off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit. The terminal or lead to be connected to the grounded supply conductor shall be the one that is electrically connected to screw shells of lampholders and to which no switch or overcurrent-protective device of the single-pole type other than an automatic control without a marked off position is connected.

13.4.18 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.

14 Current-Carrying Parts

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

14.2 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:

a) If acceptable in accordance with 3.1, or

b) Within a motor or associated governor.

14.3 The restriction in 14.2 does not apply to stainless steel.

15 Insulating Material

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

15.2 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.

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

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

16 Gaskets and Seals

16.1 Gaskets and seals relied upon to reduce the risk of electric shock or injury to persons shall comply with the Standard for Gaskets and Seals, UL 157.

Exception: Rubber or neoprene compounds relied upon for protection from rain are only required to comply with Accelerated Aging Test, Section 55.

17 Internal Wiring

17.1 Mechanical protection

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

Exception: A length of flexible cord may be employed for external connections if flexibility is essential. Guarding or protection may be required to reduce the likelihood of damage or stress to the cord. See 17.1.2.

17.1.2 Insulated wiring is considered to be protected as required in 17.1.1 if, when judged as though it were film-coated wire, it would be acceptable in accordance with 13.1.3 – 13.1.13. Internal wiring not so protected may be acceptable if it is secured within the enclosure so that it is unlikely to be subjected to stress or mechanical damage.

17.1.3 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.

17.1.4 If wiring or flexible cord between parts of a product is located so that it may be in proximity to flammable material or may be subjected to mechanical damage, it shall be enclosed in armored cable, rigid metal conduit, electrical metallic tubing, or enclosed metal raceway, or shall be otherwise equivalently protected.

17.1.5 A hole through which insulated wires pass in a sheet-metal wall within the overall enclosure shall be provided with a smooth, rounded bushing or shall have smooth, rounded surfaces upon which wires may bear, to prevent abrasion of the insulation. A flexible cord used for external interconnection as mentioned in 17.1.1 shall be provided with strain relief and bushings in accordance with 13.2.2 – 13.3.9 unless the construction is such that the cord will be protected from stress or motion. If Type SP-1, SPT-1, SP-2, SPT-2, or other cord lighter than Type SV is employed, and if the wall or barrier is of metal, and is such that the cord may be subjected to stress or motion, an insulating bushing shall be provided.

17.1.6 A flexible cord used for external connections shall be as serviceable as the power-supply cord and shall be so located as to reduce the likelihood of damage or stress.

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

17.2 Types of wire

17.2.1 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.

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

17.3 Splices and connections

17.3.1 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.

17.3.2 The requirement in 17.3.1 will necessitate the use of a lock washer or other equivalent means to prevent a wire-binding screw or a nut from becoming loosened.

17.3.3 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.

17.3.4 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.

17.3.5 With reference to the requirements in 17.3.4, 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.

17.3.6 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 V. 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.

17.3.7 If stranded internal wire is connected to a wire-binding screw, loose strands of wire shall be positively prevented from contacting an uninsulated live part that is not always of the same polarity as the wire and from contacting a dead metal part. This may be accomplished by use of a pressure terminal

connector, soldering lug, or crimped eyelet, by soldering all strands of the wire together, or by other equivalent means.

17.3.8 A nominal 0.110-in, 0.125-in, 0.187-in, 0.205-in, or 0.250-in wide quick-connect terminal shall comply with the requirements for quick-connect terminals, UL 310. Other sizes shall be investigated with respect to crimp pullout, engagement-disengagement forces of the connector and tab, and temperature rises, all tests to be conducted in accordance with the requirements for quick-connect terminals, UL 310.

18 Separation of Circuits

18.1 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.

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

18.3 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, as defined in the National Electrical Code, ANSI/NFPA 70, 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 in (6.4 mm) can be maintained between the conductors of the different circuits including the conductors to be field installed.

19 Capacitors

19.1 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 prevent 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 in (0.51 mm). Sheet metal having a thickness less than 0.026 in (0.66 mm) is not recommended.

Exception: The individual container of a capacitor may be of sheet metal less than 0.020 in thick or may be of material other than metal if the capacitor is mounted in an enclosure that houses other parts of the product and provided that such housing is acceptable for the enclosure of live parts.

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

19.3 A capacitor connected from one side of the line to the enclosure of a product shall have a capacitance rating of not more than 0.10 µF. See 46.1.1.

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

19.5 Under both normal and abnormal conditions of use, a capacitor employing a liquid dielectric medium more flammable than askarel shall not expel the dielectric medium when tested in accordance with the applicable performance requirements in this standard.

19.6 If a product is constructed to be controlled by or operated in conjunction with a capacitor or a capacitor/transformer unit, such a capacitor or unit shall be supplied with the product. See 64.1.5.

20 Grounding

20.1 General

20.1.1 A product shall have provision for grounding.

Exception No. 1: See 21.3 for double-insulated product.

Exception No. 2: A hand-held or hand-supported battery-operated product that does not employ an integral charger, and is not intended to be recharged outdoors need not have provision for grounding.

Exception No. 3: A blower-type inflator intended for indoor, residential use only, having a nonmetallic enclosure, need not comply with this requirement.

20.1.2 If a grounding means is provided, it shall be in accordance with 20.1.3 and if the product is cord connected, it shall comply with the requirements in 20.1.5. 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.

20.1.3 The following are acceptable means for grounding:

a) In a product intended to be permanently connected to the power supply, the equipment grounding terminal or lead and the point at which the power-supply wiring system will be connected.

b) In a cord-connected product, the equipment grounding conductor of the power-supply cord.

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

20.1.5 The grounding conductor and exposed dead metal parts that are likely to become energized of a cord-connected product shall be electrically conductively connected to the grounding member of an attachment plug. The grounding member shall be fixed.

20.1.6 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.

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

20.1.8 The grounding terminal, intended 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.

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

20.1.10 With reference to the requirement in 20.1.2, the following dead metal parts are not considered likely to become energized:

a) A small metal part, such as an adhesive-attached foil marking, a screw, a handle, and the like, that is:

1) On the exterior of the enclosure and separated from all electrical components by grounding metal, or

2) Electrically isolated from all electrical components;

b) A panel, cover, or other metal part that is isolated from all electrical components by a barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture-resistant insulating material not less than 1/32 in (0.80 mm) thick and securely mounted in place;

c) A panel, cover, or other metal part that does not enclose uninsulated live parts and is electrically isolated from other electrical components; and

d) Cores and assembly screws of a relay, a solenoid, and the like.

20.2 Grounding identification

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

20.2.2 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.

20.2.3 A wire-binding screw intended for the field connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal or slotted, or both or the unit shall be marked at the screw with the symbol ⏚ (IEC 417 No. 5019). A pressure wire connector intended for field connection of an equipment-grounding conductor shall be plainly identified, such as by being marked "G," "GR," "Ground," the symbol ⏚ (IEC 417 No. 5019), or by marking on the wiring diagram provided on the product.

21 Double Insulation

21.1 A cord-connected product may be provided with a system of double insulation that complies with the applicable requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, in lieu of a means for grounding.

21.2 A double-insulated product shall comply with the requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097, and with the applicable requirements in this standard.

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

21.3 A product marked as being provided with double insulation shall not be provided with a means for grounding. See 64.1.13.

22 Lampholders

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

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

23 Motors

23.1 Construction

23.1.1 A motor shall be acceptable for the application, and shall be capable of handling the maximum normal load of the product as described in 46.2.1 – 46.2.7 without creating a risk of fire, electric shock, or injury to persons.

23.1.2 A motor winding shall resist the absorption of moisture.

23.1.3 With reference to the requirement in 23.1.2, film-coated wire is not required to be additionally treated to prevent 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 prevent moisture absorption.

23.2 Overload protection

23.2.1 A motor shall be provided with thermal protection as described in 23.2.2.

Exception: A product that is hand-supported and/or attended while in use is not required to be provided with motor protection. This includes a hand-supported and/or attended portable nontank type compressor if it complies with Loaded Starting Test, Section 44. See also Exception No. 4 to 23.2.2. This exception does not apply to automatically controlled units, such as those that employ pressure switches, or permanently connected products that are manually started and operate on continuous duty.

23.2.2 A product as specified in 23.2.1 shall have motor-overload protection consisting of one of the following:

a) Thermal protection complying with the applicable requirements in either the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Thermally Protected Motors, UL 1004-3.

Exception No. 1: For a product that includes a control as specified in 23.2.3, the duration of the temperature test and the endurance test, both under locked-rotor conditions, is able to be less than that specified, and in no case less than the period of operation intended for the product.

Exception No. 2: In the event that the time required to operate a manually reset protective device through 10 c of operation is longer than the time that the product is to be operated during intended use, the number of operations of the device for the temperature test under locked-rotor conditions shall be less than 10 c. In any case, the number of cycles shall not be less than 4 c.

Exception No. 3: 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, is required to have locked-rotor protection only.

Exception No. 4: A portable nontank type air compressor that complies with Exception No. 1 to 23.2.1, but does not start under load when tested in accordance with Loaded Starting Test, Section 44, is required to have locked-rotor protection only.

Exception No. 5: A linear style pump is required to have locked-rotor protection only.

b) Impedance protection complying with the applicable requirements in either the Standard for Overheating Protection for Motors, UL 2111, or the Standard for Impedance Protected Motors, UL 1004-2, when the motor is tested as used in the product under locked rotor conditions.

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

23.2.3 The control mentioned in Exception No. 1 to 23.2.2(a) is a control that positively and reliably limits the length of time the product can be operated– for example, a timer.

23.2.4 For a multispeed motor that employs a separate overload protective device to provide running heating protection, the requirement in 23.2.1 applies at all speeds at which the motor is intended to operate.

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

23.2.6 The motor of a product 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 as specified in 23.2.2 to protect the motor against those conditions likely to occur.

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

23.2.8 Overload devices employed for running heating 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.

23.2.9 Fuses employed for motor-running heating protection shall be located in each ungrounded conductor; and in the case of a 3-phase, 3-wire, alternating-current motor, they shall be located in each of the three phases.

23.3 Brushes and brush holders

23.3.1 A brush cap shall be recessed, enclosed, or otherwise protected from mechanical damage that might occur during use of the product.

23.3.2 A brush cap that is accessible to the user without the removal of a guard or enclosure shall be provided with a positive means that will prevent its disengagement from the brush-holder assembly. Screw threads only on the brush cap are not considered a positive means.

23.3.3 A brush-holder assembly shall be constructed so that when a brush is worn out – no longer capable of performing its function – the brush, spring, and other parts of the assembly will be retained to the degree necessary to reduce the likelihood of:

a) Accessible dead metal parts becoming energized, and

b) Live parts becoming accessible.

24 Overload- or Thermal-Protective Devices

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

24.2 A product employing subdivided circuits within that product feeding two or more power-consuming components (for example, motors, motor-control circuits, electric heating elements) that are connected in parallel with each other across any pair of main-supply terminals or leads, shall be provided with overcurrent protection for the conductors of each terminal circuit in accordance with the National Electrical Code, ANSI/NFPA 70.

24.3 A protective device such as a fuse, the functioning of which requires renewal or replacement, shall be in a readily accessible location. A protective device shall be wholly inaccessible from outside the product 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 enclosure.

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

25 Receptacles

25.1 A 15- or 20-A general-use attachment-plug receptacle in a product provided with a means for grounding – a permanently wired product or a cord-connected product 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 product is in use.

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

25.3 If a product includes one or more attachment-plug receptacles intended for general use, and if the overcurrent protection of the branch circuit to which the product will properly be connected exceeds that acceptable for the receptacle or receptacles, each receptacle circuit shall have overcurrent protection of the time-delay type rated not more than 20 A provided as a part of the product.

25.4 A fuseholder provided in accordance with 25.3 shall be of Type S construction or shall be of the Edison-base type with a factory-installed nonremovable Type S adapter.

25.5 A portable product provided with a general purpose receptacle shall be marked in accordance with 65.19 at the receptacle so that the combined ampacity of the product operated under maximum normal load and the equipment connected to the receptacle does not exceed the rating of the product. A general purpose receptacle on a portable product shall not increase the risk of fire, electric shock or other injury to the user.

25.6 The face of a general-use receptacle shall:

a) Be flush with or project beyond a nonconductive surrounding surface, or

b) Project at least 0.015 in (0.38 mm) beyond a conductive surrounding surface.

25.7 Ground-fault circuit protection shall be provided for 120-V, single-phase, 15- and 20-A general-use receptacles that are part of a product intended to be used outdoors.

26 Switches and Controls

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

26.2 With reference to the requirement in 26.1, 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.

26.3 A line-connected, single-pole switch or an overcurrent (overload) protective device of the single-pole type other than an automatic control without a marked off position shall be connected to a terminal or lead intended for connection to an ungrounded conductor of the supply circuit.

26.4 A switch or other control shall be guarded or located so that it is not likely to be damaged during use of the product. A through-cord switch shall not be employed unless:

a) It cannot contact the floor during use of the product, or

b) It has been investigated for such abuse as may occur during use.

26.5 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.

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

27 Spacings

27.1 All uninsulated live parts connected to circuits of different voltage ratings shall be spaced from each other as though they were parts of opposite polarity in accordance with the requirements in 27.3 and 27.4, and shall be judged on the basis of the highest voltage involved.

27.2 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.

27.3 The spacing between a field-wiring terminal and any other uninsulated live or dead metal part not of the same polarity shall not be less than the applicable value specified in Table 27.1. See 13.4.6 and 27.7.

27.4 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 27.2 or as provided in Alternative Spacings – Clearances and Creepage Distances, Section 27A.

Exception: Spacings may be as specified in 27.10.

27.5 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.

Table 27.1
Spacings at field-wiring terminals

Potential involved, V	Minimum spacings, in (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 in, 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.

27.6 In a product incorporating two or more motors of different sizes, the spacings in the product are to be judged on the basis of the size of the largest motor in the product. See 27.8.

27.7 The spacing requirements in 27.3 – 27.6 do not apply to the inherent spacings of a component of a product, such as a snap switch; such spacings are to be judged on the basis of the requirements for the component.

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

27.9 At terminal screws and studs to which connection may be made in the field by means of the wire connectors, eyelets, or the like, as described in 13.4.6, spacings shall not be less than those specified in Table 27.2 when such connectors, eyelets, or the like are in such position that minimum spacings – opposite polarity and to dead metal – exist.

Table 27.2
Spacings at other than field-wiring terminals

Potential involved, V	Diameter of motor used in product							
	7 in (178 mm) or less[a]				More than 7 in (178 mm)[a]			
	Over surface,		Through air,		Over surface,		Through air,	
	in	(mm)	in	(mm)	in	(mm)	in	(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)[c]	3/8	(9.5)[c]

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

[b] For a motor rated 1/3 hp (250 W output) or less, these spacings may not be less than 1/16 in (1.6 mm).

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

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

a) Live parts of opposite polarity,

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

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

the spacing may not be less than 3/64 in (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 27.2.

27.11 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 in (0.8 mm) thick, and shall be so located or of such material that it will not be adversely affected by arcing, except that vulcanized fiber not less than 1/64 in (0.4 mm) thick may be used in conjunction with an air spacing of not less than 50 percent of the spacing required for air alone.

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

27.12 An insulating lining or barrier of polymeric material shall comply with the requirements for insulating materials as specified in the Standard for Polymeric Materials-Use in Electrical Equipment Evaluations, UL 746C.

27A Alternative Spacings – Clearances and Creepage Distances

27A.1 As an alternative to the spacing requirements in Section 27, as applicable, the spacing requirements in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, are to be used. The spacing requirements of UL 840 shall not be used for field wiring terminals and spacings to a dead metal enclosure. In determining the pollution degree and overvoltage category, the end-use application is to be taken into account and is capable of modifying those characteristics given in 27A.2 and 27A.3.

27A.2 The level of pollution for indoor use products, and for portable compressors or paint sprayers not intended to be exposed to rain, shall be pollution degree 2. For outdoor use products, the level of pollution shall be pollution degree 3. Hermetically sealed or encapsulated enclosures, or coated printed wiring boards in compliance with the Printed Wiring Board Coating Performance Test of the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, shall be pollution degree 1.

27A.3 The equipment shall be rated overvoltage category II as defined in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

27A.4 In order to apply Clearance B (controlled overvoltage) clearances, control of overvoltage shall be achieved by providing an overvoltage device as an integral part of the product.

27A.5 All printed wiring boards are considered to have a minimum comparative tracking index of 100 without further investigation.

27B Low Voltage Limited Energy Circuits

27B.1 A low voltage limited energy (LVLE) circuit is defined as a circuit involving a potential of not more than 42.4 volts peak or 60 V dc with the energy available to the circuit limited:

a) By a fuse or nonadjustable manually reset circuit protective device that is rated or set at not more than the value specified in Table 27B.1; or

b) So that the current, measured in amperes, is not more than 8 for potentials up to 42.4 V peak, and $150/V_{max}$ for potentials from 30 to 60 V dc.

27B.2 With reference to the current specified in 27B.1(b), the maximum current is to be measured under any condition of loading, including short circuit. The measurement is made using a resistor that is continuously readjusted during a 1-minute period to maintain maximum load current. This current shall not exceed the value indicated in 27B.1(b).

Table 27B.1
Rating for fuse or circuit protective device

Open-circuit potential, V	Current rating, A
0 – 21.2 (peak)	5
21.3 – 42.4 (peak)	3.2
Over 30 to 60 dc only	$150/V_{max}$ [a]
[a] V_{max} is defined as the maximum potential, in volts, obtained under any condition of load or no load.	

PROTECTION AGAINST INJURY TO PERSONS

28 General

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

28.2 When judging a product with respect to the requirement in 28.1, consideration shall be given to reasonably foreseeable misuse of the product.

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

28.4 Specific constructions, tests, markings, guards, and the like are detailed for some common constructions. Specific features and products not covered herein are to be given appropriate consideration. See the requirements for marking in Section 65, Cautionary.

29 Sharp Edges

29.1 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.

30 Enclosures and Guards

30.1 A moving part or high-pressure discharge opening that may cause risk of injury to persons shall be enclosed, guarded, located or otherwise arranged to reduce the likelihood of unintentional contact, and such a part shall not be contacted by the probe illustrated in Figure 12.1.

Exception No. 1: An opening in the integral enclosure of a motor that is not used in either a hand-held product or a hand-supported portion of a product is acceptable if a moving part cannot be contacted by the probe illustrated in Figure 12.2.

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 30.3.

30.2 A moving part that may involve a risk of injury to persons shall be considered with respect to:

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.

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

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

a) Removability without the use of tools;

b) Removability for servicing;

c) Strength and rigidity;

d) Completeness;

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

f) Usage – household or commercial.

30.4 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.

30.5 If complete guarding of a moving part that would obviously cause injury to persons would defeat the utility of a product:

a) A control shall be provided; and

b) A marking shall be provided in accordance with 65.11.

30.6 During the examination of a product to determine whether it complies with the requirements in 30.1, 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 it is marked in accordance with 65.10.

31 Materials

31.1 As a result of the tests in 31.2, there shall not be exposed moving parts that result in a risk of injury to persons.

31.2 Guards molded of polymeric material that are serving as protection of moving parts only and not serving as enclosures of insulated or uninsulated live parts, shall have a flammability rating of HB minimum. They shall be subject to mold stress, impact and cold impact at minus 35°C (minus 31°F) as specified in the Standard for Polymeric Materials-Use in Electrical Equipment Evaluations, UL 746C.

Exception No. 1: A product marked in accordance with 65.13 shall be subject to the cold impact test at 0° C (32°F) rather than at minus 35°C (minus 31°F).

Exception No. 2: A product marked in accordance with 65.14 is not required to be subject to the cold impact test.

Exception No. 3: For blower-type inflators intended for indoor, residential use only, a guard covering the impeller or fan blades need only be subjected to an impact of 1.5 ft-lb (6.67 N).

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

31.4 The requirement in 31.3 applies to those portions of a part adjacent to a moving part considered to involve a risk of injury to persons.

32 Surface Temperatures

32.1 During the temperature test described in Section 46, Temperature Test, the temperature of a surface that may be contacted by the user shall not be more than the maximum acceptable value specified in Table 32.1.

Exception: The temperature of a compressor head and associated fittings and a motor frame may exceed the applicable limit specified in Table 32.1 if the product is marked in accordance with 65.9.

Table 32.1
Surface temperature

Location	Composition of surface[a]			
	Metallic		Nonmetallic	
A handle or knob that is grasped for lifting, carrying or holding	50°C	(122°F)	60°C	(140°F)
A handle or knob that is contacted but does not involve lifting, carrying, or holding and other surfaces subject to contact in operation and user maintenance	60°C	(140°F)	85°C	(185°F)
A surface subject to casual contact	70°C	(158°F)	95°C	(203°F)

[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 in (0.13 mm) or less is judged as nonmetallic part.

32.2 All values for temperatures specified in Table 32.1 are based on a 25° C (77° F) ambient temperature; however, tests may be conducted at any ambient temperature within the range of 20 – 30°C (68 – 86°F).

33 Stability

33.1 Overturning of a portable or free-standing product, not secured in place, when it is tested as described in 33.2 and 33.3, shall not result in a risk of injury to persons.

Exception: A product that is completely hand supported in use need not be tested.

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

a) The position of all doors, drawers, casters, and other movable or adjustable parts, including that of the supply cord resting on the surface supporting the product;

b) Connection of or omission of any attachment made available by or recommended by the manufacturer;

c) Provision of or omission of any normal load if the product is intended to contain a liquid or other mechanical load; and

d) Direction in which the product is tipped or the supporting surface is inclined. See 33.3.

33.3 In conducting the stability test, the product 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.

34 Strength of Handles and Mounting Means

34.1 A handle or mounting means used to completely support or carry a product shall withstand a force of four times the weight of the product without damage – to the handle or the mounting means, its securing means, or that portion of the enclosure to which the handle or mounting means is attached.

Exception No. 1: A product that weighs less than 10 lb (4.53 kg) and is completely hand-supported in intended use is not required to comply with this requirement.

Exception No. 2: A handle provided on a unit with wheels with the only intended purpose of pushing or pulling the product, as specified in the manufacturer's instructions, is not required to comply with this requirement.

34.2 To determine whether a product complies with the requirements in 34.1, the weight of the product plus a force of three times its weight is to be used. The load is to be applied to the product and its mounting means, or when a handle is present, applied over a 3 in (76.2 mm) width at the center of the handle without clamping. The load is to be started at zero and gradually increased so that the test value will be reached in 5 to 10 s and is to be maintained for 1 min. If more than one handle is furnished on a product, and the product cannot be carried by one handle, the force is to be distributed between the handles. The distribution of force is to be determined by measuring the percentage of the product weight sustained by each handle with the product in the normal carrying position. If a product is furnished with more than one handle and can be carried by only one handle, each handle is to sustain the total force.

35 Rotating or Moving Members

35.1 A rotating member employed in a product provided with a series motor shall be constructed so as to reduce the likelihood of its breakage, or the release or loosening of a part that could become a risk of injury to persons.

35.2 To determine whether a product employing a series motor complies with the requirement in 35.1, it is to be tested as described in 35.3. A part that can become a risk of injury to persons shall not work loose as a result of the test.

35.3 For the test mentioned in 35.2, a product employing a series motor is to be operated for 1 min at the no-load speed resulting from application of 1.3 times rated voltage.

Exception: Blower-type inflators for indoor, residential use only, need not comply with this requirement.

35.4 A product with a user-removable rotating part, secured by threaded hardware – such as a nut – shall be constructed so that the direction of rotation tends to tighten the nut that secures the rotating part in place.

35.5 Unless secured as described in 35.4, a removable rotating part not intended to be removed by the user, shall be secured by a keyed nut, a jam nut, a nut locked in place with a pin, or other equivalent means.

36 Pressure Vessels and Parts Subject to Pressure

36.1 Pressure vessel

36.1.1 A pressure vessel shall be constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Pressure Vessels, Division I, and shall be marked with the pressure vessel symbol "U" or "UM" when the following occurs:

a) The pressure vessel has a capacity of more than 30 gal (114 L); or

b) The pressure vessel is for use with a compressor having:

1) A drive motor rated more than 3 hp (2.2 kW output), or

2) Any marking indicating a rating of more than 3 hp (2.2 kW output).

36.1.2 A pressure vessel marked with the symbol "U" or "UM" shall have a working pressure not less than the relief-valve setting to be provided in the final assembly.

36.1.3 A pressure vessel shall comply with the requirements in 36.1.4 – 36.1.9.

Exception: A pressure vessel marked with the "U" symbol is only required to comply with 36.1.4 – 36.1.8.

36.1.4 A pressure vessel shall be constructed of plate or strip steel, stainless steel, or other ductile alloys.

36.1.5 An opening providing access to the interior of a pressure vessel shall have tapered threads conforming to the Standard for Pipe Threads, ANSI/ASME B1.20.1, dry-seal threads conforming to the Standard for Pipe Threads, ANSI B1.20.3, straight-thread O-ring boss type fittings conforming to the Society of Automotive Engineers 1998 Handbook Section J514j, or pipe flanges conforming to the appropriate American National Standard.

36.1.6 A pipe-threaded opening in a pressure vessel shall provide at least the minimum number of threads specified in Table 36.1.

Table 36.1
Pipe threads for connections

	Trade size of pipe connection, in				
	1/4, 3/8	1/2, 3/4	1, 1-1/4, 1-1/2	2	2-1/2, 3
Minimum number of threads engaged by a fitting connected to a tank port	6	6	7	8	8
Minimum depth of threaded port in (mm)	0.34 (8.9)	0.43 (10.-9)	0.61 (15.-5)	0.70 (17.8)	1.0 (2-5.4)

36.1.7 A saddle-type pressure vessel support or mount provided on the top of a cylindrical horizontal or vertical-style pressure vessel for mounting a compressor, motor, or other part shall be welded to the pressure vessel.

36.1.8 When the unit is in its normal operating position, a drain hole shall be provided in the lowest portion of a pressure vessel. The hole shall be a threaded hole of not smaller than 1/4-in NPT and shall be provided with a removable plug or piping to a drain cock. The system shall have provision for gravity or pressure drainage of the vessel.

Exception No. 1: Pressure vessels which have a drain hole located at the maximum of 45° from the lowest point of the vessel, comply with the requirement when:

a) The product is marked in accordance with 65.15;

b) The instruction manual informs the user of the way in which to drain the pressure vessel properly; and

c) The product can be tilted so that the drain hole is at the lowest point for complete draining without introducing a risk of injury to persons.

Exception No. 2: As an alternative, pressure vessels may be provided with a drain assembly system, (manual or automatic) operated through a valve and tubing assembly where the end of the tubing is maintained at the bottom of the vessel. An automatic drain assembly system shall also have the provision to manually drain the vessel. See 65.15.1, 66.9, and 66.10.

36.1.9 When required by 36.1.3, one sample of the pressure vessel assembly described in 57.1 shall comply with the Vibration Test, Section 57. A second sample consisting of only the pressure vessel shall comply with the Hydrostatic Strength Test, Section 58.

36.2 Parts subject to pressure

36.2.1 A part of a product other than a pressure vessel that is subject to air or vapor pressure during normal or anticipated abnormal operation shall withstand, without rupture, a pressure corresponding to five times:

a) The start-to-discharge setting of the relief device provided in the system as determined in accordance with 37.7,

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

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

Exception No. 1: A section of a pressure system constructed of continuous copper or steel tubing or of lengths of copper or steel tubing connected by conventional tubing fittings or hard-soldered, brazed, or welded joints provided the wall thickness of the tubing is not less than the value specified in Table 36.2.

Exception No. 2: A motor-operated air compressor intended for use with sprinkler systems shall be tested at a pressure corresponding to five times the maximum relief valve setting.

Table 36.2
Wall thickness for copper and steel tubing

Outside diameter		Minimum wall thickness		Maximum pressure to which tubing is subjected, psig (mPa)					
in	(mm)	in	(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)

36.2.2 In the event that a test is required to determine whether a part complies with the requirement in 36.2.1, two samples of the part are to be subjected to the hydrostatic strength test described in Hydrostatic Strength Test, Section 58. Prior to the test, parts molded of polymeric material are to be conditioned in an air-circulating oven for 7 h at a temperature of 70°C (158°F) or 10°C (18°F) higher than the maximum temperature measured on the part under normal load, whichever is greater. The samples are to be removed from the oven and cooled to room temperature prior to the test.

36.2.3 A pipe fitting, check valve, relief valve, or a similar device that is threaded into a pressure vessel shall engage the minimum number of threads specified in Table 36.1.

37 Pressure Relief Means

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

37.2 A means for relieving pressure – a pressure relief device, a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent means – shall be employed to comply with the requirement in 37.1.

Exception: A motor-operated air compressor intended for use with sprinkler systems shall be provided with a pressure relief valve.

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

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

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

37.6 The start-to-discharge pressure setting of a pressure-relief device shall not be higher than the working pressure marked on the ASME coded vessel.

37.7 To determine the start-to-discharge pressure setting of a pressure-relief device, each of three samples of the device is to be subjected three times to a gradually increasing air pressure. The pressure at which the device begins to open is to be recorded. The start-to-discharge pressure setting of each sample is considered to be the average value of the three trials. The start-to-discharge value mentioned in 37.6 is the highest average value for the three samples tested.

37.8 A pressure-relief device shall:

a) Be connected as close as possible to the pressure vessel or part of the product 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;

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; and

d) Have a discharge rate adequate to relieve the pressure.

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

38 Pressure-Regulating Control Switches

38.1 A compressor system with an air-holding tank shall be provided with:

a) A pressure-regulating control switch that complies with the requirements in 38.2, to limit pressure build-up within the tank;

Exception: A switch need not be provided on a product that uses other means of limiting tank pressure, such as an air dumping valve or a compressor design that inherently limits pressure.

b) A pressure gauge or other equivalent device to indicate when pressure is retained within the tank. A product with a pressure indicator that is not calibrated in pressure units shall be marked in accordance with 64.1.9.

38.2 A pressure-regulating control switch depended upon to limit the pressure in a vessel shall:

a) Comply with the applicable requirements in UL 353, or the applicable requirements for refrigeration limiting devices in UL 873, or the applicable requirements for pressure and float operated devices in UL 508 or UL 873. Compliance with UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series complies with the UL 873 requirements. It shall also have a maximum pressure setting of not more than 90 percent of the rating of the pressure-relief device, or

b) Prevent the pressure-relief device described in 37.8 from operating during or after the test described in 38.3.

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

38.4 For a motor-operated compressor intended for use with sprinkler systems, a pressure-regulating control switch shall perform under rated load for 100,000 cycles of operation with no shift in calibration greater than 5 percent above initial calibration pressure setting. An adjustable pressure-regulating control switch is to be tested at its highest pressure setting unless the adjusting means is reliably sealed, to prevent tampering, at a lower setting.

39 Switches, Controls, and Interlocks

39.1 A product shall be constructed so as to prevent unexpected operation of any parts capable of causing injury to persons.

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

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

39.4 A device that automatically starts a product, such as a pressure-regulating control switch, timer, an automatically reset overload-protective device, or the like, shall not be employed unless it can be demonstrated that automatic starting will not present a risk of injury to persons.

39.5 The requirement in 39.4 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.

39.6 The actuator of an interlock switch shall be located so that unintentional operation is unlikely. See 39.3.

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

39.8 An interlock shall not be likely to be defeated by materials that could accumulate during use of the product.

39.9 An interlock shall be such that it can be defeated readily only by:

a) Damaging the product,

b) Making wiring connections or alterations, or

c) Using materials that are not readily available.

39.10 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 requirement in 39.6.

39.11 A product that is not hand-supported and provided with a maintained contact switch or a switch that can be locked on shall not create a risk of injury to persons, such as by excessive travelling, when the product is in an at rest position and connected to the source of supply with the switch on.

39.12 For a product that is not hand-supported during actual use, the requirement in 39.11 will necessitate a means to prevent the product from traveling more than 6 inches (152 mm) in any one direction in 15 s when the product is placed on a hardwood surface while energized.

Exception: Blower-type inflators need not comply with this requirement.

PERFORMANCE

40 General

40.1 Tests are to be conducted with the product connected to a supply circuit of rated frequency. The voltage of the supply circuit is to be as indicated in Table 40.1. For a product rated other than as specified in Table 40.1, the voltage of the supply circuit is to be the maximum rated voltage.

Table 40.1
Test voltages

Nameplate rating, V	Test voltage
110 – 120	120
200 – 208	208
220 – 240	240
254 – 277	277
440 – 480	480
550 – 600	600

40.2 A product rated 50 – 60 Hz is to be tested at 60 Hz. A product rated 50/60 Hz is to be tested at both 50 and 60 Hz.

40.3 *Deleted November 1, 2013*

41 Leakage Current Test

41.1 The leakage current of a cord-connected product rated 250 V or less, when tested in accordance with 41.3 – 41.9 shall not be more than:

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

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

Exception: For portable equipment using 1 hp (0.75 kW) and larger motors, the leakage limit shall be 0.75 mA.

c) 0.75 mA for a grounded (3-wire) stationary or fixed product.

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

41.3 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 12.1 – 12.7. 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.

41.4 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 product.

41.5 The measurement circuit for leakage current is to be as illustrated in Figure 41.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

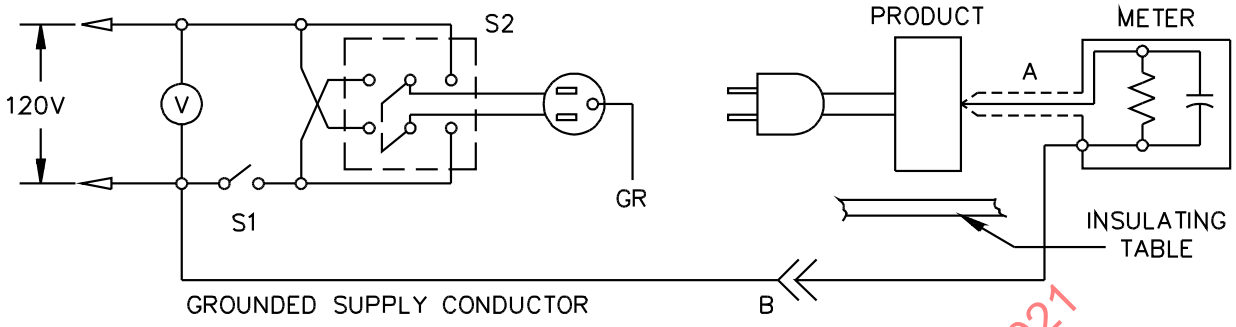
a) The meter is to have an input impedance of 1500 Ω resistive shunted by a capacitance of 0.15 µF.

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

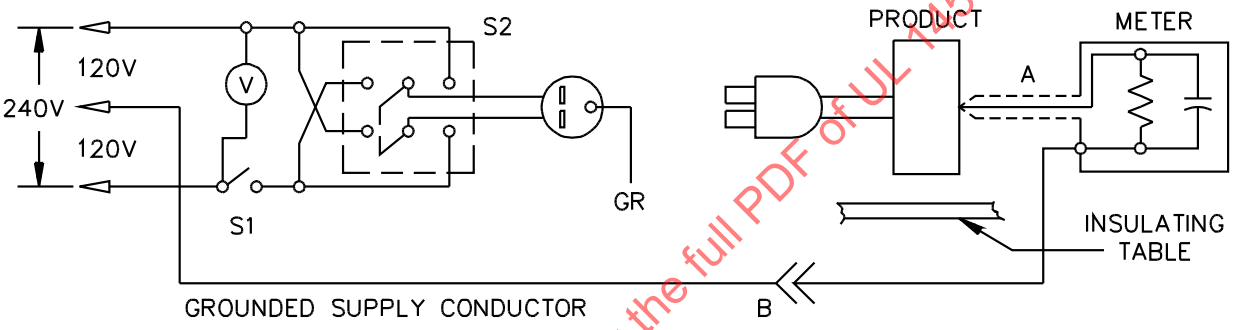
c) Over a frequency range of 0 – 100 kHz, the measurement circuitry is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500 Ω resistor shunted by a 0.15 µF capacitor to 1500 Ω. At an indication of 0.5 or 0.75 mA, the measurement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

Figure 41.1

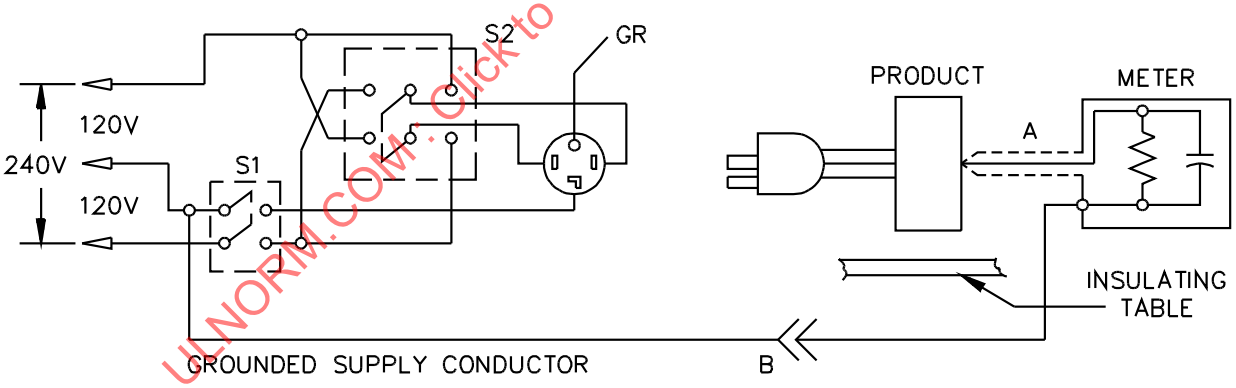
Leakage-current measurement circuits



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



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



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

LC300J

NOTES –

a) Probe with shielded lead.

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

41.6 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 a product.

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

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

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

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

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

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

41.8 The test sample is to be arranged so that all parallel ground paths – such as through fill and drain lines – are eliminated.

41.9 The leakage current test sequence, with reference to the measuring circuit, Figure 41.1, is to be as follows:

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

b) Switch S1 is then to be closed energizing the product, and within 5 s, the leakage current is to be measured using both positions of switch S2, and with the product 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 temperature test.

42 Leakage Current Test Following Humidity Conditioning

42.1 A product as described in 41.1 shall comply with the requirements for leakage current, Section 41 Leakage Current Test, following exposure for 48 h to moist air having a relative humidity of 88 ±2 percent at a temperature of 32.0 ±2.0°C (89.6 ±3.6°F). The product is to be tested as follows:

a) The product is to be at a temperature just above the test chamber temperature when it is placed in a humidity chamber.

b) The product is to remain in the humidity chamber for 48 h.

c) Following this exposure, while still in the test chamber, the sample is to be tested unenergized as indicated in 41.9(a).

d) The sample is then to be removed from the test chamber and tested while energized as indicated in 41.9(b) and (c), until the leakage current has stabilized or decreased.

43 Starting Current Test

43.1 A product 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 product should be

connected. The performance is unacceptable if the fuse opens or an overload protector provided as part of the product trips.

Exception: A time-delay fuse may be employed if the product is marked in accordance with 64.1.8.

43.2 In a test to determine whether a product complies with the requirement in 43.1, the product is to be started three times. The product is to be at room temperature at the beginning of the test. Each start of the motor is to be made under conditions representing the beginning of normal operation – the beginning of the normal operating cycle, in the case of an automatic product – and the motor is to be allowed to come to rest between successive starts. The air outlet of a nontank type product is to be blocked. A tank type product is to be filled with air to the cut-in pressure of the pressure regulating control.

44 Loaded Starting Test

44.1 A portable nontank type air compressor as described in Exception No. 1 to 23.2.1 and that is not provided with motor protection in accordance with 23.2.2 shall start and operate as intended when started under loaded conditions as described in 44.2.

44.2 The product is to be operated with the outlet blocked and then de-energized when the maximum amount of air pressure is attained in the compressor assembly. Following this operation, the product is to be reenergized.

45 Input Test

45.1 The input measured for a product shall not exceed either of the following conditions when the product is operated under the condition of maximum normal load as described in 46.2.1 – 46.2.6 and when connected to a supply as specified in 40.1:

a) 110 percent of the marked rated value; and

b) The branch circuit rating for permanently connected products or the attachment plug rating for cord connected products.

Exception: If the product is rated in wattage in accordance with 63.2, then it is only required to comply with part (a) of this requirement.

46 Temperature Test

46.1 General

46.1.1 A product, when tested under the conditions of maximum normal load as described in 46.2.1 – 46.2.7, shall not reach a temperature high enough to cause a risk of a fire, to damage any materials used, or exceed the temperature rises specified in Table 46.1. See Section 32, Surface Temperature.

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

46.1.3 All values of temperature rise in Table 46.1 are based on an assumed ambient temperature of 25° C (77°F). Tests may be conducted at any ambient temperature within the range of 10 – 40°C (50 – 104°F).

Table 46.1
Temperature rises

Material and components	°C	°F
A. MOTORS		
1. Class 105(A) insulation systems on coil windings of an a-c motor having a frame diameter of 7 in (178 mm) or less, not including a universal motor and a vibrator coil[a,b]		
(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
2. Class 105(A) insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 in (178 mm), of a d-c motor and of a universal motor[a,b]		
(a) In an open motor:		
Thermocouple method	65	117
Resistance method	75	135
(b) In a totally enclosed motor:		
Thermocouple method	70	126
Resistance method	80	144
3. Class 130(B) insulation systems on coil windings of an a-c motor having a frame diameter of 7 in (178 mm) or less, not including a universal motor[a,b]		
(a) In an open motor:		
Thermocouple or resistance method	95	171
(b) In a totally enclosed motor:		
Thermocouple or resistance method	100	180
4. Class 130(B) insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 in (178 mm), of a d-c motor, and of a universal motor[a,b]		
(a) In an open motor:		
Thermocouple method	85	153
Resistance method	95	171
(b) In a totally enclosed motor:		
Thermocouple method	90	162
Resistance method	100	180
5. Class 155(F) insulation systems on coil windings of an a-c motor having a frame diameter of 7 in (178 mm) or less (not including a universal motor) and on vibrator coils.		
(a) In an open motor and/or vibrator coils (thermocouple or resistance method)	120	216
(b) In a totally enclosed motor (thermocouple or resistance method)	125	225
6. Class 155(F) insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 in (178 mm) and of a d-c motor and a universal motor.		
(a) In an open motor,		
Thermocouple method	110	198
Resistance method	120	216
(b) In a totally enclosed motor,		

Table 46.1 Continued on Next Page

Table 46.1 Continued

Material and components			°C	°F
		Thermocouple method	115	207
		Resistance method	125	225
	7.	Class 180 (H) insulation systems on coil windings of ac motors having a frame diameter of 7 inches (178 mm) or less-not including a universal motor.		
		(a) In an open motor:		
		Thermocouple method or Resistance method	135	243
		(b) In a totally enclosed motor:		
		Thermocouple method or Resistance method	140	252
	8.	Class 180 (H) insulation systems on coil windings of ac dc motors having a frame diameter of more than 7 inches (178 mm) of a dc motor, and a universal motor:		
		(a) In an open motor:		
		Thermocouple method	125	225
		Resistance method	135	243
		(b) In a totally enclosed motor:		
		Thermocouple method	130	234
		Resistance method	140	252
	11.	Class 220 (R) insulation systems on coil windings of ac motors having a frame diameter of 7 inches (178 mm) or less-not including a universal motor:		
		(a) In an open motor;		
		Thermocouple method or Resistance method	165	297
		(b) In a totally enclosed motor;		
		Thermocouple method or Resistance method	170	306
	12.	Class 220 (R) insulation systems on coil windings of ac motors having a frame diameter of more than 7 inches (178 mm), of a dc motor, and a universal motor:		
		(a) In an open motor;		
		Thermocouple method	155	279
		Resistance method	165	297
		(b) In a totally enclosed motor;		
		Thermocouple method	160	288
B.		COMPONENTS		
	1.	Capacitors:		
		(a) Electrolytic[c]	40	72
		(b) Other types[d]	65	117
	2.	Fuses[e]	65	117
	3.	Relay, solenoid, and coils (except motor coil windings and transformers) with		
		(a) Class 105(A) insulated systems		
		Thermocouple method	65	117
		Resistance method	85	153
		(b) Class 130(B) insulation systems		
		Thermocouple method	85	153
	4.	Sealing Compound	40	104

Table 46.1 Continued on Next Page

Table 46.1 Continued

Material and components	°C	°F
	less than melting point	
5. Transformers		
(a) Class 155(F) insulation systems:		
Thermocouple method	110	198
Resistance method	115	207
(b) Class 180(H) insulation systems:		
Thermocouple method	125	225
Resistance method	135	243
C. CONDUCTORS		
1. Rubber- or thermoplastic insulated wires and cords[e,f]	35	63
D. ELECTRICAL INSULATION – GENERAL		
1. Fiber employed as electrical insulation	65	117
2. Phenolic composition employed as electrical insulation or as a part the deterioration of which could result in a risk of fire or electric shock[e]		
(a) Laminated	100	180
(b) Molded	125	225
3. Varnished-cloth insulation	60	108
E. SURFACES		
1. A surface upon which a product is placed or mounted in service, and a surface that is adjacent to the product when it is so placed or mounted[g]	65	117
2. Any point within a terminal box or wiring compartment of a permanently connected product in which power-supply conductors are to be connected, including such conductors themselves, unless the product is marked in accordance with 64.2.1	35	63
3. Wood or other combustible material, including the inside surface of the test enclosure and the surface supporting the product	65	117

[a] 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 greater than the limit specified, if the temperature, as measured by the resistance method, is not greater than that specified. The temperature measured by means of a thermocouple is able to be greater than the specified value by:

1. 5°C (9°F) for Class 105(A) insulation systems on coil windings of alternating-current motors having a diameter of 7 in (178 mm) or less, open type,

2. 10°C (18°F) for Class 130(B) insulation systems on coil windings of alternating-current motors having a diameter of 7 in or less, open type,

3. 15°C (27°F) for Class 105(A) insulation systems on coil windings of alternating-current motors having a diameter of more than 7 in, open type,

4. 20°C (36°F) for Class 130(B) insulation systems on coil windings of alternating-current motors having a diameter of more than 7 in, open type.

[b] See note a to Table 27.2.

[c] For an electrolytic capacitor that is physically integral with or attached to a motor, the maximum temperature rise on insulating material integral with the capacitor enclosure is not more than 65°C (117°F).

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

[e] A fuse that has been investigated, and found to comply with requirements for use at a higher temperature is able to be used at that temperature.

[f] A rubber-insulated conductor within a motor, a rubber-insulated motor lead, and a rubber-insulated conductor of a flexible cord entering a motor is able to be subjected to a higher temperature when the conductor is provided with sleeving or a braid that has been investigated and found to comply with requirements for use at the higher temperature. This does not apply to thermoplastic-insulated wires or cords.

[g] See 46.1.14 and 46.1.15.

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

46.1.5 A product having a single frequency rating is to be tested at that frequency. A product rated ac/dc or dc-60 Hz is to be tested on direct current or 60-Hz alternating current, whichever results in higher temperatures. A product rated 50/60 Hz alternating current is to be tested on either 50-Hz or 60-Hz alternating current, whichever results in higher temperatures. A product rated 25 – 60 Hz or 50 – 60 Hz is to be tested on 60-Hz alternating current.

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

46.1.7 For a product that is obviously not intended for continuous operation, the probable intermittent or short-time operation of the product is to be taken into consideration when conducting the temperature test. In addition, the requirements in 46.1.8 – 46.1.13 shall apply.

46.1.8 An inflator default duty cycle rate is 15 min on, 5 min off.

Exception: Commercial inflators employing a timer circuit that positively and reliably limits the length of time the product can operate shall be operated for the maximum preset duration of operation, followed by a period of 5 min "off". Following the "off" period, normal load is applied again. This mode of cycling shall be repeated five times. Temperatures shall be measured at the end of the 5th cycle of operation.

46.1.9 For inflator products employing a timer, the "on" cycle can be adjusted based upon information provided by the manufacturer, see 46.1.11, but shall never be less than the maximum timer adjustment. The "off" period shall not exceed 5 min.

46.1.10 For inflator products employing a momentary contact switch, the "on" cycle can be adjusted based upon information provided by the manufacturer, see 46.1.11, but shall never be less than 3 min. The "off" period shall not exceed 5 min.

46.1.11 For inflator products, if a manufacturer specifies a duty cycle less than that described in 46.1.8, 46.1.9, or 46.1.10, documentation shall be provided listing the inflatable products that the inflator is intended or recommended to be used with. This list shall include the inflatable products expected inflation time. This information shall be used to establish a realistic and appropriate duty cycle within the parameters described in 46.1.8 – 46.1.10.

46.1.12 An inflator product intended for use with a duty cycle as outlined in 46.1.11, shall be marked with the duty cycle. See 65.20.

46.1.13 An inflator product intended for use with a duty cycle as outlined in 46.1.11, shall indicate the duty cycle in the operating instructions. See 67.7.

46.1.14 A small, cord-connected product of the hand-supported type shall not attain a temperature of more than 125°C (257°F) on any exterior surface that may be laid on flammable material or against which flammable material may be laid, and there shall be no emission of smoke or molten material.

46.1.15 To determine whether a product complies with the requirement in 46.1.8, the product is to be operated at the voltage and frequency specified in 46.1.4 and 46.1.5 until constant temperatures are attained. The product may be stationary during the test, and simulation of actual service conditions need not be attempted.

46.1.16 A short length of rubber- or thermoplastic-insulated flexible cord exposed to a temperature of more than 60°C (140°F), such as at terminals, is acceptable if supplementary heat-resistant insulation of adequate dielectric strength is employed on the individual conductors of the cord to prevent deterioration of the conductor insulation.

46.1.17 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-min intervals, indicate no change.

46.1.18 Coil winding temperatures are to be measured by thermocouples or by using the change-of-resistance method, whichever is appropriate. For a thermocouple measured temperature of a coil of an alternating-current motor having a diameter of 7 in (178 mm) or less and a universal motor – see items 1 and 3 in Table 46.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor. For any other motor, the thermocouple may be applied on the outer surface of a wrap that is not more than 1/32 in (0.8 mm) thick and consists of cotton, paper, rayon, or the like.

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

46.1.20 When using the resistance method, the windings are to be at room temperature at the start of the test, and the temperature rise of a winding is to be calculated using the formula:

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

in which:

Δt = the temperature rise in °C,

R = the resistance of the coil in ohms at the end of the test,

r = the resistance of the coil in ohms at the beginning of the test,

t_1 = the initial room temperature in °C at the time resistance "r" is being measured (which is also the initial coil temperature),

t_2 = the room temperature in °C at the end of the test, and

k = 234.5 for copper and 225.0 for electrical conductor grade (EC) aluminum; values of the constant for other conductors are to be determined.

46.2 Maximum normal load

46.2.1 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 product. A product having features not contemplated in these test procedures may be tested as necessary to meet the intent of these requirements.

46.2.2 The temperature tests on a nonpneumatic paint sprayer are to be conducted with the product spraying water, oil, or some other liquid representative of actual use. If the paint pump is separate from the

spray gun, the sprayer is to be operated continuously, with the spray gun adjusted to result in maximum load, until constant temperatures are attained. A paint pump that is integral with the spray gun is to be operated for the maximum number of cycles possible in 1 h. Each cycle is to consist of continuous spraying until the reservoir is empty or continuous spraying for 5 min, whichever is shorter, followed by a 1 min off period for refilling. The reservoir is to be the largest available for the product. If an accessory is recommended, such as a paint siphon tube, that will permit operation without a reservoir attached, the on period of the cycle is to be 5 min.

46.2.3 A pigment dispenser is to be operated continuously until temperatures become constant. Paint pigment or 10W30 oil is to be used as the dispensing medium.

46.2.4 A paint mixer is to be operated until temperatures become constant. The mixer is to be loaded with the maximum number and size of full paint cans. If the mixer has timer, the mixer is to be operated for continuous cycles consisting of mixing for the maximum time permitted by the timer followed by 1 min off. If the mixer has no timer, it is to be operated for continuous cycles consisting of 10 min on and 1 min off.

46.2.5 A tank-type compressor is to be operated continuously until constant temperatures have been attained. The tank is to be maintained at a value midway between the pressure controller's cut-in and cut-out pressure.

46.2.6 A compressor or vacuum pump other than the tank type, is to be operated continuously if possible – without pressure switches cycling – until constant temperatures are reached, with the air intake or discharge adjusted sufficiently to cause a maximum wattage input to the product.

Exception: A linear style compressor and/or vacuum pump shall be tested continuously under both the blocked outlet (compressor) or inlet (vacuum pump) and also the open outlet or inlet depending upon which condition represents the most severe conditions of normal use, for example, highest temperatures during Temperature Test, Section 46, or highest current draw during Input Test, Section 45.

46.2.7 A permanently installed product is to be mounted in the intended manner in a nominal 3/8-in thick, black-painted plywood corner alcove consisting of a floor, a 90-degree wall angle formed by two vertical plywood sheets, and an 8-ft (2.4-m) high ceiling with all surfaces of the alcove extending not less than 2 ft (610 mm) beyond the physical limits of the product. The product is to be located as close to the walls and to the floor or ceiling as its construction will permit unless marked in accordance with 64.2.3.

47 Grounding Continuity Test

47.1 The resistance between the point of connection of the equipment-grounding means at or within the product and any other point in the grounding circuit of the product shall not be more than 0.1 Ω as determined by an ohmmeter or other equivalent means.

47.2 If unacceptable results are observed with an ohmmeter, a low voltage current source can be employed. With the low voltage current source, an alternating current of 25 A (for 15 A maximum rated products) from a power supply of 12 V or less is to be passed for one minute minimum. The current shall be passed from the point of connection of the equipment grounding means to the metal part in the grounding circuit under test. The resulting drop in potential is measured between the two points. The power cord resistance is not included in the measurement.

48 Dielectric Voltage Withstand Test

48.1 A product shall withstand for 1 min without breakdown the application of a 60-Hz essentially sinusoidal potential between live parts and dead metal parts, between circuits that are different potentials and are not electrically connected, or between live parts of opposite polarity for a test on a capacitor as

mentioned in (c), with the product at the maximum operating temperature reached in normal use. The test potential shall be:

a) One thousand volts for a product employing a motor rated 1/2 hp (373 W output) or less and 250 V or less;

b) One thousand volts plus twice the rated voltage for a product employing a motor rated at more than 1/2 hp or more than 250 V; or

c) One thousand volts plus twice rated voltage between the terminals of a capacitor used for radio-interference elimination or arc suppression.

48.2 The test potential for the secondary circuit of a product employing a transformer or auto-transformer shall be:

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

b) One thousand volts if the secondary operates at 51 – 250 V; or

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

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

48.3 To determine whether a product complies with the requirements in 48.1 and 48.2, the product is to be tested by means of a 500 VA or larger transformer, having an output voltage that is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test value is reached and is to be held at that value for 1 min. 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.

Exception: A 500 VA or larger capacity transformer need not be used if the transformer is provided with a voltmeter to measure directly the applied output potential.

49 Resistance to Moisture Test

49.1 A product intended for outdoor use and not marked in accordance with 65.13 shall be conditioned as described in 49.3 and 49.4. There shall be no obvious wetting of any electrical component, and no water shall enter a compartment that houses field-installed wiring. Following the test, the product:

a) Shall comply with the dielectric voltage withstand requirements in Section 48, Dielectric Voltage Withstand Test; and

b) Shall:

1) For a cord-connected product rated 250 V or less, comply with the leakage current requirements as described in Section 41, Leakage Current Test.

2) For a cord-connected product rated more than 250 V and a permanently-connected product, have an insulation resistance between current-carrying parts and exposed dead metal parts of not less than 50,000 Ω. See 49.2.

49.2 Insulation resistance is to be measured by means of a high resistance voltmeter using a 250-V direct-current circuit.

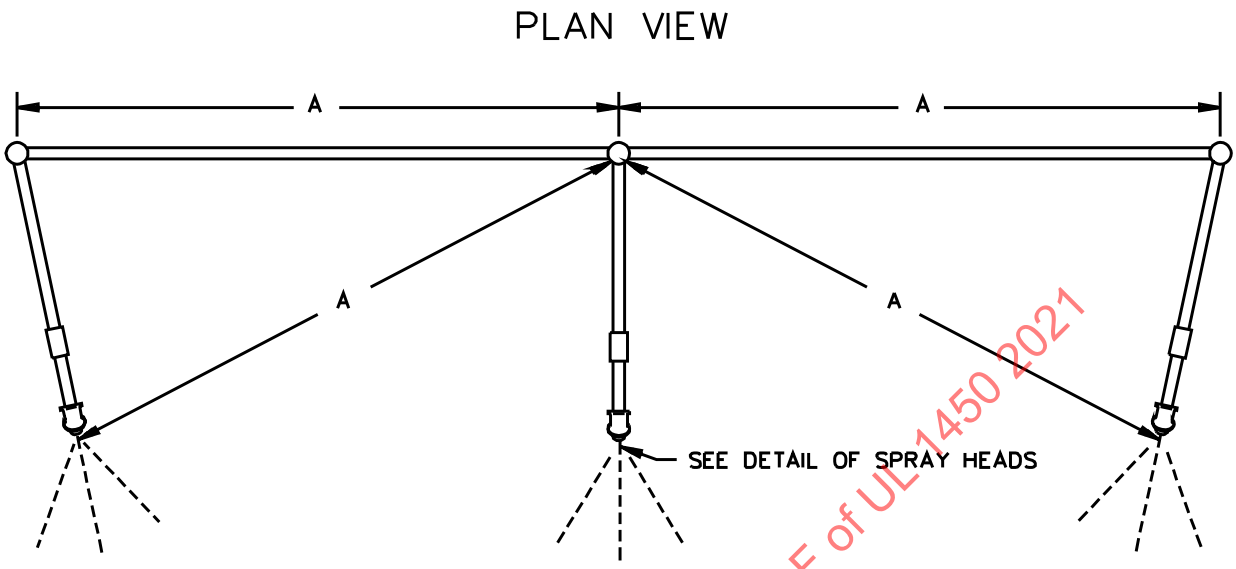
49.3 The product is to be subjected to a water spray as described in 49.4. The leakage current or insulation resistance, as applicable, is then to be measured, following which the product is to be tested for dielectric voltage withstand in accordance with 48.1.

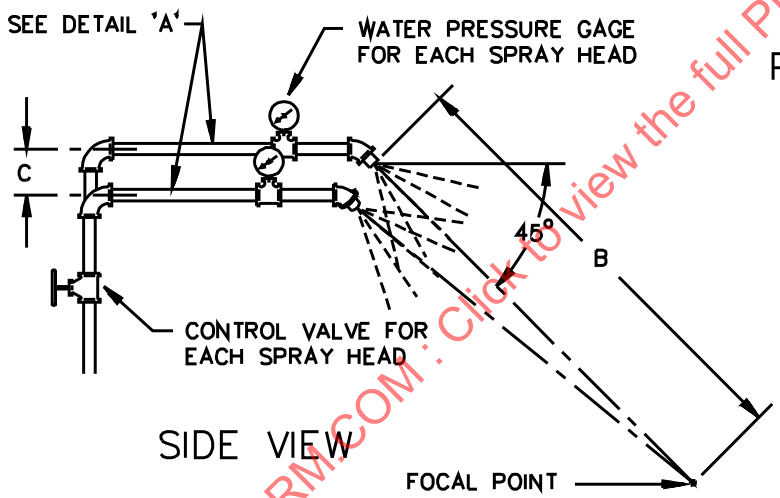
49.4 The rain test apparatus is to consist of three spray heads mounted in a water supply pipe rack as illustrated in Figure 49.1. The spray heads are to be constructed in accordance with the details illustrated in Figure 49.2. The water pressure for all tests is to be maintained at 5 psi (34.5 Pa) at each spray head. The distance between the center nozzle and the product is to be approximately 5 ft (1.5 m). The product is to be brought into the focal area of the three spray heads in such a position and under such conditions as are most likely to result in entrance of water into the enclosure. The spray is to be directed at a 45 degree angle to the vertical toward the product. The total exposure is to be for 1 h.

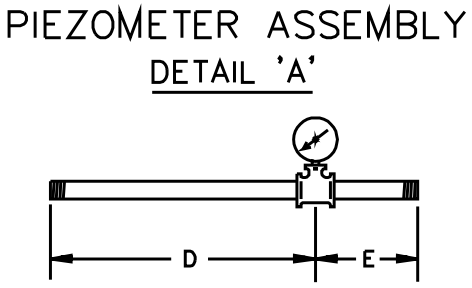
49.5 With reference to the test described in 49.4, it may be necessary to operate the product in various positions or under various modes of operation, or more than one sample may be tested if alternate modes are possible. The product may be de-energized if more adverse conditions could result.

Figure 49.1

Spray-head pipe rack





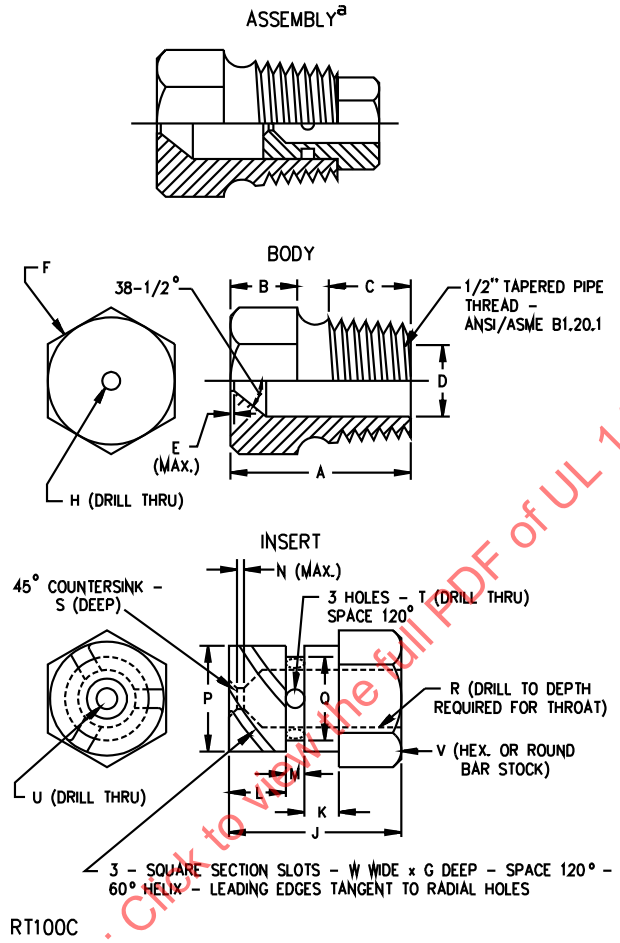


Item	inch	mm
A	28	710
B	55	1400
C	2–1/4	55
D	9	230
E	3	75

RT101D

Figure 49.2

Spray-head assembly



Item	in	mm	Item	in	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	0.575	14.61
C	9/16	14.0		0.576	14.63
D	.578	14.68	Q	0.453	11.51
	.580	14.73		0.454	11.53
E	1/64	0.40	R	1/4	6.35
F	[c]	[c]	S	1/32	0.80
G	.06	1.52	T	(No. 35)[b]	2.79
H	(No.9)[b]	5.0	U	(No. 40)[b]	2.49
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

[a] Molded nylon Rain-Test Spray Heads area available from Underwriters Laboratories Inc.

[b] ANSI B 94.11 Drill Size.

[c] Optional - To serve as wrench grip.

50 Paint Entry Test

50.1 To determine whether a paint sprayer or compressor complies with the requirements in 9.9, the product shall be subjected to the test described in 50.2 and 50.3. During the test, the leakage current of a cord-connected product rated 250 V or less shall comply with the requirements in 41.1. At the completion of the test:

a) There shall be no evidence of the tracer dye on uninsulated live parts of any product, and

b) Each product shall comply with the requirements in 49.1(a) and (b).

50.2 A paint sprayer or compressor is to be placed in a three wall alcove with an upper closure. The alcove is to be 2 ft (0.61 m) wide, 2 ft deep, and 4 ft (1.22 m) high. A compressor is to be placed on the floor with the surface most susceptible to paint entry located parallel to and 18 in (457 mm) from the front of the alcove. An integral paint sprayer or separate spray gun, if provided, is to be placed at the center of the alcove with the tip of the spray tip located 2 ft above the floor and 1 ft (0.30 m) from the front of the alcove. The discharge is to be aimed into a corner.

50.3 The unit is to be filled with water containing a tracer dye and operated for 20 c. Each cycle is to consist of continuous spraying until the unit is empty, followed by 1 min off to permit a refilling of the unit.

51 Test on Switches and Controls

51.1 A switch or other device that controls a solenoid, a relay coil, or the like, and that has not been previously found to be acceptable for the purpose shall perform acceptably when subjected to an overload test consisting of 50 c of operation as described in 51.2. There shall be no electrical or mechanical breakdown of the device or undue burning or pitting of the contacts as a result of the test, and the fuse in the grounding connection shall not open.

51.2 To determine whether a switch or other device complies with the requirement in 51.1, the product is to be connected to a supply circuit of rated frequency and 110 percent of maximum rated voltage. The load on the device being tested is to be the same as that which it is intended to control in normal service. During the test, exposed dead metal parts of the product are to be connected to ground through a 3-A plug fuse. The device is to be operated at a rate of not more than 10 c per min, except that a faster rate of operation may be employed if agreeable to those concerned.

51.3 A switch or other device that controls a motor of a product, unless it has been found to be acceptable for the application or is interlocked so that it will never break the locked-rotor motor current, shall perform acceptably when subjected to a test consisting of 50 c of operation, making and breaking the locked-rotor current of the product. There shall be no electrical or mechanical breakdown of the device or undue pitting or burning of the contacts, and the fuse in the grounding connection shall not open.

51.4 To determine whether a switch or other control device complies with the requirement in 51.3, the product is to be connected to a grounded supply circuit of rated frequency and maximum rated voltage – see 46.1.4 and 46.1.5 – with the rotor of the motor locked in position. During the test, exposed dead metal parts of the product are to be connected to ground through a 3-A plug fuse, and the connection is to be such that any single-pole, current-rupturing device will be located in the ungrounded conductor of the supply circuit. If the product is intended for use on direct current or on direct current as well as alternating current, the exposed dead metal parts of the product are to be connected so as to be positive with respect to a single-pole, current-rupturing control device. The device is to be operated at a rate not more than 10 c per min, except that a faster rate of operation may be employed if agreeable to those concerned.

52 Strain Relief Test

52.1 The strain relief means provided on an attached flexible cord, flexible conduit, or armored cable, when tested in accordance with 52.2, shall withstand for 1 min without displacement a direct pull of 35 lbf (156 N) applied to the cord, with the connections within the product disconnected.

52.2 A 35-lb (15.9 kg) weight is to be suspended on the cord and supported by the product so that the strain-relief means will be stressed from any angle that the construction of the product permits. The strain relief is not acceptable if, at the point of disconnection of the conductors, there is such movement of the cord as to indicate that stress would have resulted on the connections.

53 Push-Back Strain Relief Test

53.1 A product with a non-detachable cord is to be tested in accordance with 53.2 without occurrence of any of the conditions specified in 13.2.2.

53.2 The supply cord or lead is to be held 1 in (25.4 mm) from the point where the cord or lead emerges from the product and is then to be pushed back into the product. When a removable bushing which extends further than 1 in is present, it is to be removed prior to the test. When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The cord or lead is to be pushed back into the product in 1-inch increments until the cord buckles or the force to push the cord into the product exceeds 6 lbf (26.7 N). The supply cord or lead within the product is to be manipulated to determine compliance with 13.2.2.

54 Abnormal Operation Test

54.1 If a product employs a semiconductor device, a capacitor, or a combination of both, a risk of fire, electric shock, or injury to persons shall not result when either the semiconductor device or the capacitor is short- or open-circuited.

Exception: The test is not required:

a) If circuit analysis indicates that a risk of fire, electric shock, or injury to persons is not likely as a result of the open circuiting or short circuiting of a semiconductor device or capacitor.

b) For components whose failure may result in an increased risk of fire or electric shock and that have previously been investigated and found suitable for the application.

54.2 In a test to determine whether a product complies with 54.1, the product is to be connected to a grounded supply of rated frequency and maximum rated voltage operating at no load with the short- or open-circuited condition introduced. Only one abnormal condition is to be simulated at a time.

54.3 During the tests described in 54.2, the product is to be connected in series with a nontime-delay fuse representative of the maximum current that could be passed in the circuit by the branch circuit protective device. The maximum current rating shall be based on the maximum current rating that can be accommodated by the fuseholder of the branch circuit to which the product could properly be connected, in accordance with the National Electrical Code, ANSI/NFPA 70.

54.4 Exposed dead metal parts of the product are to be connected to ground through a 3-A fuse, and the test is to be continued until ultimate results are obtained. The results are unacceptable if the fuse opens during the test. If the product is provided with a momentary-contact switch having no provision for being locked on, and if there is indication of malfunction of the product such as emission of smoke, failure to operate in the intended manner, or other indication, the test is to be discontinued when the malfunction becomes evident.

55 Accelerated Aging Test

55.1 A rubber or neoprene compound forming a part that is depended upon for protection from rain shall have physical properties as noted in Table 55.1 before and after aging.

55.2 The test procedure for determining whether a part complies with the requirement in 55.1 depends upon the material of which it is composed, its size and shape, the application in the product, and other factors. The test procedure may include visual inspection for cracks, deformation, and the like after accelerated aging, as well as comparison of hardness, tensile strength, and elongation before and after accelerated aging.

55.3 With reference to the requirements in 55.1 and 55.2, a part of rubber or neoprene, if tested to compare its tensile strength and elongation before and after accelerated aging, is acceptable if these properties are not less than the minimum values specified in the Table 55.1, corresponding to the temperature of the component during the temperature test.

Table 55.1
Accelerated aging test

Temperature of component during temperature test		Accelerated aging procedure	Minimum acceptable percent of unaged value for samples	
°C	°F		Tensile strength	Elongation
60 or less	140 or less	Air oven aging for 70 h at 100°C	60	60
61 – 75	142 – 167	Air oven aging for 168 h at 100°C	50	50
76 – 90	169 – 194	Air oven aging for 168 h at 121.0 ±1.0°C (249.8 ±1.8°F)	50	50
91 – 105	196 – 221	Air oven aging for 168 h at 136.0 ±1.0°C (276.8 ±1.8°F)	50	50

56 Permanence of Marking Tests

56.1 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 that complies with the requirements in the Standard for Marking and Labeling Systems, UL 969. Ordinary usage, handling, storage, and the like of a product are considered in the determination of the permanence of a marking.

56.2 In addition to complying with the requirement in 56.1 and, after being tested as described in 56.6, a tag used for a cautionary marking in accordance with 65.5 is considered to be permanently affixed to a power-supply cord or hose if there is no:

a) Tearing at any point for more than 1/16 in (1.6 mm),

b) Movement of the tag more than 1/2 in (12.7 mm) along the length of the power-supply cord or hose,

Exception: A tag applied to a hose may move more than 1/2 in provided a fitting on each end of the hose prevents the tag from sliding off.

c) Shrinkage, wrinkling, cracking, or other deformation that renders the marking illegible, or

d) Visible curling or loosening around the edges of a tag with an adhesive back.

Exception: A tag used for a cautionary marking complying with the applicable requirements in the Standard for Marking and Labeling Systems – Flag Labels, Flag Tags, Wrap-Around Labels and Related Products, ANSI/CAN/UL 969A, is not required to comply with this requirement. With respect to a tag applied to a hose, the exception in (b) above is also applicable.

56.3 Nine samples of a cord or hose tag are to be tested as described in 56.6. Each sample is to consist of a length of power-supply cord or hose to which the tag has been attached in the intended manner. If the tag is secured by an adhesive, the test is to be conducted no sooner than 24 h after application of the tag. Three samples are to be tested as received; the additional samples are to be conditioned as described in 56.4 and 56.5 prior to testing.

56.4 Three samples are to be conditioned for 240 h in an air-circulating oven maintained at a uniform temperature of 87.0 ±1.0°C (188.6 ±1.8°F). Following removal from the oven, the samples are to remain at a temperature of 23.0 ±2.0° C (73.4 ±3.6° F) and a relative humidity of 50 ±5 percent for 30 min before testing.

56.5 Three additional samples are to be conditioned for 72 h at a temperature of 32.0 ±2.0°C (89.6 ±3.6° F) and a relative humidity of 85 ±5 percent. The samples are to be tested within 1 min after exposure.

56.6 Each sample power-supply cord or hose with attached tag is to be tightly suspended and clamped at each end in a vertical plane with the attachment plug on a cord pointing upward. A 5-lb (22.2-N) force is to be applied for 1 min at the uppermost corner of the tag farthest from the cord or hose and within 1/4 in (6.4 mm) of the vertical edge of the tag. The force is to be applied vertically downward in a direction parallel to the major axis of the cord or hose. Following the test, the sample shall comply with the requirements in 56.2. Manipulation of the tag, such as straightening by hand, is permitted.

57 Vibration Test

57.1 With reference to 36.1.9, a sample pressure vessel assembly is to be placed on a vibration table in its normal upright position and not secured in place. Loose restraint shall be used to limit the area of travel. For an assembly provided with a mounting means intended to support a motor, compressor, or a similar device, a load equal to the maximum load that the tank is to support in normal use shall be secured to the intended mounting surface. The load is to be imposed by the heaviest motor, compressor, controls, and piping that are to be supported by the tank or by weights representing an equivalent load secured in position to simulate the actual construction. An assembly with wheels is to be tested with the wheels in place.

57.2 The test apparatus is to consist of a vibration table that provides continuous circular motion with a total displacement of 1 inch (25.4 mm) in a vertical plane with the table level at all times. The speed of the apparatus is to be adjusted so that the vibration frequency generates a 1/16-in (1.6-mm) vertical displacement of the pressure vessel assembly from the table.

57.3 During the test, the pressure vessel assembly is to be rotated 90 degrees from the initial position so that the sample is subjected to both longitudinal and transverse circular vibration. The sample is to be subjected to vibration in each position for 3-1/2 h – 7 h of total vibration time. After making the change in position of the sample – 90-degree rotation – the speed of the test apparatus is to be readjusted to maintain a 1/16-in (1.6-mm) tank displacement.

57.4 After completion of the test, the pressure vessel assembly shall not show visual evidence of cracking or other indication of vessel or support damage. Damage to a wheel or mounting shall not result in a risk of fire, electric shock, or injury to persons. The pressure vessel shall withstand a hydrostatic strength test as described in 57.5.

57.5 A hydrostatic strength test is to be conducted by filling the pressure vessel with water so as to exclude all air, connecting the pressure vessel to a hydraulic pump, and gradually increasing the pressure to 1-1/2 times the relief valve setting. The sample shall not leak. The pressure is then to be gradually increased to five times the relief valve setting and held at that value for 1 min. The sample shall not rupture.

58 Hydrostatic Strength Test

58.1 With reference to 36.1.9, 36.2.1, and 36.2.2, a hydrostatic strength test is to be conducted by filling the sample with water, oil or some other liquid representative of actual use so as to exclude all air, connecting the sample to a hydraulic pump, gradually increasing the pressure to the specified test value, and holding it for a period of 1 min. As a result of the test:

a) A pressure vessel shall withstand without leakage or rupture a pressure of five times the relief valve setting, or

b) A part, other than a pressure vessel, that is subject to pressure shall withstand without rupture a test pressure of five times the value specified in 36.2.1.

Exception: Rupture of a nonmetallic fluid transfer line and its connections, or at a gasket complies with the requirements when repeated tests conducted with media they are intended to contain show no evidence of resulting in a risk of electric shock or injury to persons.

MANUFACTURING AND PRODUCTION TESTS

59 Dielectric Voltage Withstand

59.1 Each product shall withstand without electrical breakdown, as a routine production-line test, the application of a 40 – 70 Hz or a direct current potential:

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

b) Between primary wiring and accessible low-voltage metal parts, including terminals.

59.2 The production-line test shall be in accordance with either Condition A or Condition B of Table 59.1.

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

Table 59.1
Production-line test conditions

Rating of motor in product	Condition A			Condition B		
	Potential, V ac	Potential, V dc	Time, s	Potential, V ac	Potential, V dc	Time, s
1/2 hp (373 W output) or less and 250 V or less	1000	1400	60	1200	1700	1
More than 1/2 hp or more than 250 V	1000+2V[a]	1400 +2.8V[a]	60	1200 +2.4V[a]	1700 +3.4V[a]	1

[a] V = maximum marked voltage but not less than 120 V.

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

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

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

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 59.2, but the circuitry may be rearranged for the test to reduce the likelihood of solid-state-component damage while retaining representative dielectric stress of the circuit.

59.5 The test equipment shall have 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. When an alternating-current test potential is applied, the test equipment shall include a transformer having an essentially sinusoidal output.

59.6 If the output of the test equipment is less than 500 VA, the equipment shall include a voltmeter in the output circuit to directly indicate the test potential.

59.7 If the output of the test equipment is 500 VA or larger, 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.

59.8 Test equipment other than that described in 59.5 – 59.7 may be used if found to accomplish the intended factory control.

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

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

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

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

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

60 Grounding Continuity

60.1 Each product 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 product that are likely to become energized.

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

60.3 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 60.1.

61 Pressure Vessel Assembly

61.1 Each pressure vessel manufactured shall be visually examined for quality of welds, pipe connection fittings, and general assembly details.

61.2 Each non-ASME coded vessel and ASME vessel coded "UM" shall be tested as described in 61.3 and shall show no evidence of permanent deformation or external leakage.

61.3 The test is to be conducted on a fully assembled vessel after all fabrication, including the attachment of saddles, legs, wheel supports, fittings, or the like, has been completed. For the test, the vessel is to be filled with water to exclude all air and then subjected to the test pressure specified in 61.4 for a period of 20 s minimum. The pressure shall be maintained for a longer period if necessary to complete the inspection for leaks.

Exception: The production-line testing may be conducted using an aerostatic pressure if:

a) Acceptable protection for personnel conducting the test is provided, and

b) Suitable means for detection of external leakage is provided.

61.4 The test pressure for a non-ASME coded vessel is to be 1-1/2 times the start-to-discharge setting of the pressure relief device. The test pressure for an ASME vessel coded "UM" is to be 1.3 times the rated working pressure of the vessel.

62 Start-to-Discharge of Pressure-Relief Device

62.1 Each non-ASME coded pressure-relief device shall be tested by the manufacturer for the start-to-discharge pressure by subjecting the pressure-relief device to a gradually increasing air pressure until the device begins to open. The start-to-discharge pressure shall be in the range of 90 to 100 percent of its assigned start-to-discharge pressure setting.

RATING

63 Details

63.1 A product 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 63.2, in amperes. The frequency may be expressed as _____/dc – for example, 60/dc – if a universal motor nameplate serves as the product rating marking. If a product is intended for use on a polyphase circuit, the number of phases shall be included in the rating.

63.2 Instead of the ampere rating mentioned in 63.1, a product may be rated in watts if the full-load power factor is 0.80 or more or if the rating of a cord-connected product is 50 W or less.

MARKING

64 Details

64.1 General

64.1.1 A product shall be legibly and permanently marked where it will be readily visible – after installation in the case of a permanently connected appliance – but not on a removable part of the product, such as on the blades of an attachment plug, with the following:

a) The manufacturer's name, trade name, trademark, or other descriptive markings by which the organization responsible for the product may be identified;

Exception: The manufacturer's identification may be in a traceable code if the product is identified by a brand or trademark owned by a private labeler.

b) The date or other dating period of manufacture not exceeding any three consecutive months. The date code shall not repeat in less than 20 years;

Exception: The date of manufacture may be abbreviated or in an established or otherwise acceptable code.

c) A distinctive catalog number or the equivalent; and

d) The electrical rating. A product intended for connection to a 120/240 V, 3-wire, single-phase power source shall be marked "3-wire."

64.1.2 A product that employs a single motor as its only electric-energy-consuming component need not show the electrical rating given on the motor nameplate elsewhere on the product if this nameplate is permanent and readily visible after the motor has been installed in the product.

64.1.3 If the motor nameplate of a dual-voltage motor is employed to give the electrical rating of the product as provided in 64.1.2, the product shall be additionally and permanently marked to indicate the voltage for which it is intended when shipped from the factory. If the product employs an attachment plug, instructions shall be provided to indicate the type of plug that should be used if the product is reconnected for the alternate voltage.

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

64.1.5 A capacitor or capacitor transformer unit, as described in 19.6, that is not physically a part of a product shall be permanently marked with an identification symbol; this symbol shall also appear on the nameplate of the motor.

64.1.6 A product that is packaged with an attachment as a complete unit shall be marked in a manner that will identify the attachment. The identification of the attachment shall appear in at least one of the following locations:

a) On the product;

b) On the attachment; or

c) On the package housing the product.

64.1.7 If the design of a product contemplates cleaning or servicing, such as the replacement of a pilot lamp or a fuse, 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 product shall be plainly and permanently marked to indicate that such servicing or cleaning be done with the product disconnected from the supply circuit.

64.1.8 A product that will not start and attain normal running speed when connected to a circuit protected by an ordinary – not a time-delay – fuse as specified in the Exception to 43.1 shall be plainly and permanently marked with the words: "If connected to a circuit protected by fuses, use time-delay fuses with this product," or with an equivalent wording.

64.1.9 A compressor system with an air-holding tank that is provided with a pressure indicator not calibrated in pressure units shall be permanently marked to define the significance of the markings on the gauge.

64.1.10 A compressor that weighs 20 lb (9.07 kg) or more and that has not been subjected to a paint-entry test in accordance with Exception No. 2(b) to 9.9 shall be marked: "Do not carry while painting," or with an equivalent wording.

64.1.11 A compressor or pump, to which a spray gun is intended to be connected by at least 15 ft (4.57 m) of separately available hose and that has not been subjected to a paint-entry test in accordance Exception No. 2(a) of 9.9 shall be marked: "Use a minimum of 15 ft of hose when connecting the spray gun to the compressor" or with an equivalent wording.

64.1.12 A product that is intended for installation or use in a commercial 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 in (457 mm) or more above the floor."

Exception: A product in which arcing or sparking parts are located at least 18 in above a floor need not be marked.

64.1.13 A product 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 applicable requirements in the Standard for Double Insulation Systems for Use in Electrical Equipment, UL 1097.

64.2 Permanently connected products

64.2.1 If any point within a terminal box or wiring compartment of a permanently connected product in which the power-supply conductors are intended to be connected, including such conductors themselves, attains a temperature rise of more than 35° C (63° F) during the temperature test, the product shall be permanently marked "For supply connection, use wires acceptable for at least ... C (... F)," or with an equivalent statement, and the temperature value shall be in accordance with Table 64.1. 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 product.

Table 64.1
Outlet-box marking

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

64.2.2 A product 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 product are being made.

64.2.3 If a specific spacing is necessary between a permanently-installed product and the surfaces of the test alcove described in 46.2.7 to prevent the attainment of excessive temperatures within the product or an adjacent surface, the product shall be permanently marked in a location that will be readily visible after installation "Mount at least ... inches from side walls (and floor or ceiling)." See 67.5.

64.2.4 A motor-operated air compressor intended for use with sprinkler systems shall be marked with the maximum rated operating pressure.

64.3 Cord-connected products

64.3.1 If a product is provided with a power-supply cord 18 in (457 mm) or less long or with a motor-attachment plug in accordance with 13.1.8 and 13.1.9, a statement advising of the availability of an extension cord and the importance of using such a cord shall be marked on the product.

Exception: As an alternative to marking, the required statements may be contained in the operating instructions. See 67.3.

64.4 Household type products

64.4.1 A product evaluated in accordance with the Exceptions to 9.4 shall be marked "Household Use Only" or the equivalent. The lettering shall not be less than 3/32 in (2.4 mm) high.

64.4.2 A carton (individual marketing container) for a product evaluated in accordance with the Exceptions to 9.4 shall be marked "Household Use Only" or the equivalent. The marking shall:

a) Be located on at least one outside surface, and

b) Appear in lettering not less than the height specified in Table 64.2.

Table 64.2
Lettering height

Smallest dimension of the carton panel to be marked in inches (mm)		Minimum height of lettering in inches (mm)
More than	Less than or equal to	
0	6 (152)	1/8 (3.2)
6 (152)	10 (254)	3/16 (4.8)
10 (254)	–	1/4 (6.4)

65 Cautionary

65.1 A product having a hidden or unexpected risk of injury to persons shall be marked to inform the user of the risk.

65.2 A cautionary marking shall be permanent and legible and shall be located on a permanent part of the product.

65.3 A cautionary marking intended to instruct the operator shall be legible and visible from the position normally assumed by the operator when starting the product 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.

65.4 A cautionary marking on a paint sprayer or paint gun shall be in lettering raised not less than 0.020 in (0.51 mm) above the surrounding surface, or of a similar type not likely to become unreadable with several layers of paint covering it.

Exception: The cautionary marking on a paint sprayer having a motor rated 3 hp (2.2 kW output) or less may be on a tag if the tag complies with the requirements in 65.5.

65.5 A tag used for a cautionary marking in accordance with the Exception to 65.4 or 65.12 shall:

a) Be permanently affixed to a hose or an attached power-supply cord,

b) Be located not more than 6 in (152.4 mm) from the attachment plug, if on a cord,

c) Be made of substantial material such as cloth, plastic, or the equivalent that provides the necessary mechanical strength and prevents easy removal, and

d) Comply with the requirements in 56.2 – 56.6. The tag shall be of a size that facilitates legibility of the required markings, and all exposed surfaces shall have a clear plastic overlay, or the equivalent, to protect the markings. The tag shall be either of the following forms:

1) A flag-type tag having a hole to permit securement to the power-supply cord or hose by a plastic strap or equivalent means. The strap shall not be removable without cutting; or

2) A flag-type tag with a adhesive back. The tag is to be wrapped tightly once around and is to adhere to the supply cord or hose. The ends of the tag are to adhere to each other and project as a flag. The required markings are to be positioned on the projecting flag portion of the tag.

65.6 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." Upper case letters shall not be less than 0.080 in (2.0 mm) high. The signal word shall be more prominent than any other required marking on the product.

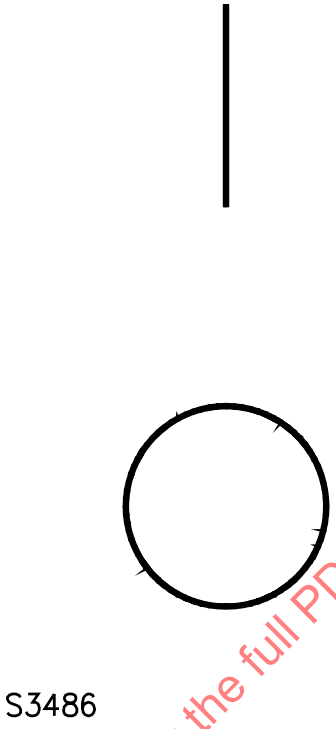
Exception: For products on which space precludes the full size marking and for products requiring languages in addition to English, upper case letters shall not be less than 0.060 in (1.5 mm) high and legible from a safe viewing distance.

65.7 In the event that, when energized, a product has a part or function that involves a risk of injury to persons, a switch that controls the motor that drives the part shall have a plainly marked off position. The symbols shown in Figure 65.1 comply with the requirement when the user instruction manual identifies the symbols.

Exception: A momentary-contact switch without a locking feature need not be marked.

Figure 65.1

On and off symbols



IEC Publication 417, Symbols 5007 and 5008.

65.8 A product 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 product 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 product.

65.9 A compressor having a head or associated fittings and a motor frame that may:

a) Be contacted by the user, and

b) Attain a temperature that exceeds the applicable limit specified in Table 32.1 shall be permanently marked with the word "WARNING" and the following or the equivalent: "Hot Surface – To reduce the risk of burns, do not touch." The marking shall be located on or adjacent to the hot surfaces.

65.10 A part of an enclosure as described in the Exception to 30.6 shall be marked to indicate that such servicing is to be done with the product disconnected from the supply circuit.

65.11 If complete guarding of a moving part that would obviously cause injury to persons would defeat the utility of a product a marking shall be provided warning the user of the potential risk of injury.

65.12 A compressor or attachment shall be provided with the following markings as applicable. The pressure value to be indicated shall be the maximum rated operating pressure. Upon investigation, other markings may be found to be necessary:

a) On a compressor without a pressure regulator: "CAUTION" and the following or equivalent: "Risk of Bursting – Use only recommended air-handling parts acceptable for pressures not less than ___ psi;"

b) On a compressor with a pressure regulator: "CAUTION" and the following or equivalent: "Risk of Bursting – Do not adjust regulator to result in output pressure greater than marked maximum pressure of attachment;" or

c) On a compressor capable of obtaining pressures higher than 50 psi (344.7 Pa): "WARNING" and the following or equivalent: "Risk of Injury – Do not direct air stream at body."

65.13 A portable compressor or paint sprayer not intended to be exposed to rain shall be marked with the word "CAUTION" and the following or equivalent: "To reduce the risk of electric shock, do not expose to rain. Store indoors."

65.14 A product intended for indoor use only shall be marked with the word "CAUTION" and the following or equivalent: "To Reduce the Risk of Electric Shock or Injury, Use Indoors Only." in letter height not less than 3/32 in (2.4 mm). This marking shall also be included in the instruction manual in accordance with 66.8.

65.15 A product constructed in accordance with Exception No. 1 to 36.1.8 shall be marked adjacent to the drain hole and visible while the product is in use with the word "CAUTION" and the following or equivalent: "Risk of Bursting – Tilt tank to drain."

65.15.1 A product constructed with a door to gain access to a tank drain assembly in accordance with Exception No. 2 of 36.1.8 shall be marked on the door panel with the word ″CAUTION″ and the following or equivalent: ″Risk of Bursting – Open Door To Access Drain Assembly.″

65.16 A compressor shall be permanently marked with the word "WARNING" and the following or equivalent: "Risk of Fire or Explosion – Spray area must be well ventilated. Do not smoke while spraying or spray where spark or flame is present. Keep compressors as far from spraying area as possible."

Exception: A compressor:

a) Having a threaded coupling other than size 1/4 – 18 in accordance with the American National Standard for straight pipe threads for mechanical joints, ANSI/ASME B1.20.1, (NPSM), and

b) That is not intended to operate a spray gun is not required to be marked.

65.17 A paint sprayer shall be permanently marked with the word "WARNING" and either the text specified in 65.16 or the following or equivalent: "Risk of Explosion – Do not spray flammable liquids."

65.18 With reference to the requirement in 65.6, a marking that combines two or more applicable markings need not include the signal word more than once.

65.19 With reference to 25.5, a portable product provided with a general purpose receptacle shall be marked "_____ Amps Maximum" at the receptacle so that the combined ampacity of the product operated under maximum normal load and the equipment connected to the receptacle does not exceed the rating of the product.

65.20 A product intended for use with a duty cycle as described in 46.1.7 shall be marked with the duty cycle.

65.21 Linear pumps intended for use in aerating septic tanks, fishponds, and similar applications, shall be marked with the following wording or the equivalent: "WARNING - To prevent electrical shock from back-siphoning, locate the pump above the water level."

65.22 A nitrogen generator shall be permanently marked with the word ″WARNING″ and the following or equivalent: ″To reduce the risk of asphyxiation or fire, install the nitrogen generator in a well ventilated area, and/or provide for exhaust ventilation of the waste gas and O2 monitoring.″

INSTRUCTION MANUAL

66 General

66.1 A product shall be provided with legible instructions pertaining to:

a) Its operation and installation,

b) User-maintenance and storage, and, as applicable,

c) Grounding or double insulation.

66.2 The cautionary prefix "WARNING" required in 69.1, and all upper-case text indicated in 67.1 – 70.1 shall be entirely in upper-case letters or otherwise emphasized to distinguish them from the rest of the text.

66.3 The text of all required instructions shall be in the words specified or words that are equivalent, clear, and understandable.

Exception: If a product is such that the specified wording is unnecessary or conflicting, the wording may be omitted or modified, as appropriate.

66.4 Instructions or illustrations shall be provided to identify important parts of the product, such as a pressure regulator. An illustration may be used with a required instruction to clarify the intent, but shall not replace the written instruction.

66.5 Wording in parentheses in Sections 67 – 70 is explanatory, indicating options, alternatives, or cross-references. Wherever the words "the (or this) product" are used, the name of the specific product may be substituted in the final text.

66.6 A product evaluated in accordance with the Exceptions to 9.4 shall have the statement "Household Use Only" or the equivalent appearing in the instruction manual.

66.7 With reference to the requirement in 7.3, a tank-type compressor that does not employ a pressure vessel marked with the code symbol of "U" or "UM" of the American Society of Mechanical Engineers (ASME) shall not include reference to a horsepower rating of more than 3 hp (2.23 kW output) on the product or in the instruction manual provided with the product.

66.8 A product marked in accordance with 65.14 shall have the statement "For Indoor Use Only" or the equivalent appearing in the instruction manual.

66.9 A product marked in accordance with 65.15.1 shall have the statement ″CAUTION – Risk of Bursting – Open Door To Access Drain Assembly.″ or the equivalent appearing in the instruction manual.

66.10 A product evaluated in accordance with the Exception No. 2 to 36.1.8 shall include instructions in the manual on how to manually drain the system in the event of malfunction of the automatic drain system.

67 Operating and Installation Instructions

67.1 The operating and installation instructions shall include all information needed to operate and install the product as intended.

67.2 *Deleted November 1, 2013*

67.3 With reference to the Exception to 64.3.1, a statement advising of the availability of an acceptable extension cord and the importance of using such a cord included in the operating and installation instructions is an acceptable alternative to the marking on the product. When the extension cord is not furnished by the manufacturer with the product, the instructions shall specify the type, electrical rating, and maximum length of the extension cord to be used with the product.

67.4 Instructions shall be provided with a product that is intended to be secured in place to indicate when it is necessary to fasten equipment to a floor or other part of a building in order to obtain proper stability.

67.5 A statement equivalent to that required in 64.2.3 shall also be included in the operating and installation instructions.

67.6 A product provided with a 2-blade polarized attachment plug shall be provided with the following instructions or the equivalent: 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.

67.7 A product intended for use with a duty cycle as described in 46.1.7 shall indicate the duty cycle in the operating instructions.

67.8 For a motor-operated compressor intended for use with sprinkler systems, the instructions shall indicate that the compressor is intended to be installed in accordance with the Standard for Installation of Sprinkler Systems, NFPA 13.

67.9 For linear pumps intended to aerate septic tanks, fishponds, and similar applications, the installation instructions shall contain a statement regarding the installation of the pump above the water level.

67.10 A nitrogen generator shall be provided with installation and maintenance instructions that includes the following items:

a) Detailed instructions for properly installing the unit.

b) If the air compressor is provided separately, detailed instructions for properly connecting the air compressor to the nitrogen generator unit.

c) Detailed instructions for maintaining the unit including maintenance required to maintain the desired level of nitrogen within the system.

d) Reference to the need for proper ventilation and installation in accordance with OSHA regulations to avoid an excessive concentration of oxygen in an area.

68 User-Maintenance Instructions

68.1 User-maintenance instructions shall include:

a) Instructions for cleaning and user maintenance operations recommended by the manufacturer, such as lubrication or nonlubrication; and a statement to the user that any other servicing should be performed by an authorized service representative or that the product has no user serviceable parts.

b) For a product employing an automatically reset thermal limiter, which shuts off the entire product, instructions to the user of what to expect in the event the thermal limiter operates.

c) Specific instructions for the proper method of cord storage, total product storage, and the like when the product is not in use; and for cord care while in use (such as for hand-supported products, untwisting, or the like).

69 Grounding Instructions

69.1 The grounding instructions shall include those instructions in (a) – (e) applicable to the product. The applicable instructions in (a) – (e) are able to be included in the operating instructions. See 66.2 and 66.3.

Exception: For high-pressure paint spraying products, the applicable grounding instructions in (a) – (e) shall be provided in the important safety instructions specified in Important Safety Instructions, Section SA16.

a) For all grounded, cord-connected products:

GROUNDING INSTRUCTIONS

This product must be grounded. In the event of an electrical short circuit, grounding reduces the risk of electric shock by providing an escape wire for the electric current. This product is equipped with a cord having a grounding wire with an appropriate grounding plug. The plug must be plugged into an outlet that is properly installed and grounded in accordance with all local codes and ordinances.

WARNING – Improper installation of the grounding plug is able to result in a risk of electric shock. When repair or replacement of the cord or plug is required, do not connect the grounding wire to either flat blade terminal. The wire with insulation having an outer surface that is green with or without yellow stripes is the grounding wire.

Substitution of the signal word “DANGER” for “WARNING” is not prohibited when the risk associated with the product is such that a situation exists which if not avoided will result in death or serious injury.

Check with a qualified electrician or serviceman when the grounding instructions are not completely understood, or when in doubt as to whether the product is properly grounded. Do not modify the plug provided; if it does not fit the outlet, have the proper outlet installed by a qualified electrician.

b) For a grounded, cord-connected product rated less than 15 A and intended for use on a nominal 120-V supply circuit, the instructions in either (1) or (2):

1) This product is for use on a nominal 120-V circuit, and has a grounding plug similar to the plug illustrated in sketch A in Figure 69.1. A temporary adapter similar to the adapter illustrated in sketches B and C may be used to connect this plug to a 2-pole receptacle as shown in sketch B when a properly grounded outlet is not available. The temporary adapter shall be used only until a properly grounded outlet (sketch A) is installed by a qualified electrician. The green colored rigid ear, lug, or similar part extending from the adapter must be connected to a permanent ground such as a properly grounded outlet box cover. Whenever the adapter is used, it must be held in place by a metal screw.

2) This product is for use on a nominal 120-V circuit and has a grounding plug similar to the plug illustrated in sketch A in Figure 69.1. Only connect the product to an outlet having the same configuration as the plug. Do not use an adapter with this product.

Exception: A high-pressure airless paint sprayer, as defined in 2.7, shall have the instructions specified in (2). An adapter shall not be used for a high-pressure airless paint sprayer.

c) For all other grounded, cord-connected products:

This product is for use on a circuit having a nominal rating more than 120 V (or "This product is rated more than 15 A and is for use on a circuit having a nominal rating of 120 V") and is factory-equipped with a specific electric cord and plug for connection to a proper electric circuit. Only connect the product to an outlet having the same configuration as the plug. Do not use an adapter with this product. When the product must be reconnected for use on a different type of electric circuit, the reconnection shall be made by qualified service personnel.

d) For a permanently connected product:

GROUNDING INSTRUCTIONS

This product must be connected to a grounded, metallic, permanent wiring system, or an equipment-grounding terminal or lead on the product.

e) Extension Cords:

Use only a 3-wire extension cord that has a 3-blade grounding plug, and a 3-slot receptacle that accepts the plug on the product. Make sure your extension cord is not damaged. When using an extension cord, be sure to use one heavy enough to carry the current your product draws. For lengths less than ___ ft, ___ AWG extension cords shall be used. An undersized cord results in a drop in line voltage and loss of power and overheating. (NOTE: Table 69.1 shows the correct size to use depending on cord length and nameplate ampere rating. When in doubt, use the next heavier gauge. The smaller the gauge number, the heavier the cord.)

Exception: A 2-conductor or 3-conductor extension cord may be used for a double-insulated or 2-wire product.

Figure 69.1

Grounding methods

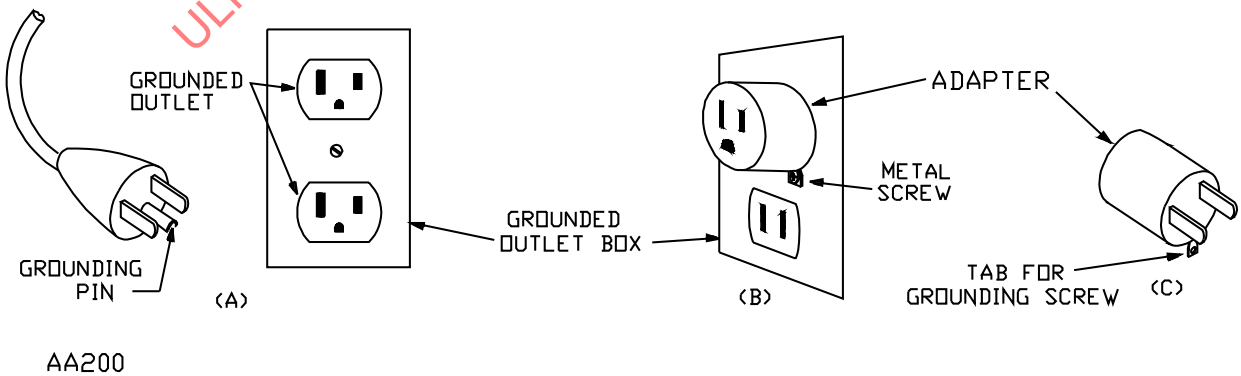


Table 69.1
Minimum gauge for extension cords

Ampere Rating Range	Voltage	Length of cord in ft								
	120V	25 ft	50 ft	100 ft	150 ft	200 ft	250 ft	300 ft	400 ft	500 ft
	240V	50 ft	100 ft	200 ft	300 ft	400 ft	500 ft	600 ft	800 ft	1000 ft
0 – 2		18	18	18	16	16	14	14	12	12
2 – 3		18	18	16	14	14	12	12	10	10
3 – 4		18	18	16	14	12	12	10	10	8
4 – 5		18	18	14	12	12	10	10	8	8
5 – 6		18	16	14	12	10	10	8	8	6
6 – 8		18	16	12	10	10	8	6	6	6
8 – 10		18	14	12	10	8	8	6	6	4
10 – 12		16	14	10	8	8	6	6	4	4
12 – 14		16	12	10	8	6	6	6	4	2
14 – 16		16	12	10	8	6	6	4	4	2
16 – 18		14	12	8	8	6	4	4	2	2
18 – 20		14	12	8	6	6	4	4	2	2

70 Double-Insulation Instructions

70.1 The instructions for a double-insulated, cord-connected product shall include the following, or the following may be included in the user-maintenance instructions:

SERVICING OF A DOUBLE-INSULATED PRODUCT

In a double-insulated product, two systems of insulation are provided instead of grounding. No grounding means is provided on a double-insulated product, nor should a means for grounding be added to the product. Servicing of a double-insulated product requires extreme care and knowledge of the system, and should be done only by qualified service personnel. Replacement parts for a double-insulated product must be identical to those parts in the product.

A double-insulated product is marked with the words "DOUBLE INSULATION" or "DOUBLE INSULATED." The symbol

may also be marked on the product.

BATTERY-OPERATED PRODUCTS

71 Scope

Section 71 reinstated from revisions dated August 21, 2019

71.1 These requirements cover battery-operated products. Such a product shall comply with the requirements in Sections 1 – 3 and 6, 9.6 – 9.10, and Sections 10, 14 – 19, 22, 23, and 25 – 39, supplemented, and in some cases amended by Sections 72 and 73.

72 Construction

Section 72 reinstated from revisions dated August 21, 2019

72.1 The battery of a battery-operated product shall be encased or enclosed to resist breakage of the battery case and reduce the risk of explosion.

72.2 A lead for a battery shall have ampacity acceptable for the application. It shall be resistant to acids and alkalies depending upon the type battery employed, and shall be able to withstand flexing, handling, and impact at temperatures between 54°C (129°F) and minus 35°C (minus 31°F). The minimum insulation thickness shall be as specified in Table 72.1.

Table 72.1
Thickness of battery-lead insulation

Conductor size,		Thickness of insulation	
AWG	(mm^2)	in	(mm)
8 – 2	(8.4 – 33.6)	1/16	(1.6)
1 – 4/0	(53.5 – 107.2)	5/64	(2.0)

72.3 A battery-operated product shall be equipped with a battery connector or the like located so as to have the same degree of protection required by 9.1.

72.4 The connector mentioned in 72.3 shall be permanently secured either to the product or to the battery enclosure. The length of cable attached to the plug that fits into the connector shall not be so short that it interferes with the disconnecting operation or places stress on terminals.

72.5 Live parts shall be recessed from the face of a connector to reduce the likelihood of short circuiting.

72.6 A battery connector shall be rated or evaluated for use in the application.

72.7 The removable portion of a connector shall be provided with means for being grasped to permit removal.

72.8 If pressure may build up or if the accumulation of an explosive hydrogen-air mixture is possible in a lead-acid battery compartment, the battery compartment shall be vented.

72.9 Cells employing metal containers, such as alkaline batteries, shall be insulated from each other and from a metal tray or metal battery compartment. Insulation of wood or other material shall be:

a) Treated or painted to reduce deterioration by the battery electrolyte, unless it is inherently resistant to such deterioration; and

b) Constructed to withstand the effects of operation and maintenance of the product.

72.10 The cells shall be connected so that the nominal potential between any two adjacent cells will be not more than 24 V.

72.11 Movement of a battery within a product is not acceptable if such movement may cause a risk of fire or electric shock.

73 Performance

Section 73 reinstated from revisions dated August 21, 2019

73.1 The horizontal top surface of a metal enclosure for lead-acid batteries shall have strength and rigidity so that, in conjunction with an air spacing provided between it and the battery terminals, the battery terminals will not be short-circuited when a force of 250 lb (1100 N) is applied to the top surface. In lieu of the spacing, insulation to reduce the likelihood of short-circuiting of the battery terminals may be provided as part of the enclosure or secured to the inner surface of an enclosure.

73.2 With reference to the requirement in 73.1, the 250-lb (1100-N) force is to be applied through a 13-1/2 in (343 mm) diameter rigid plate, regardless of the area of the cover.

73.3 A battery-operated product shall withstand without breakdown for 1 min the application of a 60-Hz essentially sinusoidal potential of 240 V between current-carrying parts and accessible dead metal parts with the product at the temperature reached during the temperature test.

73.4 To determine whether a battery-operated product complies with the requirement in 73.3, it is to be tested as described in 48.3.

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