UL 775

STANDARD FOR SAFETY

Graphic Arts Equipment

UL Standard for Safety for Graphic Arts Equipment, UL 775

Third Edition, Dated February 27, 1998

Summary of Topics

This revision to UL 775 is being issued to remove the reference to the withdrawal date of UL 873 and to address universal upkeep of UL Standards for Safety. These revisions are considered to be non-substantive and not subject to UL's STP process.

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. Changes in requirements are marked with a vertical line in the margin and are followed by an effective date note indicating the date of publication or the date on which the changed requirement becomes effective.

The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a ″SUPERSEDED REQUIREMENTS″ notice.

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UL 775

Standard for Graphic Arts Equipment

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Second Edition – March, 1994

Third Edition

February 27, 1998

This UL Standard for Safety consists of the Third Edition including revisions through November 19, 2013.

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 http://csds.ul.com.

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INTRODUCTION

1 Scope

1.1 These requirements cover products that are intended for use in printing establishments. Included are such products as sheet–fed, web–fed, and offset presses and controls, composing and typesetting machines, cutting and folding machines, and other products that are used in the preparation of mats. The products covered are for connection to interior wiring systems in accordance with the National Electrical Code, and are rated at 600 V or less.

1.2 These requirements do not cover white printers, photocopy machines, typewriters, or any other product that is covered by individual requirements that are separate from this Standard.

1.3 Products that generally would be covered by the requirements in this Standard, such as duplicating equipment, are covered by the requirements in the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1, when the product is not intended for use in printing establishments.

1.3 revised April 29, 2010

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

1.4 added February 27, 1998

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 when one or more of the following conditions occur:

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, a motor stops and restarts one or more times.

c) Upon energizing the product, the initial starting of a motor is intentionally delayed beyond intended, conventional starting.

d) During any single predetermined cycle of operation, changing of the mechanical load reduces the motor speed to reestablish starting–winding connections to the supply circuit.

2.3 CONTINUOUS-DUTY MOTOR – A motor is considered to be subjected to continuous duty when, under any intended condition of use, it is capable of operating unattended and under load for a period of 3 hours or more.

2.4 FIELD-WIRING TERMINAL – Any terminal to which a supply or other wire is capable of being connected by an installer in the field is a field-wiring terminal unless the wire is provided as part of the product and a pressure terminal connector, soldering lug, soldered loop, crimped eyelet, or other means for making the connection is factory-assembled to the wire.

2.5 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.

2.6 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 of the performance requirements for a Class 2 transformer. A circuit that is 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.

2.7 OPERATING SERVICING – Any form of servicing that is able to be performed by personnel other than those who are trained to maintain the particular product is operator servicing. Some examples of operator servicing are as follows:

a) The attachment of accessories by means of attachment plugs and receptacles or by means of other separable connectors,

b) The changing of tapes or ribbons that do not involve complicated operations (see 2.8),

c) The replacement of recording tapes, disks, program boards, punched cards, or paper forms, and

d) Resetting or replacement of circuit breakers, fuses, and lamps that are accessible without the use of tools; also, replacement of lamps that require frequent replacement – such as lamps of the projector type – whether or not the operation requires the use of tools.

2.8 Changing ribbons is considered to be a function of service personnel rather than operator servicing when the act involves extensive disassembly of the product.

2.9 REMOTELY CONTROLLED PRODUCT – A product that is out of sight of the operator.

2.10 SAFETY CIRCUIT – Any primary or secondary circuit that is relied upon to reduce the risk of fire, electric shock, or injury to persons. An interlock circuit, for example, is considered to be a safety circuit.

2.11 SECONDARY CIRCUITS – Secondary circuits are those circuits supplied from the secondary windings of isolating transformers. See 33.1 – 33.3.

2.12 TRANSFER SWITCH – A switch so located in a circuit that it is unable to make or break current during normal or abnormal conditions. A voltage selector is an example of a transfer switch.

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.

3.1 revised February 27, 1998

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.

3.2 added February 27, 1998

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

3.3 added February 27, 1998

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.

3.4 added February 27, 1998

4 Units of Measurement

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

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

CONSTRUCTION

5 General

5.1 A product shall employ materials that are acceptable for the particular use, as determined by the performance requirements of this Standard.

5.2 When metals are depended upon to meet the requirements of this Standard, they shall not be used in such combination as to cause galvanic action that affects any part of the product.

6 Frame and Enclosure

6.1 A product shall be formed and assembled so that it has the strength and rigidity required to resist the abuses to which it is likely to be subjected, without presenting 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.

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

6.3 The enclosure of a product shall be complete. Dependence shall not be placed on adjacent walls or adjacent equipment to complete an enclosure.

6.4 An enclosure of sheet metal shall be evaluated with respect to its size and shape, the thickness of metal, and the particular application, considering the intended use of the product. Sheet steel having a thickness less than 0.026 inch (0.66 mm) when uncoated, or 0.029 inch (0.74 mm) when galvanized, or of nonferrous sheet metal having a thickness less than 0.036 inch (0.91 mm) shall only be used for relatively small areas or for surfaces that are curved or otherwise reinforced. See also 10.2.1.2, in which the thickness requirement is given for metal to which a wiring system is to be attached in the field.

6.5 Among the factors taken into account for an enclosure other than that as described in 6.2 or 6.4 are its relative:

a) Physical strength,

b) Resistance to impact,

c) Moisture-absorptive properties,

d) Combustibility,

e) Resistance to corrosion, and

f) Resistance to distortion at the temperatures to which the enclosure is subjected under conditions of intended and unintended use. For a nonmetallic enclosure, all of these factors are also taken into account with respect to thermal aging.

6.6 Polymeric materials used for the enclosure to render inaccessible parts that present a risk of electric shock or injury to persons or reduce the risk of propagation of flame, shall comply with the requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

6.7 The bottom shall be complete to protect all electrical parts. For the bottom of movable products, consideration shall be given to the possibility of the products being placed on objects that are able to damage wiring or other components.

6.8 The enclosure of a product shall be constructed so that molten metal, burning insulation, flaming particles, or other similar debris, are unable to fall upon combustible materials, including the surface that supports the product.

6.9 The requirement in 6.8 requires the use of noncombustible barriers, bottom panels, or protective pans under:

a) Wire unless it is of the flame-retardant type. Thermoplastic- and neoprene-insulated wires are examples of this type.

b) A switch, relay, solenoid, transformer, motor, or other component, unless it is shown that malfunction of the component does not result in a risk of fire.

c) Printed-circuit boards.

6.10 The barrier mentioned in 6.9:

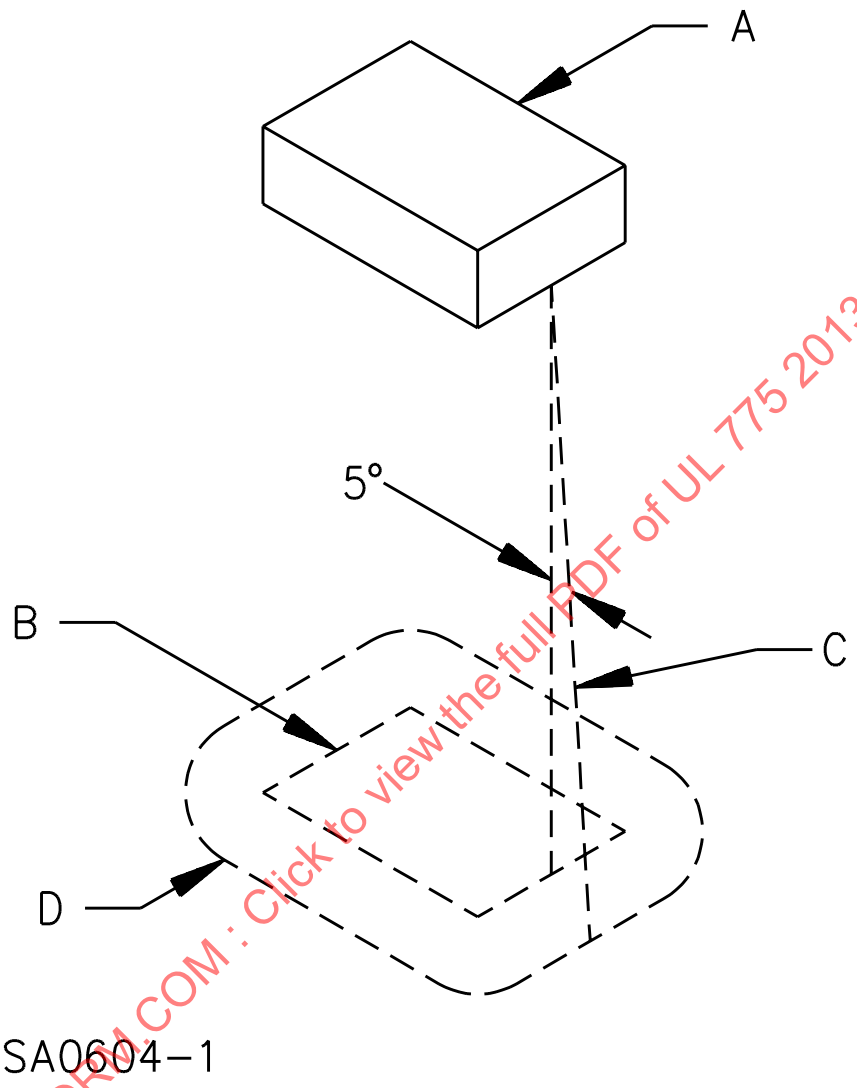
a) Shall be horizontal or constructed to provide equivalent protection,

b) Shall be located as indicated in Figure 6.1, and

c) Shall not be smaller in area than indicated in the figure.

Openings for drainage, ventilation, and other similar purposes, shall not be employed in the barrier unless the openings are protected, such as by a baffle or screen, so that molten metal, burning insulation, and other similar debris, are unable to fall outside the enclosure.

Figure 6.1
Location and extent of barrier



NOTES –

A – Region to be shielded by barrier. This consists of the entire component when it is not otherwise shielded and consists 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) So oriented that the area traced out on a horizontal plane is maximum.

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

6.11 When a liquid, powder, or other material that must be replenished, removed, or replaced is present in a product:

a) Spilled material shall not contact uninsulated parts that involve a risk of electric shock or fire, and

b) Any other condition that results in a risk of fire, electric shock, or injury to persons from filling, emptying, storage, intended movement of the product, and similar actions, shall not occur.

6.12 When malfunction of any part that contains, conducts, or otherwise contacts a liquid results in an unacceptable condition, the part shall be resistant to degradation that may be caused by the liquid involved under any condition of use.

7 Accessibility of Live Parts

7.1 The electrical parts of a unit shall be so located or enclosed that a person is unable to unintentionally contact uninsulated live parts that involve a risk of electric shock. Insulated brush caps do not require an additional enclosure.

7.2 A risk of electric shock is capable of occurring at any part where the potential between the part and earth ground or any other accessible part is more than 42.4 V peak and the continuous current flow through a 1500 ohm resistor exceeds 5 mA.

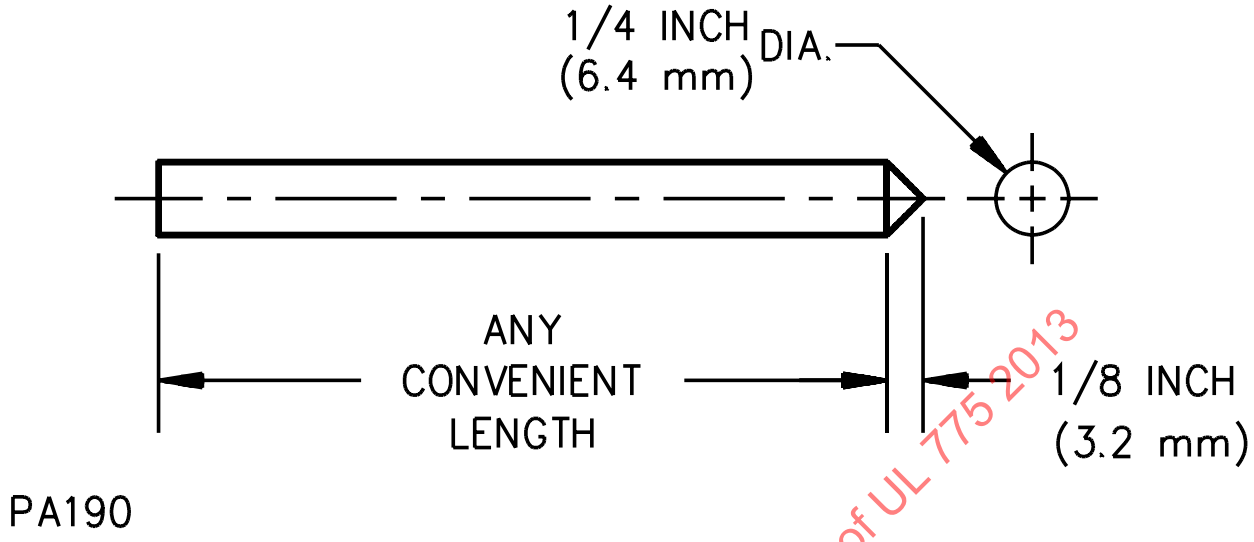
7.3 During the examination of a product in connection with the requirements in 7.1, a part of the outer enclosure that is capable of being removed without the use of tools by the user of the product for the attachment of accessories, to allow access to means for making operating adjustments, or for another reason shall be disregarded – that is, it shall not be assumed that the part affords protection against the risk of electric shock.

7.4 An opening anywhere in a hand-supported product or in any portion of a product hand-held in intended use, is acceptable when a probe as illustrated in Figure 7.1 and inserted point first as far as possible into the opening;

a) Does not enter the opening for a distance of more than 1/8 inch (3.2 mm), and

b) Does not touch any uninsulated live part or film-coated wire.

Figure 7.1
Probe for hand-supported enclosure



7.5 The opening illustrated in Figure 7.4 is acceptable when, within the enclosure, there is no uninsulated live part or film-coated wire less than X distance from the perimeter of the opening, as well as within the volume generated by projecting the perimeter distance X perpendicular to its plane. X equals five times the diameter of the largest round rod that is capable of being inserted through the opening, but not less than 4 inches (102 mm). In evaluating an opening, any barrier located within the volume is to be ignored unless it intersects the boundaries of the volume in a continuous, closed line.

7.6 In the enclosure of a product other than one described in 7.4:

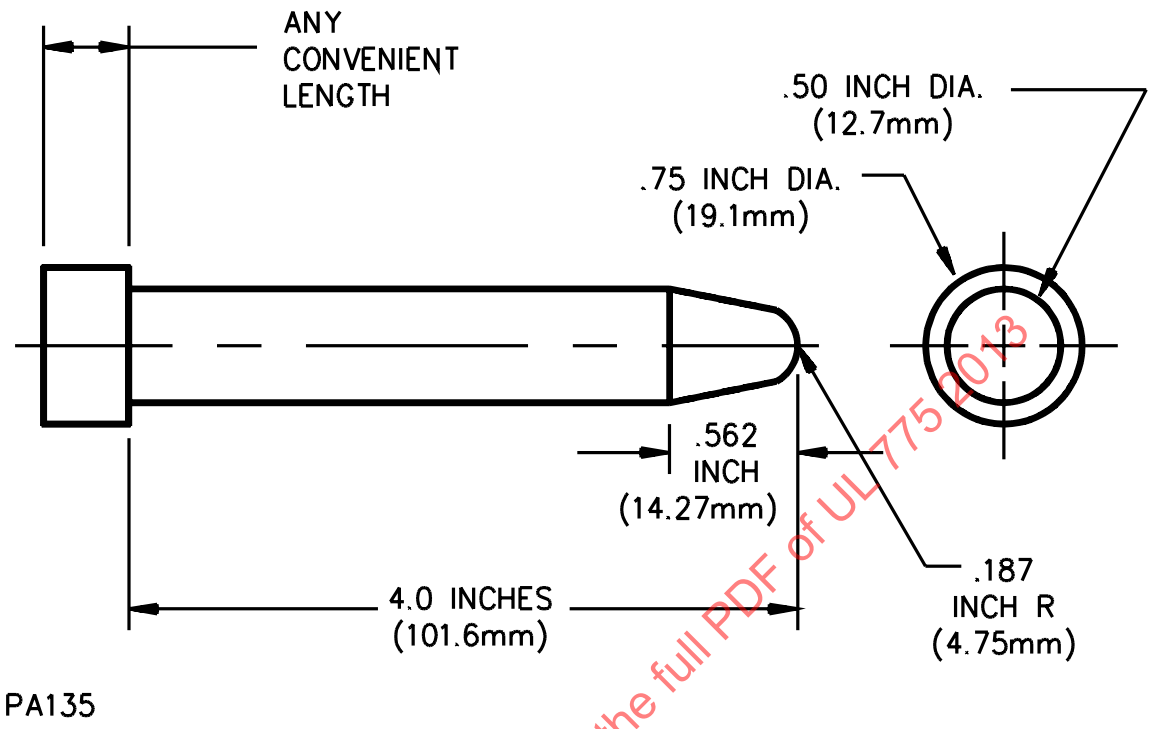
a) An opening through which a 3/4-inch (19.1-mm) diameter round rod is unable to pass is acceptable when:

1) A probe as illustrated in Figure 7.2 is not capable of touching any uninsulated live part when inserted through the opening, and

2) A probe as illustrated in Figure 7.3 is not capable of touching film-coated wire when inserted through the opening.

b) An opening through which a 3/4-inch (19.1-mm) diameter round rod is able to pass is acceptable under the conditions described in Figure 7.4.

Figure 7.2
Probe for uninsulated live part



7.7 The probes mentioned in 7.4 and 7.6 are to be applied without the part in place in any part of the enclosure:

a) Must be opened or removed for operator servicing with or without the use of tools, or

b) Can be opened or removed without the use of tools.

7.8 For a floor-mounted product, the probes mentioned in 7.6 are to be applied to every part of the bottom of the enclosure that is accessible without tipping, turning over, or otherwise moving the product from its intended installed position. Any other product is to be moved in whatever way is necessary to make the entire bottom of the enclosure accessible for application of the probes.

Figure 7.3
Probe for film-coated wire

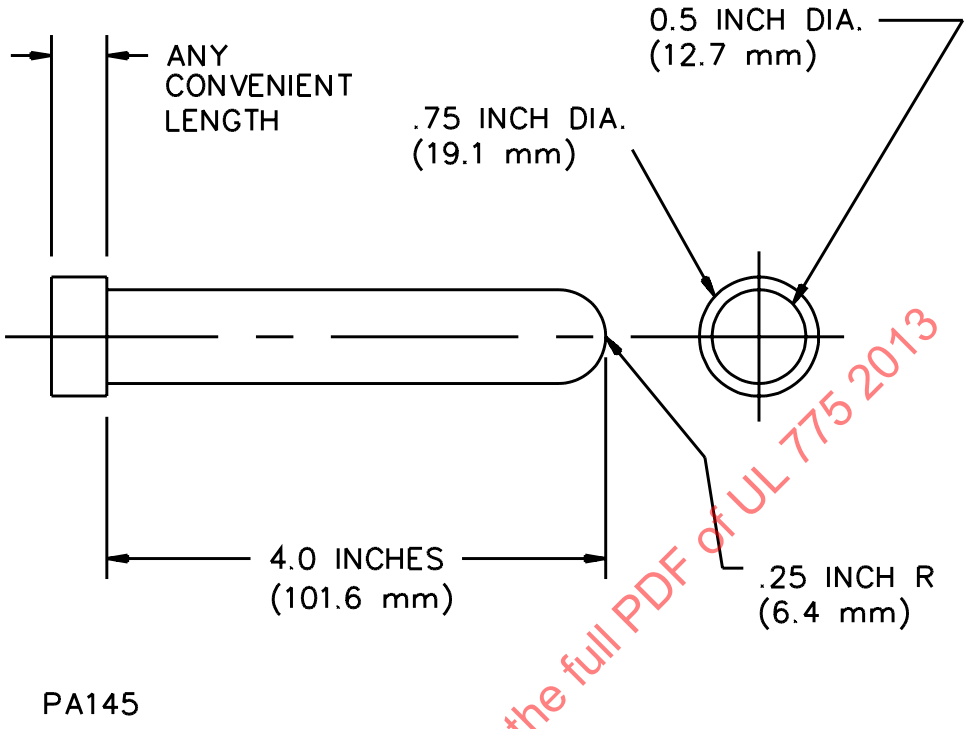
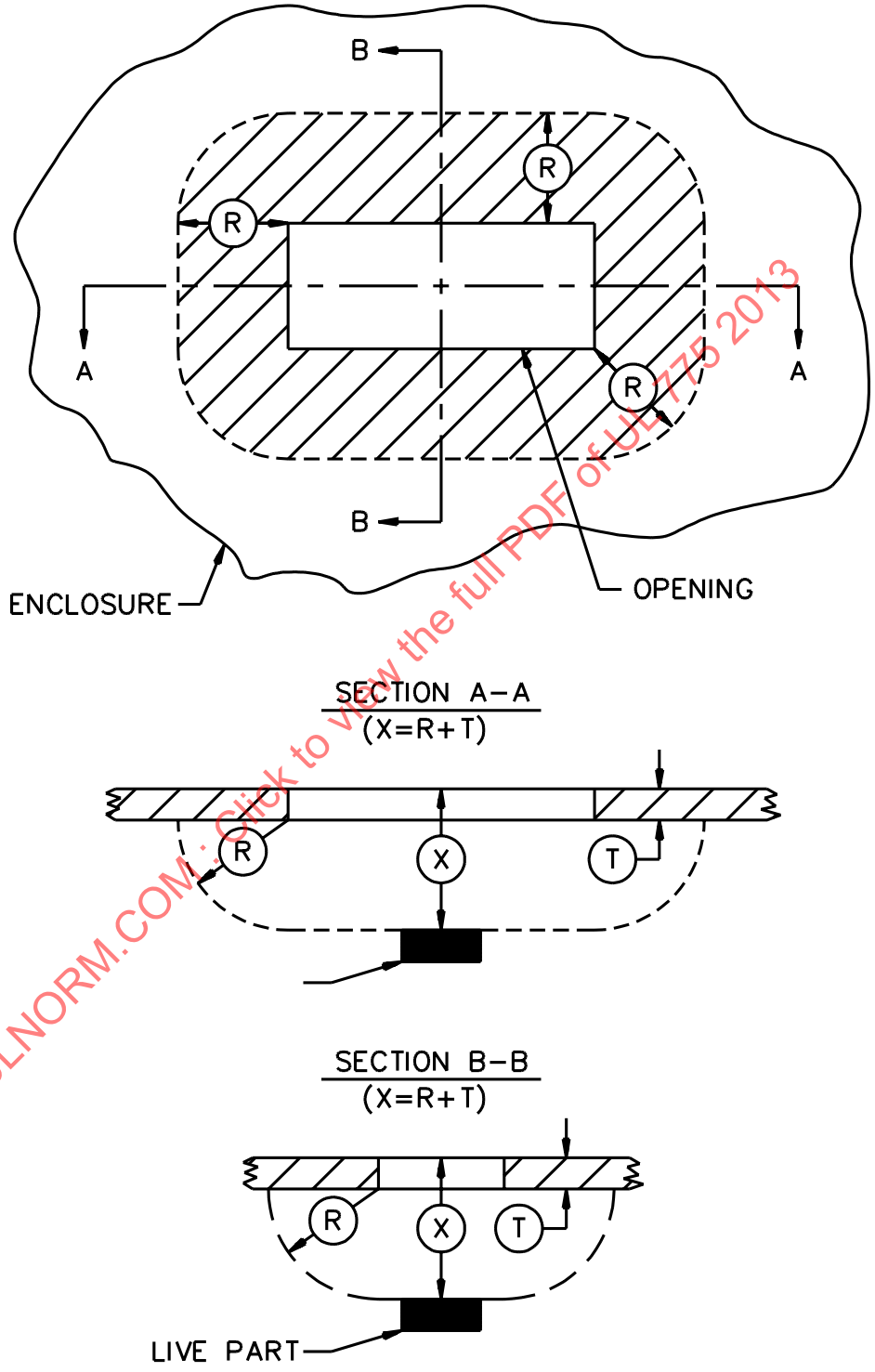


Figure 7.4
Opening in enclosure
Proportions exaggerated for clarity



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7.9 An interlock provided for the purpose of protecting personnel shall open all current carrying conductors of a cord-connected product and all ungrounded conductors of a permanently connected product. See 7.10.

7.10 An interlock switch that opens all conductors in the area in which the interlock provides protection is acceptable even though conductors outside the protected area remain energized.

7.11 Unless the product is marked in accordance with 62.1.7, lampholders, fuseholders, and circuit breakers shall be so located and installed that persons servicing the lamps, fuses, or circuit breakers are unable to unintentionally contact an uninsulated part that involves risk of electric shock or fire other than the screw shells or the clips of fuseholders.

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

Exception: A cover, panel, door, or other part of the enclosure that, by its function or size, obviously must be in place if the product is to operate as intended is not required to be permanently attached.

7.13 Means shall be provided for holding the door or cover over a fuseholder in a closed position. The door or cover shall be tight fitting.

8 Mechanical Assembly

8.1 Parts of the product shall remain in position and shall not be affected in an unacceptable manner by vibration of intended operation.

8.2 A switch, fuseholder, lampholder, attachment-plug receptacle, motor-attachment plug, or other component that is handled by the user shall be mounted securely and shall not turn.

Exception No. 1: When turning of a switch is possible, all four of the following conditions shall be met:

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

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

c) The spacings are not reduced below the minimum acceptable values when the switch rotates.

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

Exception No. 2: A lampholder of the type in which the lamp is unable to be replaced, such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel, may turn when rotation is not able to reduce spacings below the minimum acceptable value.

8.3 Friction between surfaces is not acceptable for securing the position of the parts mentioned in 8.2. A lock washer is one means of securing the position of a device having a single-hole mounting means.

8.4 A product that is shipped from the factory disassembled or unassembled to the degree necessary to facilitate shipment shall comply with each of the following:

a) All parts shall be furnished by the manufacturer.

b) Electrical continuity shall be maintained between field-assembled parts.

c) The product shall be such that the field assembly is able to be accomplished without the necessity of drilling, cutting, threading or any alteration other than for permanent connection to the power supply.

d) The assembly arrangement, location, and orientation of the separate parts shall be established at the time of manufacture and shall not be dependent on the installer.

9 Protection Against Corrosion

9.1 Iron and steel parts shall be protected against corrosion by enameling, galvanizing, plating, or other equivalent means, when corrosion of unprotected parts is capable of resulting 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 are not required to be protected against corrosion when oxidation of the metal due to exposure to air and moisture does not weaken the parts resulting in a condition of risk. The thickness of metal and temperature are also to be taken into account.

Exception No. 2: Bearings, laminations, or minor parts of iron or steel such as washers, screws, and similar parts, are not required to be protected against corrosion.

9.2 When deterioration of a liquid container provided as a part of a product results 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.

10 Supply Connections

10.1 General

10.1.1 A product intended for permanent connection to the building structure shall be provided with a means for permanent connection to the branch-circuit supply.

10.2 Permanently connected product

10.2.1 General

10.2.1.1 A product intended for permanent connection to the branch-circuit supply shall have provision for the connection of one of the wiring methods in accordance with the National Electrical Code, ANSI/NFPA 70.

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

10.2.2 Terminal compartment

10.2.2.1 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 are able to be inspected after the product is installed as intended.

10.2.2.2 A terminal compartment intended for connection of a supply raceway shall be attached to the product so that it is unable to turn.

10.2.3 Wiring terminals and leads

10.2.3.1 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 connections.

10.2.3.2 A field-wiring terminal is a terminal to which a wire is able to 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, and similar means – factory-assembled to the wire, are provided as a part of the product.

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

Exception: The lead is capable of being less than 6 inches (150 mm) long when it is evident that the use of a longer lead results in a risk of fire or electric shock.

10.2.3.4 A field-wiring terminal shall be prevented from turning by some means other than friction, such as a properly applied lock washer.

10.2.3.5 A field-wiring terminal shall be provided with a soldering lug or pressure terminal connector firmly bolted or held by a screw; except that a wire-binding screw is able to be employed at a wiring terminal intended to accommodate a 10 AWG (5.3 mm^2) or smaller conductor when upturned lugs, cupped washers, or the equivalent are provided to hold the wire in position.

10.2.3.5 revised April 29, 2010

10.2.3.6 Upturned lugs or cupped washers shall be capable of retaining a supply conductor of the size indicated in 10.2.3.5 under the head of the screw or washer.

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

Exception No. 1: A No. 8 screw is able to 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 is able to be used for the connection of a 16 or 18 AWG (1.3 or 0.82 mm^2) conductor.

10.2.3.7 revised April 29, 2010

10.2.3.8 As the smallest usable conductor for branch-circuit wiring is 14 AWG (2.1 mm^2), this is the smallest conductor that is to be anticipated at a terminal for connection of a branch-circuit conductor.

10.2.3.9 A wire-binding screw shall thread into metal.

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

Exception: An alloy plate shall be no less than 0.030 inch (0.76 mm) thick when the tapped threads have acceptable mechanical strength.

10.2.4 Identified terminals and leads

10.2.4.1 A permanently connected product having a normal rating of 120 or 120/240 V employing a lampholder of the Edison screw-shell type, a single-pole switch, or an overcurrent-protective device other than an automatic control without a marked off position, shall have one terminal or lead identified for the connection of the grounded conductor of the supply circuit.

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

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

10.2.4.3 revised April 29, 2010

10.3 Cord-connected products

10.3.1 Cords and plugs

10.3.1.1 A product shall be provided with a length of flexible cord and an attachment plug when intended for such means of connection to the branch-circuits supply.

10.3.1.2 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.

10.3.1.3 Only one supply cord shall be provided to connect a product to the primary circuit power unless one or more of the following requirements are met:

a) More than one voltage or kind of power is required. For example, 3- and 1-phase, regulated and unregulated, 60 Hz and d-c.

b) The function of the product is intended to be extended at a later date.

c) Redundant power-supply sources are necessary.

10.3.1.4 When more than one supply cord is provided on a product, the construction shall be such that physical disconnection of any one power-supply cord automatically causes the deenergization of all circuits within the product supplied by the cords.

Exception No. 1: Cords, terminal strips, circuit breakers, and parts of a product on the line side of a disconnect device may remain energized when they are enclosed or otherwise protected against unintentional contact by service personnel performing service functions not involving these parts.

Exception No. 2: Automatic deenergization is not required when the product is provided with the marking specified in 62.1.6.

10.3.1.5 When a polarized attachment plug is used, a fuseholder, an overcurrent protective device other than an automatic control without a marked off position, the center contact of an Edison-base lampholder, an interlock, and a manual on-off switch with a marked off position shall be connected to the ungrounded side of the line when used in the primary circuit.

10.3.1.6 When a polarized attachment plug is used, the screw shell of a plug fuseholder and the accessible contact of an extractor fuseholder shall be connected toward the load.

10.3.1.7 The flexible cord shall be as specified in Table 10.1 or shall be of a type at least equally serviceable for the application.

Table 10.1
Cords for appliances

Type of product	Type of cord
Table or desk models[a]	SVT, SVTO, SPT-2
Floor-mounted products	SJT, SJTO

[a] Products that are not likely to be moved frequently are able to employ Type SPT-3 cord.

10.3.1.8 The ampacity of the attachment plug for products rated 15 A or more and intended to be continuously loaded for 3 hours or more, shall not be less than 125 percent of the product input rating.

10.3.1.9 The voltage rating of the attachment plug shall be equal to the rated voltage of the product. When a product is intended 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 wired when shipped from the factory. See 62.1.5.

10.3.1.10 The flexible cord shall be either attached permanently to the product or in the form of a detachable power-supply cord.

10.3.1.11 When a product incorporates a detachable power–supply cord, the arrangement shall be such that live parts shall not be exposed under any intended condition of use.

10.3.2 Strain relief

10.3.2.1 A metal strain-relief clamp or band (without auxiliary protection) is acceptable with a Type SV, SVO, SJ, SJO, S, SO, SJT, SJTO, ST, or STO cord. A metal strain-relief clamp or band is acceptable with Type SP-2 rubber-insulated cord and with Type SPT-2, SVT, or SVTO cord only when nonconducting auxiliary mechanical protection is provided over the cord.

10.3.2.2 Means shall be provided to restrict the flexible cord from being pushed into the product through the cord-entry hole when such displacement results in damage to the cord or exposure of the cord to a temperature higher than that for which the cord is rated or reduces spacings, such as to a metal strain-relief attachment, below the minimum required values.

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10.3.2.3 A strain relief means provided on a flexible cord shall comply with the test criteria of 58.1 and 58.2.

10.3.3 Bushings

10.3.3.1 At the point at which a supply cord passes through an opening in a wall, barrier, or the overall enclosure, there shall be an acceptable bushing or the equivalent that shall be acceptably secured in place, and shall have a smooth, well-rounded surface against which the cord can bear. When a cord other than S, SO, ST, STO, SJ, SJO, SJT, SJTO, SV, SVO, or SVTO is employed and the wall or barrier is of metal, an insulating bushing shall be provided.

10.3.3.2 When the cord hole is in porcelain, phenolic composition, or another acceptable nonconducting material, a smooth, well-rounded surface is equivalent to a bushing.

10.3.3.3 A bushing of the same material as and molded integrally with the supply cord is acceptable on a Type SP-2 or heavier cord when the thinnest section is not less than 1/16 inch (1.6 mm) thick at the point where the cord passes through the enclosure.

11 Current-Carrying Parts

11.1 Except as noted in 11.2, current-carrying parts shall be of silver, copper, a copper alloy, stainless steel, aluminum, or other material acceptable for the application.

11.2 Plated steel is able to be used for secondary-circuit parts, and for some primary-circuit parts such as capacitor terminals when a glass-to-metal seal is required and for leads or threaded studs of semiconductor devices. Blued steel or steel with an equivalent corrosion resistance is acceptable for the current-carrying arms of mechanically or magnetically operated leaf switches and within a motor and motor governor in which the motor terminals are included or when the temperatures are in excess of 100°C (212°F), but not elsewhere.

12 Internal Wiring

12.1 General

12.1.1 The wiring and connections between parts of a product shall be protected or enclosed.

12.1.2 Internal wiring shall be routed and secured so that the wires and electrical connections shall not be subjected to stress or mechanical damage.

12.1.3 When operator servicing involves moving assemblies such as reading heads, optical-systems and similar assemblies that have wiring connections to other parts of the product, any wiring, other than an acceptable flexible cord, that involves a risk of shock and is able to be handled during such servicing shall comply with one or more of the following:

a) The wiring shall have supplementary insulation consisting of two thicknesses of tape acceptable for the application.

b) The wiring shall be enclosed in a length of acceptable tubing.

c) Circuits shall not be energized during the servicing operation.

12.1.4 When operator servicing involves the removal and replacement of parts such as solution-containers and similar parts, all wiring involving a risk of electric shock in the area shall be so located and secured that contact between the part and wiring is not possible during an intended servicing operation.

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

12.1.6 Internal wiring shall be acceptable for the application, with respect to the temperature and voltage, exposure to oil, grease, solvents, acids, and other conditions of service.

12.1.7 If internal wiring is likely to be exposed to moisture, including any condensation resulting from operation of the product, the wiring shall be acceptable for such operation.

12.1.8 Wiring that is able to be subjected to mechanical damage shall be in armored cable, rigid metal conduit, electrical metallic tubing, metal raceway, or be otherwise equivalently protected.

12.1.9 Care is to be taken in considering the effects of vibration, impact, and handling during operator servicing for wires smaller than 24 AWG (0.21 mm^2).

12.1.9 revised April 29, 2010

12.1.10 Wiring that is subject to motion and any supplementary insulation provided on the wire may be subjected to a flexing test to determine the acceptability for the application.

12.1.11 Metal clamps and guides used for routing stationary internal wiring shall be provided with smooth, well-rounded edges. Auxiliary nonconducting mechanical protection shall be provided under a clamp at which pressure is exerted on a conductor having thermoplastic insulation that is less than 1/32 inch (0.8 mm) thick and has no overall braid.

12.1.12 Wires shall be routed away from sharp edges such as those found on screw threads, burrs, fins, moving parts, and other similar parts, that are capable of damaging the wire insulation.

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

12.1.14 Attention is to be paid to possible inductive heating when wires carrying large currents are involved.

12.2 Splices and connections

12.2.1 All splices and connections shall be mechanically secure and shall provide acceptable electrical continuity. A soldered connection shall be made mechanically secure before being soldered when breaking or loosening of the connection results in a risk of fire or electric shock. Consideration is to be given to the effect of vibration on electrical connections. Mechanical splicing devices are acceptable.

12.2.2 A splice shall be provided with insulation equivalent to that of the wires involved when permanence of spacing between the splice and other metal parts is unable to be maintained.

12.2.3 Aluminum conductors, insulated or uninsulated, that are 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.

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12.2.4 With reference to the requirements in 12.2.3, a wire-binding screw or 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 similar conditions.

12.2.5 Insulation consisting of two layers of friction tape, two layers of thermoplastic tape, or one layer of friction tape on top of one layer of rubber tape is acceptable on a splice when the voltage involved is less than 250 V. In determining whether 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 similar factors. Thermoplastic tape wrapped over a sharp edge is not acceptable.

12.2.6 When stranded internal wiring is connected to a wire-binding screw, there shall be no loose strands of wire that are capable of contacting other live parts or dead metal parts. This may be accomplished by use of pressure terminal connectors, soldering lugs, crimped eyelets, soldering all strands of the wire together, or other acceptable means.

13 Interconnecting Cords and Cables

13.1 Flexible-cord or -cable assemblies used for external interconnections between sections of a product or between products shall be provided with bushings and strain reliefs in accordance with 10.3.2.1 – 10.3.3.3.

13.2 Inserting a male connector in a female connector other than the one intended to receive it, misalignment of male and female connectors, and other manipulations of parts that are accessible to the operator shall not result in a risk of fire, electric shock, or injury to persons.

13.3 When the ends of external interconnecting cables terminate in connectors on which there are one or more contacts, and when more than 42.4 V peak open-circuit potential exists between ground and any contact or between two contacts that are exposed on either the connector or its receptacle while the connector is out of its receptacle, not more than 5.0 mA of current shall flow through a 1500-ohm noninductive resistor connected between ground and any exposed contact, or between the two contacts.

13.4 An interlock circuit in the cable to deenergize the exposed contacts whenever an end of the cable is disconnected constitutes compliance with the requirement in 13.3. In the absence of such an interlock, compliance, or the lack thereof, is to be determined by means of the procedure indicated in 13.5.

13.5 While the interconnected products are operating as intended, the cable connectors mentioned in 13.3 are to be disengaged from their receptacles one at a time. The open-circuit voltages are to be measured between each of the exposed contacts and grounded metal. The 1500-ohm resistor is to be connected between each of the exposed contacts and grounded metal and the current through the resistor is to be measured in each position.

14 Insulating Material

14.1 Uninsulated live parts shall be mounted on porcelain, phenolic composition, or other material that is acceptable for the application.

14.2 Ordinary vulcanized fiber is able to be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live parts when shrinkage, current leakage, or warpage can introduce a risk of electric shock or fire. Thermoplastic materials are not considered to be acceptable for the sole support of uninsulated live parts, but they can be employed when found to have the mechanical strength and rigidity, resistance to heat, resistance to flame propagation, and dielectric and other properties acceptable for the application.

14.3 Molded parts shall have the mechanical strength and rigidity to withstand the stresses of actual service.

14.4 Printed-circuit boards that are located in the following circuits shall be acceptable for the application:

a) In primary circuits.

b) In secondary circuits in which separation between the conductor and the base material is capable of constituting a risk of electric shock.

c) In secondary circuits in which the voltage exceeds 100 V and the available energy exceeds 200 VA.

15 Motor Construction

15.1 A motor shall be capable of handling the maximum intended load without a risk of fire, electric shock, or injury to persons.

15.2 A motor winding shall resist the absorption of moisture.

15.3 With reference to the requirement in 15.2, film-coated wire is not required to be treated against absorption of moisture, but fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials are to be impregnated or otherwise treated to stop moisture absorption.

15.4 A brush-holder assembly shall be constructed so that when a brush is worn out - no longer capable of performing its function - the brush, spring, and other parts of the assembly are retained so that an accessible dead metal part is unable to become energized and live parts are unable to become accessible.

16 Motor Overcurrent Protection

16.1 A continuous-duty motor in a permanently connected product, an automatically controlled fractional horsepower motor in a product, the motor of a product intended to be operated remotely or unattended, a motor whose operation or inability to operate is not evident to the operator, and a continuous-duty integral horsepower motor shall be provided with overcurrent (overload) protection. Except as specified in 16.4, the protection provided is to be as indicated in 16.2. For a multispeed motor, the protection is to be effective at all speed settings.

16.2 When a product includes a motor and when the overcurrent (overload) protection of a branch circuit to which the product is capable of being connected does not provide protection for the motor in accordance with the National Electrical Code , ANSI/NFPA No. 70, such protection shall be included in the product.

16.3 The protection against overheating required in 16.1 may be accomplished by one of the following:

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

b) Impedance protection complying with the Standard for Motor-Operated Appliances, UL 73, when tested as used in the application.

c) A sensing circuit that serves to disconnect power from the motor in time to protect it from overheating using the temperature criteria in the Standard for Overheating Protection for Motors, UL 2111. This sensing circuit may be the one used to shut the motor down when it does not perform its intended function.

d) Other protection equivalent to the protection in (a).

16.4 Motors that are supplied by circuits described in 33.1.2 – 33.1.8 is not required to be protected from overheating as the result of any condition of load up to and including stalled rotor.

16.5 A motor that drives only a blower or fan attached directly to the motor shaft is considered to have overcurrent (overload) protection when it is protected against locked-rotor conditions only.

16.6 A shaded-pole motor having a difference of 1 A or less between no-load and locked-rotor currents and having a 2:1 or smaller ratio between locked-rotor and no-load currents is to be considered to have overcurrent (overload) protection when it is protected against locked–rotor conditions only.

16.7 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.

16.8 Devices, other than those that are inherent in a motor, that are employed for motor-running overcurrent protection shall be located in each ungrounded conductor; and in each of the phases of a 3-phase, 3-wire, alternating-current motor.

16.9 Fuses employed for motor-running overcurrent protection shall be located in the ungrounded conductor of a single phase system or in each ungrounded conductor of the phases of a 3-phase supply.

16.10 A thermal or overcurrent (overload) protective device shall not open the circuit during the intended use of the product.

17 Overcurrent or Thermal-Protective Devices

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

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

Exception: Additional overcurrent protection is not required as a part of the product for the conductors of the subdivided circuits described in (a) and (b):

a) For each separate motor or heating-element circuit supplied by insulated conductors having an ampacity at least one-third that of the protective device in the branch circuit to which the product is to be connected.

b) For each separate motor-control circuit supplied by insulated conductors having an ampacity at least one-fifth that of the protective device in the branch circuit to which the product is to be connected.

17.2 revised February 27, 1998

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

Exception: The protective device need not be accessible when it complies with both of the following:

a) The product, with the protective device shunted out of the circuit, complies with all applicable requirements in this Standard.

b) The presence of the protective device may be unknown to the user of the product because of its location and the omission of reference to the device in the operating instructions, circuit diagrams, and the like for the product.

17.4 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 product's enclosure.

17.5 A fuseholder shall be located or protected so that no uninsulated live part other than the screw shell or clips are exposed to contact by persons removing or replacing fuses.

Exception: The requirement does not apply when the presence of the protective device is unknown to the user of the product because of its location and the omission of reference to the device in the operating instructions, circuit diagrams, and the like.

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

18 Lampholders

18.1 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 when the motor is rated more than 230 V.

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

19 Receptacles

19.1 A 15-A or 20-A general-use attachment-plug receptacle in a product provided with a means for grounding shall be of the grounding type. The grounding contact of the receptacle shall be electrically connected to dead metal that shall be grounded when the product is in use. See 23.1.

19.2 The nominal voltage supplied to a receptacle shall be the same as the voltage rating of the receptacle.

19.3 Each circuit having an attachment-plug receptacle intended for general use, shall have overcurrent protection of not more than 20 A provided as a part of the product when the overcurrent protection of the branch circuit to which the product will be connected exceeds 20 A.

19.4 The face of a receptacle shall comply with both of the following requirements:

a) The face shall be flush with or project beyond a nonconductive surrounding surface.

b) The face shall project at least 0.015 inch (0.38 mm) beyond a conductive surrounding surface.

20 Switches and Controls

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

20.2 With reference to the requirement in 20.1, the ampacity of a switch that controls an inductive load other than a motor – such as a transformer or an electric-discharge-lamp ballast – shall not be less than twice the rated full-load current of the transformer or ballast unless the switch has been determined acceptable for the application.

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

20.4 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).

20.5 A switch that controls a medium-base lampholder of other than a 15-W or smaller pilot or indicating light shall be rated for use with tungsten-filament lamps.

20.6 The operation of a control, such as a switch intended to adapt the product to different supply voltages, that is accessible to the operator without the use of tools shall not result in a risk of fire, electric shock, or injury to persons.

21 Capacitors

21.1 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 of power-factor correction, shall be housed within an enclosure or container that shall protect the plates against mechanical damage and prevent the emission of flame or molten material resulting from malfunction of the capacitor. The container shall be of metal providing strength and protection not less than that of uncoated steel having a thickness of 0.020 inch (0.51 mm).

Exception: The individual container of a capacitor may be of sheet metal less than 0.020 inch (0.51 mm) thick or may be of material other than metal when 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.

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

21.3 The total capacitance connected from one or more ungrounded sides of the line to the frame or enclosure of a product shall be such that not more than 5.0 mA of leakage current flows to ground through a 1500-ohm noninductive resistor under intended operating conditions at the rated voltage of the product. The current limit per capacitor in other than a single-phase system is not specified.

21.4 A means, such as a bleeder resistor, shall be provided to drain the charge stored in a capacitor to the extent that the potential measured between the terminals of the capacitor 1 minute after the capacitor has been disconnected from its source of energy is less than 50 V and the energy stored is less than 20 J as determined from the following relation, in which C is in °F:

$$J = 5 \times 10^{-7} CV^2$$

21.5 The requirement is 21.4 does not apply to a product in which it is required to remove a panel to reach the capacitors. In such a product, tools shall be required for removing the panel, and an instruction shall be clearly marked on or near the panel indicating that the panel shall not be removed for whatever time (5 minutes maximum) is required for the capacitor to discharge to the values specified in 21.4 after the product has been disconnected from its source of power.

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

22 Spacings

22.1 The spacings between field-wiring terminals of opposite polarity and the spacings between a field-wiring terminal and any other uninsulated metal part, dead or live, not of the same polarity shall not be less than indicated in Table 22.1.

22.2 In primary circuits other than at field-wiring terminals, the spacings between an uninsulated live part and any other uninsulated metal part (dead or live) not of the same polarity shall not be less than indicated in Tables 22.1 and 22.2. See also 22.4. When an uninsulated live part is not rigidly fixed in position, by means other than friction between surfaces, or when a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that at least the minimum required spacing shall be maintained with the movable part in any position.

22.3 At terminal screws and studs to which connection is able to be made in the field by means of the wire connectors, eyelets, and similar connecting means – as described in 10.2.3.2 – spacings shall not be less than those specified in Table 22.1 when such connectors, eyelets, and similar connecting means are in such position that minimum spacings – between opposite polarity and to dead metal – exist.

Table 22.1
Spacings at field-wiring terminals

Potential involved volts	Minimum spacings, inches (mm)					
	Between field-wiring terminals, through air or over surface		Between terminals and other uninsulated parts not always of the same polarity[a]			
			Over surface		Through air	
0 – 50	1/8	(3.2)	1/8	(3.2)	1/8	(3.2)
51 – 250	1/4	(6.4)	1/4	(6.4)	1/4	(6.4)
250 – 600	1/2[b]	(12.7)	1/2[b]	(12.7)	3/8	(9.5)

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

[b] When it is intended that the supply connections be made to the motor of a product, the terminal compartment on the motor shall comply with the requirements for terminal compartments in the Standard for Electric Motors, UL 1004.

22.4 Primary-circuit spacings apply in all secondary circuits that are safety circuits and in all secondary circuits supplied by a transformer winding of 200-VA or a higher capacity (maximum available power) at a potential higher than 100 V. The spacings in all other secondary circuits that are not safety circuits are considered on the basis of the dielectric voltage-withstand test mentioned in 55.2.1.

22.5 The spacings specified as the minimum in Table 22.2 do not apply to the inherent spacings of a component of the product, such as a snap switch. The acceptability of spacings of a component is based on the requirements that cover the component.

Table 22.2
Minimum primary-circuit spacings in inches (mm) elsewhere than in field-wiring terminals and in motors

Table 22.2 revised February 27, 1998

Potential involved		Over surface		Through air	
V rms	(V peak)				
0 – 50	0 – 70.7	3/64	(1.2)	3/64	(1.2)
51 – 125	72.1 – 176.8	1/16	(1.6)[a]	1/16	(1.6)[a]
126 – 250	178.2 – 353.5	3/32	(2.4)[a]	3/32	(2.4)[a]
251 – 600	354.9 – 848.4	1/2	(12.7)[b,c]	3/8	(9.5)[b,c]
601 – 3000	849.8 – 4242.0	3/4	(19.1)[c,d,e]	3/4	(19.1)[c,d,e]
3001 – 5000	4243.4 – 7070.0	1	(25.4)[d,e]	1	(25.4)[d,e]
5001 – 10000	7071.4 – 14140.0	1-1/2	(38.1)[d]	1-1/2	(38.1)[d]
		1-1/8	(28.6)[e]	1-1/8	(28.6)[e]
10001 – 15000	14141.4 – 21210.0	1-1/2	(38.1)[d,e]	1-1/2	(38.1)[d,e]

[a] At closed-in points only, such as a screw and washer construction of an insulated stud mounted in metal, a spacing of 3/64 inch (1.2 mm) is acceptable.

[b] Film-coated wire is to be considered as though it were an uninsulated live part. However, 3/32-inch (2.4-mm) and greater spacings over the surface and through the air are acceptable between dead metal parts and film-coated wire that is rigidly supported and held in place on a coil.

[c] On printed-wiring boards and their connectors wired on the load side of line filters or similar voltage-peak-reduction networks and components, 3/32 inch (2.4 mm) plus 0.0002 inch (0.005 mm) per V peak above 353.5 V peak + 0.0002 (V_{pk} − 353.5)] – spacings over surface and through the air are acceptable between an uninsulated live part and any other uninsulated conductive part, live or dead, not of the same polarity.

[d] Between uninsulated high-voltage parts and

1) uninsulated high-voltage parts of opposite polarity or of different potentials,

2) grounded metal parts, and

3) uninsulated primary-circuit parts.

[e] Between uninsulated high-voltage parts and

1) insulated primary-circuit parts, and

2) insulated high-voltage parts of opposite polarity or of different potentials.

22.6 Spacings in a motor shall comply with the spacing requirements in the Standard for Electric Motors, UL 1004.

22.7 An insulating liner shall be acceptable for the purpose. Vulcanized fiber or a similar material employed where spacings are not provided shall be 1/32 inch (0.8 mm) thick or thicker for up to 600 V, and shall be so located or of such material that it is unable to be damaged by arcing. However, 1/64 inch (0.4 mm) or thicker vulcanized fiber is acceptable in conjunction with an additional air spacing of 50 percent or more of the spacing for air alone. Barriers shall be held in place by a means more secure than friction between surfaces. The elasticity of tubing shall not be depended upon to hold the tubing in place, but dilated or heat-shrunk tubing is acceptable.

Exception: Thinner insulating material is able to be used, when it is acceptable for the application.

22.8 When an uninsulated live part is not rigidly fixed in position by means other than friction between surfaces, or when a movable dead metal part is in proximity to an uninsulated live part, the construction shall be such that the required minimum spacings shall be maintained.

22.9 In products incorporating two or more motors of different sizes, the spacings required inside each motor are to be based on the size of each motor, and the spacings required elsewhere in the product are to be based on the size of the largest motor in the product.

22.10 When an isolated dead metal part is interposed between or is in the 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 shall not be less than 3/64 inch (1.2 mm) between the isolated dead metal part and any one of the other parts mentioned, provided the total spacing between the isolated dead metal part and the two other parts is not less than the value specified in Table 22.2.

22.11 All uninsulated live parts connected to different – line- or low-voltage – circuits shall be spaced from one another as though they were parts of opposite polarity, in accordance with the requirements in 22.1 and 22.2, and shall be considered as operating at the highest voltage involved.

22.12 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.

23 Grounding

23.1 All cord-connected products and all permanently connected products shall have provision for the grounding of all exposed dead metal parts that are capable of becoming energized.

23.2 When 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.

23.3 When grounding means is provided on a product, all exposed dead metal parts that are capable of becoming energized and all dead metal parts within the enclosure that are exposed to contact by an operator or service personnel and that are likely to become energized by a single-fault condition from a circuit involving electric shock, shall be connected together and to the grounding means.

Exception: Internal dead metal parts that are capable of being touched only by service personnel and that can become energized from a circuit involving electric shock at an a-c potential greater than 30 V rms (42.4 V peak) or a d-c potential greater than 60 V, with reference to ground or other accessible parts, is not required to be connected to the earth-grounding means when a marking as described in 62.1.20 is located on the part (parts) or adjacent to it (them).

23.4 When two or more products are electrically or mechanically connected to one another and one of them is grounded;

a) All exposed dead metal parts that are capable of becoming energized shall be grounded on all of the products and

b) Each product of the systems that has a separate supply cord shall have a grounding–type cord.

When the products are interconnected electrically and one of them is grounded, they shall be bonded together – such as by means of a conductor included in an interconnecting cable.

23.5 In a permanently connected product, a field-wiring terminal or a lead intended solely for connection of an equipment-grounding conductor shall be provided.

23.6 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size rated for the application in accordance with the National Electrical Code, ANSI/NFPA 70.

23.7 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal, slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified as such by being marked ″G″, ″GR,″ ″GND,″ ″Ground,″ ″Grounding,″ or the equivalent or by a marking on the wiring diagram provided on the product. The wire-binding screw or pressure wire connector shall be so located that it is unlikely to be removed during intended servicing of the product.

23.8 In a cord-connected product, the provision of a multiple-conductor flexible cord having one conductor connected to the enclosure or frame of the product is an acceptable means for grounding.

23.9 The grounding conductor in a flexible cord shall be green with or without one or more yellow stripes. The grounding conductor shall be secured to the frame or enclosure of the product by means of a screw, rivet, or similar securement means that is not likely to be removed during intended servicing not involving the supply cord. Solder shall not be used for securing the grounding conductor. The grounding conductor shall be connected to the grounding terminal of an attachment plug.

23.10 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.

23.11 Convenience receptacles provided on grounded products shall be of the grounding type and shall be grounded.

23.12 When a means for grounding is provided on the product even though it is not required, it shall comply with the requirements in 23.1 – 23.11.

PROTECTION AGAINST RISK OF INJURY TO PERSONS

24 General

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

24.2 With respect to the requirement in 24.1, consideration shall be given to reasonably foreseeable misuse of the product.

24.3 A functional attachment that is made available or recommended by the manufacturer for use with the basic product shall be included in the evaluation of the product.

24.4 The acceptability of a guard, a safety release, an interlock, and the like, and whether such a device is required, is to be determined from consideration of the complete product, its operating characteristics, and the likelihood of a risk of injury to persons. Consideration shall be given to 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. When breakdown or malfunction of a component results in a risk of injury to persons, the component shall be considered further.

25 Sharp Edges

25.1 An enclosure, an edge, a frame, a projection, a guard, an opening, a handle, or the like shall be smooth and not sharp enough to constitute a risk of injury to persons during intended maintenance and use.

Exception: A sharp edge that must be exposed to enable the product to perform its intended function is not required to comply with 25.1.

25.2 For edges where the degree of sharpness is unable to be determined by inspection, compliance with the requirements of 25.1 is determined by the test procedure in the requirements in the Standard for Test for Sharpness of Edges on Equipment, UL 1439.

26 Enclosures and Guards

26.1 The rotor of a motor, a pulley, a belt, a gear, or other moving parts that are capable of causing an injury to persons shall be enclosed or guarded to reduce the risk of unintentional contact therewith.

Exception: A part or portion of a part that is necessarily exposed to perform the work function is not required to be enclosed but, when necessary, guarding shall be provided. See 26.4.

26.2 The degree of protection required of the enclosure in 26.1 depends upon the construction and intended use of the product.

26.3 Among the factors to be considered when determining the acceptability of an exposed moving part are the:

a) Degree of exposure necessary to perform the intended function,

b) Sharpness of the moving part,

c) Likelihood of unintentional contact therewith,

d) Speed of the moving part, and

e) Likelihood that a part of the body or clothing could come in contact with the moving part.

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

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

a) Removability without the use of 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 other servicing means.

26.5 An enclosure or guard over a rotating part shall be complete to retain a part that, because of breakage or other reasons, becomes loose or separates from a rotating part, and to retain a foreign object when struck and propelled by the rotating part.

26.6 When complete guarding of a moving part that is capable of causing an injury to persons defeats the utility of a product such as the cutting blades in a scissor-like action;

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

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

26.7 A feeding mechanism either manual or automatic, shall be constructed to minimize the likelihood or necessity of the operator being in an area that is capable of causing injury.

26.8 The drive mechanism shall be guarded so that no moving part, such as a pulley, belt, gear, and similar moving part is exposed to unintentional contact. An opening in a guard or enclosure around a moving part shall not be more than 3/8 inch (9.5 mm) wide.

26.9 A cutting or slicing mechanism shall be guarded.

Exception: When exposure of the blade or equivalent part is required for the cutting or slicing operation, it is not required to comply with 26.9.

27 Materials

27.1 When breakage or deterioration of a part such as an enclosure, a frame, a guard, or a similar part results in a risk of injury to persons, the part shall be constructed to meet the demand of expected loading conditions.

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

28 Rotating or Other Moving Parts

28.1 When disengagement of a rotating or other moving part results in a risk of injury to persons, a means to retain the part upon disengagement shall be provided.

28.2 A rotating or other moving part, the breakage of which is able to cause injury to persons, shall be constructed to reduce the likelihood of its breakage, or if breakage occurs, the release or loosening of a part that is able to cause injury to persons.

28.3 To determine whether a product employing a series motor complies with the requirement in 28.2, it is to be tested as described in 28.4. Parts that involve a risk of injury to persons shall not work loose as a result of the test.

28.4 For the test discussed in 28.3, a product employing a series motor is to be operated for 1 minute at the no-load speed resulting from application of 1.3 times rated voltage.

29 Parts Subject to Pressure

29.1 A pressure vessel having an inside diameter more than 6 inches (152 mm), and subjected to a gauge pressure of more than 15 psi (102 kPa) shall be marked with the boiler and pressure vessel code symbol of the American Society of Mechanical Engineers (ASME) for a working pressure not less than the pressure determined in accordance with 29.3.

29.2 A pressure vessel that is not marked in accordance with 29.1 shall be constructed so that it complies with the requirements in 29.3.

29.3 A part or an assembly that is subject to air or vapor pressure, including the vapor pressure in a vessel containing only a superheated fluid, during intended or unintended operation shall withstand a pressure equal to the highest of the following that is applicable.

a) Five times the pressure corresponding to the maximum setting of a pressure-reducing valve provided as part of the product, but not more than five times the marked maximum supply pressure from an external source and not more than five times the pressure setting of a pressure-relief device provided as a part of the product.

b) Five times the marked maximum supply pressure from an external source, unless the pressure is limited by a pressure-relief device in accordance with (a);

c) Five times the pressure setting of a required pressure-relief device;

d) Five times the maximum pressure that is developed by an air compressor that is part of the product unless the pressure is limited by a pressure-relief device in accordance with (a); or

e) Five times the working pressure marked on the part.

Exception No. 1: A section of a pressure system constructed of continuous tubing or of lengths of tubing connected by hardsoldered, brazed, or welded joints is not required to comply with the requirement when the wall thickness of tubing is not less than the value specified in Table 29.1.

Exception No. 2: A pressure vessel bearing the ASME code inspection symbol – other than the UM symbol – is not required to comply with the requirement when the vessel is marked with a value of working pressure not less than that to which it is subjected during intended or unintentional operation.

Table 29.1
Wall thickness for copper and steel tubing

Outside diameter		Minimum wall thickness		PSI (MPa)					
				Seamless copper		Butt–welded steel		Seamless steel	
Inch	(mm)	Inch	(mm)						
3/8 or smaller	(9.5)	0.016	(0.41)	500	(3.45)	600	(4.14)	1000	(6.89)
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	(4.41)
5/8	(15.9)	0.021	(0.53)	420	(2.90)	504	(3.47)	840	(5.79)
3/4	(19.1)	0.021	(0.53)	360	(2.48)	432	(2.98)	720	(4.96)
3/4	(19.1)	0.025	(0.64)	420	(2.90)	504	(3.47)	840	(5.79)
1	(25.4)	0.021	(0.53)	260	(1.79)	312	(2.15)	520	(3.58)
1	(25.4)	0.025	(0.64)	320	(2.21)	384	(2.65)	640	(4.41)

29.4 When a test is required to determine whether a part complies with requirements in 29.3, two samples of the part are to be subjected to a hydrostatic pressure test. Each sample is to be filled with water to exclude air and connected to a hydraulic pump. The pressure is to be raised gradually to the specified test value and held at the value for 1 minute. The test result does not meet the intent of the requirement when either sample bursts or leaks.

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

29.5 A part supported or actuated hydraulically that involves a risk of injury to persons when pressure loss occurs shall comply with the requirement in 29.4 when tested at a pressure equal to five times the maximum pressure capable of being developed in the system.

30 Pressure-Relief Devices

30.1 A means for acceptably relieving pressure shall be provided for a part in which pressure is able to be generated by an external source of heat.

30.2 A pressure-relief device, a fusible plug, a soldered joint, nonmetallic tubing, or other equivalent pressure-relief means may be employed to comply with the requirements in 30.1.

30.3 A pressure-actuated valve or rupture member that is intended to relieve excessive pressures automatically is acceptable as a pressure relief valve.

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

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

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

30.7 A pressure-relief device shall comply with all of the following requirements:

a) A pressure-relief device shall be located as close as possible to the pressure vessel or part of the system that it is intended to protect.

b) A pressure-relief device shall be accessible for inspection and repair, and be such that it is unable to be rendered inoperative so that it does not perform its intended function.

c) A pressure-relief device shall have its discharge opening located and directed so that:

1) Operation of the device does not deposit moisture on uninsulated live parts or on insulation or components affected by moisture, and

2) The risk of scalding of persons is reduced.

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

30.9 The control that limits the pressure in a vessel required to have a pressure-relief device shall perform under rated load for 100,000 cycles of operation, and shall prevent the pressure from exceeding 90 percent of the relief device setting, under any condition of intended operation.

31 Switches, Controls, and Interlocks

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

31.2 Each function of a multiple-function product is to be taken into consideration in determining whether the product complies with the requirements in 31.1.

31.3 If, when energized, a product has a moving part that is capable of causing injury to persons, a motor control switch, other than a momentary-contact switch on the product, shall have a plainly marked off position.

31.4 When unintentional operation of a switch results in a risk of injury to persons, the actuator of the switch shall be located or guarded so that such operation is not likely to occur.

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

31.6 A floor- or ground-supported product that travels or rotates to an extent that is capable of resulting in injury to persons when left unattended shall be provided with a momentary contact switch that is unable to remain in the on position.

31.7 A device that automatically starts a product – such as a timer, an automatically reset overload-protective device, or similar device – shall not be employed unless it is demonstrated that automatic starting is not able to result in a risk of injury to persons.

31.8 The requirement in 31.7 necessitates the use of an interlock when moving parts or the like result in a risk of injury to persons upon the automatic starting or restarting of the motor.

31.9 The actuator of an interlock switch shall be located so that unintentional operation is not likely. See 31.5.

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

31.11 An interlock shall not be capable of being defeated by materials such as wood chips, plastic, paper or fiber scraps, metal chips, or similar materials that can accumulate during intended use.

31.12 An interlock shall be such that it is unable to be defeated:

a) Without damaging the product,

b) Without making wiring connections or alterations, or

c) By using materials that are readily available.

31.13 When 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 causes operation of the parts being guarded. With the guard removed, the interlock shall comply with the requirements in 31.9.

32 Stability

32.1 Under all conditions of servicing and intended use after installation, a fully assembled unit shall not become physically unstable to the degree that it presents a risk of injury to operators or service personnel.

32.2 A unit shall not tip over when tilted 10 degrees from its intended upright position, while all doors, covers, gates, drawers, and similar movable parts are in place and closed.

32.3 The requirements of 32.4 – 32.8 apply to all free-standing units. A free-standing unit is defined as one that is floor standing and not intended to be secured to other units or to the floor or other parts of the building.

32.4 In conducting the tests described in 32.5 – 32.7, when casters and jacks are provided, they are to be placed in their most unfavorable positions. However, when casters are being used only to transport the unit and jacks are lowered after installation, the jacks (and not the casters) are to be used in their most unfavorable position for the test, consistent with reasonable leveling of the unit.

32.5 A free-standing unit that has an external surface (work top or ledge) at a height not exceeding 39-3/8 inch (1.00 m) from the floor and that is likely to be stepped or sat upon shall not tip over when a continuous downward force of 179.8 lbf (800 N) is applied to that surface at the point of maximum moment. For this test all doors, covers, gates, drawers, and similar movable parts shall be in place and closed.

32.6 With respect to the requirement in 32.5, parts such as keyboards, control panels, spools, and similar parts are not considered likely to be stepped or sat upon.

32.7 A free-standing unit more than 39-3/8 inches (1.00 m) high and weighing more than 55.1 lb (25.0 kg) shall not tip over when a force equal to 1/5 the weight of the unit but not more than 56.2 lbf (250 N) is applied in any direction, except upward, at a height not exceeding 78-3/4 inches (2.00 m) from the floor. For this test, all doors, drawers, frames, and similar movable parts that are able to be opened for operator servicing, or servicing by service personnel, are to be opened and in the most unfavorable position. Separate tests may be performed when operator and service extensions are different or when stabilizers are employed in accordance with 32.8.

32.8 A stabilizing means may be used to improve stability when doors, drawers, and similar movable parts are opened. The stabilizing means shall be automatic in operation when associated with operator use. For service personnel, where it is not automatic in operation, a conspicuous marking shall be provided to caution the personnel on its use. See 62.1.15.

33 Secondary Circuits

33.1 General

33.1.1 All safety circuits shall be evaluated under the requirements for primary circuits. All other secondary circuits except as specified in 33.1.2 – 33.1.8 are to be evaluated under the requirements in this Standard.

33.1.2 Circuits supplied by a single source consisting of an isolating transformer, or a power supply that includes an isolating transformer, are acceptable when the open-circuit potential is not more than 42.4 V peak and the energy available to the circuit is limited so that the current under any condition of load including short circuit is not more than 8 A measured after 1 minute of operation.

33.1.3 With reference to the voltage limit specified in 33.1.2, measurement is to be made with the product, the power supply, or the transformer primary connected to the voltage specified in 53.1.6 and all loading circuits disconnected from the transformer or the power supply under test. Measurement can be made at the output terminals of the transformer or power supply. When a transformer winding is used to supply a full-wave rectifier, voltage measurements are to be made from each end of the winding to the tap.

33.1.4 When the power supply mentioned in 33.1.2 is not limited to available short-circuit current by construction of the transformer, but the circuit includes either a fixed impedance, a fuse, a nonadjustable manual-reset-circuit-protective device, or an acceptable regulating network, the circuits in which the current is limited in accordance with 33.1.5 or 33.1.6 are not required to be tested.

33.1.5 A secondary fuse or circuit protective device used to limit the current in accordance with 33.1.4 shall be rated or set at not more than the values specified in Table 33.1. Equivalent primary protection may be provided.

Table 33.1
Rating for use or circuit protector

Open-circuit V peak	A
0 – 21.2	5
21.3 – 42.4	3.2

33.1.6 A fixed impedance or regulating network used to limit the current in accordance with 33.1.4 shall be such that the current under any condition of load including short circuit does not exceed 8 A measured after 1 minute of operation.

33.1.7 When a regulating network is used to limit the voltage or current in accordance with 33.1.2 and 33.1.4 and the performance is capable of being affected by a malfunction, either by short-circuit or open-circuit, of any single component in the network, the likelihood of such malfunction occurring shall be determined by consideration of that component.

33.1.8 In a circuit of the type described in 33.1.4, the secondary winding of the transformer, the fuse or circuit-protective device, or the regulating network and all wiring up to the point at which the current and voltage are limited shall be evaluated under the applicable requirements of this Standard.

33.2 Connections to frame

33.2.1 Secondary circuits can be connected to the frame of the product.

33.2.2 When the frame is used as a current-carrying part of a secondary circuit, hinges or other movable parts shall not be used as a current-carrying means.

33.3 Protection of secondary-circuit wiring

33.3.1 The wiring in the secondary circuits covered in 33.1.2 and 33.1.4 shall be routed away from the wiring of other circuits or shall be provided with acceptable insulation that is rated for use at the highest of the voltages in the other circuits.

33.3.2 Wires and cables that are part of the secondary circuits covered in 33.1.2 and 33.1.4 shall be provided with strain relief in accordance with 10.3.2.1 – 10.3.2.3 when stresses on wire or cable can cause the internal wiring of the circuits to contact uninsulated live parts of other circuits.

34 Liquid Containers

34.1 When the deterioration of a liquid container, seal, tubing, or the like involves a risk of fire, electric shock, or injury to persons, the container, seal, or the like shall be resistant to deterioration from the liquid intended to be used in contact with it.

34.2 Determining whether a part complies with the requirement in 34.1 depends upon the material of which it is constructed, its size and shape, the application in the product and other factors. The test procedure can include visual inspection – for detection of cracks, deformation, and the like – after artificial aging, as well as comparison of hardness, tensile strength, and elongation, before and after artificial aging.

35-50 *Reserved For Future Use*

PERFORMANCE

51 Starting Current

51.1 Except as noted in 51.2, a product shall be capable of starting and operating as intended (see 51.3) on a branch circuit protected by a fuse that is other than a time-delay type, and has a current rating corresponding to that of the branch circuit to which the National Electrical Code, ANSI/NFPA 70, indicates the product should be connected.

51.2 The requirement in 51.1 does not apply when all three of the following conditions are satisfied:

a) The construction of the product or the nature of its use is such that the product is likely to be used on the same branch circuit after installation.

b) The product starts and operates as intended on a circuit protected by a time-delay fuse.

c) The product is marked in accordance with 62.1.8.

51.3 In a test to determine whether or not a product complies with the requirement in 51.1, the product is to be started three times from standstill without opening the fuse. The product is to be at room temperature at the beginning of the test. The test is to be conducted at the voltage and frequency specified in 53.1.3 and 53.1.6. Each start is to be made under conditions representing the beginning of as intended operation and any motor is to be given time to come to rest between successive starts. Tripping of an overload protector provided as part of the product or opening of the fuse constitutes an unacceptable condition.

52 Input

52.1 The input current to a product shall not exceed 110 percent of the rated value when the product is operated under the condition of maximum intended load while connected to a supply circuit of voltage and frequency, as indicated in 53.1.6.

53 Normal Temperature

53.1 General

53.1.1 A product shall be tested as described in 53.2.1 and 53.2.2, and shall not reach a temperature at any point high enough

a) To cause a risk of fire,

b) To damage any materials in the product, or

c) To exceed the temperature rises at specific points as specified in Table 53.1.

53.1.2 A thermal- or overcurrent-protective device shall not open the circuit during the temperature test.

53.1.3 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 25 – 60 Hz or 50 – 60 Hz is to be tested on 60-Hz alternating current.

53.1.4 Ordinarily, coil winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of thermocouples – for example, a coil immersed in sealing compound – or unless the coil wrap includes thermal insulation of more than two layers – 1/32 inch (0.8 mm) maximum in total thickness – of cotton, paper rayon, or the like. For a thermocouple-measured temperature of a coil of an a-c motor, other than a universal motor, having a diameter of 7 inches (178 mm) or less – items 7 and 9 in Table 53.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor.

53.1.5 All values of temperature rise in Table 53.1 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).

53.1.6 For the temperature test, the voltage of the test circuit is to be 120 V when the product is rated between 110 and 120 V, or 240 V when the product is rated between 220 and 240 V. At any other voltage rating, the product is to be tested at its marked voltage rating. A product that is rated for use at more than one voltage or for a range of voltages and contains a tapped transformer or other means of being adapted to different supply voltages shall be tested at the most unfavorable combination of supply voltage and internal adjustment, except that it may be tested while connected in accordance with the manufacturer's instructions when all three of the following conditions are met:

a) Clear, permanent marking adjacent to the cord or supply compartment is to warn the user that internal adjustments shall be made when the product is installed or moved.

b) Detailed instructions clearly showing the adjustments that shall be made for various voltages are to be permanently attached to the product. These instructions may be on the outside or inside of the overall enclosure of the product where visible at the point at which adjustments for supply voltages are to be made.

c) The means provided for adjusting for different voltages are to comply with the requirements for wiring terminals, specified in Protection Against Corrosion, Section 9.

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

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

53.1.9 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 (0.05 mm^2) iron and constantan wire and a potentiometer-type instrument are to be used. The thermocouple wire is to conform with the requirements for 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.

53.1.9 revised November 19, 2013

Table 53.1
Maximum temperature rises

Table 53.1 revised February 27, 1998

Materials and component parts	°C	°F
1. Capacitors:		
Electrolytic[a]	40	72
Other types[b]	65	117
2. Fuses	65	117
3. Fiber employed as electrical insulation	65	117
4. At any point within a terminal box or wiring compartment of a permanently connected product in which power-supply conductors are to be connected, including such conductors themselves, unless the product is marked in accordance with 62.2.1	35	63
5. A surface upon which a cord-connected or permanently wired product is capable of being mounted in service, and surfaces that are capable of being adjacent to the product when it is so mounted	65	117
6. Class A insulation system on coil windings of an a-c motor having a diameter of more than 7 inches (178 mm), of a d-c motor, and of a universal motor:[c]		
a) In an open motor:		
Thermocouple method	65	117
Resistance method	75	135
b) In a totally enclosed motor:		
Thermocouple method	70	126
Resistance method	80	144
7. Class A insulation systems on coil windings of an a-c motor having a diameter of 7 inches (178 mm) or less, not including a universal motor, and on a vibrator coil:[c]		
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

Table 53.1 Continued on Next Page

Table 53.1 Continued

Materials and component parts	°C	°F
8. Class B insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 inches (178 mm), of a d-c motor, and of a universal motor:[c]		
a) In an open motor:		
Thermocouple method	85	153
Resistance method	95	171
b) In a totally enclosed motor:		
Thermocouple method	90	162
Resistance method	100	180
9. Class B insulation system on coil windings of an a-c motor having a diameter of 7 inches (178 mm) or less, not including a universal motor:[c]		
a) In an open motor:		
Thermocouple or resistance method	95	171
b) In a totally enclosed motor:		
Thermocouple or resistance method	100	180
10. Class 105 insulation systems on windings of a relay, a solenoid, and like:[c]		
Thermocouple method	65	117
Resistance method	85	153
11. Class 130 insulation systems:		
Thermocouple method	85	153
12. Phenolic composition employed as electrical insulation or as a part the deterioration of which results in a risk of fire or electric shock.[d]	125	225
13. Rubber- or thermoplastic-insulated wire and cord[d,e,f]	35	63
14. Sealing compound	40	104
	less than melting point	
15. Varnished-cloth insulation	60	108
16. Wood and other similar material	65	117

Table 53.1 Continued on Next Page

Table 53.1 Continued

Materials and component parts	°C	°F
[a] A capacitor operating at a temperature rise higher than 40°C (72°F) may be accepted on the basis of its marked temperature rating, or when not marked with a temperature rating, shall be evaluated to determine its acceptability at the higher temperature. [b] A capacitor that operates at a temperature rise of more than 65°C (117°F) may be accepted on the basis of its marked temperature limit. [c] At a point on the surface of coil where the temperature is affected by an external source of heat, the temperature rise measured by a thermocouple may be higher by the following amount than the maximum indicated:		
Item	Additional temperature rise	
	°C	°F
Part A of item 6	15	27
Part A of item 7	5	9
Part A of item 8	20	36
Part A of item 9	10	18
10	15	27
provided that the temperature rise of the coil, as measured by the resistance method, is not more than specified in the table. [d] The limitations on phenolic composition and on rubber and thermoplastic insulation do not apply to compounds that have been found acceptable for use at higher temperatures. [e] Rubber-insulated conductors within a Class A insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35°C (63°F), provided that a braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords. [f] 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 when supplementary heat-resistant insulation of acceptable dielectric strength is employed on the individual conductors of the cord to protect the conductor insulation against deterioration.		

53.1.10 Rubber and other material subject to deterioration shall be removed from feet and other supports of the product when absence of the material results in the product attaining higher temperatures or higher temperatures on the supporting surface, adjacent vertical walls, and the like.

53.2 Maximum intended load

53.2.1 In testing a product, maximum intended load is considered to be the load that approximates as closely as possible the most severe conditions of intended use. It is not a deliberate overload except that the conditions of actual use are capable of being more severe than the maximum load conditions that are recommended by the manufacturer of the product.

53.2.2 Installation against a wall, in a right-angle corner of a room, or in an alcove is to be simulated when the product lends itself to such placement and when such placement results in restricted ventilation. When the construction makes installation against a wall, in a corner, or in an alcove possible but inconvenient enough to make such an installation unlikely, the test conducted under these conditions is to be considered an abnormal test. The results of such an abnormal test are to be considered on the basis of evidence of a risk of fire, emission of flame or molten metal, or opening of a 3-A fuse connected between the frame and ground.

54 Ozone

54.1 A product that produces ozone during intended operation shall not produce an average time weighted concentration above background in excess of 0.1 parts per million, nor a transitory concentration of more than 0.3 parts per million, when tested in accordance with 54.2 and 54.3. The average time weighted concentration shall be considered as the average concentration over the operating period.

54.2 Ozone concentration measurements shall be made at all probable operator positions with the product installed in the center of a closed room of 1000 ft^3 (28.3 m^3), which is 8 by 12 by 10 feet (2.4 by 3.7 by 3.0 m) high. The product is to be operated in the same manner as for the normal temperature test. There is to be no circulation of air other than that resulting from intended operation of the product. During the test, the test room is to be maintained at a temperature of 22.0 ±2.0°C (72.0 ±3.6°F) and a relative humidity of 20 – 25 percent. Prior to the start of and immediately after this test, the ozone background level is to be measured with the product deenergized. The background level average is to be calculated and subtracted from the maximum measurement during the test.

54.3 When operation of the product is possible with any of its fans or heaters not functioning or with paper, or fluid supplies, or both exhausted, the test described in 54.2 is to be repeated, as necessary, with the various components not operating or without paper or fluid to determine that these conditions do not result in ozone concentrations above that specified in 54.1.

55 Dielectric Voltage-Withstand

55.1 Primary circuits

55.1.1 While at its maximum operating temperature under conditions of intended use, a product shall withstand for 1 minute without breakdown the application of a 60-Hz essentially sinusoidal potential:

a) Between live parts and dead metal parts.

b) Between circuits that are at different potentials and are not electrically connected. This includes the primary and secondary circuits of isolating transformers.

c) Between terminals of opposite polarity of capacitors that are across the line.

55.1.2 The test potential:

a) Shall be 1000 V for a product rated at 250 V or less.

b) Shall be 1000 V plus twice rated voltage for a product rated at more than 250 V.

55.1.3 When an autotransformer is in the circuit, a 60-Hz essentially sinusoidal potential of 1000 V plus twice rated voltage shall be applied to all circuits operating at more than 250 V.

55.1.4 The primary of the autotransformer shall be disconnected and the test potential shall be applied directly to the wiring that involves the higher potentials.

55.1.5 The test potential mentioned in 55.2.1 is able to be obtained from any convenient source having a capacity of at least 500 VA to maintain the potential indicated in Table 55.1 except in case of breakdown. The voltage of the source shall be continuously variable. A direct-current source shall be used for a direct-current circuit.