UL 2442

STANDARD FOR SAFETY

Wall- and Ceiling-Mounts and Accessories

UL Standard for Safety for Wall- and Ceiling-Mounts and Accessories, UL 2442

Second Edition, Dated June 18, 2019

Summary of Topics

This revision of ANSI/UL 2442 dated January 13, 2023 includes clarification of a Trained Person; 2.47A

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

The new requirement is substantially in accordance with Proposal(s) on this subject dated December 9, 2022.

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UL 2442

Standard for Wall- and Ceiling-Mounts and Accessories

First Edition – March, 2011

Second Edition

June 18, 2019

This ANSI/UL Standard for Safety consists of the Second Edition including revisions through January 13, 2023.

The most recent designation of ANSI/UL 2442 as an American National Standard (ANSI) occurred on January 13, 2023. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

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INTRODUCTION

1 Scope

1.1 These requirements apply to shelves, brackets, and similar devices, that provide structural support for the mounting of audio/video equipment, information technology equipment, and similar products, to the building structure as the primary support means (it is not touching the floor) and are intended for indoor use only.

1.2 These requirements also apply to accessories that are used to expand the capability of a mounting device; accessories that are used to secure the mounting device to a wall, ceiling, suspended ceiling, truss, joist, "I" beam, or other building structural component specified by the manufacturer; and any accessories used to secure an apparatus to the mount. Examples of such products include extension columns, extension arms, ceiling plates, floor plates, ceiling brackets, fastener kits, and VCR/DVD brackets.

1.3 A furnishing intended to support audio equipment or a video display (such as CRT, LCD, and Plasma) is to be evaluated in accordance with one of the following:

a) A furnishing such as a desk, motorized cart or stand, or a retail store display intended to support a video display, but not intended for use as a non-motorized cart or stand for a video display is covered by the Standard for Household and Commercial Furnishings, UL 962;

b) A video display sign is covered by the Standard for Electric Signs, UL 48;

c) If the non-motorized furnishing is provided with casters, wheels, or is an entertainment center, the Standard for Household, Commercial, and Institutional-Use Carts, Stands and Entertainment Centers for Use with Audio and/or Video Equipment, UL 1678 applies;

d) If the audio or video equipment is intended to be mounted to walls, ceilings or another permanent part of a building as the primary support means (it is not touching the floor), this standard applies;

e) If a furnishing is supplied with all of the video and/or audio components by the manufacturer of those components, the requirements contained in the Standard for Audio, Video and Similar Electronic Apparatus – Safety Requirements, UL 60065, or the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or the Standard for Safety for Audio/Video, information and communication technology equipment – Part 1: Safety Requirements, UL 62368-1, apply as appropriate.

Exception: A video display support system evaluated in accordance with (a) – (d) above and supplied with all of the video and/or audio components is not subject to (e).

1.4 These requirements do not apply to carts and stands. The Standard for Safety for Household, Commercial, and Institutional-Use Carts, Stands and Entertainment Centers for Use with Audio and/or Video Equipment, UL 1678, applies to non-motorized carts and stands, and the Standard for Household and Commercial Furnishings, UL 962, applies to motorized carts and stands.

1.5 These requirements do not apply to a mounting device provided with a specific product when the specific product standard is provided with requirements to address the mounting device. Such combinations are covered by the applicable requirements of the end-use product standard.

1.6 These requirements do not cover products intended for use in patient care areas. Patient care products are covered by the Standard for Medical Electrical Equipment, Part 1: General Requirements for Safety, UL 60601-1.

1.7 These requirements do not cover products that are specifically intended for infants or juveniles.

1.8 These requirements do not cover the mount to supported apparatus interface.

2 Glossary

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

2.2 APPARATUS – Video display, computer, amplifier, speaker and similar components intended to be supported by the mounting system.

2.3 ATTENDED EQUIPMENT – Equipment intended for use where operator presence is required for the equipment to function but is not necessarily required for the equipment to operate.

2.4 BALLAST – A current limiting device required to start and operate fluorescent and cold cathode lamps.

2.5 BULB (LAMP) – A device which emits light.

2.6 CLASS 2 CIRCUIT – An isolated secondary circuit involving a potential of not more than 30-volt rms maximum 42.4 volts peak open circuit secondary potential under any condition of loading or open circuit. There shall be no electrical connection between the primary and secondary windings of a transformer or between a primary or secondary circuit and the enclosure.

a) An inherently-limited Class 2 transformer;

b) A combination of an isolated transformer secondary winding and a fixed impedance or regulating network that together comply with the performance requirements for an inherently limited Class 2 transformer; or

c) One or more combinations of a transformer and an overcurrent protective device that together comply with the performance requirements for a noninherently-limited Class 2 transformer.

2.7 CLEARANCE DISTANCE – The shortest distance measured through air between conductive parts.

2.8 DECORATIVE PART – A part of the mounting system that has no safety function.

2.9 DEDICATED STORAGE AREA – An integral part of a mounting system intended to accommodate specific accessories such as media tapes and discs.

2.10 DETACHABLE POWER-SUPPLY CORD – A flexible cord, for supply purposes, able to be connected to or disconnected from the mounting system by means of a suitable mounting system coupler.

2.11 NON-DETACHABLE POWER-SUPPLY CORD – A flexible cord, for supply purposes, fixed to or assembled with the mounting system.

2.12 ENCLOSURE, ELECTRICAL – That part of the mounting system that:

a) Renders inaccessible all or any parts of the equipment that may otherwise present a risk of electric shock; and/or

b) Retards propagation of flame initiated by electrical disturbances occurring within.

2.13 ENCLOSURE, MECHANICAL – A part of the mounting system intended to reduce the risk of injury due to mechanical and other physical hazards.

2.14 EXPOSED PART – A part that is not enclosed to prevent contact.

2.15 FLAMMABILITY CLASSIFICATION – The flammability classification of a material is determined by tests described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, or for surfaces greater than 10 square feet, the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723.

2.16 FRICTION MATERIAL – Rubber or elastomer with or without dimples or ridges. Plastic or metal with or without dimples or ridges is not a friction material.

2.17 GLAZING – To furnish or fit with glass or a clear polymer.

2.18 GUARD – That portion of the mounting system that reduces the risk of electric shock or injury to persons.

2.19 HAZARDOUS SUBSTANCES AND ARTICLES – As defined by the United States Code of Federal Regulations 16 CFR PART 1500 to 1512.

2.20 INSTALLER ASSEMBLY – Any mechanical assembly and installation of a mounting system performed by a trained installer.

2.21 INSULATION

a) INSULATION SYSTEM – An assembly of insulating materials used to isolate the live parts from ground and from parts of opposite polarity. All materials in contact with the windings are considered part of the system.

b) BASIC INSULATION – Insulation to provide basic protection against electric shock.

c) SUPPLEMENTARY INSULATION – Independent insulation applied in addition to BASIC INSULATION in order to reduce the risk of electric shock in the event of a failure of the BASIC INSULATION.

d) DOUBLE INSULATION – Insulation comprising both BASIC INSULATION and SUPPLEMENTARY INSULATION.

e) REINFORCED INSULATION – A single insulation system which provides a degree of protection against electric shock equivalent to DOUBLE INSULATION under the conditions specified in this standard.

2.22 INTERLOCK – A switch or other device that de-energizes the load when an enclosure or guard is opened, displaced, or the mount is serviced.

2.23 INTERMITTENT DUTY MOTOR – A motor intended to be connected to a load other than a fan or blower and that is intended to operate for a specified time period.

2.24 INTERMITTENT OPERATION EQUIPMENT – Operation in a series of specified cycles each composed of a period of operation under NORMAL LOAD, followed by a rest period with the equipment switched off or running idle.

2.25 ISOLATED SECONDARY CIRCUIT – A circuit derived from an isolated secondary winding of a transformer and that has no direct connection back to the line-connected circuit (other than through grounding means). A secondary circuit that has a direct connection back to the line-connected circuit is part of the line-connected circuit.

2.26 LIMITED POWER SOURCE (LPS) – A limited power source is as defined in the Standard for Information Technology Equipment Safety – Part 1: General Requirements, UL 60950-1, and that complies with the requirements of UL 60950-1 or the Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

2.27 LIVE PART – A conductive part that has a potential difference during operation with respect to ground or any other conductive part.

2.28 LOCKED-ROTOR CURRENT – The current measured from the line when the armature or rotor is prevented from rotating.

2.29 LOW-VOLTAGE CIRCUIT – A circuit involving a potential of not more than 30 volts alternating current (42.4 peak) open circuit.

2.30 MOTOR-OPERATED MOUNTING SYSTEM – A mounting system provided with a motor for movement of some portion of the mounting system.

2.31 MOUNTING BRACKET – The interface that attaches the apparatus to a mounting system.

2.32 MOUNTING SURFACE – The building structure intended to fasten to or support the mounting device.

2.33 MOUNTING SYSTEM – A device that allows an apparatus to be attached to a building structure.

2.34 MOUNTING SYSTEM TYPES

a) STATIC MOUNT – A mounting device designed as a single component or constructed of nonadjustable components intended to support an apparatus in a fixed position.

b) ADJUSTABLE MOUNT – A mounting system designed with components that may be adjusted once (or infrequently) and intended to support the apparatus in a fixed position after assembly and installation. All joints and connections of an adjustable mount shall be rigid when assembled according to the installation and assembly instructions.

c) ARTICULATING MOUNT – A mounting system intended to allow active movement, adjustment, and/or repositioning, after installation.

d) MOTOR OPERATED ARTICULATING MOUNT – A motor-operated mounting system intended to allow frequent movement, adjustment, and/or repositioning, after installation.

2.35 NORMAL MAINTENANCE AND USE – The cleaning, adjusting, moving, maintaining, and using of the mounts. Includes items such as:

a) Replacing a lamp, starter or fuse;

b) Adjustment of a movable, removable or flexible part; and

c) Removal or cleaning of all parts not secured by use of tools.

2.36 OPEN MOTOR – A motor having ventilating openings that provide for the passage of external cooling air over and around the windings.

2.37 ORDINARY TOOLS – Tools which are normally expected to be available to the user for installing the mounting system, such as flat-bladed and cross-recessed head (Phillips-type) screwdrivers, hammers, nut drivers, wrenches, pliers, electric drills, and similar tools, or those provided with the product.

2.38 POLYMERIC MATERIAL – Thermoplastic, thermosetting, and elastomeric materials.

2.39 PRINTED-WIRING BOARD (PWB) – The finished combination of a pattern of conductive paths either on or within multilayer sheets of insulating material.

2.40 RISK OF ELECTRIC SHOCK – A risk of shock exists between any two uninsulated conductive parts or between an uninsulated conductive part and earth ground, if the continuous current flow through a 1500 ohm resistor in parallel with a 0.015 µF capacitor connected between the two points exceeds a 5 mA rms (7 mA peak) and if the open circuit voltage exceeds 30 V rms (42.4 V peak) for dry and damp or 15 V rms (21.2V peak) for wet locations.

2.41 SAFETY CIRCUIT – A circuit involved with sensing the presence of a user or bystander which is in danger of risk of injury from the mounting system and places or stops the mounting system in a position that prevents a risk of injury to a user or bystander under normal and abnormal circuit operation.

2.42 SAFETY INTERLOCK – A means either of preventing access to a hazardous area until the hazard is removed, or of automatically removing the hazardous condition when access is gained.

2.43 SECONDARY CIRCUIT – A circuit that is supplied by an induced voltage from a primary where a primary circuit is that supplied by a branch circuit.

2.44 SUPPORTING SURFACE – Any surface (shelf, platform, mounting bracket or similar surface) that is intended to support products such as audio/video equipment, information technology equipment, and video and audio discs and tapes.

2.45 THERMAL-DEVICE-PROTECTED MOTOR – A motor that relies upon a device (protector) to prevent overheating.

2.46 THERMAL PROTECTOR – A device installed integrally within a motor that is responsive to motor current and temperature or temperature only and that, when applied as intended, prevents overheating. Types are: thermal-cutoff, automatically reset, manually reset and single-operation.

2.47 TOTALLY-ENCLOSED MOTOR – A motor that is enclosed to prevent the free exchange of air between the inside and outside of the winding enclosure and not so enclosed as to be airtight.

2.47A TRAINED PERSON – A person with relevant training and education in the operation of the mount, including safety, to enable them to identify hazards and to take appropriate actions to reduce risks of injury to themselves or others.

2.48 USER ADJUSTABLE FASTENER – A fastener or pivot of an Adjustable Mount intended to be loosened or tightened to allow adjustment or to provide tension adjustment for an Articulating Mount.

2.49 USER ASSEMBLY – Any mechanical assembly and installation of a mounting system performed by the user.

2.50 USER SERVICING – See Normal Maintenance and Use, 2.35.

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.

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

a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or

b) Is superseded by a requirement in this standard.

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

3.4 Specific components are 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.

4 Units of Measurement

4.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

5 Undated References

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

CONSTRUCTION

GENERAL

6 General

6.1 A mounting device shall be constructed so that:

a) User assembly and normal use do not result in a risk of fire, electric shock, or injury to persons; and

b) The materials and components are used within their mechanical, electrical, and temperature limits.

7 Accessories

7.1 A mounting device having provisions for the use of a mechanical or electrical accessory intended to be attached in the field shall comply with the requirements in this standard, with or without the accessory installed.

7.2 Installation of an electrical accessory by the user shall be by means of keyed mating electrical connectors.

7.3 When an accessory is to be installed by the user, the mounting device shall comply with this Standard before and after the installation of the accessory.

7.4 The installation of electrical connectors of an installer-assembled accessory shall be by means of receptacles, plug-in connectors, insulated wire connectors, or by connection to existing wiring terminals.

7.5 With reference to 7.4, an installation shall not require the cutting of wiring or the soldering of connections by the installer. Installations shall not require cutting, drilling, or welding in electrical enclosures and in other areas where such operations may damage electrical components and wiring within the enclosure.

7.6 A means for strain relief of wires and cords shall be provided and comply with the Strain Relief Test, Section 61, and the Push-Back Relief Test, Section 62, for the wiring in the accessory if there is a possibility of transmitting stress to the terminal connections during installation.

7.7 All terminals and wiring intended to be field connected shall be identified on the accessory, on the mounting device if connections are made between the mounting device and the apparatus, and on the wiring diagram.

7.8 The intended installation of the accessory shall be indicated in the installation instructions included on or with the accessory. See 78.3.

7.9 As part of the investigation, an accessory is to be trial installed to determine that the installation is feasible, the instructions are detailed and correct, and the use of the accessory does not introduce a risk of electric shock, fire, or injury to persons.

8 Assemblies of Parts

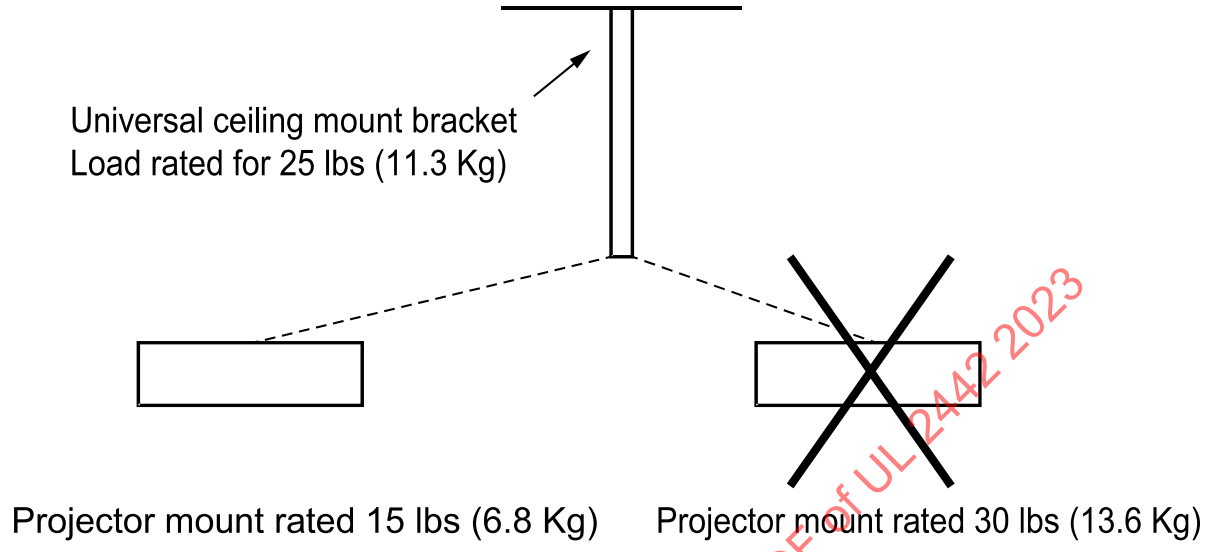
8.1 A mounting system or systems comprised of parts that some or all of the parts can be used in different combinations and configurations to support the audio/video equipment shall comply with 8.2 – 8.4.

8.2 The recommended configurations when assembled in accordance with the manufacturers installation instructions shall comply with the construction and performance requirements in each of the configurations specified in the installation instructions.

8.3 When the parts of the system are assembled as specified in the installation instructions, no part of the assembly shall support more weight than the lowest load rating of any individual part. See Figure 8.1 as an example. The weight of the system parts shall be considered in the total supported weight rating specified in the instructions.

Figure 8.1

Acceptable Combinations of Assemblies



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8.4 Installation instructions shall be provided as indicated in General, Section 78.

9 Dropped or Suspended Ceilings

9.1 The weight of an audio/video support system shall not be carried by a dropped or suspended ceiling. The weight of the support system and the audio/video components of the support system shall be supported independently from the dropped or suspended ceiling by attachment to the building structure.

10 Other Spaces Used for Environmental Air (Plenums)

10.1 A support system that extends above a suspended ceiling that is intended for use in “Other spaces used for environmental air (Plenums)” shall comply with the following:

a) Enclosure systems intended to be installed in air-handling spaces shall be constructed of metal or constructed of non-metallic material that complies with the requirements in the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043.

Note 1: The space over a hung ceiling used for environmental air-handling purposes is an example of air handling spaces to which this section applies. 300.22 (C) of National Electrical Code, ANSI/NFPA 70, describes these spaces as “other spaces used for environmental air (plenums)”, or “spaces not specifically fabricated for environmental air-handling purposes”.

Note 2: Products evaluated in accordance with these requirements are considered to comply with the fire retardant and low smoke producing requirements of Article 300 of National Electrical Code, ANSI/NFPA 70, Chapter 4 of the Standard for the Installation of Air-Conditioning and Ventilating Systems, NFPA 90A, Article 602 of the International Mechanical Code, and Article 602 of the Uniform Mechanical Code.

b) Enclosure systems intended for installation in air-handling spaces shall limit the amount of smoke that may enter the space in the event of a fire in any installed equipment. Openings in sections of the enclosure that separate installed equipment from the air-handling spaces shall be limited to small mounting holes, narrow slots associated with unused/unpunched knockouts, and the like. An example of a construction that complies with this requirement is as follows:

Openings in the enclosure that are not closed during the assembly and comply with the following:

1) The largest dimension of an opening shall not be more than 6.4 mm (1/4 in) and the smallest dimension shall not be more than 1.6 mm (1/16 in);

2) There shall be a maximum of five openings in any one side or end of the enclosure and the total area of all openings shall not be more than 1.3 cm^2 (0.2 in^2); and

3) There shall be a maximum of 15 openings in the enclosure and the total area of all openings shall not be more than 3.2 cm^2 (0.5 in^2) enclosure.

10.2 A support system that complies with 9.1 shall be marked according to the following:

a) An enclosure system investigated for use in other spaces used for environmental air (spaces not specifically fabricated for environmental air-handling purposes but used for air-handling purposes, such as a plenum) may be marked “Suitable for Use in Other Space Used for Environmental Air (Plenums)”, “Suitable for Use in Air-handling Spaces”, or equivalent wording.

b) Since enclosure systems covered by these requirements are not intended to house equipment that takes action on or senses the air in Ducts Specifically Fabricated for Environmental Air (see 300.22 (B) of the National Electrical Code, ANSI/NFPA 70), it is not permitted to identify enclosure systems either by marking or instructions as being suitable for use in ducts specifically fabricated for environmental air.

c) An enclosure system intended for installation in air handling spaces that is provided with knockouts or removable panels shall be provided with instructions that require any punched openings to be sealed with a plug constructed of metal or a nonmaterial complying with the Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043, or the Standard for Fire Tests of Through-Penetration Firestops, UL 1479, and any covers or panels to be replaced and secured.

d) An enclosure system that is designed for use in drop-ceiling constructions and similar applications that are commonly used for environmental air but is not intended to be used in air handling spaces shall be clearly marked “Not for use in air handling spaces”.

10.3 A support system that complies with 10.1 shall be provided with installation instructions in accordance with Other Spaces Used for Environmental Air (Plenums), Section 84.

ELECTRICAL CONSTRUCTION

11 General

11.1 A mount system that employs an electromagnetic interference filter shall also comply with the Standard for Electromagnetic Interference Filters, UL 1283. A product that employs a transient voltage surge suppressor shall also comply with the Standard for Surge Protective Devices, UL 1449. Telephone equipment and communication circuit protectors included in a mounting system shall comply with the requirements in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or the Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, and the requirements in the Standard for Secondary Protectors for Communications Circuits, UL 497A, respectively. A mounting system that incorporates an antenna

discharge unit or provides antenna connections to a television, a high-voltage video product, or antenna shall comply with the applicable requirements in the Standard for Antenna Discharge Units, UL 452, and the Standard for Audio-Video Products and Accessories, UL 1492. A product that employs ground-fault protection shall comply with the requirements in the Standard for Ground-Fault Circuit Interrupters, UL 943.

11.2 Portable luminaires used in a mount system covered by this standard shall comply with the requirements in the Standard for Portable Electric Luminaires, UL 153. Non-portable luminaires shall comply with the Standard for Luminaires, UL 1598.

11.3 Safety Circuits employing solid-state devices shall comply with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. Mounting systems that incorporate neon lamps shall also comply with the Standard for Neon Transformers and Power Supplies, UL 2161.

11.4 A mount system shall be completely wired with each electrical component mounted in place and with each splice and connection completed or as indicated below:

a) A detachable power-supply cord may be disconnected from the product, provided it is packaged with the product.

b) A mounting system that is disassembled for shipping may be provided with mating connectors that are keyed to maintain correct polarity and can be assembled by hand.

12 Electrical Enclosures

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

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

12.3 An enclosure of sheet metal shall be judged with respect to its size, shape, thickness of metal, and its application, considering the intended use of the complete appliance. Sheet steel having a thickness of less than 0.026 in (0.66 mm) if uncoated or 0.029 in (0.74 mm) if galvanized or of nonferrous sheet metal having a thickness of less than 0.036 in (0.91 mm) shall not be used, except for relatively small areas or for surfaces that are curved or otherwise reinforced and tested according to the Electrical enclosure impact test, 65.2.

12.4 Sheet metal to which a wiring system is to be connected in the field shall have a thickness not less than 0.032 in (0.81 mm) if uncoated steel, not less than 0.034 in (0.86 mm) if galvanized steel, and not less than 0.045 in (1.16 mm) if nonferrous.

12.5 Among the factors that shall be taken into consideration when judging a nonmetallic enclosure are resistance to:

a) Mechanical damage;

b) Impact;

c) Moisture-absorption;

d) Combustion; and

e) Distortion at temperatures to which the material may be subjected under conditions of normal or abnormal use.

12.6 An electrical enclosure of polymeric material shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. A cord and plug connected mounting system shall be considered under UL 746C path II – (portable attended and unattended commercial equipment, and portable unattended household equipment). Permanently connected mounting systems shall be considered under UL 746C path III – (all other equipment).

12.7 Operating parts, such as gear mechanisms, relays, and similar devices, shall be enclosed to protect against malfunction from dust or from other material that may impair their intended operation and to reduce the risk of fire, electric shock, or injury to persons. (See also 51.1, Mechanical enclosures and guards.)

12.8 A mount shall be constructed so that all user servicing is completed without subjecting any wiring, component, or part, to mechanical damage, or reducing electrical spacings.

12.9 A decorative part, the failure of which does not result in a risk of fire, electric shock, or injury to persons, is permitted to be constructed of any material.

13 Enclosure Openings

13.1 An electrical enclosure shall reduce the risk of molten metal, burning insulation, flaming particles, or the like, from falling on combustible materials, including the surface upon which the mounting system is supported.

13.2 The requirement in 13.1 will necessitate that a switch, a relay, a solenoid, or the like be individually and completely enclosed, except for terminals, unless it can be shown that malfunction of the component would not result in a risk of fire, or there are no openings in the bottom of the mounting system enclosure. It will also necessitate the use of a barrier of noncombustible material under a motor unless:

a) The structural parts of the motor or of the mounting system provide the equivalent of such a barrier;

b) The protection provided with the motor is such that no burning insulation or molten material falls to the surface that supports the mounting system when the motor is energized under each of the following fault conditions:

1) Open main winding;

2) Open starting winding;

3) Starting switch short-circuited; and

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

c) The motor complies with the requirements in the Standard for Overheating Protection for Motors, UL 2111, the Standard for Impedance Protected Motors, UL 1004-2, or the Standard for Thermally Protected Motors, UL 1004-3, and the temperature of the motor winding will not exceed 150°C during the first 72 h of operation with the rotor of the motor locked; or

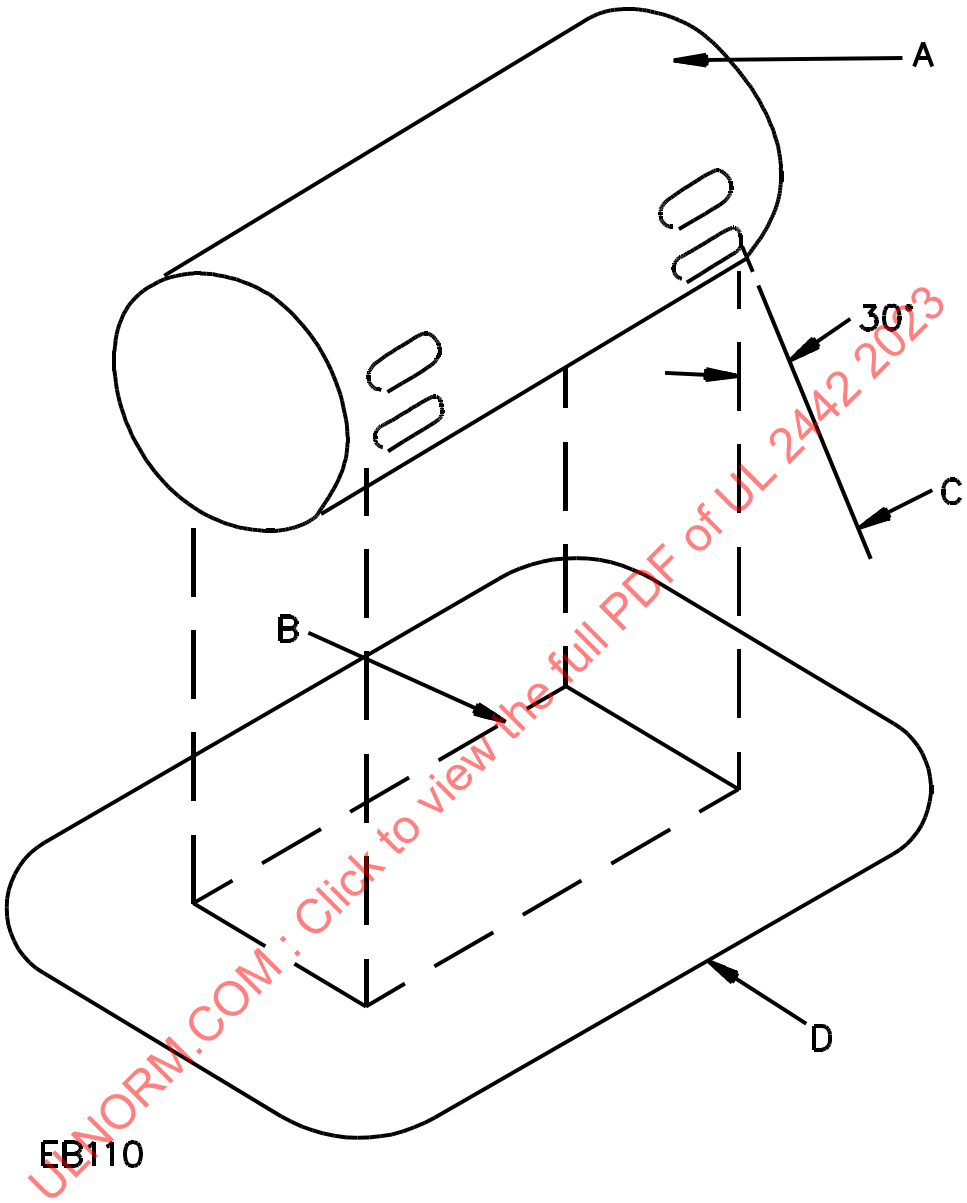
d) Under wiring, unless it is rated VW-1.

13.3 A part such as a splice connection, a wire, a transformer, a capacitor, a ballast, a current-carrying part, or a device with an exposed live part shall be contained in an enclosure.

13.4 The barrier mentioned in 13.2 shall be located as illustrated in Figure 13.1, and shall not have an area less than that described in that illustration. Openings for drainage, ventilation, and the like may be employed in the barrier, provided such openings would not permit molten metal, burning insulation, or the like to fall on combustible material.

Figure 13.1

Location and Extent of Protective Barrier



A – The entire component under which a barrier (flat or dished, with or without a lip or other raised edge) of nonflammable material is to be provided. The sketch above is of a metal enclosed component with ventilating openings to show that the protective barrier is required only for those openings from which flaming parts might come. If the component or assembly does not have its own nonflammable enclosure, the area to be protected would be the entire are occupied by the component or assembly.

B – Projection of the outline of the area of (A) which needs a bottom barrier vertically downward onto the horizontal plane of the lowest point on the outer edge (D) of the barrier.

C – Inclined line that traces out an area (D) on the horizontal plane of the barrier. Moving around the perimeter of the area (B) which needs a bottom barrier, this line projects at a 30-degree angle from the line extending vertically at every point around the perimeter of (A) and oriented to trace out the largest area, except that the angle may be less than 30 degrees if the barrier or portion of the bottom cover contacts a vertical barrier or side panel of nonflammable material, or if the horizontal extension of the barrier (B) to (D) would exceed 6 inches (152 mm).

D – Minimum outline of the barrier, except that the extension B-D need not exceed 6 inches (flat or dished, with or without a lip or other raised edge). The bottom of the barrier may be flat or formed in any manner if every point of area (D) is at or below the lowest point on the outer edge of the barrier.

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

a) An uninsulated live part.

b) Magnet wire.

c) Internal wiring.

d) Moving parts.

e) Any other part likely to create a risk of fire or electric shock.

13.6 Louvers and other openings in the enclosure shall be constructed and located to reduce the risk of contact by persons with uninsulated high-voltage live parts as indicated below:

a) Parts such as covers, panels, and grilles used as part of the enclosure are to be removed unless tools are required to remove the cover, panel or grill.

b) Covers, panels, and grilles are to be opened if it is intended that a user is to make adjustments under a cover, panel or grill while energized.

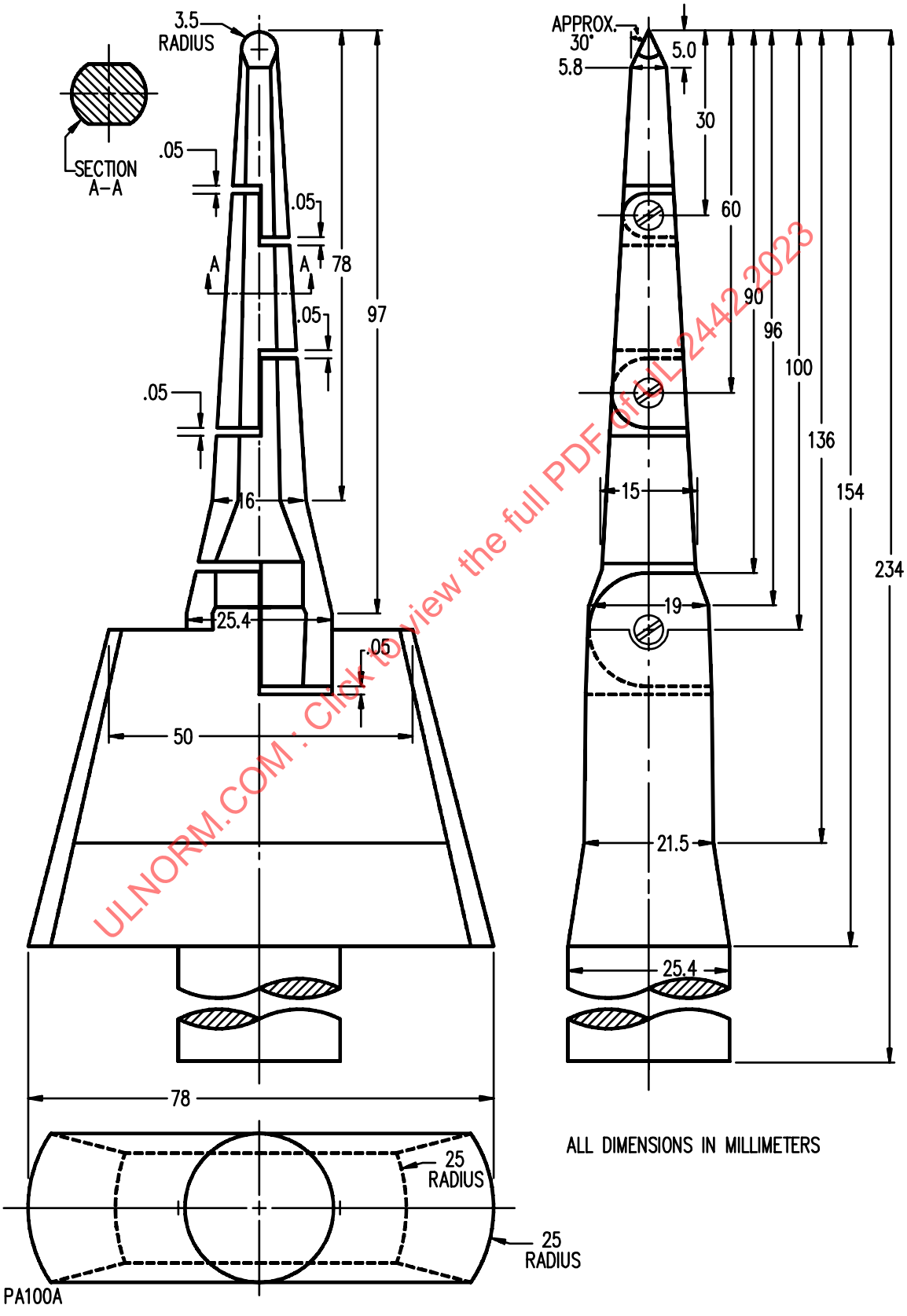
c) A safety interlock system may be provided that deenergizes uninsulated high-voltage live parts and/or mitigates the risk of pinching and crushing when the cover, panel or grill is removed.

13.7 A component that has an integral outer housing that has been evaluated as an enclosure is not required to be additionally enclosed.

13.8 An uninsulated live part is determined to be inaccessible when a probe as illustrated in Figure 13.2 is unable to be manipulated such that it touches any uninsulated live part. The probe is to be articulated into any configuration and rotated or angled to any capable position before, during, or after inserting into the opening.

Figure 13.2

Articulate Probe with Web Stop



13.9 A current-carrying part of a wiring device (such as the screw shell and center contact of a lampholder, the lampholder contacts, starter holder contacts, or similar components of a fluorescent lamp) that is normally fitted with a functional component (a lamp, a starter, or similar component) during use of the mounting system is not required to be additionally enclosed.

13.10 An uninsulated live part that operates at a potential of 30 volts rms (42.4 volts peak) and supplied by a Class 2, LPS or SELV power source is able to be accessible.

13.11 The following are not considered to be uninsulated live parts:

a) Coils of relays and solenoids, transformer and ballast windings only if the coils, windings, cross-over leads and primary and secondary supply leads are provided with insulation rated for the Temperature, Voltage and Current.

b) Terminals and splices with insulation rated for the Temperature, Voltage and Current.

c) Insulated wire – Rated for the Temperature, Voltage and Current.

d) Edison-based lamp holders.

13.12 Openings in the enclosure shall be constructed and sized to reduce the risk of direct entry of foreign objects. See Figure 13.3 for examples of acceptable top cover constructions. See also Figure 13.4 and Figure 13.5 for examples of acceptable side openings.

Figure 13.3

Top Cover Designs

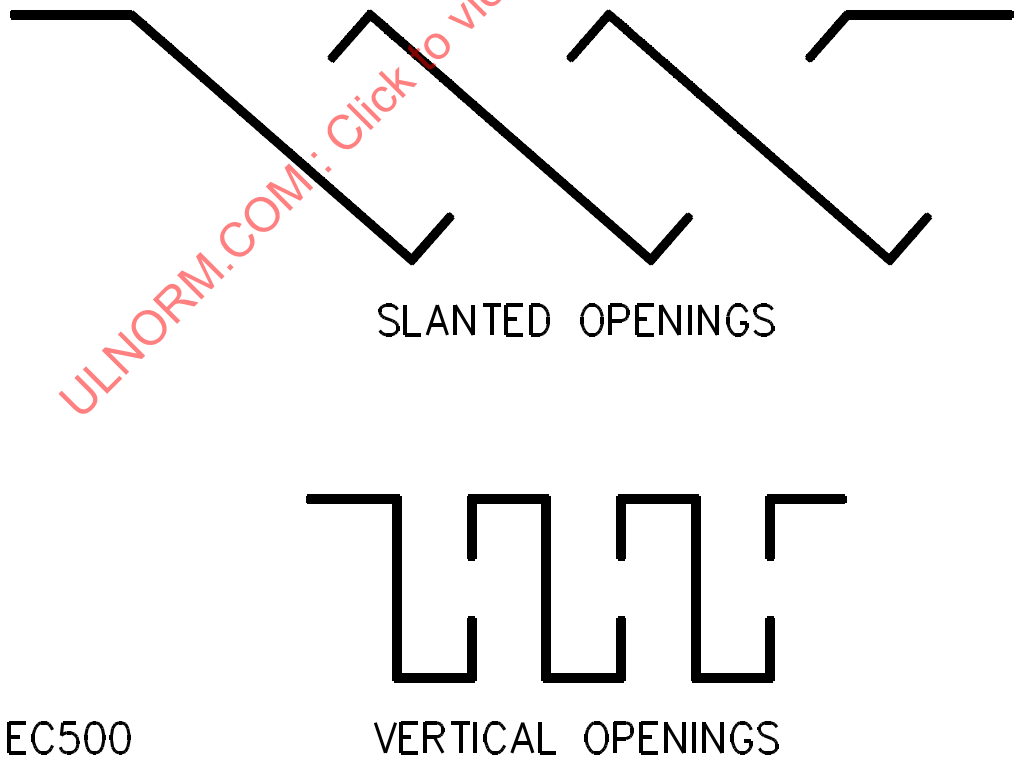
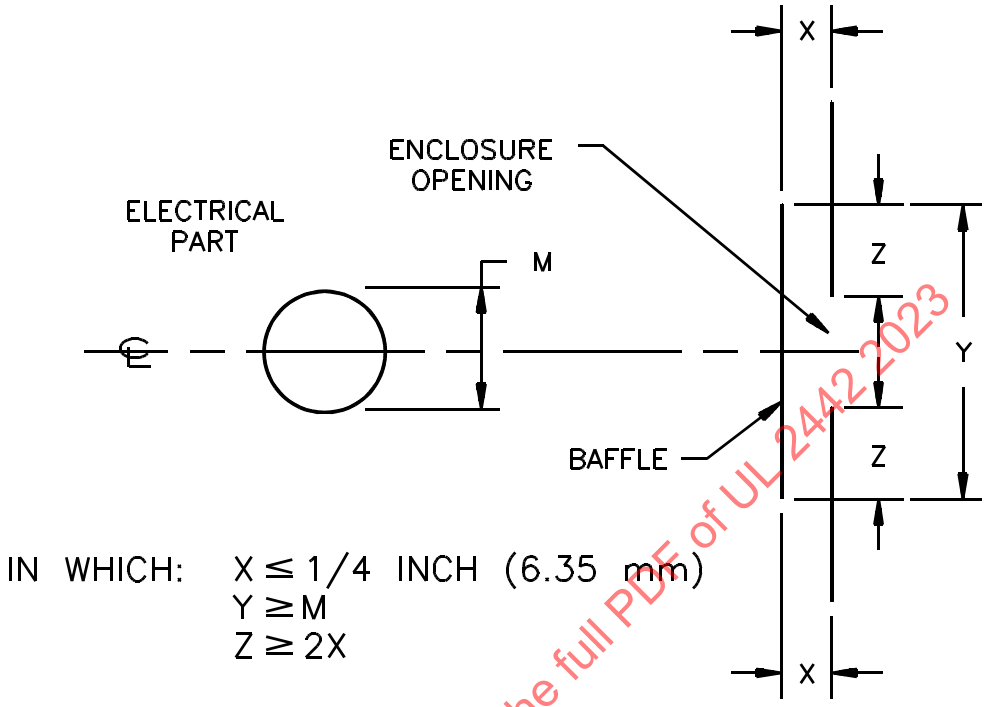


Figure 13.4

Relationship of Baffle and Electrical Part to Prevent Emission



IN WHICH: $X \leq 1/4$ INCH (6.35 mm)
$Y \geq M$
$Z \geq 2X$

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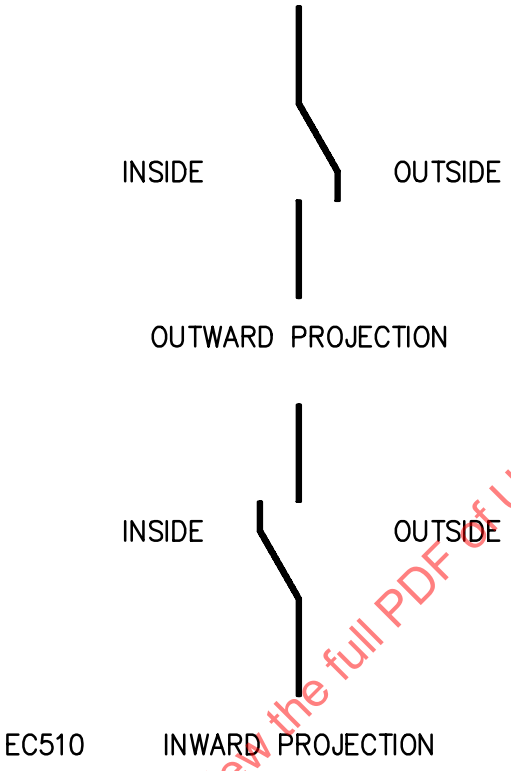
Figure 13.5

Louver Designs



13.13 An opening in a bottom panel or protective pan may be used if the following conditions are met:

a) The interior above the panel or pan contains no material classified as HB, V-2 or V-1 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

b) The panel or pan by its construction prevents materials from falling from the interior of the product directly onto the supporting surface or anything else under the product. Positions of movable components shall be considered. Manufacturers installation instructions shall be used for the proper positioning of adjustable pans and panels.

13.14 Openings may be used, without limitation of the size or number of openings, in areas where:

a) The mounting system wiring material is rated VW-1;

b) Plugs, receptacles and connectors are constructed of V-0, 5VA or 5VB rated material; and

c) Underneath impedance protected or thermally protected motors.

13.15 The bottom of the enclosure under areas containing only materials classified as V-0, 5VA, or 5VB, or less flammable, may have openings not larger than 1/16 in^2 (40.3 mm^2).

14 Screens and Expanded Metal

14.1 A screen or mesh of expanded metal used as a guard, enclosure, or part of an enclosure, shall comply with the requirements of 14.2 – 14.4 and with the Electrical enclosure impact test, 65.2.

14.2 Perforated sheet steel or sheet steel used for expanded metal mesh shall not be less than 0.042 inch (1.07 mm) in thickness [0.045 inch (1.17 mm) if zinc coated] if the mesh openings or perforations are 1/2 in^2 (323 mm^2) or less in area. For larger openings, the steel shall not be less than 0.080 inch (2.03 mm) in thickness [0.084 inch (2.13 mm) if zinc coated]. The largest dimension shall not exceed 4 inches (102 mm).

14.3 With reference to the requirements in 14.2, expanded steel mesh or perforated sheet steel that is 0.020 inch (0.53 mm) thick [0.023 inch (0.58 mm) thick if zinc coated] may be used if the indentation of a guard or the enclosure will not alter the clearance between uninsulated live parts and grounded metal so as to impair performance or reduce spacings below the minimum required values (see Electrical Spacings, Section 17). If this is the case, then either:

a) The exposed mesh on any one side or surface of the product so protected shall have an area of not more than 72 in^2 (464 cm^2) and no dimension greater than 12 inches (305 mm); or

b) The width of an opening so protected shall not be greater than 3-1/2 inches (89 mm).

14.4 The wires of a screen shall not be less than 16 AWG (1.29 mm diameter) steel if the screen openings are 1/2 in^2 (323 mm^2) or less in area and shall not be less than 12 AWG (2.05 mm diameter) steel for larger screen openings.

15 Doors and Covers

15.1 A part of an enclosure, such as a door or a cover, shall be provided with a means – such as latches, locks or screws – for firmly securing it in place.

15.2 An enclosure shall be provided with a door when it gives access to a fuse or any other overload protective device that requires renewal or when it is required to be opened in connection with the user servicing or installation of the device.

Exception: A door is not required for an enclosure:

a) In which the only fuse enclosed is a control-circuit fuse, when the fuse and control-circuit load – other than a fixed control-circuit load, such as a pilot lamp – are within the same enclosure; or

b) In which a means is provided for resetting all overload-protective devices from outside the enclosure, or kits are available to provide a means for resetting all overload-protective devices from outside the enclosure.

15.3 A door provided in accordance with the requirement in 15.2 shall be provided with a snap latch or a captive multi-turn or partial-turn fastener. Such securing means shall be located or used in multiple so as to hold the door closed over its entire length. A captive fastener shall be operable by hand or by a simple hand tool such as a screwdriver.

15.4 A door more than 48 inches (1.2 m) long on the hinged side shall be provided with one of the following:

a) A multipoint latch operated by a single knob or handle;

b) Two or more snap latches or captive fasteners; or

c) One knob-operated latch and one snap latch or captive fastener.

15.5 Doors and covers of mechanical enclosures shall comply with Mechanical enclosures and guards, 51.1.

15.6 Doors and covers of mechanical and electrical enclosures shall comply with Doors and Covers, Section 15, and Mechanical enclosures and guards, 51.1.

16 Screws and Mechanical Connections for Electrical Enclosures

16.1 Screwed connections, electrical or otherwise, shall withstand the mechanical stresses occurring in normal use. Screws transmitting contact pressure and screws that are likely to be tightened by the user and have a nominal diameter less than No. 6 (3 mm) shall screw into metal. Screws shall not be of metal which is soft or liable to creep, such as zinc or pure aluminum. Screws of polymeric material shall have a nominal diameter of at least No. 6 (3 mm); they shall not be used for any electrical connection. Screws shall not be of insulating material if their replacement by a metal screw could impair supplementary insulation or reinforced insulation, neither shall screws which may be removed when replacing a power supply cord or undertaking other routine servicing, be of insulating material if their replacement by a metal screw could impair electrical insulation. Screws or nuts which are likely to be tightened by the user include terminal screws or nuts, screws for fixing covers and position of the mount, screws that have to be loosened to open or to remove the cover or reposition the apparatus support, and screws for fixing handles and knobs.

16.2 Screws in engagement with a thread of insulating material shall have a length of engagement of at least 1/8 inch (3 mm) plus one-third of the nominal screw diameter, or 5/16 inch (8 mm), whichever is the shorter.

17 Electrical Spacings

17.1 The spacing between uninsulated live parts of opposite polarity, and between uninsulated live parts and metal that is capable of being grounded shall not be less than 1/4 inch (6.4 mm) through air or 3/8 inch (9.5 mm) over surface. See Figure 17.1.

Exception No. 1: See 3.1, the spacing requirements do not apply between uninsulated live parts of a component, such as a lampholder or switch, and dead metal that is part of the component.

Exception No. 2: See Sections 34 and 35, the spacing between uninsulated live parts on the output of a NEC Class 2, LPS or SELV power supply and between such parts and dead metal that is grounded in service is not specified.

17.2 As an alternate to 17.1, the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840, may be used to determine electrical spacing. This only applies to conductive parts that are rigidly held in place and reliably spaced in production such as conductors and components on a printed wiring board. The spacing requirements in UL 840 shall not be used for spacing to a dead metal enclosure, or to uncontrolled components such as wiring device terminals, transformers, and ballasts. Creepage distances shall not be less than clearances. When using the requirements specified in UL 840, the following conditions apply:

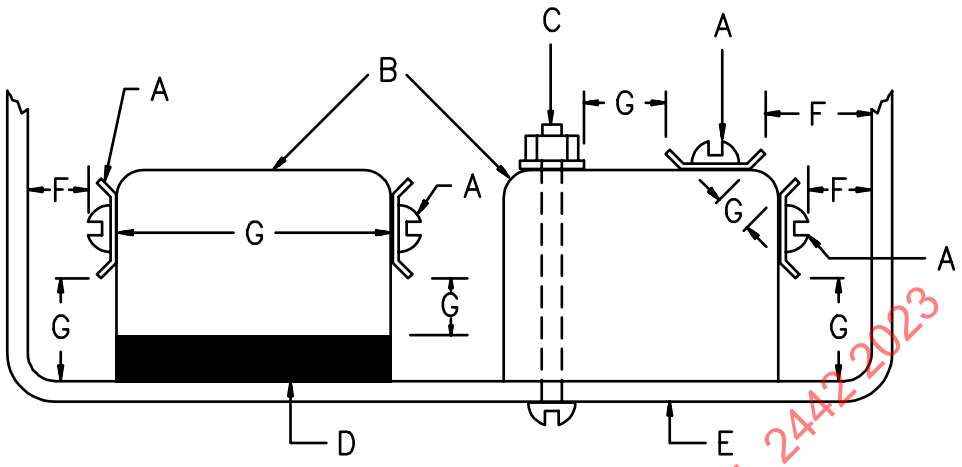
a) A mounting system marked for wet locations or requiring the humidity conditioning test shall be considered exposed to environmental pollution degree 3 and over voltage category of II.

b) A mounting system other than (a) shall be considered exposed to environmental pollution degree 2 and over voltage category of II.

c) The portion of a printed wiring board covered with a potting compound or a conformal coating that complies with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluation, UL 746C, shall be considered exposed to environmental pollution degree 1 and over voltage category of II.

Figure 17.1

Spacings of Components



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A. Uninsulated live parts of wiring device.

B. Insulating material of wiring device.

C. Mounting screw of wiring device.

D. Dead metal part of wiring device.

E. Dead metal parts of mount or mount display.

F. Spacings to which Figure 17.1 applies.

G. Spacings to which Figure 17.1 does not apply.

17.3 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 when the unfixed part is in any position, the required minimum spacing is maintained.

18 Electrical Insulating Materials

18.1 A polymeric material used as an electrical insulator, or as direct or indirect support of a live part, shall comply with the requirements in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

19 Electrical Ratings

19.1 Each electrical device and insulated conductor shall have a voltage rating at least equal to the voltage applied to it in normal use.

19.2 Each electrical device shall have an ampere rating and each insulated conductor shall have an ampacity rating for the maximum current to which it is subjected in normal use.

19.3 The ampere rating of the mounting system shall be calculated by adding the ratings of all of the following that are provided on the unit:

a) The marked ampere rating on each receptacle;

b) The ampere rating of each ballast;

c) The calculated load of each line voltage incandescent lampholder is to be determined by dividing the marked wattage rating by 115 volts;

d) The ampere rating of each transformer, and

e) The ampere rating of any other line-voltage parts, such as a clock, a motor, and similar parts.

19.4 The maximum ampacity rating of an insulated conductor shall be as specified in Table 19.1.

Table 19.1
Ampacities of Wires and Cords with Copper Conductors

Types of wire and cord[a]	Ampacity			
	18 AWG (0.82 mm^2)	16 AWG (1.3 mm^2)	14 AWG (2.1 mm^2)	12 AWG (3.3 mm^2)
Fixture wires	6	8	17	23
Flexible cords – As specified in Table 24.1	10	13	18	25
Appliance wiring material	6	8	17	23

[a] Some of the types of wire and cord are not made in each of the sizes shown. For each such type and size, the ampacity shown is inapplicable.

20 Wiring and Conductors – Conductor Size

20.1 A conductor of a wire or cord shall be 18 AWG (0.82 mm^2) or larger. See Electrical Ratings, Section 19.

20.2 A conductor smaller than 18 AWG (0.82 mm^2) is able to be used for internal wiring when it is investigated and found to meet the requirements for the intended application; for example, consideration is

to be given for internal fusing, lead routing, and degree of enclosure required under any condition of loading, including short circuit and abnormal operation.

20.3 A conductor in a high-voltage circuit smaller than 18 AWG (0.82 mm^2) and not smaller than 24 AWG (0.21 mm^2) is usable as a permanently attached lead for a motor, transformer or other load when:

a) The lead is completely enclosed;

b) Stalling of the motor, or any load on the secondary of the transformer, including a short circuit, does not result in a risk of fire; and

c) The lead may pass over openings in the enclosure provided the wire cannot be contacted by the probe in Figure 13.1 and it is rated VW-1.

20.4 A conductor smaller than 18 AWG (0.82 mm^2) is usable in a low-voltage Class 2 power-limited circuit.

20.5 Wiring or cord rated 90°C (194°F) is suitable up to 150°C (302°F) when each individual conductor is provided with a glass insulation extending from the terminals of the heat producing component a minimum of 3 inches (76 mm) as indicated below:

a) Consisting of snug fitting woven-glass sleeving not less than 0.010 inch (0.25 mm) thick; or

b) Woven-glass electrical tape applied in two or more layers having a total thickness of not less than 0.010 inch.

21 Splices and Connections

21.1 All internal wiring terminations shall be mechanically secured, provide electrical continuity and shall be soldered unless provided with pressure wire connectors that comply with the Standard for Splicing Wire Connectors, UL 486C, or the Standard for Electrical Quick-Connect Terminals, UL 310, or the Standard for Terminal Blocks, UL 1059.

21.2 A soldered splice and a splice made with an uninsulated wire connector shall be covered with insulation that has a voltage and temperature rating equivalent to that required on the conductors.

21.3 An insulated wire connector shall be rated for the required voltage and temperature of the conductors involved.

21.4 A soldered joint shall be mechanically secured before soldering by being:

a) Wrapped at least halfway (180 degrees) around a terminal;

b) Provided with at least one right angle bend when passed through an eyelet or opening; or

c) Twisted with other conductors.

21.5 A connection to a wire-binding screw shall be made as follows such that no loose strands protrude from the connection:

a) Solid wire formed into a loop at least three-quarters (270 degrees) around the terminal; or

b) Stranded wire that is:

1) Soldered;

2) Connected to a terminal provided with upturned ends;

3) Connected to a terminal provided with a cup washer; or

4) Connected to a crimped pressure terminal connector or eyelet.

21.6 A connection to a terminal of a component shall be made by:

a) Wire inserted directly into a pressure wire terminal of the component;

b) Quick-connect terminal of the component, where the mating part is provided with a dimple, depression, or spring-type connection such that a mechanical snap-action connection is made that does not rely solely upon friction between the two parts;

c) Crimped-on pressure terminal connector or closed-loop eyelet;

d) Solder terminal;

e) Wire-binding screw; or

f) Open-type eyelet.

21.7 An open-type eyelet shall have:

a) Upturned ends that engage the terminal screw head;

b) Fork- or crimp-type ends that engage the terminal screw shank; or

c) A flat terminal that supports the wire such that loosening of a terminal screw does not result in the conductor disengaging from the intended connection.

21.8 Multiple conductors secured to a single termination point shall result in a reliable electrical and mechanical connection made without loose, unretained, or severed stranding, and without a reduction in the electrical spacings.

21.9 Uninsulated live parts shall be secured to their supporting surfaces so that they are prevented from turning or shifting in position when such motion results in a reduction of spacings to less than those indicated in Electrical Spacings, Section 17.

22 Wiring Attached to Movable or Flexible Parts

22.1 Internal wiring attached to or routed through a movable or a flexible part shall have stranded conductors and be secured so that the wiring is not cut or abraded and shall be routed and supported so that there is no strain or motion at the splice or connections.

22.2 Type SV, SVO, SVOO, SVT, SVTO, or SVTOO cord shall not be attached to a movable or a flexible part that bends the cord in a radius less than 20 times its diameter.

23 Internal Wiring

23.1 The internal wiring and connections between parts of a mounting system shall be enclosed or guarded, except that a length of flexible cord may be employed for external connections (See Section 27, Interconnected Units).

23.2 For the purpose of these requirements the internal wiring of a mounting system is considered to be all the interconnecting wiring from the point where the power-supply cord of a cord-connected mounting system enters the enclosure.

23.3 Unless it is to be judged as an uninsulated live part, insulated internal wiring of a mounting system (including a grounding conductor) shall consist of wire that is appropriate for the particular application, when considered with respect to:

a) The temperature and voltage to which the wiring is likely to be subjected;

b) Exposure to oil, grease, or other substances likely to have a deleterious effect on the insulation;

c) Exposure to moisture; and

d) Other conditions of service to which it is likely to be subjected.

23.4 Thermoplastic-insulated wire employed for internal wiring shall be standard building wire or appliance-wiring material that is provided with insulation appropriate for the purpose.

23.5 Wiring shall be protected from sharp edges (including male screw threads), burrs, fins, moving parts, and other agents that might abrade the insulation of conductors.

23.6 A hole by which insulated wires pass through a sheet metal wall within the overall enclosure shall be provided with a smoothly rounded bushing or shall have smooth surfaces, free of burrs, fins, sharp edges, and the like, upon which the wires may bear, to prevent abrasion of the insulation.

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

23.8 When the material through which the cord or wiring passes is wood, porcelain, phenolic composition, or other insulating material not less than 3/64 inch (1.2 mm) thick, a smoothly rounded surface is determined to be equivalent to a bushing.

23.9 Ceramic materials and molded urea, phenolic, and melamine compositions are determined to meet the intent of the requirement for insulating bushings; a bushing of wood or rubber is not usable. Other compositions are able to be used when they have been investigated and found usable for the application.

23.10 Polymeric sleeving shall not be used for reducing the risk of cutting or abrasion of wiring. Fiberglass sleeving not less than 0.010 inch (0.25 mm) thick is capable of being used when the wiring is not subject to flexing.

23.11 A bushing shall be securely held in place.

24 Supply Connections

24.1 Power-supply cords

24.1.1 For a cord-connected mounting system, the rating (both current and voltage) of the cord and the fittings, shall not be less than that of the mounting system. The current rating of the attachment plug shall not be less than 125 percent of the current rating of the mounting system including the marked rating of all convenience outlets.

24.1.2 A cord-connected mounting system shall be provided with a power supply cord consisting of one of the types of flexible cords specified in Table 24.1.

Table 24.1
Flexible Cord Types

S	SJ	SP-2	SV[a]
SE	SJE	SPE-2	SVE[a]
SEO	SJEO	SPT-2	SVEO
SO	SJO	SPT-3	SVO[a]
SOO	SJOO	NISPT-1	SVOO[a]
ST	SJT		SVT[a]
STO	SJTO		SVTO[a]
STOO	SJTOO		SVTOO[a]

[a] Individual conductors shall be provided with supplementary insulation or spaced away from metal.

24.1.3 Except as noted in 24.1.4, the conductors of a power-supply cord shall not be smaller than 18 AWG (0.82 mm^2).

24.1.4 The conductors of a power-supply cord of a mounting system provided with convenience receptacles shall not be smaller than 16 AWG (1.3 mm^2).

24.1.5 The maximum ampacity rating of a power-supply cord shall be as specified in Table 24.2.

Table 24.2
Size of Power-Supply Cord

Cord size	Maximum rating (amperes)	
AWG (mm^2)	3 current-carrying conductors	2 current-carrying conductors
12 (3.3)	20	25
14 (2.1)	15	18
16 (1.3)	10	13
18 (.82)	7	10

24.1.6 A power-supply cord shall be at least 5 feet (1.5 m) but not longer than 15 feet (4.6 m) measured from the point where the cord emerges from the body of the mounting system to the face of the attachment plug or connector.

24.1.7 When a direct plug-in ballast or power supply is used, the overall length of the cord shall not be less than 5 feet (1.5 m) but not longer than 15 feet (4.6 m) to the ballast or power supply from the point where the cord emerges from the body of the mounting system.

24.1.8 The power supply cord of a mounting system provided with convenience receptacles shall be provided with an attachment plug of the 15- or 20-ampere, grounding-type.

24.1.9 The equipment grounding conductor of the flexible cord shall be green with or without one or more yellow stripes.

24.1.10 Flexible cord shall be secured to the mount every 12 inches (305 mm) or less.

24.1.11 Raised projections, open channels and the like shall be provided for mechanical protection of the power supply.

24.1.12 The identified conductor (neutral) of the flexible cord (the conductor having white or gray insulation) shall be connected to the identified terminal (neutral) of the cord connector body (female) and the attachment plug (male).

24.1.13 A cord connected mount may be provided with NEMA 5-15R receptacles to facilitate connection of Audio and Video components. When mounts are provided with NEMA receptacles, the receptacles and receptacle wiring shall comply with the Standard for Furniture Power Distribution Units, UL 962A.

24.2 Permanently-connected

24.2.1 A product provided with means for permanent connection to the power supply shall comply with the requirements in this Section.

24.2.2 A permanently-connected product shall be provided with field-wiring terminals or leads for the connection of conductors having an ampacity rated as intended for the product and in accordance with the National Electrical Code, ANSI/NFPA 70. A product shall be provided with a splice compartment or a junction box to make the connections.

24.2.3 A lead that is intended to be connected in the field to a power-supply circuit conductor shall not be smaller than 18 AWG (0.82 mm^2) and shall be sized based on the rated current of the product.

24.2.4 A terminal or splice compartment shall be complete and shall enclose all field-wiring terminals and splices to be made in the field.

24.2.5 Each terminal or splice compartment in which power-supply connections are to be made in the field shall be located so that the connections are able to be readily inspected after installation of the product.

24.2.6 The compartment specified in 24.2.5 shall be located so that, when making conduit connections, internal wiring and electrical components are not exposed to mechanical abuse or strain.

24.2.7 A terminal compartment intended for connection of a supply electrical enclosure shall be attached so as to be prevented from turning with respect to the supporting surface.

24.2.8 A wiring terminal shall be prevented from turning or shifting in position.

24.2.9 A wire-binding screw at a wiring terminal shall not be smaller than No. 10 (4.8 mm diameter). If a pretapped hole is not provided, a thread-forming screw shall be used.

Exception: A No. 8 (4.2 mm diameter) screw is able to be used at a terminal intended only for connection of a 14 AWG (2.1 mm^2) conductor.

24.2.10 A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.050 inch (1.27 mm) thick.

24.2.11 A wire-binding screw shall be provided with an upturned lug, cupped washer, or equivalent means that retains a supply conductor of the size intended.

24.2.12 A terminal (for example, a plate and screw) intended for the connection of the grounded supply conductor shall be formed of, or plated with, metal that is substantially white in color and shall be readily distinguishable from other terminals or shall be clearly identified in some other manner, such as on an attached wiring diagram.

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

24.2.14 The free length of a lead located inside an outlet box or field-wiring compartment and intended for field connection to a branch circuit shall not be less than 6 inches (152 mm).

24.2.15 When a terminal block is provided, it shall be suitable for field wiring.

24.2.16 An opening for conduit shall have dimensions as indicated in Table 24.3.

Table 24.3
Dimensions Associated with Openings for Conduit

Nominal trade size of conduit	Unthreaded opening diameter[a]		Throat minimum		Diameter maximum		Minimum diameter of flat surface	
inch	inch	(mm)	inch	(mm)	inch	(mm)	inch	(mm)
1/2	0.875	(22.2)	0.56	(14.2)	0.62	(15.7)	1.15	(29.2)
3/4	1.109	(28.2)	0.74	(18.8)	0.82	(20.8)	1.45	(36.8)
1	1.375	(34.9)	0.94	(23.9)	1.05	(26.7)	1.80	(45.7)
1-1/4	1.734	(44.0)	1.24	(31.5)	1.38	(35.1)	2.31	(58.7)

[a] A plus tolerance of 0.031 inch (0.79 mm) and a minimum tolerance of 0.015 inch (0.38 mm) applies to the knockout diameter. Knockout diameters are measured other than at points where a tab remains after removal of knockout.

24.2.17 The minimum unobstructed diameter of the flat surface surrounding the back of an opening for unthreaded conduit shall be as indicated in Table 24.3.

24.2.18 When threads for the connection of threaded conduit are tapped all the way through a hole, there shall be no fewer than 3-1/2 or more than 5 threads. The construction of the hole shall be such that a conduit bushing is able to be properly attached and the minimum unobstructed diameter surrounding the back of the hole shall be as indicated in Table 24.3.

24.2.19 When threads for the connection of threaded conduit are not tapped all the way through a hole, there shall be no fewer than 5 full threads. The unthreaded parts of the hole and the back edge shall be smooth and well rounded for protection of the conductors. The unthreaded throat diameter of the hole shall have an internal diameter as noted in Table 24.3.

24.2.20 Receptacle configurations constructed in accordance with Wiring Devices – Dimensional Specifications, ANSI/NEMA WD6, shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

24.2.21 Receptacles shall be connected to the branch circuit conductors installed within the product with conductors sized in accordance with Table 24.4.

Table 24.4
Receptacle Conductor Size Based Upon Conductor Insulation Rated for 60°C (140°F)

	Branch circuit rating[a]					
	15	**20**	**30**	**40**	**50**	**60**
Receptacle conductor size, (Copper, AWG)	14	12	10	8	8	4
Receptacle rating, A	15	15 or 20	30	40 or 50	50	60

[a] Terminals of receptacles rated 30 A and above not marked "AL-CU" are for use with copper conductors only. Terminals of receptacles rated 30 A and above marked "AL-CU" are for use with aluminum, copper and copper-clad aluminum conductors.

24.2.22 Receptacles provided on the product for the connection of electrical loads shall be marked on or adjacent to the receptacle with the maximum intended load rating. See 73.8.

24.2.23 The receptacle ratings required in 24.2.22 shall not be less than 180VA (1.5 A per 120 V outlet min.) per receptacle outlet provided.

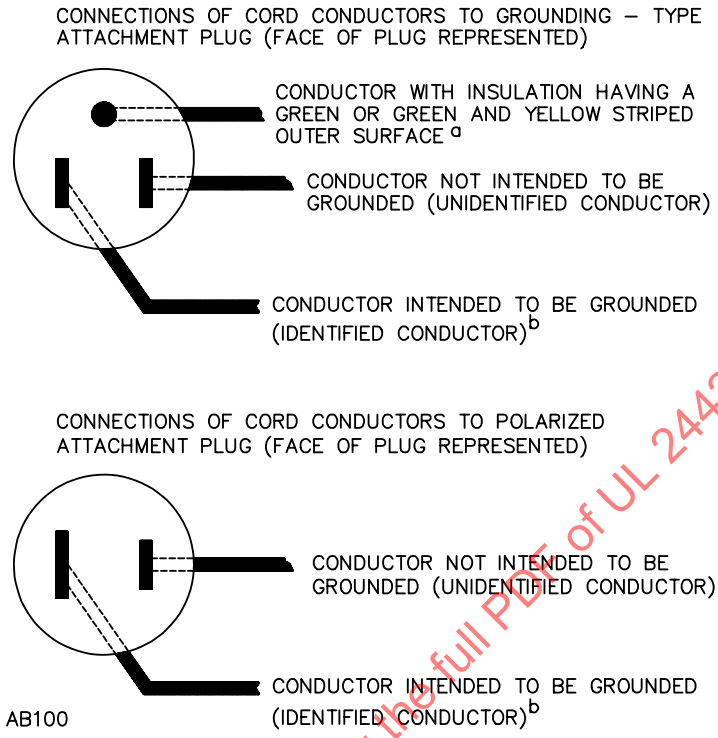
24.2.24 The total product load of the marked receptacle load(s) required in 24.2.22 and other electrical loads provided by the product shall not exceed 80 percent of the intended branch circuit load rating (12 A for a 15 A branch circuit and 16 A for a 20 A branch circuit).

25 Attachment Plugs

25.1 A cord-connected mounting system shall be provided with a polarized attachment plug of the 2-wire, parallel-blade or a 3-wire grounded type. The plug shall be of a 15 ampere, 125 volt configuration (NEMA 1-15P or 5-15P) and shall comply with the requirements in the Standard for Attachment Plugs and Receptacles, UL 498, the Standard for Cord Sets and Power-Supply Cords, UL 817, or both. See also Figure 25.1.

Figure 25.1

Connections to Attachment Plug



[a] In the above illustration, the blade to which the green conductor is connected may have a U-shaped or a circular cross section.

[b] Signifies a conductor identified in accordance with 24.1.12.

26 Interlock Switch

26.1 An interlock switch that is required to prevent injury shall be rated for the load it controls and shall comply with the Standard for Special-Use Switches, UL 1054, or the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1, when subjected to 100,000 cycles of operation.

27 Interconnected Units

27.1 Interconnected units may not have a NEMA Style plug or receptacles for interconnection.

27.2 Interconnected units that do not limit the number of interconnected units by inherent design shall be provided with suitable overcurrent protection located within the unit enclosure that is provided with the power supply cord for connection to the building branch circuit power.

27.3 Interconnected units, where a ballast or transformer of one unit powers adjacent units, the unit powered by the ballast or transformer does not require separate over-current protection.

27.4 The connectors used for interconnection shall have ratings consistent with the temperature, voltage, current available and shall comply with the Standard for Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977.

27.5 If the interconnecting power exceeds Class II power limits, the interconnecting conductors shall comply with requirements for power supply cords including the strain relief tests.

27.6 The ground connection when required by Section 29, Grounding, and Section 30, Bonding, shall make first and break last.

27.7 Any portion of a mounting system that is capable of being detached thereby breaking electrical connections – such as a detachable power-supply cord, interlocking connectors, or cord connector – shall be constructed such that it is only able to be assembled in the manner which is required to maintain polarity.

28 Polarization and Identification

28.1 A supply-circuit conductor that is connected to the grounded supply conductor (neutral) shall be marked in accordance with Table 28.1 and shall be connected to the wide blade of a 2-wire attachment plug, or the left-hand blade of a 3-wire attachment plug when looking at the face of the plug with the grounding pin up. See Figure 25.1.

28.2 A Class 2 low voltage plug-in transformer is not required to be provided with a polarized type 2-wire attachment plug.

Table 28.1
Polarity Identification of Flexible Cords

Method of identification	Color combinations	
	Wire intended to be grounded[e] – connected to the screw shell of lampholders	**All other wires[e]**
Color of braids on individual conductors	Solid white or gray – without tracer	Solid color other than white or gray – without tracer
	Solid white or gray – without tracer[a]	White or gray with tracer in braid[a]
	Color other than white or gray, with tracer in braid	Solid color other than white or gray – without tracer
Color of insulation on individual conductors	Solid white, gray, or blue[b]	Solid color other than white, gray, or blue[b]
Color of separators	White or gray[c]	Color other than white or gray[c]
	Tin or other white metal on all strands of the conductor[d]	No tin or other white metal on the strands of the conductor[d]
Other means	A stripe, ridge, or groove on the exterior surface of the cord[c]	

[a] Only for Types C and PD cords.

[b] Only for cords – other than Types SP-1, SP-2, SPE-1, SPE-2, SPT-1, and SPT-2 cords and AWM complying with Figure 28.1 – having no braid on any individual conductor.

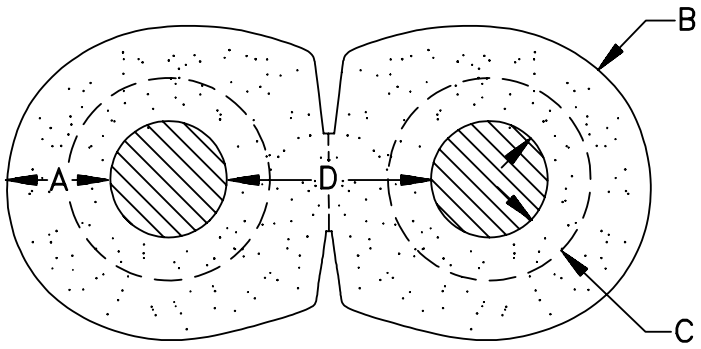
[c] Only for Types SP-1, SP-2, SPE-1, SPE-2, SPT-1, and SPT-2 cords, and AWM complying with Figure 28.1.

[d] Only for types SPT-1 and SPT-2 cords and AWM complying with Figure 28.1.

[e] A wire finished to show a green color with or without one or more yellow stripes or tracers shall be used only as an equipment-grounding conductor. See Figure 25.1.

Figure 28.1

Specifications for Appliance Wiring Material



S3527

A – Minimum acceptable average thickness away from tear area and outside point – 0.040 inch (1.02 mm).

B – Minimum acceptable thickness at any point (before separation) – 0.035 inch (0.89 mm).

C – Minimum acceptable thickness at any point after separation – 0.019 inch (0.49 mm).

D – (1) Minimum acceptable distance between copper conductors – 0.060 inch (1.52 mm). (2) Stranding shall consist of 36 – 34 AWG (0.013 – 0.020 mm^2) strands.

28.3 The screwshell or screwshell contact of each Edison-base lampholder shall be connected to the grounded supply conductor of the supply cord.

28.4 A switch or a fuse or other protective device shall not be connected to the grounded supply conductor.

29 Grounding

29.1 A metallic enclosure and other dead metal parts that are exposed to contact by persons shall be conductively connected to the grounding conductor of the power-supply cord or the grounding lead of the building wiring system.

Exception No. 1: Dead metal parts that are isolated from grounded metal and are not a part of the enclosure are not required to be connected to the grounding conductor of the power-supply cord or the grounding lead of the building wiring system.

Exception No. 2: A small metal part, such as an adhesive-attached foil label, a screw, or the like, that is on the exterior of the enclosure and separated from all electrical components by grounded metal or is electrically isolated from all components, is not required to be connected to the grounding conductor of the power-supply cord or the grounding lead of the building wiring system.

Exception No. 3: A metallic enclosure and other dead metal parts that are exposed to contact by persons but are provided with double insulation between electrically live parts is not required to be connected to the grounding conductor of the power-supply cord or the grounding lead of the building wiring system.

29.2 A mounting system unit having a 125/250 V rating shall not use the neutral circuit conductor as the equipment-grounding conductor.

29.3 The conductive connection of parts required by 29.1 shall be by a clamp, bolt, screw, braze, weld or an equivalent positive means that cannot be loosened from the outside and may include a corrosion resistant strap or jumper; see 30.2. Mechanical connections shall be secured. A solder connection is not prohibited from being used when the power-supply cord or field wiring grounding lead is mechanically secured to the enclosure in accordance with 21.4. A push-in (screwless), quick-connect, or similar friction-fit connector shall not be used for this connection.

29.4 Connections in the equipment-grounding conductor path from the receptacle grounding contact to the equipment-grounding conductor shall be welded, bolted, mechanically secured and soldered, or made by equivalent positive means. A quick-connect, or similar friction-fit connector shall not be used in the grounding conductor path.

29.5 The equipment-grounding conductor shall be green, with or without one or more yellow stripes, and of the same size as the current-carrying conductors. No other lead in the power-supply cord or field wiring leads shall be so identified. The equipment-grounding conductor shall be secured to the frame or enclosure of a metallic mounting system by a reliable means, such as a screw, that is not removed during ordinary servicing not involving the power-supply cord. The grounding connection shall penetrate nonconductive coatings, such as paint or vitreous enamel. All conductors in the grounding circuit of a mounting system shall be green, with or without one or more yellow stripes.

29.6 The yoke or faceplate mounting screws of a receptacle shall not be used to provide or maintain the grounding means of the receptacle or enclosure of a mounting system.

29.7 When a receptacle used in a mounting system is provided with a grounding screw, this screw shall be used to provide the ground connection to the receptacle.

29.8 A mounting system grounding conductor shall be of copper, copper alloy, or other material that has been investigated for use as an electrical conductor. A ferrous metal part in the grounding path shall be protected against corrosion.

29.9 A copper-base-alloy rivet that is used to secure parts in the grounding path, or that forms a part of the grounding path, shall contain not less than 80 percent copper.

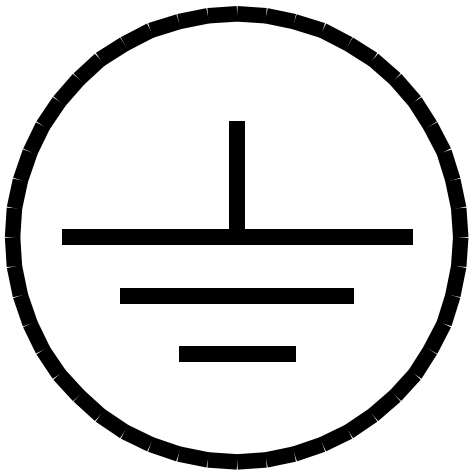
29.10 The line and neutral circuit conductor path shall not be connected to the grounding circuit conductor path.

Exception: Connection between the line or neutral conductor path and the grounding conductor path are able to be made when the components are investigated for the application (such as an across-the-line capacitor investigated to the Standard for Capacitors and Suppressors for Radio- and Television-Type Appliances, UL 1414).

29.11 A wire-binding screw intended for the connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal or slotted, or both. A pressure wire connector intended for connection of such a conductor shall be plainly identified, such as by being marked with the grounding symbol in Figure 29.1, "G", "GR", "Ground", or "Grounding", or by a marking on a wiring diagram provided on the mounting system.

Figure 29.1

Grounding Symbol



30 Bonding

30.1 Accessible dead-metal or other conductive parts that may become energized and not connected directly to the grounding conductor shall be bonded to grounded parts by clamps, rivets, bolts, screws, brazes, welds, or an equivalent positive means that is capable of including a corrosion-resistant strap or jumper.

30.2 Metal parts in a bonding path shall be galvanically compatible so as to reduce electrolytic action between dissimilar metals.

30.3 A bonding member shall:

a) Be protected from mechanical damage;

b) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is not omitted after removal or replacement of the fastener; and

c) Have the flexibility required to withstand mechanical stress.

30.4 When a bonding means depends on screw thread, two or more screws shall be employed, or at least two full threads of a single screw shall engage metal.

30.5 A bonding connection shall penetrate a nonconductive coating such as paint.

30.6 A bonding conductor shall not be spliced.

31 Safety Circuits

31.1 The requirements of this Section are to be used in the investigation of the circuit covered by 51.1.6 for compliance with the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991.

31.2 Supervised safety circuits as defined by UL 991, shall not rely on a trouble signal or indicator to reduce the risk of injury.

31.3 A product relying on a safety circuit shall be supplied, for the investigation of the product, with a failure-mode and effect analysis in accordance with Failure-Mode and Effect Analysis (FMEA) in accordance with UL 991.

31.4 With regard to electrical supervision of critical components, a motor operated mounting system being inoperative with respect to movement of the device meets the criteria for trouble indication.

31.5 A field strength of 3 V per meter is to be used for the Radiated EMI Test of UL 991.

31.6 A vibration level of 5 g is to be used for the Vibration Test of UL 991.

31.7 When a Computational Investigation is conducted, (λp) shall not be greater than 6 failures/106 hours for the entire system. For external secondary entrapment protection devices that are sold separately, (λp) shall not be greater than 0 failures/106 hours. For internal secondary entrapment protection devices whether or not they are sold separately, (λp) shall not be greater than 0 failures/106 hours. The Operational Test of UL 991 is to be conducted for 16 days.

31.8 The Endurance Test of UL 991 is to be conducted concurrently with the Operational Test. The control shall perform its intended function while being conditioned for 16 days in an ambient air temperature of 60°C (140°F), or 10°C (18°F) greater than the operating temperature of the control, whichever is higher. During the test, the control is to be operated in a manner representing the full range of motion of the mounting system.

31.9 For the Electrical Fast Transient Burst Test of UL 991, test level 3 is to be used for the mounting systems.

32 Control Circuits

32.1 A control circuit shall comply with the requirements for line-voltage circuits.

Exception: A secondary control circuit is not required to comply with the requirements for line-voltage circuits when all of the following conditions are met:

a) The circuit complies with the requirements for a Class 2 circuit or a limited power source circuit; and

b) A secondary circuit shall comply with the Standard for Solid-State Controls for Appliances, UL 244A. Compliance with the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1, and/or the applicable Part 2 standard from the UL 60730 series fulfills these requirements.

33 Laser Devices

33.1 Laser products shall comply with the Code of Federal Regulations (CFR), 21 CFR, Part 1040.

33.2 With reference to 33.1 compliance of laser products with the Code of Federal Regulations (CFR), Title 21, Part 1040, shall be determined by:

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

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

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

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

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

34 Motors

34.1 Motor construction

34.1.1 A motor shall be capable of handling the maximum normal load of the mount without a risk of fire, electric shock, or injury to persons and shall comply with the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1.

34.1.2 A motor winding shall resist the absorption of moisture.

34.1.3 With reference to the requirement in 34.1.2, film-coated wire is not required to be additionally treated to resist absorption of moisture, and fiber slot liners, cloth coil wrap, and similar moisture-absorptive materials are to be provided with impregnation or otherwise treated to resist moisture absorption.

34.2 Motor overload protection

34.2.1 A motor-operated mount shall incorporate thermal or overload protection in accordance with 34.2.2.

34.2.2 Motor-overload protection required for a mount shall consist of one of the following:

a) Thermal protection complying with the applicable requirements in the Standard for Thermally Protected Motors, UL 1004-3. If such a device relies on software as part of the protection, the software shall comply with the Standard for Software in Programmable Components, UL 1998, or the Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 and/or the applicable standard from the UL 60730 series.

Exception No. 1: For a mount that includes a control that positively and reliably limits the length of the time the mount is able to operate, the duration of the temperature test and the endurance test, both under locked-rotor conditions, is able to be less than that specified in UL 1004-3, and shall not be less than the time the mount is able to operate.

Exception No. 2: A shaded-pole motor with a 2:1 or smaller ratio between locked-rotor and no-load currents and a 1-ampere or smaller difference between no-load and locked-rotor currents is able to be protected against locked-rotor conditions only.

b) Impedance protection complying with the requirements in the Standard for Impedance Protected Motors, UL 1004-2, when the motor is tested as used in the mount under locked-rotor conditions;

c) Protective electronic circuits integral to the motor that comply with the Standard for Electronically Protected Motors, UL 1004-7; or

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

34.2.3 When a requirement in this standard refers to the horsepower rating of a motor and the motor is not rated in horsepower, use is to be made of the appropriate table of the National Electrical Code,

ANSI/NFPA 70, that gives the relationships between horsepower and full-load currents for motors. For a universal motor, the table applying to a single-phase, alternating-current motor is to be used when the mount is marked for use on alternating current only; otherwise the table applying to direct-current motors is to be used.

34.2.4 The motor of a mount with load characteristics resulting in an overload or locked-rotor condition that is not evident to the user shall incorporate thermal or overload protection in accordance with the requirements in 34.2.2.

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

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

34.2.7 With reference to 34.2.2(d), an overload-protective device conforming with the National Electrical Code, ANSI/NFPA 70, is identified as an overload device that is responsive to motor current and is rated or set as specified in column A of Table 34.1. When the rating of the motor-running overload protection determined to comply with the foregoing does not correspond to a standard size or rating of a fuse, nonadjustable circuit breaker, thermal cutout, thermal relay, or heating element of a thermal-trip motor switch, the next higher size, rating, or setting is able to be used, and is not able to be more than that specified in column B of Table 34.1. For a multispeed motor, each winding connection is to be evaluated separately.

Table 34.1
Maximum Rating or Setting of Overload-Protective Device

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

34.2.8 Motor-overload protection in which contacts control a relay coil in a motor starter shall comply with the requirements in 34.2.2.

35 Requirements for Loads on the Output of a NEC Class 2, LPS or SELV Power Supply

35.1 Motor controllers

35.1.1 Loads on the output of a NEC Class 2, LPS or SELV power supply shall comply with the following requirements. Consideration shall be given to loads operating concurrently or independently. When controllers are designed to load switch [manage current to multiple loads], the reliability of the switching or load sharing shall be investigated so that under a fault condition, a risk of fire or injury to persons is not created.

35.1.2 A combination motor(s) and motor(s) controller shall comply with the requirements in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, the Standard for Industrial Control Equipment, UL 508, or the Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

35.1.3 The failure of a motor controller shall not introduce a risk of electrical shock, fire or casualty as follows:

a) When a controller is designed to load switch (manage current to multiple loads) the reliability of the switching or load sharing shall be investigated so that under a fault condition an electrical shock, fire or causality hazard is not created.

b) When multiple motors apply a force to a portion of the furnishing the load on each motor shall be determined. Load management (switching) if provided by a controller shall be determined to be suitable for the loads or if it is determined the load management is not reliable then consideration shall be given to each motor applying its force to the furnishing portion singly or in combination which ever is determined to be worse case.

Exception: The above conditions do not apply where electronic drive circuits are determined to be reliable by single component faults as determined by evaluation with Section 31, Safety Circuits.

35.1.4 A motor shall incorporate one of the following forms of protection:

a) Thermal protection complying with the Standard for Thermally Protected Motors, UL 1004-3, where the motor is marked Thermally Protected or T.P.

b) Impedance protection complying with the Standard for Impedance Protected Motors, UL 1004-2, where the motor is marked Impedance Protected or Z.P.

c) A self-protected combination motor(s) and motor(s) controller shall comply with the requirements in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, the Standard for Industrial Control Equipment, UL 508, or the Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

d) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991. When the protective electronic circuit is relying upon software as a protective component, it shall comply with the requirements in the Standard for Tests for Software in Programmable Components, UL 1998. If software is relied upon to perform a safety function, it shall be considered software Class 1.

e) The Standard for Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements, UL 60730-1 and/or the applicable standard from the UL 60730 series. If software is relied upon to perform a safety function, it shall be considered software Class B.

f) The use of a device responsive to motor current.

g) The use of a sensing circuit that disconnects power from the motor in a sufficiently short time to reduce the risk of fire.

h) Motors that limit exposed motor surfaces [a case of an enclosed motor or a winding of an open motor] to 150°C (302°F) while wrapped in cheesecloth.

35.2 Electrical enclosures

35.2.1 Electrical enclosures shall be non-combustible or of a polymeric material that complies with the flammability requirements defined in the Enclosure Table of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

35.3 Luminaires

35.3.1 Luminaires shall comply with the requirements of the Standards for Low Voltage Lighting Systems, UL 2108, Flexible Lighting Products, UL 2388, Portable Electric Luminaires, UL 153, or Luminaires, UL 1598.

35.4 Interconnecting cables

35.4.1 Cables not contained within a metal or other raceway found to comply with the Standard for Surface Metal Raceways and Fittings, UL 5, or the Standard for Nonmetallic Surface Raceways and Fittings, UL 5A, or within an overall fire enclosure shall be rated VW-1, CL3, CL3R, CL3P, or be of another power-limited circuit cable.

35.5 Connectors

35.5.1 Connectors shall comply with any of the following: Standard for Attachment Plugs and Receptacles, UL 498, Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459, or Component Connectors for Use in Data, Signal, Control and Power Applications, UL 1977, provided the connector meets voltage and current requirements for the intended load. Connectors evaluated to UL 1977 shall meet minimum flammability class rating of HB, V-2, V-1, V-0, VTM-2, VTM-1, or VTM-0.

Note: The minimum flammability requirement in UL 1977 is HB.

MECHANICAL CONSTRUCTION

36 Mounting of Parts

36.1 All parts shall be securely mounted in position and prevented from loosening or turning when such motion affects the risk of fire or injury to persons. Friction between surfaces is not to be used as a means to prevent turning, loosening, or shifting of a parts. However, a toothed-lock washer or equivalent means is not prohibited from being used.

36.2 When installed as intended, articulating mounts providing rotation shall have a positive stop limiting maximum rotation to no more than 360 degrees. When a mount design or use will not cause electrical cords, cables or conductors to twist or bend during rotation, the mount may rotate more than 360 degrees.

36.3 The stop required by 36.2 shall not be accomplished by a user installed piece unless the piece is an essential part of the mount. Example: A user-assembled joint requiring the assembler to install a tabbed washer that may be omitted or installed ineffectively shall not be considered a reliable positive stop.

37 Flammability of Mounts

37.1 Mounting systems that are constructed of or coated with combustible materials shall comply with one or more of the requirements in 37.2 – 37.4.

Exception: These requirements do not apply to a mount, connector, shelf, or similar component, consisting of metals with organic or inorganic coatings with a thickness of 0.06 inch (1.52 mm) or less.

37.2 A mounting system constructed of combustible materials, that has an individual or a mechanically contiguous surface area of 10 square feet (0.93 m^2) or more, shall have a flame-spread index of 100 or less, and smoke-developed index of 100 or less when tested in accordance with the Standard for Test for Surface Burning Characteristics of Building Materials, UL 723.

37.3 A molding, cover, shelf, top cap, or similar part not forming an electrical enclosure, that is formed of polymeric material shall be classed HB or higher in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: This requirement does not apply to the following:

a) External accessories that are not permanently attached to the mount, such as a screwdriver, container of lubricating oil, and similar accessories.

b) Small parts that satisfy all of the following:

1) The maximum volume does not exceed 0.122 inch^3 (2 cm^3), and

2) The maximum dimension does not exceed 1.18 inches (3 cm).

c) Polymeric material 0.010 inch (0.254 mm) thick or less.

37.4 A polymeric mounting system shall comply with 12.6 for an electrical enclosure and with this Section for the construction not comprised of the electrical enclosure.

37.5 Fabric materials that have an individual or a mechanically contiguous surface area of 10 square feet (0.93 m^2) or more shall comply with Standard Test Methods of Fire Tests for Flame Propagation of Textiles and Films, NFPA 701.

37.6 Molded foam structure or other structures are to be made of a material that complies with the Standard for Fire Tests for Foamed Plastics Used for Decorative Purposes, UL 1975, with a maximum allowable rate of heat release of 150 kilowatts; providing the part occupies a volume greater than 2 cubic centimeters (0.122 cubic inch), has any dimension greater than 3 cm (1.18 inch), and is located so it can propagate flame from one area to another or bridge between a possible source of ignition and other ignitable parts. The mount shall comply with the requirements when fully assembled as intended.

38 Adhesives Used to Secure Parts

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

38.2 The requirement in 38.1 also applies to an adhesive used to secure a conductive part, including a nameplate, that may, if loosened or dislodged:

a) Energize an accessible dead metal part;

b) Make a live part accessible;

c) Reduce spacings below the minimum acceptable values; or

d) Short-circuit live parts.

38.3 Whether the conditions mentioned in 38.2 (a) – (d) can occur is to be considered with respect to both:

a) A part inside the device; and

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

39 Fasteners

39.1 A User Adjustable Fastener such as a bolt, pin, or screw, that when loosened for adjustment can be loosened to the point that its partial or full removal could result in an injury to persons, shall be provided with a secondary securement means such as a lock nut, cotter pin or similar feature that would require the user to deliberately defeat it.

39.2 Motor operated mounting systems shall be provided with fasteners that are not subject to loosening from vibration or movement of the articulating components. Lock nuts, locking adhesives, cotter pins and retaining rings are some but not all of the features that are to be used to prevent articulating joints from unintentionally becoming disassembled.

40 Lubrication

40.1 Motor operated mounting systems shall be provided with lubricated articulated joints or be constructed with materials that have self-lubricating properties. (Example: Teflon).

40.2 If a motor operated mounting system requires periodic lubrication, the type of lubricant, the frequency of lubrication and the points to be lubricated shall be specified in the User-maintenance instructions, see 81.1.

41 Corrosion Protection

41.1 All exposed exterior and interior surfaces of ferrous metal parts shall be protected by one of the following:

a) A coating of nonferrous metal applied by the hot dip process method;

b) A plating of nonferrous metal applied either by electro-deposition or by chemical means;

c) A coating of vitreous enamel;

d) Baked paint, or similar type of coating;

e) Epoxy powder coating;

f) Air-dry paint; or

g) Other coating providing equivalent corrosion protection.

41.2 Copper, aluminum, and alloys of copper and aluminum, stainless steel, and similar materials having inherent resistance to atmospheric corrosion may be used without additional corrosion protection.

42 Wireways and Tubing

42.1 A mounting system shall be constructed so that when wires are pulled through, or the unit otherwise wired, the covering or insulation on the conductors is not damaged against any surface they are able to contact.

42.2 Wireways shall be free from burrs and fins.

42.3 Tubing that is used as a wireway shall be free from kinks and cracks.

42.4 Screw threads of sheet metal screws and self-tapping screws shall not be exposed for a distance of more than 3/16 inch (4.8 mm) in a wireway unless the wires are held away from or prevented from contacting the screw threads.

43 Strain Relief

43.1 Strain relief shall be provided so that mechanical stress on a flexible cord will not be transmitted to terminals, splices, or interior wiring. To determine compliance, the supply cord is to be tested in accordance with Section 61, Strain Relief Test, and Section 62, Push Back Relief Test.

43.2 A knot shall not be employed to provide strain relief.

43.3 Means shall be provided to prevent the supply cord or lead from being pushed into the enclosure of a mounting system through the cord-entry hole when such displacement results in:

a) Subjecting the supply cord or lead to mechanical damage;

b) Exposing the supply cord or lead to a temperature higher than that for which it is rated;

c) Reducing spacings below the minimum required values; or

d) Damaging internal connections or components.

To determine compliance, the supply cord or lead shall be tested in accordance with the Push-Back Relief Test, Section 62.

44 Bushings

44.1 At the point where a flexible cord passes through an opening in a wall, barrier, or enclosing case, there shall be a bushing or the equivalent that shall be substantial, secured in place as intended, and shall have a smooth, rounded surface against which the cord may bear. The heat-resistant properties of a nonmetallic bushing material shall comply with the requirements of the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C. If the bushing is necessary to meet enclosure requirements of Section 12, Electrical Enclosures, it shall additionally meet the enclosure requirements of UL 746C.

44.2 When the material through which the cord passes is wood, porcelain, phenolic composition, or other insulating material, not less than 3/64 inch (1.2 mm) thick, a smoothly rounded surface is determined to be equivalent to a bushing.

44.3 Ceramic materials and some molded compositions are generally capable of being used for insulating bushings. Separate bushings of wood or hot-molded shellac-and-tar compositions are prohibited.

44.4 Vulcanized fiber may be employed when the bushing is not less than 3/64 inch (1.2 mm) thick and is formed and secured in place so that it is not adversely affected by conditions of ordinary moisture and temperature.

44.5 A separate soft-rubber, neoprene, or polyvinyl chloride bushing is capable of being employed:

a) Anywhere in an mounting system when it is used in conjunction with a type of cord for which an insulating bushing is not required and the edges of a hole in which such a bushing is used is free from burrs, fins, and other conditions that can damage the bushing; or

b) In the frame of a motor or in the enclosure of a capacitor attached to a motor when:

1) The bushing is not less than 3/64 inch (1.2 mm) thick; and

2) The bushing is located so that it will not be exposed to oil, grease, oil vapor, or other substances that can have a deleterious effect on the compound employed.

45 Thermal Insulation

45.1 Thermal insulation shall be:

a) Located and mounted or supported so that it will not be adversely affected by any intended operation of the mounting system;

b) Noncombustible or be classed V-0, 5VA, or 5VB minimum, in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94;

c) Non electrically conductive; and

d) Meet spacings from uninsulated live parts of a mounting system.

46 Glass Panels

46.1 Glass shall not be less than 0.115 inch (2.92 mm) thick if the length or width of the glass is not greater than 12 inches (305 mm). Glass having a length or width greater than 12 inches (305 mm) shall not be less than 1/8 inches (3.2 mm) thick and the glass shall be a non-shattering or tempered type that, when broken, complies with the requirements in the Standard Performance Specifications and Methods of Test for Safety Glazing Material Used in Buildings, ANSI Z97.1.

47 Counter Balance Mechanisms

47.1 Any device that stores energy (example: spring, pressurized cylinder) to counter balance the normal load applied to the mounting system shall be fully enclosed or otherwise guarded or restrained to reduce the likelihood of injury in the event of device failure.

47.2 The enclosure shall have sufficient strength and rigidity to contain the counter balance device upon breakage of the energy storing device.

48 Sharp Edges

48.1 Sharp edges, corners, projections, or other similar parts shall not be accessible during user assembly or normal use. An accessible edge, corner, projection, or other similar part shall be smooth and well rounded to reduce the risk of a cut-type injury when contacted during user assembly or normal use. Compliance shall be determined by the Sharp Edge Test, Section 69.

49 Securement of Products for Use with the Mounting System

49.1 Shelves and platforms of a mounting system shall be provided with a means to restrict an apparatus from sliding off the surface. Friction shall not be the sole means of restricting an apparatus from sliding off a supporting surface. Fasteners that are required to be inserted into the end-use mounting system shall be evaluated for the ability to support the loads encountered under all angles of adjustment.

Exception: Fixed horizontal shelves and platforms need not comply with this requirement.

49.2 A mounting system having shelves, platforms, and mounting brackets that are intended to support an apparatus and having provision for fixed tilt or adjustable tilt shall be provided with a mechanical means of securing the apparatus to the mount.

49.3 An articulating mounting system shall be provided with a mechanical means of securing the apparatus to the mount.

49.4 Gravity and adhesives alone shall not be relied upon to secure products to articulating mounts or adjustable tilt mounts. A mechanical fastening means is required.

50 Mounting System Ventilation

50.1 If the mounting system is provided with an enclosure including doors, covers or panels that may be closed restricting ventilation to the audio/video equipment, information technology equipment, and similar products while performing their intended function, a minimum of 2 sq cms per Watt of effective ventilation opening shall be provided per the maximum recommended wattage for the components the mounting system is intended to support. Approximately one half of the area is to be located near the base of the bottom edge of the mounting system and the remaining open area is to be located near the top of the mounting system.

50.2 Mounts that incorporate both enclosed and unenclosed apparatus supports shall be provided with a minimum of 2 sq cms per Watt of effective ventilation opening per the maximum recommended wattage for the components the mounting system is intended to enclose or partially enclose.

50.3 Any internal dividers such as shelving, shall allow the flow of convection air through the mounting system.

50.4 Ventilation openings may not originate or exit into confined spaces of a building structure, walls, floors, ceilings and the like.

50.5 A reduction in the area of ventilation openings may be provided when powered ventilation is integral to the mounting system and any of the following are provided:

a) A trouble signal indicator visible to the user is activated when the air flow drops below 75 percent of the design air flow; or

b) Power to any receptacle provided as part of the mounting system deenergizes when air flow drops below 75 percent of the design air flow.

50.6 A mounting system or apparatus that recesses into an enclosure or within the building structure when not in use shall be provided with an interlock to deenergize the power to the apparatus when in the recessed position. Designs intended to be operated within an enclosure and complying with 50.1 – 50.5 are not required to have an interlock.

51 Articulating Motor Operated Mounting Systems

51.1 Mechanical enclosures and guards

51.1.1 Whether a guard, a release, an interlock, or similar device is required and whether such a device is adequate shall be determined from an investigation of the complete mounting system, its operating characteristics, and the potential risk of injury to persons. The investigation shall include evaluation of the results of breakdown or malfunction of any one component, and not more than one component at a time, unless one event contributes to another. When the investigation shows that breakdown or malfunction of a

particular component results in a risk of injury to persons, that component shall be investigated for reliability.

51.1.2 Determination as to whether a guard, a release, an interlock, or similar device is required for mounts intended for wall or shelf mounting shall be judged with consideration to the mount and/or apparatus being located at any height between one foot from the floor and one foot below a ceiling. Installation instructions indicating a specific mounting height shall not be considered in determining that a guard is not required.

51.1.3 An entrapment guard or enclosure is not required for a ceiling-mount or lifts that when lowered, its lowest point is 8 ft (2.44 m) or more above the floor. The device shall be marked as specified in 74.3 and the instructions shall contain the Warning and information specified in 79.2 and 79.3.

Exception: This requirement does apply to mounts provided with an interlocked control that complies with the requirements in Section 51A, Interlocked Control For Motor-Operated Articulating Mounts.

51.1.4 A moving part, the rotor of a motor, a pulley, belt, gear, fan, or other part that constitutes a risk of injury shall be enclosed or provided with means to reduce the risk of injury. Such a part shall not be able to be contacted by the probe illustrated in Figure 13.2 unless the mounting system is provided with a safety circuit and complies with Section 31, Safety Circuits.

51.1.5 Mounting systems that present a risk of injury as described in 51.1.1 shall be provided with either an active safety circuit or passive guard to prevent injury.

51.1.6 Safety systems that are electrical in nature shall be designed such that any failure of the system will result in the mounting system not producing a risk of injury due to the safety system failure. Also see Section 31, Safety Circuits.

51.1.7 A mechanical safety system, such as a guard, shall comply with 51.1.10 – 51.1.12.

51.1.8 During the investigation of a mounting system to determine compliance with 51.1.4, a part of the enclosure that is removable without the use of a tool (such as an accessory, the cover over an opening for an operating adjustment, or similar components) is to be opened or removed.

51.1.9 Among the factors to be evaluated with respect to both intended operation of the mounting system and any foreseeable misuse in investigating an exposed moving part are:

a) The degree of exposure required to perform the intended function;

b) The sharpness of the moving part;

c) The risk of unintentional contact;

d) The speed of the moving part;

e) The risk that a part of the body is endangered or that clothing is able to be entangled by the moving part, resulting in a risk of injury to persons; and

f) An exposed motorized moving part such as the edge of a shelf, the edge of a video display and the like, shall not exert a force greater than 40 pounds between the moving part and any object that can be inserted between the moving part and a fixed structure such as but not limited to a wall, ceiling, floor or any portion of the device. All degrees of rotation and movement shall be considered in the evaluation.

51.1.10 Guards shall:

a) Require the use of tools for their removal;

b) Have sufficient strength and rigidity;

c) Be complete;

d) Not present a risk of injury to persons such as a pinch point, during additional handling because of required service, such as cleaning, unjamming, or similar service; and

e) Be self-restoring.

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

51.1.12 When breakage or deterioration of material adjacent to a moving part results in an increased risk of injury, the material shall have such properties as to withstand the loads it is subjected to during use of the mounting system.

51A Interlocked Control For Motor-Operated Articulating Mounts

51A.1 A motor-operated ceiling-mount or lift which may descend to a height lower than 8 ft (2.44 m) above the floor shall be designed so that it can only be actuated by a trained operator in order to cause it to descend to a height lower than 8 ft (2.44 m) above the floor, and is considered to comply with Mechanical Enclosures and Guards, Section 51.1, when the mount complies with all of the following conditions:

a) A mounting device control that is accessible to the public when the trained operator is not present shall be provided with a security lockout device that disables operation of the equipment to prevent non-qualified persons from operating the equipment;

1) A trained operator is considered present when they are within sight of the mount.

2) The lockout device may be a passcode, proximity sensor that requires a unique sensor to activate (such as RFID), a physical key, a two-step process (such as pressing 2 keys in the correct order, or other means that would prevent an untrained person from operating the equipment.

3) Where multiple mounts are located within the same space and a proximity activation device is used as the access to allow movement of the equipment, each mounting device shall have a separate code or equivalent restriction to allow movement of only the intended furnishing within the specified proximity.

4) A lockout (electronic or mechanical) system shall automatically reset and lockout the movement of the equipment after a maximum of 2 minutes of inactivity. Inactivity is when the operator is no longer present.

b) Any point or part of the mounting device that is considered to present risk of an entrapment or personal injury shall be visible to the operator such that they can determine the proximity of an individual to the entrapment area when positioned at the operator controls while performing the intended function;

c) Where the operation of the exposed movable part of the mounting device is controlled by a switch, the switch shall be a momentary contact type that when released all moving parts of the device that constitute a risk of entrapment or personal injury are stopped;

d) A switch that controls the direction of travel of the mounting device shall be capable of being stopped and the direction of travel reversed at any point in the operation of the device;

e) Upon power failure the mounting device shall remain in the existing position. Upon reinstatement of power, the mounting device shall not move until the operator activates the switch controlling movement.

51A.2 A product that complies with 51A.1 shall be provided with installation and operation instructions in accordance with Mounting Instructions, Section 79, and Operating Instructions, Section 80.

52 User/Installer Assembly

52.1 A mounting system and its accessories intended to be user or installer assembled shall comply with the following:

a) The assembly shall be accomplished by the user or installer with ordinary tools including those provided with the mounting system;

b) An assembly or part intended to be cut to length, drilled or fitted by the installer may be provided if means are furnished for joining any altered part to a companion part or assembly. The field altered part shall comply with the following:

1) Mounting holes for connection to the building structure shall be factory produced.

2) Electrical enclosures shall not be subjected to field cutting or drilling.

3) An assembly where insulated conductors or cords are routed or pass through after the cutting or drilling operation is performed shall be provided with a method of preventing contact of the insulated conductor or cord with a field cut edge or drilled hole. A field installed bushing is acceptable if provided with the assembly. The bushing shall comply with Section 44 and not require a special tool to install unless provided with the assembly.

4) When drilling is specified the size of the drill bit and the instructions shall clearly describe the location or locations to be drilled.

5) Cut and drilled edges shall not be exposed to the user after the operation has been performed unless they comply with Section 48.

6) The field cut or drilled mounting system when altered as specified in the instructions shall comply with the requirements of this Standard.

c) All parts such as screws, bolts, and similar parts that are required to complete the assembly of the mounting system shall be provided;

d) Installation and assembly instructions shall be provided as detailed in Instructions, General, Section 78; and

e) The manufacturer shall provide fasteners and mounting hardware for each of the mounting surfaces. The fasteners and mounting hardware need not be provided if the installation instructions supplied by the manufacturer give complete details of the hardware to be used (At a minimum, screws or bolts are to be identified by the size or diameter, length, thread size, material hardness [when harder than grade 2 (class 4.6)], and quantity; concrete or masonry anchors are to identify the manufacturer's name, size, and model number).

53 Knockouts

53.1 Clearance

53.1.1 Openings in an enclosure for the connection of a wiring system that in some cases will not be used shall be closed by a knockout, cover, or plug. The closure shall be formed of metal not less than 1.35 mm (0.053 in) thick or of a non-metallic material acceptable for the purpose. The closure shall be such that it may be readily removed, but will not drop out in ordinary handling.

53.2 Flat surfaces surrounding knockouts

53.2.1 Flat surfaces surrounding a knockout on both the inside and outside of an enclosure shall extend beyond the edge of the knockout in all directions for at least the distance given in Table 53.1 and shall comply with 71.1. Projections or indentations in the flat surface are prohibited. The flat surface areas of adjacent knockouts that partially or wholly overlap meet the intent of this requirement.

Table 53.1
Knockout Dimensions

Conduit trade size	Knockout diameter mm (inches)					
	Minimum		Nominal		Maximum	
	mm	(inch)	mm	(inch)	mm	(inch)
1/2	21.82	(0.859)	22.23	(0.875)	23.01	(0.906)
3/4	27.79	(1.094)	28.17	(1.109)	28.98	(1.141)
1	34.52	(1.359)	34.93	(1.375)	35.71	(1.406)
1-1/4	43.66	(1.719)	44.04	(1.734)	44.86	(1.766)
1-1/2	49.73	(1.958)	50.39	(1.984)	51.21	(2.016)
2	61.80	(2.433)	62.71	(2.469)	63.50	(2.500)
2-1/2	74.12	(2.918)	75.41	(2.969)	76.20	(3.000)
3	90.50	(3.563)	91.29	(3.294)	93	(3.661)
3-1/2	103.20	(4.063)	104.78	(4.125)	106	(4.173)
4	115.90	(4.563)	117.88	(4.641)	119	(4.685)
5	142.88	(5.625)	145.26	(5.719)	147	(5.787)
6	170.18	(6.700)	173.05	(6.813)	175	(6.890)

53.3 Diameters

53.3.1 A knockout shall have a diameter that accommodates the corresponding trade sizes of conduit specified in Table 53.1. The diameter of the knockout shall be measured at points other than where a tab remains after the knockout has been removed.

53.4 Strength of knockouts

53.4.1 A knockout shall comply with 70.1. The diameter of the knockout shall be measured at points other than where a tab remains after the knockout has been removed.

PERFORMANCE

GENERAL

54 General

54.1 A mounting system shall be assembled and mounted in accordance with the manufacturer's installation instructions.

54.2 When conducting tests, a mounting system shall comply with the following:

a) Accessory shelves, platforms, brackets, arms and compartments intended to be attached or suspended from the mounting system, shall be assembled and secured to the mount;

Exception: This requirement does not apply if it is determined that the absence of an accessory is considered to present a risk of injury not present when the accessory is installed.

b) The fasteners and anchors provided or recommended by the manufacturer to be used to secure the apparatus to the mounting system and the mounting system to the building structure shall be used;

c) Tests shall be performed on each of the surfaces to which the manufacturer recommends the mount to be secured in the installation instructions;

d) As specified in each test procedure, each shelf, platform, bracket, and compartment shall be loaded in accordance with Table 54.1; and

e) Mounting systems that are adaptable to more than one size or more than one configuration and determined to present different risks than represented by the maximum size apparatus intended to be supported shall be investigated for use with all sizes necessary to determine compliance with all sections of these requirements.

Table 54.1
Supporting Surface Loading Parameters

Surface type	Load
Shelf, platform, or bracket intended to support a CRT television/monitor or similar apparatus	Weight specified in Table 54.2 or manufacturer specified load, whichever is greater
Shelf, platform, or bracket intended to support a loudspeaker or similar apparatus	Manufacturer specified load
Shelf, platform, or bracket intended to support a VCR, DVD, DVR player, satellite receiver, cable box or similar apparatus	Manufacturer specified load or 25 lbs. (11.34 kg), whichever is greater
Flat Panel Displays such as Plasma Display, Liquid Crystal Display (LCD), and Light Emitting Diode Display (LED)	Manufacturer specified load
Apparatus other than mentioned above	Manufacturer specified load or 25 lbs. (11.34 kg), whichever is greater
Dedicated storage area – Tapes, CDs, DVDs	Manufacturer specified load
Shelf, platform, or bracket intended to support a video projector	Manufacturer specified load

54.3 When conducting the Cycling Test for Articulating Mounts, Section 66, and the Mounting Securement Test, Section 67, the following shall apply:

a) Material used to simulate the load is to consist of cast or cold-rolled steel plates or bars or other equivalent dead-load or load cells and such applied in a manner duplicating dead loads. In stacking the plates or bars, they are to be overlapped or criss-crossed in such a manner that the weight is evenly distributed over the supporting surface so as to act as a rigid unit that limits the bowing or flexure of the supporting surface or bracket to a minimum;

b) For shelves, platforms, and constructions that require the load to be suspended, the weights are to be suspended from the center of the platform, bracket, or shelf to which the apparatus is to be mounted. Care is to be taken so that the securement of the load does not distort the mounting surface. If necessary, a rigid plate made of wood or metal can be used to evenly distribute the force of the load over the supporting surface or bracket. The weight of the rigid plate is to be considered as part of the load weight;

c) The mounting system is to be suitably supported to inhibit premature loading and stress on the mounting means and to minimize the risk of injury due to shifting weights or premature collapse of the mount while stacking the weights. The support is to be kept in place until all of the required weights are in place. The support is to be gradually removed until the weights are freely suspended. The mounting system shall support the freely suspended test load for the required time period;

d) For mounts intended to support CRT type displays, the mount shall be loaded with the test fixture as described in Figure 54.1;

e) For direct-mount-type products such as flat-panel displays, a suitable test plate(s) that complies with the Video Electronics Standards Association FDMITM (VESA) Flat Display Mounting Interface Standard, representative of the end product, is to be used as the test load. The load shall be mounted by drilling through the plates(s) and using nuts or tapping the plate to use the fasteners supplied by or recommended by the manufacturer. The test load is to be secured to the mounting system as the display is recommended to be positioned by the manufacturer. If other mounting or securing hardware is specified to support the display, these shall be used as specified by the mount manufacturer. The test plate is to be considered part of the load weight;

f) The force is to be applied in the direction that would represent the normal pull of gravity. For flat panel displays, the force is to be applied to the center of the suitable test plate. See Figure 54.2;

g) The minimum load weight to be used for CRT televisions and monitors shall be determined by the maximum diagonal screen size recommended by the manufacturer. See Table 54.2;

h) If there is a range of apparatus specified or multiple apparatus specified, the mount is to be loaded in any combination that results in the maximum stress on the mounting system components; and

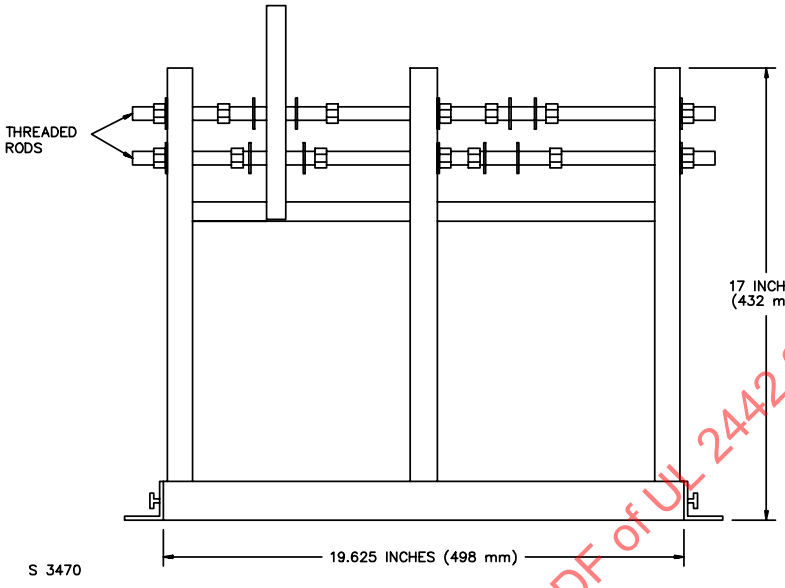
i) An adjustable mount shall be tested in the most severe position. This may require adjusting the mount to various positions to determine the worst case position. An articulating mount shall be adjusted to each extreme position of movement while loaded.

Table 54.2
Simulated Cathode Ray Tube (CRT) Television Load Parameters

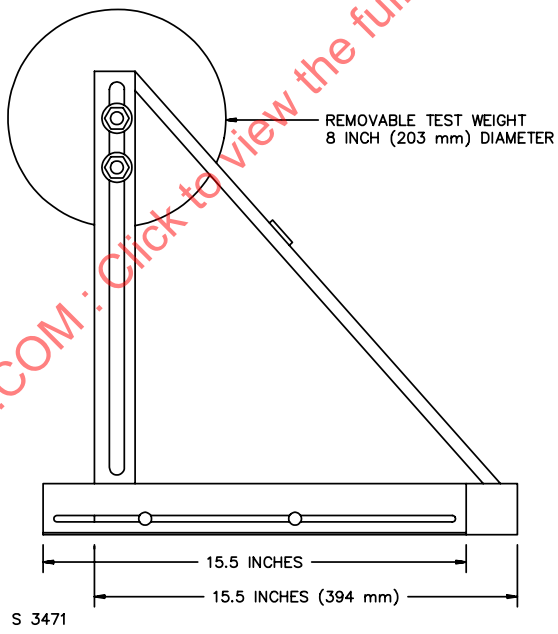
Maximum screen diagonal, inches (cm)	Weight, lbs (kg)
Up to 16 (40.64)	35 (15.88)
17 – 19 (43.18 – 48.26)	60 (27.22)
20 – 21 (50.80 – 53.34)	70 (31.82)
22 – 26 (55.88 – 66.04)	85 (38.56)
27 – 28 (68.58 – 71.12)	105 (47.63)
29 – 35 (73.66 – 88.90)	180 (81.65)
36 – 40 (91.44 – 101.60)	240 (108.86)

Figure 54.1

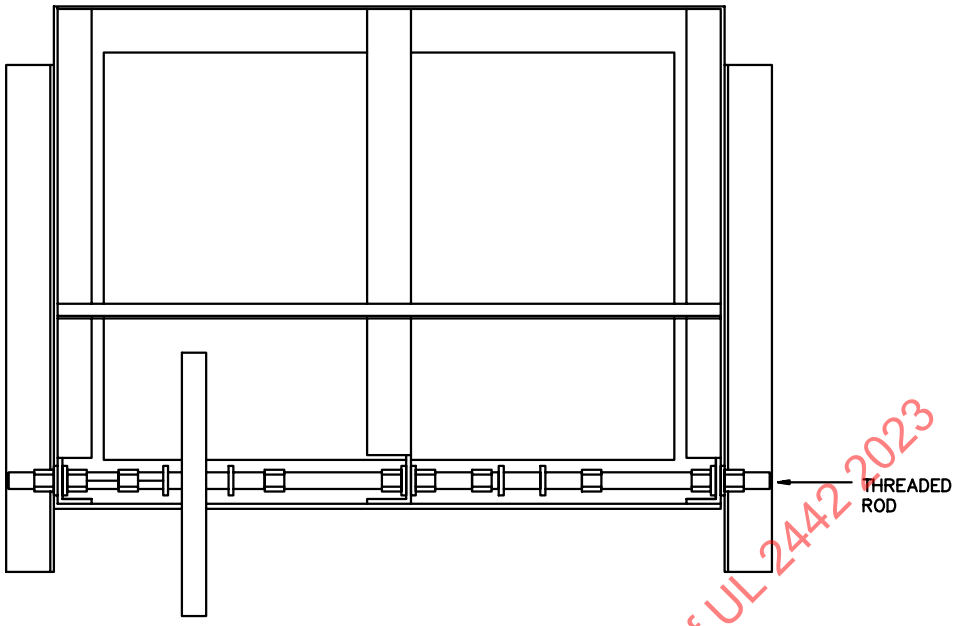
Example of Test Fixture for Simulated Television Load



Front view



Right side view



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Top view

Threaded Rods: 1/2-inch (12.7-mm) diameter Steel

Bottom: 1-1/2 × 1-1/2 × 1/8 inch (38.1 × 38.1× 3.2 mm) Steel Angle

Front: 1 × 1-1/2 × 1/8 inch (25.4 × 38.1 × 3.2 mm) Steel Angle

Angle Braces: 1 × 1 × 1/8 inch (25.4 × 25.4 × 3.2 mm) Steel Angle

Cross Brace: 1 × 1/8 inch (25.4 × 3.2 mm) Steel

Weight of Fixture: 22 lbs (10 kg)

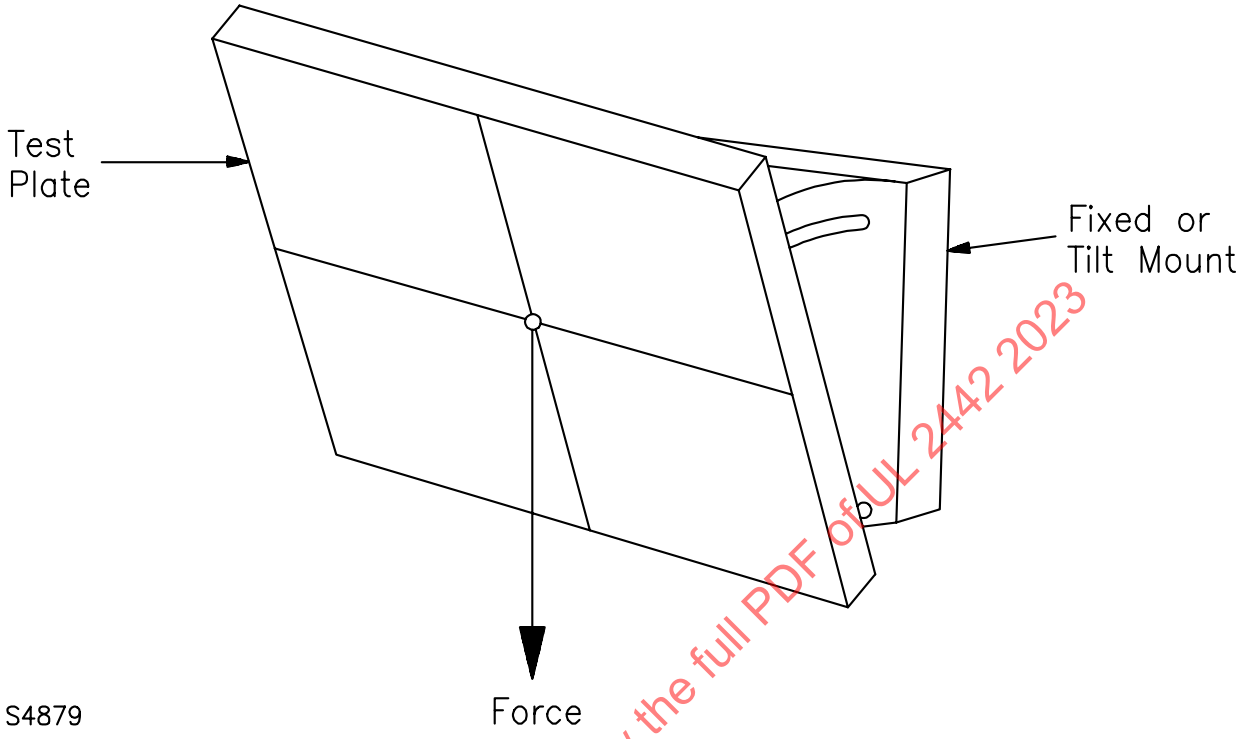
NOTES –

1) The above fixture is intended to simulate televisions with diagonal screen measurements of 19 inches (483 mm) or more.

2) Equivalent test fixtures may be employed. The fixture described in Figure 54.1 shall be used if a referee test is necessary.

Figure 54.2

Force to be applied during the Mounting Securement Test



ELECTRICAL PERFORMANCE TESTS

55 Leakage Current Test

55.1 A cord-connected mounting system rated for a nominal 120-V supply shall be tested in accordance with 55.3 – 55.7. Leakage current shall not be more than:

a) 0.5 mA for an ungrounded 2-wire mounting system; and

b) 0.75 mA for a grounded 3-wire mounting system employing an attachment plug rated 20 A or less.

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

55.3 All exposed conductive surfaces are to be tested for leakage currents. If simultaneously accessible, the leakage currents from exposed conductive surfaces are to be measured to the grounded supply conductor individually as well as collectively, and from one surface to another. A part is considered to be an exposed surface unless guarded by an enclosure that complies with the requirements in 13.8. Surfaces are considered to be simultaneously accessible when they can be readily contacted by one or both hands of a person at the same time. These measurements do not apply to terminals operating at voltages that do not present a risk of electric shock.

55.4 If a conductive surface other than metal is used for the enclosure or part of the enclosure, the leakage current is to be measured using a metal foil having an area of 10 by 20 cm in contact with the

surface. If the surface is less than 10 by 20 cm, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the mounting system.

55.5 The measurement circuit for leakage current is to be as illustrated in Figure 55.1. The measurement instrument is defined in (a) – (c). The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument.

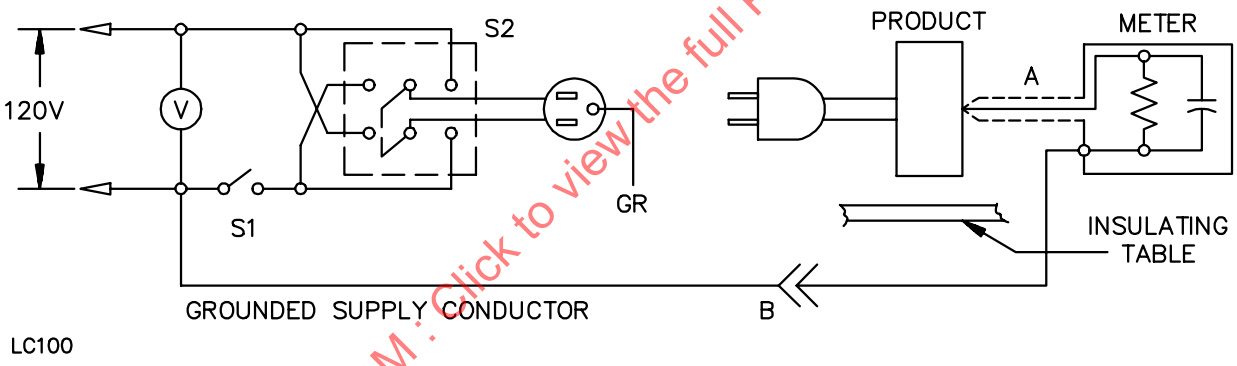
a) The meter is to have an input impedance of 1500 ohms resistive, shunted by a capacitance of 0.15 μF.

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

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

Figure 55.1

Leakage-Current Measurement Circuit



Leakage-current measurement circuit

NOTES –

A: Probe with shielded lead.

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

55.6 The meter is to be connected to the accessible part and the grounded supply conductor unless the meter is being used to measure leakage between two parts of an mounting system.

55.7 A representative mounting system is to be tested for leakage current starting with the as-received condition but with its grounding conductor, if any, open at the attachment plug. The as-received condition being without prior energization except as may occur as part of the production-line testing. The supply voltage is to be adjusted to 120 V. The test sequence, with reference to the measuring circuit – Figure 55.1 – is to be as follows:

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

b) Switch S1 is then to be closed energizing the mounting system, and within 5 s, the leakage current is to be measured using both positions of switch S2 with the mounting system switching devices in all their normal operating positions.

c) The leakage current is to be monitored until thermal stabilization. Both positions of switch S2 are to be used in determining this measurement. Thermal stabilization is to be obtained by operation as in the normal temperature test.

55.8 Normally, the complete leakage current test program as covered by 55.7 is to be conducted without interruption for other tests. However, with the concurrence of those concerned, the leakage current tests may be interrupted for the purpose of conducting other nondestructive tests.

56 Leakage Current Test Following Humidity Conditioning

56.1 A mounting system as described in 55.1 shall comply with the requirements for leakage current in 55.1 following exposure for 48 h to air having a relative humidity of 88 ±2 percent at a temperature of 32 ±2°C (90 ±4°F).

56.2 A representative mounting system is to be heated to a temperature just above 34°C (93°F) to reduce the likelihood of condensation of moisture during conditioning. The heated mounting system is to be placed in the humidity chamber and conditioned for 48 h under the conditions specified in 56.1. Following the conditioning and while still in the chamber, the mounting system is to be tested unenergized as described in 55.7.

56.3 Either while the representative mounting system is still in the humidity chamber or immediately after it has been removed from the chamber, the representative mounting system is to be energized and tested as described in 55.7. The test is to be discontinued when the leakage current stabilizes or decreases.

57 Starting Current Test

57.1 A motor operated mounting system shall start and operate normally when loaded in accordance with Section 54, General, on a circuit protected by an ordinary – not time-delay – fuse having a current rating corresponding to that of the branch circuit to which the mounting system should be connected. The performance is unacceptable if the fuse opens or an overload protector provided as part of the mounting system trips.

Exception: The requirement concerning an ordinary fuse does not apply if the mounting system will start and operate normally on a circuit protected by a time-delay fuse and is marked in accordance with 74.2.

57.2 The mounting system is to be started three times at room temperature at the beginning of the test. Each start of the motor(s) is to be made under conditions representing the beginning of normal operation – the beginning of the normal operating cycle, in the case of an automatic mounting system – and the motor(s) is to be allowed to come to rest between successive starts.

58 Input Test

58.1 The current or wattage input to a mounting system shall not be more than 110 percent of the rated value when the mounting system is operated under the condition of maximum normal load as described in 59.10 – 59.12 as applicable and when connected to a supply circuit of maximum rated voltage and rated frequency.

58.2 For a mounting system having a single voltage rating, such as 115 V, maximum rated voltage is considered to be that single value of voltage. If the rating is given in terms of a range of voltages, such as 110 – 120 V, maximum rated voltage is considered to be the highest value of the range.

59 Temperature Test

59.1 A mounting system shall be tested as described in 59.2 – 59.12 and shall not reach a temperature at any point high enough to cause a risk of fire, to damage any materials in the mounting system, or to exceed the temperature rises specified in Table 59.1.

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

59.3 All values of temperature rise in Table 59.1 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).

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

59.5 A mounting system having a single frequency rating is to be tested at that frequency. A mounting system 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 mounting system rated 25 – 60 Hz or 50 – 60 Hz is to be tested on 60-Hz alternating current.

59.6 Ordinarily, coil or winding temperatures are to be measured by thermocouples unless the coil is inaccessible for mounting of these devices – for example, a coil immersed in sealing compound – or unless the coil wrap includes thermal insulation or more than two layers – 1/32 in (0.8 mm) maximum – of cotton, paper, rayon, or the like. For a thermocouple-measured temperature of a coil of an alternating-current motor, other than a universal motor, having a diameter of 7 in (178 mm) or less – items 7 and 9 in Table 59.1 – the thermocouple is to be mounted on the integrally applied insulation on the conductor.

Table 59.1
Maximum Temperature Rises

Material and component parts	°C	°F
1. Capacitors[b]:		
Electrolytic[a]	40	72
Other types	65	117
2. Fuses		
A. Class G, J, L, T, and CC		
Tube	100	180
Ferrule or blade	85	153
B. Other[h]	65	117
3. Fiber employed as electrical insulation	65	117
4. At any point within a terminal box or wiring compartment of a permanently connected appliance in which power-supply conductors are to be connected, including such conductors themselves, unless the appliance is marked in accordance with 78.1.	35	63
5. A surface upon which an appliance may be fastened in place, and surfaces that may be adjacent to the appliance when so fastened.	65	117

Table 59.1 Continued on Next Page

Table 59.1 Continued

	Material and component parts	°C	°F
6.	Class A insulation system on coil windings of an a-c motor having a diameter of more than 7 in (178 mm), of a d-c motor, and of a universal motor:[c,d]		
	A. In an open motor:		
	Thermocouple method	65	117
	Resistance method	75	135
	B. In a totally enclosed motor:		
	Thermocouple method	70	126
	Resistance method	80	144
7.	Class A insulation systems on coil windings of an a-c motor having a diameter of 7 in or less, not including a universal motor, and on a vibrator coil:[c,d]		
	A. In an open motor and on a vibrator coil:		
	Thermocouple or resistance method	75	135
	B. In a totally enclosed motor:		
	Thermocouple or resistance method	80	144
8.	Class B insulation systems on coil windings of an a-c motor having a frame diameter of more than 7 in, of a d-c motor, and of a universal motor:[c,d]		
	A. In an open motor:		
	Thermocouple method	85	153
	Resistance method	95	171
	B. In a totally enclosed motor:		
	Thermocouple method	90	162
	Resistance method	100	180
9.	Class B insulation system on coil windings or an a-c motor having a diameter of 7 in or less not including a universal motor:[c,d]		
	A. In an open motor:		
	Thermocouple or resistance method	95	171
	B. In a totally enclosed motor:		
	Thermocouple or resistance method	100	180
10.	Class 105 insulation systems on windings of a relay, a solenoid, and the like:[c]		
	Thermocouple method	65	117
	Resistance method	85	153
11.	Class 130 insulation systems on windings of a relay, a solenoid, and the like:[c]		
	Thermocouple method	85	153
	Resistance method	105	189
12.	Class 130 insulation systems on vibrator coils:		
	Thermocouple or resistance method	95	171
13.	Phenolic composition employed as electrical insulation or as a part the deterioration of which would result in a risk of fire or electric shock.[e]	125	225
14.	Rubber- or thermoplastic-insulated wire and cord.[e,f,g]	35	63
16.	Sealing compound	40°C (104°F) less than melting point	
17.	Varnished-cloth insulation	60	108
18.	Wood and other combustible material	65	117

Table 59.1 Continued on Next Page

Table 59.1 Continued

Material and component parts	°C	°F
19. Transformers with Class 105 insulation system:		
Thermocouple method	65	117
Resistance method	75	135

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

[b] A capacitor that operates at a temperature rise of more than 65°C may be judged on the basis of its marked temperature limit.

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

Item	Additional temperature rises	
Part A of item 6	15	27
Part A of item 7	5	9
Part A of item 8	20	36
Part A of item 9	10	18
10	15	27
11	15	27

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

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

[f] Rubber-insulated conductors within a Class-A-insulated motor, rubber-insulated motor leads, and a rubber-insulated flexible cord entering a motor may be subjected to a temperature rise of more than 35°C, provided that a braid is employed on the conductor of other than a flexible cord. However, this does not apply to thermoplastic-insulated wires or cords.

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

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

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

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

59.9 The mounting system shall be loaded in accordance with Section 54, General. Normally the maximum size apparatus the mount is intended to support is to be used. If there is a range of apparatus specified or multiple apparatus specified the mount is to be loaded in any combination that results in the maximum heating of the mounting system.

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

a) All convenience receptacle outlets and all electrical accessory loads shall be loaded to the full current marked rating of the accessory and receptacle outlet provided for use on the mounting system.

b) A mounting system with one axis of movement shall comply with the normal temperature test during and after 6 complete cycles of operation. A cycle is considered to be one extreme position to the opposite extreme position and back to the original position without rest. The current draw shall be monitored and the speed of operation adjusted (if user adjustable) to maximize the current draw to the motor(s).

c) A mounting system with more than one axis of movement shall comply with the normal temperature test during and after 6 complete cycles of operation. When cycling a multi-axis mounting system, each axis is to be cycled either individually or in combination, which ever operation is allowed by the control and results in the maximum temperature rise to the motor and components. A cycle is considered to be movement through each axis from one extreme to the other extreme and returning to the original position without rest. The current draw shall be monitored and the speed of operation adjusted (if user adjustable) to maximize the current draw to the motor(s).

59.11 Components of a mounting system that are not subject to intermittent operation as described in 59.10 are to be energized under normal operation 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.

59.12 Accessories shall be installed or removed for the normal temperature test which ever is determined to be the worse case condition for heating.

60 Dielectric Voltage-Withstand Test

60.1 Immediately following the temperature test while still in a heated condition a mounting system shall withstand for 1 minute without breakdown the application of a 60-Hz essentially sinusoidal potential between live parts and dead metal parts with the mounting system. The test potential for the primary circuit shall be:

a) 1000 volts for a mounting system employing a motor rated 1/2 hp (373 W output) or less and 250 V or less;

b) 1000 volts plus twice the rated voltage for a mounting system employing a motor rated more than 1/2 hp or more than 250 V; or

c) 2500 volts for a mounting system that is contacted by a person while in a wet or moist condition.

60.2 The test potential for the secondary circuit of a mounting system employing a transformer or autotransformer shall be:

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

b) 1000 volts if the secondary operates at 51 – 250 V; or

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

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

60.3 The test potential for the secondary circuit supplied by a Class 2 transformer, SELV or LPS circuit shall be 500 volts.

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

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

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

60.5 To determine whether a mounting system complies with the requirements in 60.1 – 60.4 the mounting system is to be tested by means of a 500 VA or larger transformer, having an output voltage that is essentially sinusoidal and can be varied. The applied potential is to be increased from zero until the required test value is reached and is to be held at that value for 1 min. The increase in the applied potential is to be at a substantially uniform rate and as rapid as consistent with its value being correctly indicated by a voltmeter.

60.6 With reference to the requirement in 60.5, a 500 VA or larger capacity transformer need not be used if the transformer is provided with a voltmeter to measure directly the applied output potential.

61 Strain Relief Test

61.1 The strain relief means provided on an attached flexible cord, when tested in accordance with 61.2, shall withstand for 1 minute without displacement a direct pull of 35 pounds (156 N) applied to the cord, with the connections within the mount disconnected. At the point of disconnection of the conductors, there shall be no movement of the cord indicating that connections were stressed.

61.2 A 35 pound (15.9 kg) weight is to be suspended on the cord and supported by the mounting system so that the strain relief means is stressed from any angle that the construction of the mount allows.

62 Push-Back Relief Test

62.1 To determine compliance with 43.3, a product shall be tested in accordance with 62.2.

62.2 The supply cord or lead is to be held 1 inch (25.4 mm) from the point where the cord or lead emerges from the product and is then to be pushed back into the product. The cord or lead is to be pushed back into the product in 1 inch (25.4 mm) increments until the cord buckles or the force to push the cord into the product exceeds 6 pounds-force (26.7 N). The supply cord or lead within the product is to be manipulated to determine compliance with 43.3.

63 Performance Requirements for Loads on the Output of a NEC Class 2, LPS or SELV Power Supply

63.1 Motors

63.1.1 If the running overload and locked rotor tests were conducted on the motor under the Standards for Overheating Protection for Motors, UL 2111, Impedance Protected Motors, UL 1004-2, Thermally Protected Motors, UL 1004-3, Industrial Control Equipment, UL 508, Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or the Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, and the testing is representative of the conditions in the end-use product, the tests do not need to be repeated.

63.1.2 Under overload, locked rotor, and other abnormal conditions, motors shall not cause a risk of fire due to excessive temperatures. There shall be no ignition (charring or discoloration is acceptable) of the cheesecloth and the maximum temperature [on the case of an enclosed motor or a winding of an open motor] shall not exceed 150°C (302°F) when subjected to the Temperature Test in Section 59. Single component faults within the motor controller circuit shall be considered in determining control limiting operating time.

Exception: For a mounting system that includes a control that positively and reliably limits the length of the time the mounting system is able to operate, the duration of the temperature test, both under normal and locked-rotor conditions, is able to be less than that specified in UL 1004-2 or UL 1004-3, and shall not be less than the time the mounting system is able to operate.

63.1.3 The case of an enclosed motor or the windings of an open motor shall be thermocoupled with a minimum of four thermocouples. The case, windings, or body of the motor, shall then be wrapped in two layers of cheesecloth. The risk of fire indicator (cheesecloth) is to be double-layered, bleached cheesecloth, running 16 – 15 square yards per pound (26 – 28 m^2/kg) per layer, and having a count of 32 by 28, that is, for any square inch there are 32 threads in one direction and 28 in the other direction (for any square centimeter, there are 13 threads in one direction and 11 threads in the other direction).

63.1.4 The Dielectric Voltage-Withstand Test, Section 60, shall be conducted immediately following the running overload test while still heated.

63.2 Running overload test

63.2.1 The running overload test shall be conducted by operating the motor under normal load and then increasing the load so that the current is increased to the point just below where the power supply or controller limits the current to the motor(s). Supply voltage shall be maintained at its original value.

63.2.2 There shall be no ignition (charring or discoloration is acceptable) of the cheesecloth and the maximum temperature [on the case of an enclosed motor or a winding of an open motor] shall not exceed 150°C (302°F).

63.2.3 The Dielectric Voltage-Withstand Test, Section 60, shall be conducted immediately following the running overload test while still heated.

63.3 Locked rotor test

63.3.1 The motor is operated at the voltage used in its application and with its rotor locked for 7 hours or until steady conditions are established. There shall be no ignition (charring or discoloration is acceptable) of the cheesecloth and the maximum temperature [on the case of an enclosed motor or a winding of an open motor] shall not exceed 150°C (302°F).

63.3.2 The Dielectric Voltage-Withstand Test, Section 60, shall be conducted immediately following the locked rotor test while still heated.

MECHANICAL PERFORMANCE TESTS

64 Mold Stress Test

64.1 A mounting system incorporating a thermoplastic material used to support or carry a load whose failure would result in a risk of fire, electric shock, or injury to persons in the mounting system shall withstand the temperature-stability conditions described in 64.2. Thermoplastic material shall not have any shrinkage, warpage, or other distortion of the polymeric materials, resulting in a risk of fire, electric shock, or injury to persons.

64.2 An unloaded representative mounting system and its accessories are to be placed in a full-draft circulating-air oven. The air temperature within the oven is to be maintained at 70°C (158°F) or 10°C higher than the temperature obtained during the temperature test for 7 hours. The mounting system and its accessories are to be allowed to cool to room temperature before conducting the Cycling Test for Articulating Mounts, Section 66, and the Mounting Securement Test, Section 67.

65 Impact Tests

65.1 Mount impact test (Plastic parts only)

65.1.1 A mounting system and its accessories shall be subject to the test described in 65.1.2, under a normal load. During the test, the mount and its accessories shall be assembled and mounted in accordance with the manufacturer's installation instructions. Adjustable and articulating mounts with adjustable tension devices, shall be adjusted to provide the maximum resistance to movement. The product shall not collapse, create a risk of fire, electric shock, or injury to persons when tested in accordance 65.1.2.

65.1.2 A wall or ceiling mount and its accessories employing thermoplastic materials as part of the supporting structure or securement means shall withstand a single impact of 2.5 ft-lb (3.4 J) without damage to the structure that results in non-compliance with the requirements in this standard. The impact force is to be applied to any part likely to cause the most damage of the wall or ceiling mount and its accessories. Upon conclusion of this test, the Cycling Test for Articulating Mounts, Section 66, shall be conducted.

65.1.3 The impact is to be obtained from a solid smooth steel sphere 2 inches (50.8 mm) in diameter that has a weight of approximately 1.18 lbs (0.54 kg). The sphere is to be allowed to fall freely from rest through the vertical distance required to cause it to strike the surface with the specified impact. As an alternate method, the sphere shall be allowed to swing as a pendulum through the vertical distance required to cause it to strike the surface with the specified impact, see Figure 65.1. To apply the required impact energy, the correct height is calculated by:

$$H = \frac{E}{M}$$

Where:

H is the vertical distance in feet

E is the impact energy in ft-lb

M is the weight in lbs

$$\left[h = \frac{E}{(g \times m)} \right]$$

Where:

h is the vertical distance in meters

E is the impact energy in Joules

g is the gravitational acceleration of 9.81 m/s^2

m is the mass of the steel ball in kilograms

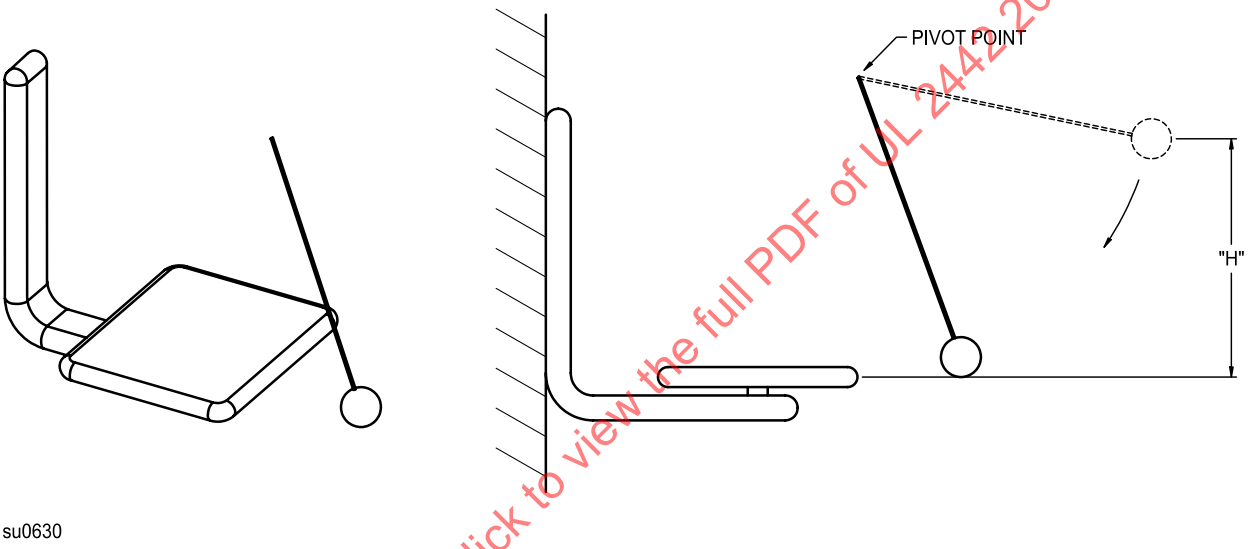
65.2 Electrical enclosure impact test

65.2.1 An enclosure or reservoir shall withstand a single impact of 5 ft-lb (6.8 J). The impact shall be applied as described in 65.2.2 to any area of the glass, except the edge.

65.2.2 A solid steel sphere 2 inches (51 mm) in diameter and weighing approximately 1.18 pounds (0.54 kg) is to fall, as in a pendulum, through a vertical distance of 50.85 inches (129.15 cm) to strike the surface with an impact of 5 ft-lb (6.8 J). The representative enclosure is to be supported by a mount or clamped in a position simulating intended use, see Figure 65.1.

Figure 65.1

Electrical Enclosure Impact Test Setup



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65.3 Glass parts – impact test

65.3.1 Structural glass parts shall comply with the requirements in the Impact Test, Section 65. Any glass part relied on for the mount to comply with the requirements in this Standard is to be evaluated as a structural glass part.

65.3.2 A decorative glass part having an area greater than 1 ft^2 (0.093 m^2) or having a major dimension greater than 18 inches (457 mm), shall not be broken, shattered (totally or in part), or displaced when tested as described in 65.3.3. A decorative glass part is any glass part not determined to be a structural part.

65.3.3 A decorative glass part shall withstand a single impact of 2.5 ft-lbf (3.39 N·m). The impact shall be applied as described in 65.1.3 to any area of the glass, except the edge.

65.3.4 Tempered glass parts with a minimum thickness of 3/16 inch (4.8 mm) are not required to be subjected to the Impact Test.

66 Cycling Test for Articulating Mounts

66.1 Following the Mount impact test, 65.1, an articulating mounting system and its accessories shall be constructed so there is no collapse, permanent damage, loosening of hinges or fasteners resulting in a risk of fire, electric shock, or injury to persons during or after the cycling test. The mount shall be installed according to the instructions provided with the mount. All threaded fasteners that may be affected by intended use movement shall be torqued to specifications. All movement tension adjustments shall be adjusted as recommended by the instructions provided.

66.2 To determine compliance with 66.1, regarding the risk of fire and electric shock, the spacings of an articulating mounting system and its accessories shall comply with Section 17, Electrical Spacings, after cycling, and the mounting systems electrical system shall comply with the Dielectric Voltage-Withstand Test, Section 60, after cycling.

Exception: Electrical systems supplied by a Class 2 or LPS power source and posing no risk of injury from failure to operate are not required to comply with the dielectric voltage-withstand test after cycling.

66.3 A manually articulating mount shall be subjected to 6000 cycles of operation as defined in 66.7 and 66.8. A motor operated articulating mounting system shall be subjected to 25,000 cycles of operation as defined in 66.7 and 66.8. Threaded fasteners and tension adjustments shall not be adjusted during the cycling test except as specified in 66.4.

66.4 A manually articulating mount shall complete 500 cycles minimum. If after each 500 cycles, the mount will no longer articulate when manually manipulated and does not cause a risk of fire or injury to persons, threaded fasteners or tension adjusters shall be readjusted and the cycling completed. If after adjustment, the mount will no longer articulate when attempting to manipulate manually and does not cause a risk of fire or injury to persons, the cycle test shall be concluded.

66.5 During the cycling test, an articulating mounting system shall be loaded as specified in General, Section 54.

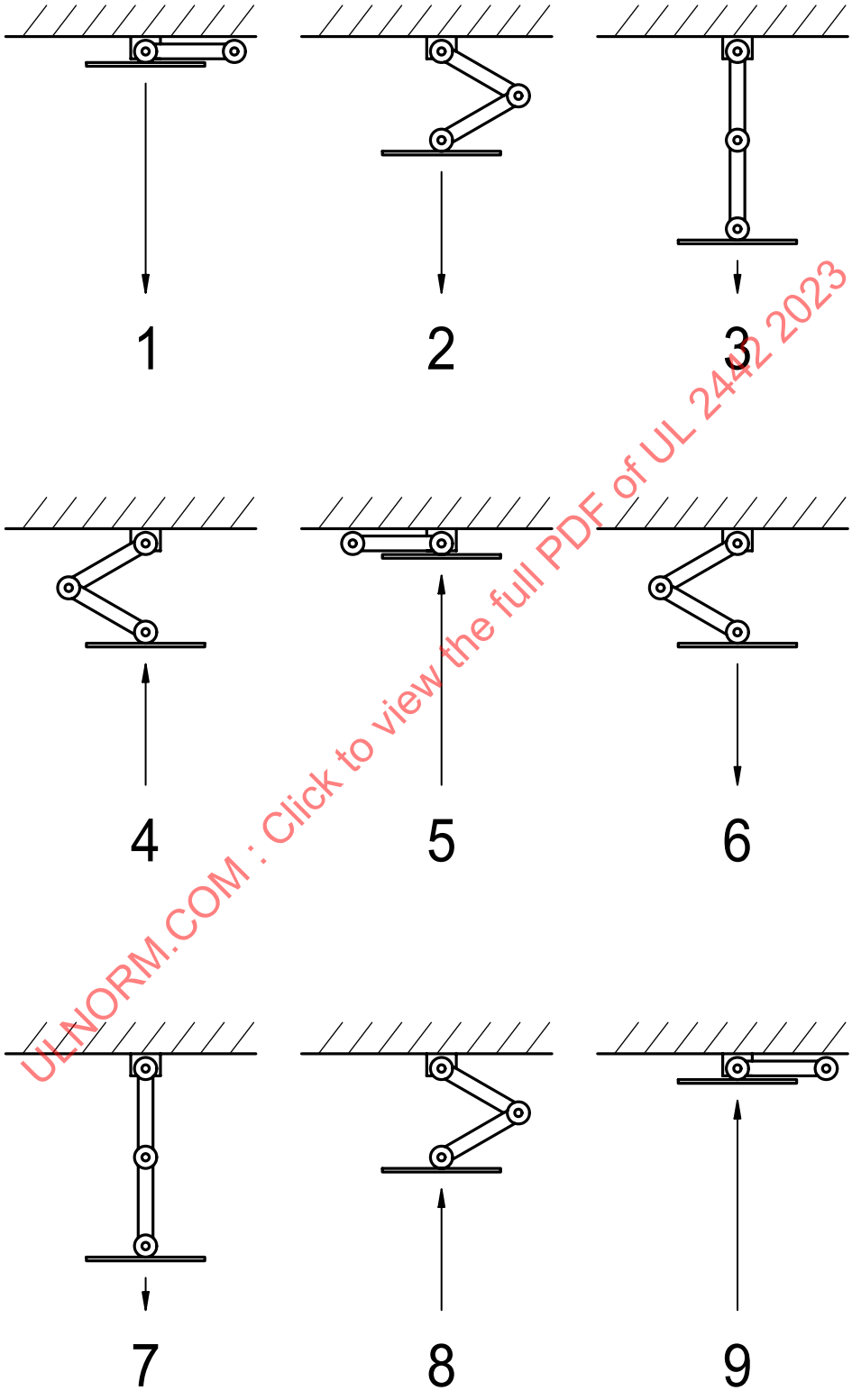
66.6 For a mounting system that is obviously not intended for continuous operation, the probable intermittent or short-time operation of the mounting system is to be taken into consideration when conducting the cycling test. The tests shall be conducted in accordance with 66.7 and 66.8.

66.7 A mounting system with one axis of movement shall be cycled as required by 66.3. A cycle is considered to be one extreme position to the opposite extreme position and back to the original position without rest. When determined that failure of the pivot, joint, or both, of the axis would not create a risk of fire, electric shock, or injury to persons, the design shall be considered as complying with this requirement without test.

66.8 A mounting system with more than one axis of movement shall be cycled as required by 66.3. When cycling a multi axis mounting system each axis is to be cycled either individually or in combination, whichever operation is allowed by the control and results in each axis being cycled the 6000 or 25,000 cycles. A cycle is considered to be one extreme position to the opposite extreme position and back to the original position without rest. See Figure 66.1 as an example of cycling a two axis double pivot design. In applying cycling test requirements, specific pivots and joints of an axis whose failure would not create a risk of fire, electric shock, or injury to persons shall be considered as complying with the requirement without test.

Figure 66.1

One Cycle of a Two Axis Double Pivot Design



66.9 During and after the tests specified in 66.7 and 66.8, the simulated apparatus shall remain stable and secured to the mount by the mechanical securement required by 49.2. The securement shall not allow the simulated apparatus to begin to tilt, tip or separate from the mounting surface to which it is secured.

66.10 Following the tests specified in 66.7 and 66.8, the mount shall not create a risk of fire, electric shock, or injury to persons.

66.11 Fasteners shall not loosen or become disassembled in a manner that would create a risk of fire, electric shock, or injury to persons.

66.12 Fasteners and/or tension adjustments of movable mounts shall not tighten to a degree that the intended movement would cause damage to the mount or mount securement or create a risk of fire, electric shock, or injury to persons.

66.13 When parts of a mounting system and its accessories are secured by adhesives and adhesives are relied upon for structural integrity, risk of fire, electric shock, or injury to persons, the cycling test shall be conducted after the Adhesive Test, Section 68.

67 Mounting Securement Test

67.1 Supporting structures

67.1.1 Masonry anchors (insert type) for vertical or horizontal supporting members

67.1.1.1 Masonry anchors are to be installed in accordance with the manufacturer's instructions for performance tests in concrete mounting samples with at least 3 inches (76 mm) around the edge of the mount wall plate when installed. The concrete thickness shall be at least 5.5 inches (140 mm) thick.

67.1.1.2 Whenever referee concrete is necessary, it shall be made from a mixture of one part Portland cement, two parts torpedo sand, and four parts crushed limestone or gravel, or of a mixture of these proportioned so that the 28 day compressive strength is from 2500 to 3000 psi (17.2 to 20.7 MPa) when tested in accordance with the Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM C39, or equivalent.

67.1.1.3 Whenever concrete block referee block is necessary, it shall comply with the Standard Specification for Loadbearing Concrete Masonry Units, ASTM C90.

67.1.1.4 Whenever clay brick referee material is necessary, it shall comply with the Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale), ASTM C216.

67.1.1.5 Following the installation of the test anchors in the concrete, the mounting system is to be secured to the anchors in accordance with the manufacturer's instructions. The mounting system is then subjected to the required loading as specified in 67.2.1 and 67.2.2.

67.1.2 Anchors/fasteners (manual and power-driven) for vertical or horizontal supporting members

67.1.2.1 Concrete anchors/fasteners including power-driven fasteners are to be driven into the concrete mounting samples according to the manufacturer's instructions. Following installation of test anchors in the concrete, each assembly is to be secured and subjected to the required loading as specified in 67.2.1 and 67.2.2.

67.1.2.2 Whenever referee concrete is necessary, it shall be made from a mixture of one part Portland cement, two parts torpedo sand, and four parts crushed limestone or gravel, or of a mixture of these proportioned so that the 28 day compressive strength is from 2500 to 3000 psi (17.2 to 20.7 MPa) or equivalent.

67.1.2.3 Representative fasteners intended for use in structural steel are to be driven into steel having thickness(es) recommended by the manufacturer. The structural steel shall have hardness values (Brinnell) of not less than 160 nor more than 240.

67.1.2.4 Each representative fastener shall be installed according to the manufacturer's instructions. The steel and fastener assembly is then to be subjected to the required loading as specified in 67.2.1 and 67.2.2.

67.1.3 Wood stud (vertical supporting member) anchoring

67.1.3.1 The mounting system manufacturer shall specify the minimum acceptable wall system to which the mounting system is intended to mount. The minimum stud size (such as 2 by 4 or 2 by 6), the minimum and maximum stud spacing, and the maximum specified wall covering thickness (such as Gypsum drywall, lath, and plaster) shall be used for the test. The wood studs shall be graded in accordance with the American Softwood Lumber Standard No. PS 20 and shall be Grade No. 2.

67.1.3.2 For a typical 2 by 4 or 2 by 6 wood stud, the fastening means used to secure the mounting system to the wood studs shall be secured to the thin edge of the stud, the 1-1/2 inch (38 mm) width. The assembly is then to be subjected to the required loading as specified in 67.2.1 and 67.2.2.

67.1.4 Steel studs (vertical supporting member)

67.1.4.1 The mounting system manufacturer shall specify the minimum acceptable wall system to which the mounting system is intended to mount. The minimum stud size (such as 2 by 4 or 2 by 6), the minimum and maximum stud spacing, and the minimum specified wall covering thickness (such as Gypsum drywall, lath, and plaster) shall be used for the test. Gypsum wallboard shall be standard non-fire-rated, secured to the studs with screws 12 inches (305 mm) on center. The steel studs shall be 0.018 inch (25 Gauge) thick and comply to the North American Specification for the Design of Cold-Formed Steel Structural Members, AISI S100 or AISI S211 requirements.

67.1.4.2 For a typical 2 by 4 or 2 by 6 steel stud, the fastening means used to secure the mounting system to the steel studs shall be secured to the thin edge of the stud, the 1-1/2 inch (38 mm) width. The assembly is then to be subjected to the required loading as specified in 67.2.1 and 67.2.2.

67.1.5 Structural steel beams and columns (vertical or horizontal supporting member)

67.1.5.1 The mounting system manufacturer shall specify the minimum acceptable structural member by web width and thickness for structural steel. The minimum diameter and thickness of round columns shall be specified.

67.1.5.2 Clamping type fasteners shall be supplied by the mounting system manufacturer or specified by minimum materials and design specifics or identified by specific catalog or part number.

67.1.5.3 When a fastener is intended to be inserted into or through structural steel building members, a self-tapping or self-threading fastener shall be used in shear, not in tension.

67.1.5.4 The mount is to be installed to the vertical or horizontal structural steel beam or column with the minimum size and quantity of fasteners recommended by the mounting system manufacturer. The assembly is then to be subjected to the required loading as specified in 67.2.1 and 67.2.2.

67.1.6 Wood beams, joists and rafters (horizontal supporting member)

67.1.6.1 The mounting system manufacturer shall specify the minimum acceptable wood framing member(s) to which the mounting system is intended to mount. The minimum size (such as 2 by 6 or 2 by 8), the minimum and maximum joist spacing, and the maximum specified wall covering thickness (such as Gypsum drywall, lath, and plaster) shall be used for the test. Unless specified by the manufacturer, the wood joists shall be graded in accordance with the American Softwood Lumber Standard No. PS 20 and shall be Grade No. 2.

67.1.6.2 If a ceiling supported mount is not evaluated and intended to be supported by manufactured trusses of less than 2" nominal 1-1/2 inch (38 mm) width, the instructions shall include a statement instructing the installer to provide additional structural framing above the ceiling to accommodate installation in truss constructed ceiling/roof assemblies.

67.1.6.3 For a typical 2 by 6 wood joist, the fastening means used to secure the mounting system to the wood shall be secured to the thin edge of the joist, the 1-1/2 inch (38 mm) width. The assembly is then to be subjected to the required loading as specified in 67.2.1 and 67.2.2.

67.1.7 Proprietary metal framing (vertical or horizontal supporting member)

67.1.7.1 The mounting system manufacturer shall supply or specify the specific clamps or hinges to attach to proprietary metal framing members. The mount is to attached to the proprietary metal framing by the method(s) recommended with the framing in either or both vertical and horizontal and the assembly is then to be subjected to the required loading as specified in 67.2.1 and 67.2.2.

67.2 Test procedure

67.2.1 Following the Mount impact test, 65.1, a mounting system and its accessories shall be constructed so there is no cracking, bending, distortion, or similar damage, to the mounting bracket, securement means, supporting structure, or any combination thereof, to the point where the product collapses and creates a risk of fire, electric shock, or injury to persons when tested in accordance with 67.2.2 and 67.2.3.

67.2.2 Each shelf, platform, and mounting bracket and associated accessories is to be separately and concurrently loaded for a period of 5 minutes with the following load:

a) Four times (4X) the load specified in Section 54, General, when the individual supporting surface type is 100 pounds (45.36 kG) or less, or

b) Two times plus 200 pounds (2x + 200 lbs) (2x + 90.72 kG) when the individual supporting surface type is greater than 100 pounds. A specified load greater than 100 pounds shall be not less than 105 pounds (47.6 kG).

67.2.3 Adjustable and articulating mounts shall be tested in all positions necessary to determine compliance to 67.2.1. When testing a mount in more than one position is considered necessary, a new representative mount may be used for each test position.

67.2.4 When the supporting structure, securement means, or both, of the mounting system are constructed of a thermoplastic material, the Mounting Securement Test shall be conducted after the Mold Stress Test, Section 64.

67.2.5 When parts of a mounting system and its accessories are secured by adhesives and adhesives are relied upon for structural integrity, risk of fire, electric shock, or injury to persons, the mounting securement test shall be conducted after the Adhesive Test, Section 68.

68 Adhesive Test

68.1 Parts of a mounting system and its accessories secured by adhesives and relied upon for structural integrity, risk of fire, electric shock, or injury to persons, shall withstand the conditioning described in 68.2. After the conditioning, the adhesive shall not deteriorate to the extent that the mount and its accessories no longer comply with the requirements of this standard. Upon conclusion of this test, the Mounting Securement Test, Section 67, shall be repeated.

68.2 Two representative mounting systems shall be conditioned as follows:

a) One mount shall be placed in an air-circulating oven for: 7 days at 100 ±1.0°C (212 ±1.8°F), or 16 days at 90 ±1.0°C (194 ±1.8°F) or 21 days at 87 ±1.0°C (188 ±1.8°F) or 60 days at 82 ±1.0°C (179 ±1.8°F); and

b) One mount shall be conditioned for 7 days in an environment of 85 ±5 percent relative humidity at 32.0 ±2.0°C (89.6 ±3.6°F).

69 Sharp Edge Test

69.1 To determine compliance with Section 48, Sharp Edges, the sharp-edge tester is to be applied to the edge in accordance with the requirements in the Standard for Test for Sharpness of Edges on Equipment, UL 1439. The edge shall be considered to not comply with the requirements if the sensing tapes – the two outer layers – are cut through as a result of the application of the tester.

69.2 The edges to be subjected to the test specified in 69.1 are those contacted during normal use or user/installer assembly.

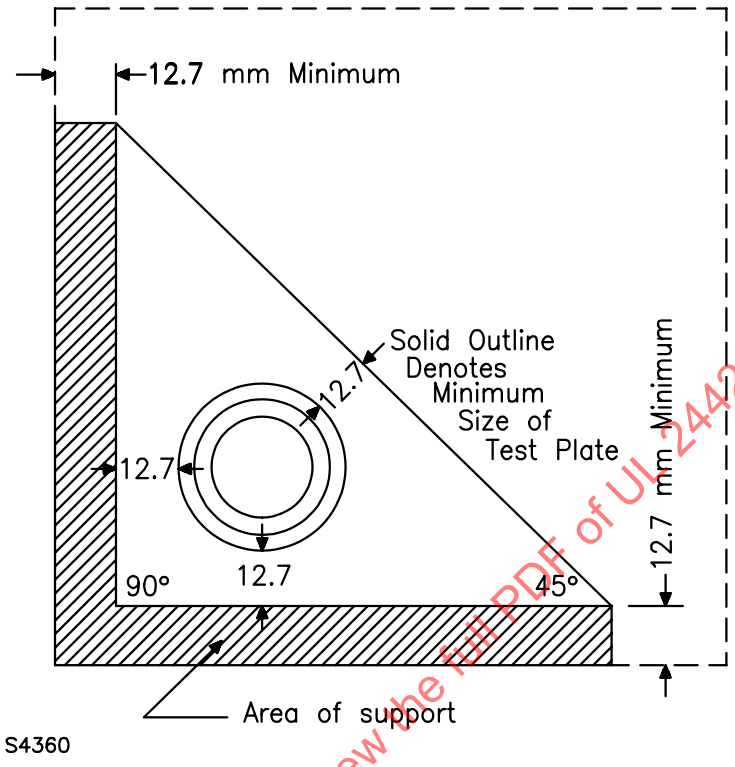
70 Multiple Knockouts Test

70.1 This clause provides test requirements to determine that a combination consisting of an inner knockout surrounded by additional rings has been manufactured such that when one or more of its elements are removed there will be no change to the remaining rings, if any, or to the enclosure in which the combination is located, either during the removal or when conduit has been properly secured in place.

70.2 Samples for testing shall be in the form of either complete enclosures or sample plates that fulfill the requirements of Figure 70.1.

Figure 70.1

Diagram of Test Plate



70.3 With a sample enclosure securely held or a test plate supported as in Figure 70.1, the following tests shall be applied:

a) The knockout shall remain in place when subjected to a load of 44 N (9.9 pounds) steadily applied for not less than 1 minute normal to the face of the plate by means of a mandrel with a 6.35 mm (1/4 inch) diameter flat end. The mandrel shall be applied at the point most liable to cause movement of the knockout in the direction in which it was originally punched; and

b) A load of 220 N (49.4 pounds) shall be steadily applied for not less than 1 minute, first in compression and second in tension, through a conduit properly installed in the knockout opening. When this test is being conducted, the conduit shall not be more than 5 degrees from the normal to the surface. There shall be no appreciable distortion of the rings or fracture of the ties.

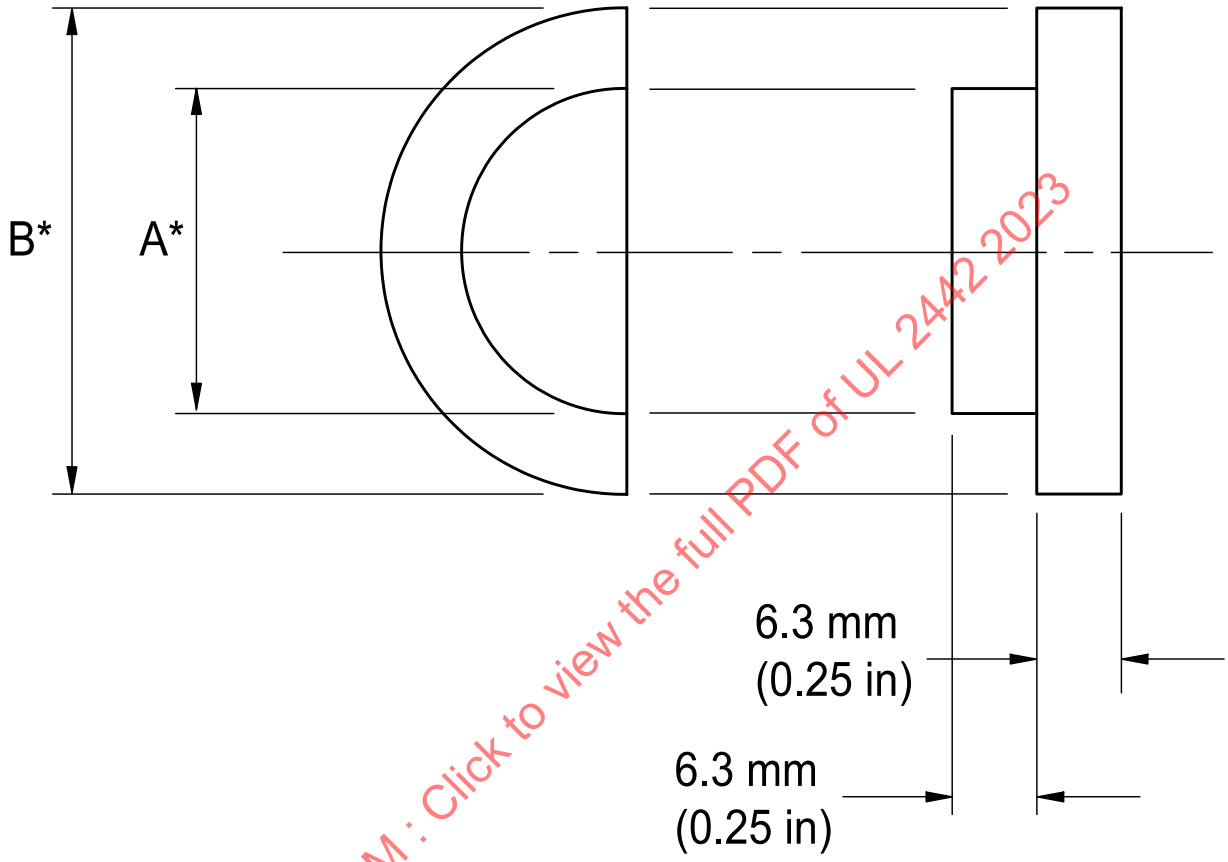
71 Flat Areas Surrounding Knockouts

71.1 With reference to 53.2.1 compliance of the flat surface that surrounds the knockouts near a radius shall be determined using a test gauge, as shown in Figure 71.1. To apply the test gauge, a knockout from each side of one enclosure shall be removed and, when required, the remaining tab shall be filed or ground flush with the inside and outside surface of the enclosure as well as at the edge surrounding the opening. An appropriate trade size test gauge shall be used, offset from the center of the knockout in a direction opposite to the area to be tested. When testing knockouts located adjacent to an enclosure radius, a steel feeler gauge, 0.005 in (0.13 mm) thick and 0.10 in (2.5 mm) wide, shall be used to verify the space between the inner enclosure surface and the flat surface of the test gauge, as shown in Figure 71.2. The test gauge shall not be canted or tilted to make the required contact with the surface of the enclosure. Successful insertion of the steel feeler gauge between the enclosure surface and the test gauge surface

verifies that the enclosure's corner radius encroaches on the required flat surface and that the enclosure is not in compliance.

Figure 71.1

Method for Checking Flat Surfaces Surrounding a Knockout near a Radius



*Tolerance ±0.030 mm (±0.001 in)

su0397

	Dimension A*	Dimension B*
Trade size of conduit or tubing (metric designator)	Nominal outside diameter of conduit, in (mm)	Dimension A plus twice width of flat surface area of Table 53.1, in (mm)
1/2 (16)	0.840 (21.3)	1.11 (28.1)
3/4 (21)	1.050 (26.7)	1.34 (34.0)

Figure 71.2

Method of Checking Flat Surfaces