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**Underwriters Laboratories Inc.®**A not-for-profit organization dedicated to public safety
and committed to quality service**April 12, 1996****Revision pages for****Standard for****Night Depositories****UL 771, Seventh Edition**

Attached to this transmittal notice is a revision of the seventh edition of UL 771.

A CHANGE ON A PAGE DATED APRIL 12, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THESE NEW AND REVISED REQUIREMENTS ARE NOW IN EFFECT.

The new and revised requirements are substantially in accordance with UL's bulletin on this subject dated December 21, 1995. The bulletin is now obsolete and may be discarded.

Attention is directed to the note on the title page of this standard outlining the procedure to be followed to retain the approved text of ANSI/UL 771-1993.

Revised and/or additional pages may be issued from time to time.

With the inclusion of the accompanying material, the standard consists of pages dated as shown in the following checklist:

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Standard for

Night Depositories

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Approval as an American National Standard (ANSI) covers the numbered paragraphs on pages dated June 23, 1994. These pages should not be discarded when revised or additional pages are issued if it is desired to retain the ANSI approved text.

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

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

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FOREWORD

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

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

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

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

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

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

4 Instructions and Drawings

4.1 Each unit shall be provided with installation instructions and drawings that shall include the following information:

- a) Typical installation drawing layouts and complete representative installation wiring diagram for the product(s) indicating recommended locations and wiring methods that shall be in accordance with the National Electrical Code, ANSI/NFPA 70.
- b) A concise description of the operation, testing, and proper maintenance procedures for the product(s).
- c) Replacement parts, such as lamps or batteries, shall be identified in the instructions by a part number, manufacturer's model number, or the equivalent.

4.1 revised April 12, 1996

4.2 The instructions shall be incorporated on the inside of the product, on a separate sheet, or as part of a manual. When not included directly on the product, the instructions or manual shall be referenced in the marking information on the product.

4.2 revised April 12, 1996

CONSTRUCTION

ASSEMBLY

5 General

5.1 All parts of the night depository entrance shall be constructed and assembled so that any unit or part shall be repaired or replaced as intended by authorized and instructed workmen.

5.2 A night depository incorporating electrical features shall be constructed to be installed in accordance with the applicable provisions of the National Electrical Code, ANSI/NFPA 70.

5.2 revised April 12, 1996

5.3 The night depository entrance shall be designed or shielded to reduce the risk of accumulation of dust, snow, ice, or rain within the night depository, that could interfere with intended operation during severe weather conditions.

5.4 Deposit bags or envelopes furnished with the night depository shall not be of such size and shape that, when filled, could become wedged in the deposit passageways.

5.5 A night depository intended for bag deposits shall be equipped with a locked entrance.

5.6 A secondary defense device in its normal inactivated position shall not restrict the normal passage of deposits through the depository head and chute into the receiving chest or other receptacle. See Tests of Secondary Defense Device, Section 36.

5.7 When a night depository is provided with a secondary defense device, the removal, by forcible methods, of the depository head from the building structure in which it is installed or from its enclosure, or the infiltration of the depository head by forcible methods, shall activate the secondary defense device to close off the resulting access to the receiving chest or other receptacle in a manner that prevents removal of the deposits. See Tests of Secondary Defense Device, Section 36.

6 Protection of Service Personnel

6.1 Uninsulated parts that can cause risk of electric shock or operate at high-voltage and that are made accessible by opening or removing a cover, door, panel, or other closure on or within the product (see 7.4.1) shall be provided with guards over the parts to reduce the risk of service personnel unintentionally touching them during servicing of the product. See also 6.2, 6.3, and 7.2.1 – 7.4.4.

6.2 A guard shall be provided for a part that must be in motion during servicing operations, and that presents a pinching, snagging, cutting, or other risk of unintentional contact with moving parts that may cause injury to persons when made accessible by opening or removing a cover, door, panel, or other closure of the product to provide access to the interior of the product. See also 6.3 and 7.2.1 – 7.4.4.

6.3 If the guard mentioned in 6.1, 6.2, and 7.4.1 must be removed during servicing of the parts mentioned in 6.1 and 6.2, the guard shall be constructed and arranged so that it can be removed and replaced with hand-operated fasteners or hand tools.

7 Enclosures

7.1 General

7.1.1 The frame and enclosure of a unit shall have the strength and rigidity to resist total or partial collapse and the attendant reduction of spacings, loosening or displacement of the parts, or other defects. See Mechanical Strength Tests for Enclosures, Section 40. See also 9.1 and 9.2.

7.1.2 An operating part, such as a gear mechanism, light-duty relay, and similar device shall be enclosed to reduce the risk of malfunction from dust or other material that may impair its intended operation.

7.1.3 The mounting means of an enclosure shall be accessible without disassembly of any operating part of the product. Removal of a completely assembled panel to mount the enclosure is not considered to be disassembly of an operating part.

7.1.4 An enclosure of a product containing other than power limited circuits shall be constructed to reduce the risk of emission of flame, molten metal, flaming or glowing particles, or flaming drops. See Ignition Through Bottom-Panel Openings Test, Section 58.

7.1.5 A construction using a nonflammable bottom in accordance with 7.9.2, or an individual barrier under a component or group of components or assemblies, as specified in Figure 7.1, is to be considered as complying with the requirement in 7.1.4. See 7.9.3.

Exception: Material or assemblies classified as 94V-1 need not comply with this requirement. See the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

7.2 Accessibility of uninsulated live parts and moving parts

7.2.1 The uninsulated live parts and moving parts of a product shall be located or enclosed so that protection is provided against risk of electric shock or injury to persons from unintentional contact with such parts. Insulated brush caps do not require an additional enclosure. See 7.9.6 and 7.9.7.

7.2.2 Any part of the external enclosure of a product to be removed for operator servicing shall be removed before the product is examined in connection with the requirement in 7.2.1.

9.3 The portions of a night depository intended to be exposed to the weather shall comply with the requirements specified in 9.4 – 9.14.

9.4 Metal shall be galvanically compatible.

Exception: When galvanic action does not result in impaired operation of the product, impaired security, or risk of fire, electric shock, or unintentional contact with moving parts that can cause risk of injury to persons; this requirement does not apply.

9.5 Hinges and other attachments shall be resistant to corrosion.

9.6 Sheet steel cabinets and enclosures exposed to the effects of weathering shall be protected against corrosion by the means indicated in Table 9.1 or by other metallic and nonmetallic coatings that have been determined to give equivalent protection as determined by the Material Corrosion Tests, Section 57. See also 9.7 and 9.10.

Table 9.1
Corrosion protection

Type of cabinet and enclosure	Minimum thickness ^a of 0.053 inch (1.35 mm) and heavier for uncoated, 0.056 inch (1.42 mm) and heavier for coated as specified by paragraph	Minimum thickness ^a less than 0.053 inch (1.35 mm) for uncoated, and 0.056 inch (1.42 mm) for coated as specified by paragraph
Outer cabinets that protect motors, wiring, or enclosed current-carrying parts	9.8	9.8
Inside enclosures that protect current-carrying parts other than motors	9.8	9.9
Outer cabinets that are the sole enclosure of current-carrying parts	9.9	9.9
^a See Table 7.2 for specified minimum thickness.		

9.7 The requirement in 9.6 is not applicable to a metal part, such as a decorative grille, that is not required to comply with the requirements of this standard.

9.8 To comply with the requirements of 9.6, one of the following coatings shall be used:

a) Hot-dipped, mill-galvanized, sheet steel conforming with the coating Designation G60 or A60 in the Specification for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-94, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement. The weight of zinc coating shall be determined by any method; however, in case of question, the weight of coating shall be established in accordance with the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM Designation A90/A90M-93. An A60 (alloyed) coating shall also comply with the requirements of 9.11.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00041 inch (0.01041 mm) on each surface with

a minimum thickness of 0.00034 inch (0.00864 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 55. An annealed coating shall also comply with the requirements of 9.11.

- c) Protection equivalent to G60 hot-dipped, mill-galvanized coating. See 9.10.

9.8 revised April 12, 1996

9.9 To comply with the requirements of 9.6, one of the following coatings shall be used:

a) Hot-dipped, mill-galvanized sheet steel conforming with the coating designation G90 in the Specification for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process, ASTM A653/A653M-94, with not less than 40 percent of the zinc on any side, based on the minimum single spot test requirement. The weight of zinc coating shall be determined by any method; however, in case of question the weight of coating shall be established in accordance with the test method in the Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM Designation A90/A90M-93.

b) A zinc coating, other than that provided on hot-dipped, mill-galvanized sheet steel, uniformly applied to an average thickness of not less than 0.00061 inch (0.01549 mm) on each surface with a minimum thickness of 0.00054 inch (0.01372 mm). The thickness of the coating shall be established by the Metallic Coating Thickness Test, Section 55. An annealed coating shall also comply with the requirements of 9.11.

c) A cadmium coating not less than 0.001 inch (0.0254 mm) thick on both surfaces. The thickness of coating shall be established in accordance with the Metallic Coating Thickness Test, Section 55.

9.9 revised April 12, 1996

9.10 With reference to 9.6, other finishes, including paints, special metallic finishes, and combinations of the two, are not prohibited from being used when comparative tests with galvanized-sheet steel (without annealing, wiping, or other surface treatment) complying with the requirements of 9.8(a) or 9.9(a), as applicable, indicate they provide equivalent protection. Among the factors that are taken into consideration when determining the acceptability of such coating systems are exposure to:

- a) Salt spray,
- b) Moist carbon dioxide (CO₂)-sulphur dioxide (SO₂)-air mixture,
- c) Moist hydrogen sulphide (H₂S)-air mixture, and
- d) Ultraviolet light (UV) and water.

The applicable corrosion-exposure tests specified in the Material Corrosion Tests, Section 57, shall be used.

9.11 A hot-dipped, mill-galvanized A60 (alloyed) coating of an annealed zinc coating that is bent or similarly formed after annealing and that is not otherwise required to be painted shall be painted in the bent or formed area when the bending or forming process damages the zinc coating.

Exception: Such areas on the inside surface of a cabinet or enclosure that water does not enter during the Rain Test, Section 47, are not required to be painted.

9.12 When flaking or cracking of the zinc coating at the outside radius of the bent or formed section is visible at 25 power magnification, the zinc coating is determined to be damaged. Simple sheared or cut edges and punched holes are not determined to be formed, but extruded and rolled edges and holes shall comply with the requirements of 9.11.

9.13 Nonferrous cabinets and enclosures are capable of being used without special corrosion protection.

9.14 Nonmetallic cabinets and enclosures shall comply with the requirements of the Mechanical Strength Tests for Enclosures, Section 40. When the cabinet or enclosure is exposed to weather and composed of polymeric material, it shall first be subjected to the UV light and water exposure test, 57.5.1 – 57.5.3, before being subjected to the Mechanical Strength Tests for Enclosures, Section 40.

10 Mechanical Assembly

10.1 Except as noted in 10.2 and 10.3, a switch (other than a through-cord switch), lampholder, attachment-plug receptacle, motor-attachment plug, or similar component shall be mounted securely and shall be prevented from turning. See 24.1.1 – 24.1.3.

10.2 The requirement that a switch be prevented from turning is capable of being waived when all four of the following conditions are met:

- a) The switch is of a plunger or other type that does not tend to rotate when operated (a toggle switch is determined 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 will loosen it.
- c) The spacings are not reduced below the minimum required values when the switch rotates; see Spacings, General, Section 33.
- d) The intended operation of the switch is by mechanical means rather than by direct contact by persons.

10.3 A lampholder of the type in which the lamp cannot be replaced (such as a neon pilot or indicator light in which the lamp is sealed in a nonremovable jewel) is not required to be prevented from turning when rotation cannot reduce spacings below the minimum required values.

10.4 The means for preventing the turning specified in 10.1 is to consist of more than friction between surfaces; for example, a lock washer applied as intended is capable of being provided as the means for preventing the turning of a small stem-mounted switch or other device having a single-hole mounting means.

10.4 revised April 12, 1996

FIELD WIRING CONNECTIONS

11 Installation Wiring Connections

11.1 A product shall be provided with field-wiring terminals or leads and shall have provision for connection of one of the wiring systems that, in accordance with the National Electrical Code, ANSI/NFPA 70, is capable of being used for the unit.

11.1 revised April 12, 1996

12 Supply Connections

12.1 Except as noted in 12.2, a product shall have provision for connection of metal-clad cable or conduit, or a nonmetallic-enclosed wiring system, for example, nonmetallic sheathed cable, as required for the application under the provisions of the National Electrical Code, ANSI/NFPA 70.

12.1 revised April 12, 1996

12.2 An enclosure without provision for the connection of metal-clad cable, conduit, or a nonmetallic-enclosed wiring system is capable of being used when definite instructions are furnished that indicate the section(s) of the product intended to be drilled in the field for the connection(s).

12.2 revised April 12, 1996

13 Terminal Compartments

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

13.2 An outlet or terminal box in which connections to the power-supply circuit will be made shall be located so that, after the unit has been installed as intended, such connections are accessible for inspection.

13.3 The compartment shall be located so that, during conduit connections, internal wiring and electrical components is not exposed to damage or strain.

13.3 revised April 12, 1996

13.4 A terminal solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size required for the particular application in accordance with the National Electrical Code, ANSI/NFPA 70.

13.4 revised April 12, 1996

13.5 When a product is designed so that it is capable of being adapted on installation for either of two different supply volts (for example, 120 volts, 2-wire or 120/240 volts, 3-wire), it shall be provided with means by which the appropriate connections shall be made without changing or disrupting internal wiring or connections other than at the point of field connections.

13.5 revised April 12, 1996

13.6 A compartment provided for making field connections in a product shall be of a volume so that connections to all field wiring terminals, leads, or both, are made as intended and without damage to wire insulation or internal components.

13.7 Protection from sharp edges for the internal components and wire insulation shall be provided by insulation or metal barriers having smooth, rounded edges.

14 Field Wiring Terminals

14.1 General

14.1.1 A field wiring terminal shall comply with the Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A; or the Standard for Equipment Wiring Terminals for Use With Aluminum and/or Copper Conductors, UL 486E; or the field wiring requirements (Code 2) in the Standard for Terminal Blocks, UL 1059; or the field wiring requirements in the Standard for Electrical Quick-Connect Terminals, UL 310; or 14.2.2 – 14.2.5, and 14.2.7 – 14.2.10. The current-carrying parts shall be silver, copper, a copper alloy, or a similar nonferrous conductive material. Securing screws and the like may be plated steel.

Exception: Equipment provided with quick-connect terminals intended for field termination of electrical conductors to the equipment and complying with UL 310 shall be provided with strain-relief and instructions for effecting the strain-relief and with reference to the specific connectors to be used.

14.1.1 revised April 12, 1996

14.2 High-voltage circuits

14.2.1 The terminals to which wiring connections are made shall consist of binding screws with terminal plates having upturned lugs or the equivalent to hold the wires in position. Other terminal connections shall be provided when determined to be equivalent.

14.2 revised April 12, 1996

14.2.2 A wire binding screw at a field wiring terminal shall not be smaller than No. 10 (4.8 mm diameter).

Exception: A No. 8 (4.2 mm diameter) screw shall be used for the connection of one No. 14 AWG (2.1 mm²) and a No. 6 (3.5 mm diameter) screw shall be used for the connection of a No. 16 or 18 AWG (1.3 or 0.82 mm²) conductor.

14.2.3 For No. 8 AWG (8.4 mm²) and larger conductors, pressure wire connectors shall be used. For No. 10 AWG (5.3 mm²) and smaller conductors, the parts to which wiring connections are made shall consist of clamps or wire binding screws with cupped washers, terminal plates, or the equivalent to hold the wire in position.

14.2.4 According to the National Electrical Code, ANSI/NFPA 70, No. 14 AWG (2.1 mm²) is the smallest conductor that the installer shall use for branch circuit wiring and thus is the smallest conductor that shall be anticipated at a terminal for the connection of a power supply wire.

14.2.4 revised April 12, 1996

14.2.5 A wire binding screw shall thread into metal.

14.2.6 A field wiring terminal shall be prevented from turning or shifting in position by means other than friction between surfaces. This is accomplished by means such as two screws or rivets; by square shoulders or mortices; by a dowel pin, lug, or offset; or by a connecting strap or clip fitted into an adjacent part.

14.2.6 revised April 12, 1996

14.2.7 Except as noted in 14.2.8, a terminal plate tapped for a wire binding screw shall be of metal not less than 0.050 inch (1.27 mm) in thickness for a No. 8 (4.2 mm diameter) or larger screw, and not less than 0.030 inch (0.76 mm) in thickness for a No. 6 (3.5 mm diameter) screw and shall not have fewer than two full threads in the metal.

14.2.8 A terminal plate formed from stock having the minimum required thickness shall have the metal extruded at the tapped hole for the binding screw so as to provide two full threads.

Exception: Two full threads are not required when a lesser number of threads results in a secure connection in which the threads will not strip with tightening torque, in accordance with the values indicated in the Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A.

14.2.9 Upturned lugs or a cupped washer shall be capable of retaining a conductor of the size rated for an ampacity at least equal to 125 percent of the full-load current of the motor, plus the full-load current ratings of the other leads supplied – but not smaller than No. 14 AWG (2.1 mm²), under the head of the screw or the washer.

14.2.10 When two or more conductors are intended to be connected by wrapping under the same screw, a nonferrous, intervening metal washer shall be used for each additional conductor. A separator washer is not required when two conductors are separated and intended to be secured under a common clamping plate. When the wires protrude above terminal barriers, the nonferrous separator shall include means such as upturned tabs on sides to retain the wire.

14.3 Low-voltage circuits

14.3.1 Terminals in low-voltage circuits to which field connections are to be made shall consist of any of the following configurations:

- a) Same as for high-voltage circuits, see 14.2.1 – 14.2.10.
- b) Nonferrous wire binding screws not smaller than No. 4 (2.8 mm diameter) for a No. 19 AWG (0.65 mm²) or smaller conductor.

- c) Nonferrous solder lugs.
- d) Terminal connections equivalent to any specified in (a) – (c).

15 Leads

15.1 General

15.1.1 Wiring of circuits that operate at different potentials shall be separated by barriers, clamps, routing, or other equivalent means, unless all conductors are provided with insulation that is rated for the highest potential and temperature involved.

15.2 High-voltage circuits

15.2.1 Leads provided for field connections in high-voltage circuits shall not be less than 6 inches (152 mm) long. In addition, the size of leads shall be rated for the ampacity of the circuit, but shall not be smaller than No. 18 AWG (0.82 mm²), shall not have insulation less than 1/32 inch (0.8 mm) thick, and shall be provided with strain relief.

Exception: A lead is capable of being less than 6 inches (152 mm) in length when it is evident that use of a longer lead results in damage to the lead insulation or product, or results in a risk of fire, electric shock, or injury to persons, or is not required for the intended operation of the product.

15.2.1 revised April 12, 1996

15.3 Low-voltage circuits

15.3.1 Leads provided for field connections in low-voltage circuits shall not be less than 6 inches (152 mm) long. In addition, leads shall not be smaller than No. 22 AWG (0.36 mm²), shall not have insulation less than 1/64 inch (0.4 mm) thick, and shall be provided with strain-relief.

Exception: A lead is capable of being less than 6 inches (152 mm) in length when it is evident that use of a longer lead results in damage to the insulation or product, or results in a risk of fire, electric shock, or injury to persons, or is not required for the intended operation of the product.

15.3.1 revised April 12, 1996

16 Grounding

16.1 Equipment grounding connections

16.1.1 A product shall be provided with an identified separate equipment grounding terminal or lead. The grounding means shall be connected to all exposed dead metal parts and all dead metal parts within the enclosure that are exposed to contact during servicing or use.

16.1.2 The following are considered to constitute means for grounding:

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

- b) Located so that it will not be exposed to oil, grease, oily vapor, or other substances that may have a deleterious affect on rubber.

If a soft rubber bushing is used in a hole in metal, the hole shall be free from sharp edges, burrs, projections, and the like, that may cut into the rubber.

19.6 An insulating metal grommet may be used instead of an insulating bushing if the insulating material:

- a) Is not less than 1/32 inch (0.8 mm) in thickness and
- b) Completely fills the space between the grommet and the metal in which it is mounted.

20 Separation of Circuits

20.1 Internal wiring of circuits that operate at different potentials shall be separated by barriers, clamps, routing, or equivalent means, unless all conductors are provided with insulation rated for the highest potential involved.

20.2 If a barrier is used to provide separation between the wiring of different circuits, it shall be of metal or of insulating material complying with the requirements of 24.2.1 – 24.2.5. A barrier of insulating material shall not be less than 0.028 inch (0.71 mm) thick. Any clearance between the edge of a barrier and a compartment wall shall not be more than 1/16 inch (1.6 mm).

21 Wireways

21.1 Wireways shall be smooth and free from sharp edges, burrs, fins, moving parts, and the like, that may cause abrasion of the conductor insulation. See Bushings, Section 19.

22 Strain Relief

22.1 A strain relief means shall be provided for internal wires or wire harnesses and cables that are subject to movement in conjunction with the operation or servicing of any product to prevent the transmission of stress to terminals, connections, or components. Movement of conductors provided with a metal ring type of strain relief shall not damage connections or components.

22.2 If a knot in a cord or cable serves as strain relief, a surface against which the knot may bear or with which it may come in contact shall be free from projections, sharp edges, burrs, fins, and the like, that may cause abrasion of the insulation on the conductors.

23 Bonding for Grounding

23.1 Exposed noncurrent-carrying metal parts in a high-voltage product that could become energized shall be bonded to the point of connection of the field equipment grounding terminal or lead and to the metal surrounding the knockout, hole, or bushing provided for field power supply connections. See 23.3 – 23.10.

23.2 Uninsulated metal parts of cabinets, electrical enclosures, mounting brackets, capacitors, and other electrical components that could become energized shall be bonded if they may be contacted by the user or by service personnel in servicing the equipment.

Exception No. 1: Adhesive-attached metal-foil markings, screws, handles, and the like, that are located on the outside of enclosures or cabinets and isolated from electrical components or wiring by grounded metal parts so that they could not become energized need not be bonded.

Exception No. 2: Isolated metal parts, such as motor controller magnet frames and armatures, small assembly screws, and the like, that are separated from both wiring and uninsulated live parts, are not required to be bonded.

Exception No. 3: Panels and covers that do not enclose uninsulated live parts are not required to be bonded when wiring is separated from the panel or cover so that it does not become energized.

Exception No. 4: Panels and covers are not required to be bonded when they are insulated from electrical components and wiring by an insulating barrier of vulcanized fiber, varnished cloth, phenolic composition, or similar material not less than 1/32 inch (0.8 mm) thick and secured in place.

23.2 revised April 12, 1996

23.3 A bonding conductor shall be of material intended for use as an electrical conductor. When of ferrous metal, it shall be protected against corrosion by painting, plating, or the equivalent. The conductor shall have the ampacity of the maximum size wire used in the circuit wiring of the component or part, and shall be installed so that it is protected from mechanical damage.

23.3 revised April 12, 1996

23.4 The bonding shall be by a positive means, such as clamping, riveting, bolted or screwed connection, brazing, or welding. The bonding connection shall penetrate nonconductive coatings, such as paint. Bonding around a resilient mount shall not depend on the clamping action of rubber or similar material.

23.5 A bolted or screwed connection that incorporates a star washer under the screwhead shall be used for penetrating nonconductive coatings when required for compliance with the requirements of 23.4.

23.5 revised April 12, 1996

23.6 Two or more screws or two full threads of a single screw engaging metal are capable of being used when the bonding means depends upon screw threads.

23.6 revised April 12, 1996

23.7 Two full threads for a single screw are not required when a lesser number of threads results in secure connection in which the threads do not strip with tightening torque, in accordance with the values indicated in the Standard for Wire Connectors and Soldering Lugs for Use With Copper Conductors, UL 486A.

23.7 revised April 12, 1996

23.8 Splices shall not be used in wire conductors used to bond electrical enclosures or other electrical components.

23.9 Metal-to-metal, hinge-bearing members for doors or covers shall be used as a means for bonding a door or cover for grounding when a multiple pin-type hinge is used.

23.10 The size of a copper or aluminum conductor, used to bond an electrical enclosure or motor frame, shall be based on the rating of the branch-circuit overcurrent device by which the equipment will be protected. The size of the conductor shall be in accordance with Table 23.1.

Table 23.1
Bonding wire conductor size

Rating of overcurrent device, amperes	Size of bonding conductor ^a			
	Copper wire,		Aluminum wire,	
	AWG	(mm ²)	AWG	(mm ²)
15	14	2.1	12	3.3
20	12	3.3	10	5.3
30	10	5.3	8	8.4
40	10	5.3	8	8.4
60	10	5.3	8	8.4
100	8	8.4	6	13.3
200	6	13.3	4	21.2

^a Or equivalent cross-sectional area.

COMPONENTS — ELECTRICAL

24 General

24.1 Mounting of components

24.1.1 All components of a product shall be securely mounted in position and prevented from turning or loosening when such motion reduces electrical spacings; impairs the intended performance of the product; or causes a risk of fire, electric shock, or unintentional contact with hazardous moving parts. See Mechanical Assembly, Section 10.

24.1.2 Friction between surfaces shall not be the sole means of preventing a device from turning in its mounting. However, turning of a small, stem-mounted switch or other device having a single-hole mounting is capable of being prevented with the use of a lock washer.

24.1.3 Uninsulated live parts, including terminals, shall be secured to their supporting surfaces by methods other than friction between surfaces so that they are prevented from turning or shifting in position when such motion results in reduction of spacings to less than the minimum required values. See Spacings, General, Section 33.

24.1.3 revised April 12, 1996

24.2 Insulating material

24.2.1 Material for the mounting of live parts shall be strong, nonflammable, and moisture-resistant insulating material, such as porcelain, phenolic composition, cold-molded composition, or equivalent material.

24.2.2 Vulcanized fiber is to be used for insulating bushings, washers, separators, and barriers, but not as the sole support of live parts.

24.2.3 Polymeric materials are to be used for the sole support of uninsulated live parts when determined to have the required mechanical strength and rigidity, dielectric strength; resistance to heat, flame propagation, arcing, creep, and moisture; and other properties beyond the minimum required level as a result of aging. See the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, and the Standard for Polymeric Materials — Use in Electrical Equipment Evaluations, UL 746C.

24.2.4 The thickness of a flat sheet of insulating material, such as asbestos-cement composition or phenolic composition used for panel-mounting of parts, shall not be less than that indicated in Table 24.1.

Table 24.1
Thickness of flat sheets of insulating material

Maximum dimensions				Minimum thickness, ^a	
Length or width,		Area,			
Inch	(cm)	Inch ²	(cm ²)		
24	60.9	360	2322	3/8	9.5
48	122.0	1152	7432	1/2	12.7
48	122.0	1728	11,148	5/8	15.9
Over 48	122.0	Over 1728	11,148	3/4	19.1

^a Material less than 3/8 inch (9.5 mm) but not less than 1/8 inch (3.2 mm) in thickness shall be used for a panel when the panel is adequately supported or reinforced to provide rigidity not less than that of a 3/8 inch sheet. Material less than 1/8 inch shall be used for subassemblies, such as supports for terminals for internal wiring, resistors, and other components.

24.2.5 A terminal block mounted on a metal surface shall be provided with an insulating barrier between the mounting surface and all live parts on the underside of the base that are not staked, upset sealed, or equivalently prevented from loosening, to prevent such parts and the ends of replaceable terminal screws from coming in contact with the supporting surface.

24.2.6 A countersunk part that is sealed shall be covered with a waterproof insulating compound that will not melt at a temperature 15°C (27°F) higher than the maximum intended operating temperature of the assembly, and at not less than 65°C (149°F) in any case. The depth or thickness of sealing compound shall not be less than 1/8 inch (3.2 mm).

24.3 Current-carrying parts

24.3.1 A current-carrying part shall be a metal, such as silver, copper, copper alloy, or other material that will provide equivalent performance.

24.3.2 Bearings, hinges, and the like, shall not be used for current carrying between fixed and moving parts.

25 Capacitors

25.1 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) shall be housed within an enclosure or container that will protect the plates against mechanical damage and prevent the emission of flame or molten material resulting from failure of the capacitor. The container shall be of sheet steel having a thickness of not less than 0.020 inch (0.51 mm) or shall be constructed to afford equivalent protection.

Exception: See 25.2 and 25.3 for details on capacitor enclosures and containers.

25.2 The container of a capacitor shall be of sheet steel of thickness less than that specified in 25.1, or of other material, when the capacitor is mounted in an enclosure that houses other parts of the unit, and when such a box, case, or the like, complies with the requirements for Enclosures, Section 7.

25.2 revised April 12, 1996

25.3 The individual enclosure of an electrolytic capacitor with means for venting is required to provide protection against mechanical damage only, and the requirement for minimum enclosure thickness does not apply. The individual enclosure of an electrolytic capacitor not provided with means for venting and with an opening more than 1/16 inch (1.6 mm) wide between the capacitor enclosure and the motor need not comply with the requirement for enclosure thickness given in 25.1 if it complies with the requirements of the Capacitor Overvoltage Test, Section 54.

26 Lampholders and Lamps

26.1 Lampholders and lamps shall be rated for the current and voltage in the circuit in which they are used when the product is operated under intended service conditions.

26.2 The outer shell of any lampholder in a product shall be connected to the identified (grounded) conductor, if it is in a high-voltage circuit.

26.3 A lampholder shall be installed so that uninsulated high-voltage live parts other than an outer shell will not be exposed to contact by persons removing or replacing lamps in service.

27 Motors and Motor Overload Protection

27.1 Motors

27.1.1 Each motor shall drive its maximum load during operation of the product without introducing a risk of fire or electric shock.

27.1.2 A motor winding shall resist the absorption of moisture.

27.2 Overload protection

27.2.1 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 failure to operate will not be evident; and a continuous-duty integral-horsepower motor shall be provided with overload protection. The protection provided is to be as indicated in 27.2.3. For a multispeed motor, the protection is to be effective at all speed settings. See also 27.2.4.

27.2.2 If overloading, stalling, and the like, of a motor can result from manipulation of the controls in any part of the system, that motor shall be provided with overload protection as described in 27.2.3.

27.2.3 The overload protection required in 27.2.1 and 27.2.2 is to consist of one of the following:

- a) Thermal protection complying with the Standard for Thermal Protectors for Motors, UL 547.
- b) Impedance protection complying with the applicable requirements in the Standard for Motor-Operated Appliances, UL 73, when tested as used in the application.
- c) Other protection that tests show is equivalent to the protection specified in (a).

27.2.4 A motor that drives only a blower or fan is considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

27.2.5 A shaded-pole motor having a difference of 1 ampere 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 considered to have acceptable overload protection if it is protected against locked-rotor conditions only.

27.2.6 Devices providing overload protection for motors shall be rated for use on branch circuits to which the unit can be connected unless additional protection is provided in the unit.

27.2.7 A thermal or overload protective device shall not open the circuit during intended use of the product.

27.2.8 The functioning of an overload protective device provided for a motor as part of a unit, whether or not such a device is required, shall not result in a risk of fire, electric shock, or unintentional contact with moving parts.

28 Overcurrent Protection

28.1 Fuseholders, fuses, and circuit breakers provided on a product shall be rated for the application.

28.2 The assembly shall be arranged so that an overcurrent protective device, such as a fuse, whose intended functioning requires renewal can be replaced and manual-reset devices can be reset without removing parts other than a service cover(s) or panel(s).

28.3 The door or cover of an enclosure shall be hinged or pivoted if it gives access to fuses or any motor-overload protective device, the intended functioning of which requires renewal, or if it is necessary to open the cover in connection with the intended operation of the protective device, such as resetting a manual-reset overload protective device.

Exception: See 28.5 for fuseholder containment conditions.

28.4 A fuseholder shall be designed, installed, or protected so that adjacent uninsulated high-voltage live parts, other than the screw shell of a plug fuseholder, cartridge fuse clips, or wiring terminals to the fuseholder, will not be exposed to contact by persons removing or replacing fuses. An insulating barrier of vulcanized fiber or similar material used for this purpose shall not be less than 0.028 inch (0.71 mm) thick.

28.5 A hinged cover is not required for a device in which the only fuses enclosed are:

- a) Supplementary control-circuit fuses of 2 amperes or less, provided the fuses and control-circuit loads (other than a fixed control-circuit load, such as a pilot lamp) are within the same enclosure;
- b) Extractor type fuses, each with its own enclosure; or
- c) Fuses in low-voltage circuits.

28.6 Hinged covers, if required, shall not depend solely upon screws or similar means requiring the use of tools to hold them closed, but shall be provided with a spring latch or catch that will retain the cover in place when swung closed. See 7.4.4.

28.7 A door or cover giving direct access to fuses in other than low-voltage circuits shall shut closely against a 1/4-inch (6.4-mm) rabbet, or the equivalent, or shall have either turned flanges for the full length of four edges or angle strips fastened to it. Flanges or angle strips shall fit closely with the outside of the box and shall overlap the edges of the box not less than 1/2 inch (12.7 mm). A construction that affords equivalent protection, such as a construction in which the fuse enclosure is located within an outer enclosure, or a combination of flange and rabbet, may be used.

29 Printed Wiring Boards

29.1 Printed wiring shall comply with the Standard for Printed-Wiring Boards, UL 796.

29.1 revised April 12, 1996

29.2 A printed wiring assembly using insulating coatings or encapsulation shall be tested for dielectric voltage-withstand before and after being treated. If it is impractical to use untreated samples, finished samples shall be subjected to the Dielectric-Voltage Withstand Test, Section 52, after they have been subjected to the Humidity Test, Section 44; the Temperature Test, Section 41; and the applicable tests described in this standard. Electrical connections between circuits being tested shall be disconnected before testing.

29.3 Components shall be secured to the board and spacings between circuits shall comply with the requirements in Spacings, General, Section 33. The board shall be mounted so that deflection of the board during servicing shall not result in damage to the board or in a risk of fire or electric shock.

36.1.3 The tools used in the attack test are to be a hammer limited to a 3-pound (1.4-kg) head weight, used separately or with chisels, crowbars, pry bars, punches, and screwdrivers limited to 24 inches (610 mm) in length.

36.1.4 For the attack test, the secondary defense device is to be mounted in relation to the depository head as it would be when installed in the field. The minimum distance between the two units is to be maintained as specified in the manufacturer's installation instructions. The removal of the depository head is not a part of a 5-minute attack time, and it can be removed by nondestructive means before the attack test is started.

36.2 Time

36.2.1 The net working time covers only the period during which an attack is actively in progress on the sample, exclusive of preparations for test, time required for safety precautions, and delays that cannot be anticipated.

36.2.2 A number of attacks may be attempted, each for the full 5-minute working time.

36.2.3 Any one attack method shall be attempted only once. Damage caused in one attack may be used in another attack if the time used to cause the damage in the first attack is deducted from the 5-minute time of the second attack.

37 Starting Current Test

37.1 A product shall start and operate as intended on a circuit protected by a (non time-delay) fuse having a current rating corresponding to that of the branch circuit to which, in accordance with the National Electrical Code, ANSI/NFPA 70, the product shall be connected.

37.1 revised April 12, 1996

37.2 For determination of compliance with the requirements of 37.1, the product is to be started three times, while at room temperature at the beginning of the test. Each start is to be made under conditions representing the beginning of intended operation (the beginning of the operating cycle in the case of any automatic product or subassembly), and the motor is to be allowed to come to rest between successive starts. Results are considered unacceptable if the fuse has opened. Tripping of an overload protector provided as part of the product is also considered to constitute unacceptable results.

38 Input Test

38.1 The input of a product shall not be more than 110 percent of the product current, wattage, or volt-ampere rating when the product is connected to a test voltage in accordance with the requirements in 38.2 and operated at maximum intended load conditions.

38.2 The test voltage for this test is to be the maximum rated voltage for the product. For a product having a single voltage rating, such as 115 volts, maximum rated voltage is to be that single voltage. If the voltage is given in terms of a range of voltages, such as 110 – 120 volts, the maximum rated voltage is the highest value of the range.

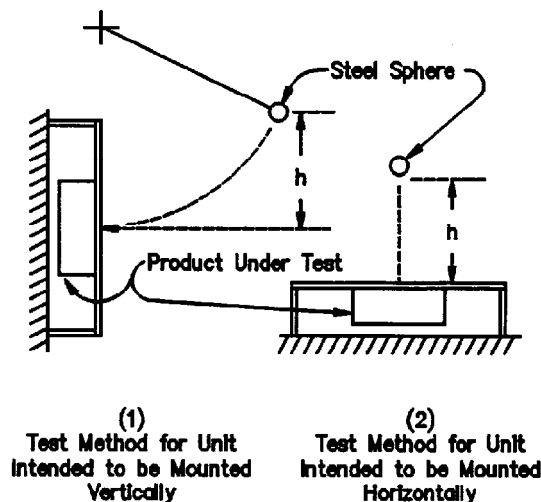
39 Jarring Test

39.1 Parts of the product impaired by jarring resulting from impact or vibration encountered under intended service conditions shall withstand the test described in 39.2. Subsequent intended operation of the product shall not be impaired.

39.2 A product that is capable of being mounted on a wall without extra support or reinforcement is to be mounted as intended to the center of a 6- by 4-foot (1.8- by 1.2-m), nominal 3/4-inch (19.1-mm) thick plywood board secured in place at four corners. A 3 foot-pound (4.08-J) impact is to be applied to the center of the reverse side of this board by means of a 1.18 pound-mass (0.54-kg), 2-inch (50.8-mm) diameter steel sphere either swung through a pendulum arc from a height of 30.5 inches (775 mm), or dropped from a height of 30.5 inches, depending upon the mounting of the equipment. See Figure 39.1.

Figure 39.1

Jarring test



IP110

39.3 A product that is freestanding or requires extra support or reinforcement of the wall for mounting shall have the impact applied directly to the most vulnerable point of the product.

39.4 For this test, the electrically operated product is to be energized in ready-to-serve mode and connected to a rated source of supply. Following the jarring, the product shall operate as intended.

40 Mechanical Strength Tests for Enclosures

40.1 The enclosure of a product containing high-voltage or low-voltage (power limited) circuits, or hazardous moving parts, shall withstand the applicable tests described in 40.2 and 40.3 without:

- a) Permanent distortion such that spacings are reduced below the minimum required values, see Spacings, General, Section 33, and
- b) Causing openings that could cause unintentional contact with hazardous moving parts or that would expose uninsulated live parts that could cause a risk of electric shock. See 7.7.1 – 7.7.3, 7.9.6, and 7.9.7.

The design and use of the product shall be taken into account in evaluating compliance with the requirements of this paragraph.

44 Humidity Test

44.1 A product shall function as intended during and after exposure for 24 hours to air having a relative humidity of 85 percent at a temperature of $30 \pm 1.6^\circ\text{C}$ ($86 \pm 3^\circ\text{F}$).

45 Electric Shock Current Test

45.1 If the open circuit potential between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part exceeds 42.4 volts peak, the part shall comply with the requirements of 45.2 – 45.4, as applicable.

45.2 The continuous current flow through a 500-ohm resistor shall not exceed the values specified in Table 45.1 when the resistor is connected between any part that is exposed only during operator servicing and either earth ground or any other exposed accessible part.

Table 45.1
Maximum current during operator servicing

Frequency, hertz ^a	Maximum current through a 500-ohm resistor, milliamperes peak
0 – 100	7.1
500	9.4
1000	11.0
2000	14.1
3000	17.3
4000	19.6
5000	22.0
6000	25.1
7000 or more	27.5

^a Linear interpolation between adjacent values may be used to determine the maximum current corresponding to frequencies not shown. The table applies to repetitive nonsinusoidal or sinusoidal waveforms.

45.3 The duration of a transient current flowing through a 500 ohm resistor connected as described in 45.2 shall not exceed:

- a) The value determined by the following equation:

$$T \leq \left[\frac{20 \sqrt{2}}{I} \right]^{1.43}$$

in which:

I is the peak current in milliamperes, and

T is the interval, in seconds, between the time that the instantaneous value of the current first exceeds 7.1 milliamperes and the time that the current falls below 7.1 milliamperes for the last time, and

- b) 809 milliamperes, regardless of duration.

The interval between occurrences shall be equal to or greater than 60 seconds if the current is repetitive. Typical calculated values of maximum transient current duration are shown in Table 45.2.

Table 45.2
Maximum transient current duration

Maximum peak current (I) through 500-ohm resistor, milliamperes	Maximum duration (T) of waveform containing excursions greater than 7.1 milliamperes peak
7.1	7.26 seconds
8.5	5.58
10.0	4.42
12.5	3.21
15.0	2.48
17.5	1.99
20.0	1.64
22.5	1.39
25.0	1.19
30.0	919 milliseconds
40.0	609
50.0	443
60.0	341
70.0	274
80.0	226
90.0	191
100.0	164
150.0	92
200.0	61
250.0	44
300.0	34
350.0	27
400.0	23
450.0	19
500.0	16
600.0	12
700.0	10
809.0	8.3

45.4 The maximum capacitance between the terminals of a capacitor that is accessible during operator servicing shall comply with the following equations:

$$C = \frac{88,400}{E^{1.43} (\ln E - 1.26)} \text{ for } 42.4 \leq E \leq 400$$

$$C = 35,288E^{-1.5364} \text{ for } 400 \leq E \leq 1000$$

in which:

E is the potential in volts across the capacitor prior to discharge and

C is the maximum capacitance of the capacitor in microfarads.

E is to be measured 5 seconds after the capacitor terminals are made accessible, such as by the removal or opening of an interlocked cover, or the like. Typical calculated values of maximum capacitance are shown in Table 45.3.

Table 45.3
Electric shock — stored energy

Potential in volts, across capacitance prior to discharge	Maximum capacitance in microfarads
1000	0.868
900	1.02
800	1.22
700	1.50
600	1.90
500	2.52
400	3.55
380	3.86
360	4.22
340	4.64
320	5.13
300	5.71
280	6.40
260	7.24
240	8.27
220	9.56
200	11.2
180	13.4
160	16.3
140	20.5
120	26.6
100	36.5
90	43.8
80	53.8
70	68.0
60	89.4
50	124.0
45	150.0
42.4	169.0

45.5 With reference to the requirements of 45.2 and 45.3, the current is to be measured while the resistor is connected between ground and:

- a) Each accessible part individually and
- b) All accessible parts collectively when the parts are simultaneously accessible.

The current also is to be measured while the resistor is connected between one part or group of parts and another part or group of parts, when the parts are simultaneously accessible.

45.6 With reference to the requirements of 45.5, parts are considered to be simultaneously accessible if they can be contacted by one or both hands of a person at the same time. For the purpose of these requirements, one hand is to be considered to be able to contact parts simultaneously if the parts are within a 4 by 8 inch (102 by 203 mm) rectangle; and two hands of a person are considered to be able to contact parts simultaneously if the parts are not more than 6 feet (1.8 m) apart.

45.7 Electric shock current refers to all currents, including capacitively coupled currents.

45.8 If the product has a direct-current rating, measurements are to be made with the product connected in turn to each side of a 3-wire, direct-current supply circuit.

45.9 Current measurements are to be made:

- a) With any operating control, or adjustable control that is subject to user operation, in all operating positions and
- b) Either with or without a vacuum tube, separable connector, or similar component in place.

These measurements are to be made with controls placed in the position that causes maximum current flow.

46 Transient Test

46.1 A product shall be subjected to 500 externally induced transients while energized from a test voltage source of supply.

46.2 The primary of a 120/240 volt, 60 Hz, 2 kVA isolating power transformer with the secondary open circuited is to be connected to the same branch circuit as the product. The input to the transformer is to be de-energized for one second by an automatic switching device at a rate of not more than 6 cycles per minute for 500 cycles. During the test, the product is to be energized in the ready-to-serve condition. Following the test the product is to be operated for its intended service operation to determine whether transients, generated by the random collapse of the magnetic field of the transformer, result in a component failure or impair its intended performance.

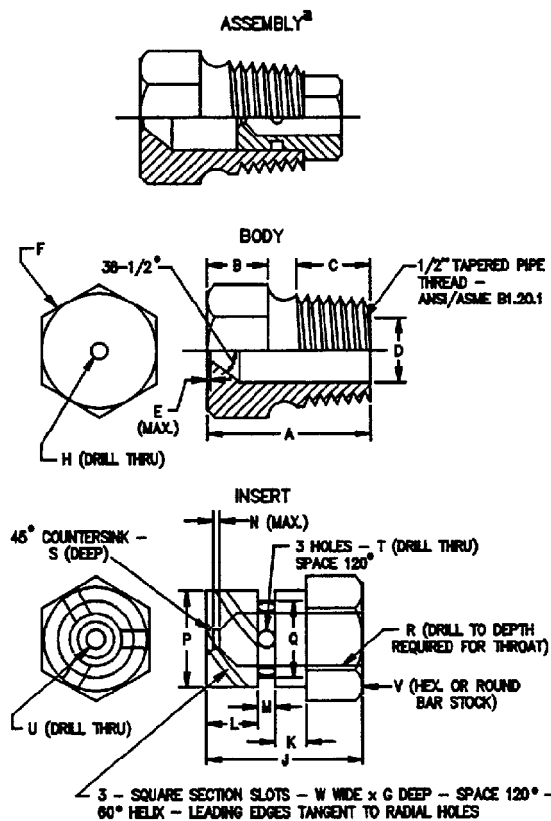
46.3 The product may fail to operate as intended, but the security of the deposits shall not be impaired. Risk of fire or electric shock shall not be caused.

46.4 The electrical characteristics of the testing transformer are to be as specified in Table 46.1.

Table 46.1
Electrical characteristics of the testing transformer

	Voltage, volts	Test frequency, hertz	Inductance (L) millihenries	Quality factor (Q)	DC resistance (R) ohms 23°C (73.4°F)
Primary winding	120	1000	21.2	11.50	0.244
Secondary winding	240	1000	109.3	4.65	0.371

Figure 47.2
Rain-test spray head



Item	inch	mm	Item	inch	mm
A	1-7/32	31.0	N	1/32	0.80
B	7/16	11.0	P	.575	14.61
C	9/16	14.0		.576	14.63
D	.578	14.68	Q	.453	11.51
	.580	14.73		.454	11.53
E	1/64	0.40	R	1/4	6.35
F	c	c	S	1/32	0.80
G	.06	1.52	T	(No. 35) ^b	2.80
H	(No. 9) ^b	5.0	U	(No. 40) ^b	2.50
J	23/32	18.3	V	5/8	16.0
K	5/32	3.97	W	0.06	1.52
L	1/4	6.35			
M	3/32	2.38			

^a Nylon Rain-Test Spray Heads are available from Underwriters Laboratories

^b ANSI B94.11M Drill Size

^c Optional — To serve as a wrench grip.

RT100E

48 Gasket Tests

48.1 The requirements in 48.2 – 48.9 apply to gaskets required for electrical enclosures as determined during the Rain Test, Section 47.

48.2 Nonfoamed elastomeric (natural rubbers, and synthetic rubbers – such as neoprene, ethylene propylene, and the like) gaskets shall have physical characteristics as indicated in Table 48.1 when tested separately after exposure to room ambient and after accelerated aging. See 48.3.

Table 48.1
Physical properties for gaskets

	Elastomers (natural rubbers and synthetic rubbers – neoprene ethylene propylene and the like)		Nonelastomers (PVC) and the like	
	Unaged specimens	Aged specimens	Unaged specimens	Aged specimens
Recovery – maximum set when 1 inch (25.4 mm) gage marks are stretched to 2-1/2 inches (63.5 mm), held for 2 minutes and measured 2 minutes after release	1/4 inch (6.4 mm)	Not applicable	Not applicable	Not applicable
Elongation – minimum increase in distance between 1 inch gage marks at break	250 percent (1 – 3-1/2 inches) (25.4 – 88.9 mm)	65 percent of original	200 percent (1 – 3 inches) (25.4 – 76.2 mm)	65 percent of original
Tensile strength – minimum force at breaking point	850 psi (5.86 MPa)	75 percent of original	1500 psi (8.27 MPa)	75 percent of original

48.3 Specimens of a gasket material to be tested shall be divided into two groups. The first group shall have physical characteristics as indicated in Table 48.1 after being exposed to room ambient for at least 30 minutes. The second group shall have physical characteristics as indicated in Table 48.1 after accelerated aging for 70 hours at $100 \pm 2^{\circ}\text{C}$ ($212 \pm 3.6^{\circ}\text{F}$) in an air-circulating oven, and then exposure to room ambient for not less than 16 hours and not more than 96 hours.

48.3 revised April 12, 1996

48.4 Foamed neoprene or foamed rubber compound gaskets are to be aged for 70 hours at $100 \pm 2^{\circ}\text{C}$ ($212 \pm 3.6^{\circ}\text{F}$) in an air-circulating oven, and then exposed to room ambient for not less than 16 hours and not more than 96 hours, before examination. The gaskets shall not shrink, crack, melt, warp, deform, harden, or otherwise deteriorate to a degree that impairs their sealing properties.

48.4 revised April 12, 1996

48.5 Nonelastomeric gaskets (PVC, and the like), shall have physical characteristics as indicated in Table 48.1 when tested separately after exposure to room ambient and after accelerated aging. See 48.6.

48.6 Specimens of a gasket material to be tested shall be divided into two groups. The first shall have physical characteristics as indicated by Table 48.1 after being exposed to room ambient for at least 30 minutes. The second group shall have physical characteristics as indicated by Table 48.1 after accelerated aging for 168 hours (7 days) in an air-circulating oven at $87 \pm 1^{\circ}\text{C}$ ($189 \pm 1.8^{\circ}\text{F}$), and then exposure to room ambient for not less than 16 hours and not more than 96 hours.

53 Solenoid Burnout Test

53.1 There shall be no emission of flame or molten metal when the armature of a solenoid used as part of a product is blocked in the de-energized position and energized continuously at rated frequency and at rated voltage from a circuit protected by a fuse rated at least ten times the current input rating of the solenoid.

53.2 The solenoid is to be wrapped in a single layer of bleached cheesecloth having an area of 14 – 15 square yards to the pound (26 – 28 m²/kg) and a count of 32 by 28, and energized. There shall be no molten metal or flame emitted from the unit as a result of this test as evidenced by ignition or charring of the cheesecloth.

54 Capacitor Overvoltage Test

54.1 To comply with the requirements of 24.1.3, samples of an electrolytic capacitor with an enclosure not provided with means for venting and with an opening more than 1/16 inch (1.6 mm) wide between the enclosure and the motor, with cotton placed around openings in the enclosure, shall be subjected to such overvoltage as to cause failure.

54.2 If the cotton ignites upon failure of the capacitor, the results are not acceptable.

55 Metallic Coating Thickness Test

55.1 If necessary, to comply with the requirements of 9.8(b) and 9.9 (b) and (c), a metal coating shall be subjected to the test described in 55.2 – 55.9.

55.2 The solution to be used for this test is to be made from distilled water and is to contain 200 grams per liter (g/L) of reagent grade chromic acid (CrO₃); and 50 g/L of chemically pure concentrated sulphuric acid (H₂SO₄). The latter is equivalent to 27 milliliters (mL) per liter of chemically pure concentrated sulphuric acid, specific gravity 1.84, containing 96 percent of H₂SO₄.

55.3 The test solution is to be contained in a glass vessel, such as a separatory funnel with the outlet equipped with a stopcock and a capillary tube of approximately 0.025 inch (0.64 mm) inside bore and 5.5 inches (140 mm) long. The lower end of the capillary tube is to be tapered to form a tip, the drops from which are to be about 0.025 mL each. To preserve an effectively constant level, a small glass tube is to be inserted in the top of the funnel through a rubber stopper and its position is to be adjusted so that, when the stopcock is open, the rate of dropping is 100 ± 5 drops per minute. If desired, an additional stopcock may be used in place of the glass tube to control the rate of dropping.

55.4 The sample and the test solution are to be kept in the test room long enough to acquire the temperature of the room, which to be noted and recorded. The test is to be conducted at an ambient temperature of 21 – 32°C (70 – 90°F).

55.5 Each sample is to be thoroughly cleaned before testing. All grease, lacquer, paint, and other nonmetallic coatings are to be removed completely by means of solvents. Samples are then to be thoroughly rinsed in water and dried. The cleaned surface to be tested is not to be contacted.

55.6 The sample to be tested is to be supported from 0.7 to 1 inch (17.8 to 25.4 mm) below the orifice, so that the drops of solution strike the point to be tested and run off quickly. The surface to be tested is to be inclined about 45 degrees from horizontal.

55.7 The stopcock is to be opened and the time in seconds is to be measured until the dropping solution dissolves the protective metallic coating, exposing the base metal. The end point is the first appearance of the base metal recognizable by the change in color at that point.

55.8 Each sample of a test lot is to be subjected to test at three or more points at places where the metallic coating may be expected to be the thinnest, excluding cut, stenciled, and threaded surfaces, on the inside surface and at an equal number of points on the outside surface. On enclosures made from precoated sheets, the external corners that are subjected to the greatest deformation may have thin coatings.

55.9 To calculate the thickness of the coating being tested, the thickness factor appropriate from the temperature at which the test was conducted is to be selected from Table 55.1 and multiplied by the time in seconds required to expose base metal as noted in 55.7.

Table 55.1
Thickness of coatings

Temperature		Thickness factors, 0.00001 inch (0.00025 mm) per second	
		Cadmium platings	Zinc platings
°F	(°C)		
70	21.1	1.331	0.980
71	21.7	1.340	0.990
72	22.2	1.352	1.000
73	22.8	1.362	1.010
74	23.3	1.372	1.015
75	23.9	1.383	1.025
76	24.4	1.395	1.033
77	25.0	1.405	1.042
78	25.6	1.416	1.050
79	26.1	1.427	1.060
80	26.7	1.438	1.070
81	27.2	1.450	1.080
82	27.8	1.460	1.085
83	28.3	1.470	1.095
84	28.9	1.480	1.100
85	29.4	1.490	1.110
86	30.0	1.501	1.120
87	30.6	1.513	1.130
88	31.1	1.524	1.141
89	31.7	1.534	1.150
90	32.2	1.546	1.160

56 Marking Label Adhesion Tests

56.1 A pressure-sensitive label or a label secured by cement or adhesive shall comply with the applicable requirements in the Standard for Marking and Labeling Systems, UL 969.

57 Material Corrosion Tests

57.1 General

57.1.1 To determine the equivalence of other finishes to galvanized sheet steel, see 9.6, a set of three samples of G90 or G60 (as applicable) hot-dipped, mill-galvanized sheet steel and a set of three samples of the alternately finished sheet steel are to be subjected together to the applicable tests described in 57.1.2 – 57.5.3. A separate pair of sets are to be subjected to each test. The samples are to be of identical size. Prior to exposure, one sample of each set is to have its coating scribed with a narrow groove so as to expose the base metal. The tests described in 57.2.1 – 57.4.2 are to be conducted until equivalency or nonequivalency is established. An alternate finish is acceptable if it provides corrosion protection to the base metal at least equivalent to that provided by the G90 or G60 (as applicable) designation zinc coating.

57.2 Salt spray (fog)

57.2.1 The apparatus used for salt spray (fog) testing is to consist of a fog chamber, the inside of which measures 48 by 30 by 36 inches (1.2 by 0.8 by 0.9 m), a salt solution reservoir, a supply of conditioned compressed air, one dispersion tower for producing a salt fog constructed in accordance with Salt Spray (Fog) Testing, ASTM B117-90, sample support, provision for heating the chamber, and necessary means of control. During the exposure, the samples are to be supported in racks composed of nonmetallic materials, such as plastic, glass, and the like, at an angle of 15 degrees from the vertical.

57.2.2 The dispersion tower for producing the salt fog is to be located in the center of the chamber and is to be supplied with humidified air at a pressure of 17 to 19 psig (0.119 to 0.131 MPa) so that the salt solution is aspirated as a fine mist or fog into the interior of the chamber.

57.2.3 The salt solution is to consist of 5 percent by weight of common salt (sodium chloride – NaCl) in de-ionized water, the pH value of the collected solution is to be between 6.5 and 7.2 with a specific gravity of 1.0255 to 1.040 at 25°C (77°F). The temperature in the chamber is to be maintained at $35 \pm 1.7^\circ\text{C}$ ($95 \pm 3^\circ\text{F}$) throughout the test.

57.2.4 Drops of solution that accumulate on the ceiling or cover of the chamber are not to be permitted to drop onto the sample and drops of solution that fall from the sample are not to be recirculated but are to be removed by a drain located in the bottom of the chamber.

57.3 Moist carbon dioxide (CO₂) – sulphur dioxide (SO₂) – air mixture

57.3.1 The test samples are to be supported in racks composed of nonmetallic materials, such as plastics, glass, and the like, at an angle of 15 degrees from the vertical in a closed chamber having openings for gas inlet and outlet. A water jacket and thermostatically controlled heater are to be provided in order to maintain a temperature of $35 \pm 1.7^\circ\text{C}$ ($95 \pm 3^\circ\text{F}$).

57.3.2 Sulphur dioxide and carbon dioxide are to be supplied to the test chamber from commercial cylinders containing these gases under pressure. An amount of sulphur dioxide equivalent to one percent of the volume of the test chamber, and an equal volume of carbon dioxide are to be introduced into the chamber each working day. Prior to the introduction of the gases each day the remaining gas from the previous day is to be purged from the chamber. A small amount of water is to be maintained at the bottom of the chamber for humidity.