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UL 111

Outline of Investigation for Multioutlet Assemblies

Issue Number: 4

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Summary of Topics

This Fourth Issue of the Outline of Investigation for Multioutlet Assemblies, UL 111, covers the revision of the Low Temperature Handling Test to match the criteria of the Mold Stress, Crush, and Cold Impact Tests.

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PART I – ALL MULTIOUTLET ASSEMBLIES

INTRODUCTION

1 Scope

1.1 These requirements cover Multioutlet Assemblies and factory assembled wiring kits for installation in Multioutlet Assemblies. Multioutlet Assemblies consist of a raceway, multiple outlet wiring devices that provide power for connection of utilization equipment and are intended for use in dry locations, other than hazardous (classified) in accordance with the National Electrical Code, NFPA 70. Multioutlet Assemblies are intended to be connected to permanently installed branch circuits operating at frequencies between 50 – 400 Hz and DC (Direct Current) circuits.

1.2 This outline does not cover devices that incorporate GFCI receptacles only. These devices are covered by the Standard for Ground Fault Circuit Interrupters, UL 943.

1.3 Multioutlet Assemblies may be provided with fuses or other supplementary overcurrent protection, switches, suppression components, EMI filters, luminaires, ballasts, motors, control circuits, transformers, relays, indicator lights and other similar equipment.

1.4 A Multioutlet Assembly may be provided with channels for additional power circuits, control circuits, power limited circuits and communication circuit wiring for audio, video and data.

1.5 These requirements cover branch circuits contained within the Multioutlet Assembly operating at potentials not exceeding 600 volts between conductors and operating at 60 amperes or less per circuit.

1.6 For a Multioutlet Assembly that employs an electromagnetic interference filter or a surge protective device, these elements of the assembly shall comply with the performance and marking requirements of the Standard for Electromagnetic Interference Filters, UL 1283, and/or with the Standard for Surge Protective Devices, UL 1449.

1.7 Telephone equipment and communication circuit protectors included in a Multioutlet Assembly shall comply with the requirements in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, and the requirements in the Standard for Secondary Protectors for Communications Circuits, UL 497A, respectively.

1.8 For a Multioutlet Assembly that incorporates an antenna discharge unit or provides antenna connections to a television, a high-voltage video product, or antenna, these elements of the Multioutlet Assembly 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.

1.9 This outline does not cover cord and plug connected outlet assemblies. These assemblies are covered by the Standard for Relocatable Power Taps, UL 1363 or the Standard for Furniture Power Distribution Units, UL 962A.

1.10 This outline does not cover Multioutlet Assemblies intended for use with medical equipment. Medical equipment is typically intended for use in General Patient Care Areas or Critical Patient Care Areas as defined by Article 517 of the National Electrical Code for Health Care Facilities. Multioutlet Assemblies intended for such use shall comply with the requirements of the Standard for Medical Electrical Equipment, Part 1: General Requirements for Safety, UL 60601-1 and the Standard for Requirements for Medical Electrical Systems, IEC 60601-1-1.

1.11 These requirements do not cover surface metal raceways or surface nonmetallic raceways. These products are evaluated to the Standard for Surface Metal Raceways and Fittings, UL 5 and the Standard for Nonmetallic Surface Raceways and Fittings, UL 5A, respectively.

2 General

2.1 Components

2.1.1 Except as indicated in 2.1.2, a component of a product covered by this outline shall comply with the requirements for that component. See Appendix A for a list of standards covering components used in the products covered by this outline.

2.1.2 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 outline, or
- b) Is superseded by a requirement in this outline.

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

2.1.4 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.

2.1.5 Surface raceways and fittings utilized in the construction of a Multioutlet Assembly shall comply with the Standard for Surface Metal Raceways and Fittings, UL 5 or the Standard for Nonmetallic Surface Raceways and Fittings, UL 5A as appropriate for the material employed.

2.1.6 An outlet receptacle used in a multioutlet assembly shall be of the grounding type and comply with the Standard for Attachment Plugs and Receptacles, UL 498, when used as a component of a Multioutlet Assembly.

2.1.7 A Pin and sleeve type receptacle used in a Multioutlet Assembly shall be of the grounding type and comply with the Standard for Plugs, Receptacles and Cable Connectors of the Pin-and-Sleeve Type, UL 1682.

2.1.8 A multipole splicing wire connector that is intended to be mated or unmated during field installation shall comply with either;

- a) The Standard for Manufactured Wiring Systems, UL 183, or
- b) The Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459, or
- c) The Outline of Investigation for Multi-Point Interconnection Power Cable Assemblies For Industrial Machinery, UL 2237, or
- d) The Standard for Cable Assemblies and Fittings for Industrial Control and Signal Distribution, UL 2238.

2.1.9 A sign that is mechanically attached to a Multioutlet Assembly shall comply with the Standard for Electric Signs, UL 48.

2.1.10 A luminaire that is mechanically attached to a Multioutlet Assembly shall comply with the Standard for Luminaires, UL 1598.

2.1.11 A low voltage luminaire that is mechanically attached to a Multioutlet Assembly shall comply with Standard for Low Voltage Lighting Systems, UL 2108.

2.1.12 A light emitting diode luminaire that is mechanically attached to a Multioutlet Assembly shall comply with the basic standard for that luminaire type and the Standard for Light Emitting Diode (LED) Equipment For Use In Lighting Products, UL 8750.

2.2 Units of measurement

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

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

2.3 Undated References

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

3 Glossary

3.1 For the purposes of this outline the following definitions apply:

3.2 ACCESSORY – A part that may be added to a Multioutlet Assembly for a special purpose or to add functionality (for example: hangers, retainers, luminaries, remote control modules, signs, etc.).

3.3 BONDED (BONDING) – The permanent joining of normally non-current carrying metallic parts to form an electrically conductive path that provides electrical continuity and the capacity to conduct the maximum ground fault current likely to be imposed without a risk of electric shock, fire, or injury to persons.

3.4 BONDING JUMPER – A conductor that insures the required electrical conductivity between metal parts required to be electrically connected.

3.5 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 by:

- 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;
- c) A dry-cell battery having output characteristics not greater than those of an inherently-limited Class 2 transformer;

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d) Any combination of (a), (b), and (c) that together comply with the performance requirements for an inherently-limited Class 2 transformer; or

e) Combination of a Class 2 transformer and an overcurrent protective device that together comply with the performance requirements for a noninherently-limited Class 2 transformer.

A circuit derived from a line-connected circuit by connecting impedance in series with the supply circuit as a means of limiting the voltage and current is not considered to be a Class 2 circuit.

3.6 COMBINATION MULTIOUTLET ASSEMBLIES – A Multioutlet Assembly that is provided with or has provision to install both power and communication circuits and may be connected to a combination raceway system.

3.7 EQUIPMENT-GROUNDING CONDUCTOR – The conductor used to connect normally non-current-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system.

3.8 GROUND – A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth.

3.9 GROUNDED – Connected to earth or to some conducting body that serves in place of earth.

3.10 GROUNDED CONDUCTOR – A system or circuit conductor that is intentionally grounded.

3.11 LIMITED - POWER CIRCUIT (LPS) – For the purpose of these requirements, LPS is considered equivalent to a Class 2 Circuit.

3.12 MULTIOUTLET ASSEMBLY – A raceway forming an enclosure intended for permanent connection to the branch circuit supply wiring for the purpose of supplying power to utilization equipment. A Multioutlet Assembly is provided with at least two outlets for connection of utilization equipment.

Type A – A Multioutlet Assembly that provides all the required parts, incorporates factory pre-wired power conductors to the wiring devices and accessories. The field wiring connection consists of one of the following: conduit whip, armored cable, manufactured wiring system, office furnishing wiring system, pigtail lead, a terminal block or is intended to terminate on installed device wiring terminals. Pre-wired communication wiring may be provided. No additional unwired raceways for power or communication conductors are provided. No field wired accessories are provided for the system.

Type A1 – Identical to a Type A Multioutlet Assembly except additional unwired raceways for power and/or communication conductors may be provided or accessories may be provided with the system but are not pre-wired and installed at the factory.

Type B – A Multioutlet Assembly that provides for the installation, routing and termination of the branch circuit conductor wiring within the Multioutlet Assembly in the field. Wiring devices, fittings and accessories are provided with the system but are not pre-wired and installed at the factory.

Type C – A Multioutlet Assembly that does not include factory installed conductors, wiring devices, or accessories, but has factory provided openings for wiring devices or accessories. The Multioutlet Assembly is marked for use with the specific kit(s) that may be shipped with the Multioutlet Assembly or shipped separately from the Multioutlet Assembly for field installation.

3.13 **MULTIOUTLET ASSEMBLY FITTING** – A part used to connect, change direction, or terminate a Multioutlet Assembly (for example, a transition coupler, an end cap, a corner, a tee, an adapter, or a box) or a specific wiring device that completes the system.

3.14 **OUTLET** – A point on the wiring system at which current is taken to supply utilization equipment.

3.15 **OVERCURRENT PROTECTION (OCP) DEVICE** – A supplementary protection device provided within a Multioutlet Assembly that provides overload and short-circuit protection. It is not intended to be a substitute for branch circuit protection.

3.16 **POWER POLE** – A Multioutlet Assembly that is installed in a vertical or nearly vertical orientation and typically is supported at the base and top but may have intermediate support(s).

3.17 **RECEPTACLE** – A receptacle is a contact device installed at the outlet for the connection of an attachment plug.

3.18 **RECEPTACLE OUTLET** – An outlet where one or more receptacles are installed.

3.19 **SUPPLEMENTARY PROTECTION DEVICE** – A device intended for use as overcurrent, overtemperature, or over- or under-voltage protection within a Multioutlet Assembly where branch circuit overcurrent protection is already provided.

3.20 **THROUGH-WIRING** – An extension of the branch circuit within the Multioutlet Assembly to supply the branch circuit wiring of another Multioutlet Assembly, raceway, conduit, enclosure or outlet device.

3.21 **WIRING DEVICE** – Part of an electrical system intended to provide a means of connection to, or provide control of a Multioutlet Assembly system (for example, switches and receptacles).

3.22 **WORK SURFACE** – A horizontal or nearly horizontal surface used to perform tasks.

a) Normally dry use work area surface (example: office desk, table)

b) Normally dry use work area located directly adjacent to a lavatory or other water source (example: kitchen sink counter).

CONSTRUCTION

4 General

4.1 A Multioutlet Assembly shall comply with the construction and performance requirements without resulting in a risk of fire, electric shock, or injury to persons.

4.2 A surface mounted Multioutlet Assembly and the fittings that comply with the Standard for Surface Metal Raceways and Fittings, UL 5, or the Standard for Nonmetallic Surface Raceways and Fittings, UL 5A, comply with the enclosure requirements of this outline unless modified. Addition of accessories, the installation of devices, conductors, circuits, splices, etc. in or on the raceway shall meet the requirements of this outline.

4.3 Type A, A1, B, and C Multioutlet Assembly systems shall be constructed to facilitate compliance with the requirements for the installation of insulated wires and cables as specified in the National Electrical Code, NFPA 70.

4.4 Each component of a Multioutlet Assembly system shall comply with the requirements for the construction, performance, and use of that component.

4.5 A Multioutlet Assembly shall consist of one or more pieces formed and constructed to make the Multioutlet Assembly readily distinguishable from electrical conduit, electrical metallic tubing and electrical nonmetallic tubing.

4.6 The Multioutlet Assembly shall provide a complete enclosure that protects the conductors and devices installed therein against damage. To accomplish this, each of the following shall apply:

a) There shall not be any openings that exceed 1.59 mm (1/16 in) in width on surfaces that are accessible when the Multioutlet Assembly is installed as intended. Type B and C Multioutlet Assemblies are investigated with devices and wiring kits installed.

b) A knockout or break-away tab shall completely cover the opening in which it is located, and the clearance between the knockout or break-away tab and the opening shall not be more than 0.76 mm (0.030 in).

Exception: Type A1, B and C Multioutlet Assemblies intended for use with accessories and/or wiring kits shall comply with Section 9 or 10 respectively.

c) Mounting holes having a maximum diameter of 7.1 mm (9/32 in), or slotted openings for mounting of one dimension not larger than 15.9 mm (5/8 in) and the other dimension not larger than 3.2 mm (1/8 in), provided on the Multioutlet Assembly base or fitting base surface that is installed flush with the mounting surface, are not prohibited.

4.7 The interior surface of the Multioutlet Assembly system shall have a smooth finish free from projections, sharp edges, burrs or fins and shall not constitute a risk of injury to persons during installation, maintenance and use when investigated in accordance with the Standard for Test for Sharpness of Edges on Equipment, UL 1439.

4.8 For Multioutlet Assemblies using conductors larger than 6 AWG (13.30 mm²), the Short Circuit Test, Section 27, shall be performed on conductors in the Multioutlet Assembly to determine whether the cover is secure under fault conditions.

4.9 Multioutlet Assembly covers shall be constructed such that the use of a tool (such as the prying action of a screwdriver) or two simultaneous deliberate actions are necessary for their removal and for gaining access to internal areas of the Multioutlet Assembly after installation.

4.10 Multioutlet Assemblies incorporating raceways and fittings that do not enclose or come in contact with any circuit connected to a branch circuit power source and are intended solely for mechanical protection and routing of Class 2, data, signal, and control circuits shall comply with the requirements of the Standard for Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits, UL 5C and shall be marked in accordance with 35.1.12.

4.11 A metallic Multioutlet Assembly shall comply with the National Electrical Code, NFPA 70, for the number of conductors and cables in a Surface Metal Raceway intended for field installed conductors and marked in accordance with 35.1.11.

Exception: Type A, or C Multioutlet Assemblies are not required to comply with this requirement when subjected to the Temperature Test, Section 28.

4.12 A non metallic Multioutlet Assembly shall be subjected to the Temperature Test, Section 28, or comply with the Standard for Nonmetallic Surface Raceways and Fittings, UL 5A, with all installed components and accessories.

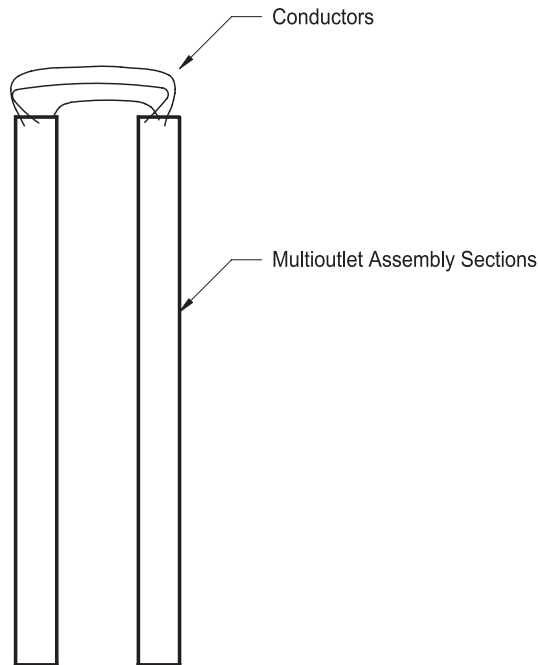
4.13 A Multioutlet Assembly shall be provided with barriers or compartments that separate Class 2 or communication circuits and conductors from power or Class 1 circuits and conductors. Each compartment intended for field wiring shall be marked in accordance with 35.1.11 and/or 35.1.12 as appropriate for the Multioutlet Assembly.

5 Assembly

5.1 A Type A or A1 Multioutlet Assembly shall be wired with all splices and electrical connections completed to the electrical components installed in the Multioutlet Assembly before the Multioutlet Assembly leaves the factory. Additional non factory wired raceways may be provided with Type A1 Multioutlet Assemblies. The Multioutlet Assembly itself is not prohibited from being shipped as subassemblies. When shipped as subassemblies the subassemblies shall be marked as indicated in 35.1.22.

5.2 When conductors pass through a joint between sections of a Multioutlet Assembly that are separable for shipping purposes, the joint shall be such that if rotated to assemble the sections the rotation of one section with respect to the other during the assembly of the sections is limited to not more than 360 degrees. Friction alone does not meet the intent of the requirement to prevent rotation. Refer to Figure 5.1.

Figure 5.1
Conductors passing through a joint separated for shipping



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5.3 Sections of a Multioutlet Assembly that are not factory wired between sections to allow for shipping shall be provided with a provision for splicing the conductors. One or more of the following methods shall be used:

- a) There shall be at least 6 inches of conductor length available to extend from each section of the Multioutlet Assembly. There shall be adequate space to apply a suitable splicing wire connector and insulation appropriate to the voltage for each conductor;
- b) A suitable field wiring terminal block shall be provided in one or both sections. Spacings and separation of circuits shall be maintained with and without the field installed conductors;
- c) Connectors that comply with the Standard for Manufactured Wiring Systems, UL 183;
- d) Connectors that comply with the Standard for Insulated Multi-Pole Splicing Wire Connectors, UL 2459. The multipole splicing connector shall be enclosed when the final assembly is completed;
- e) Connectors that comply with the Standard for Wire Connectors, UL 486A-486B, the Standard for Splicing Wire Connectors, UL 486C or the Standard for Electrical Quick-Connect Terminals, UL 310. The connectors shall be enclosed when the final assembly is completed;
- f) Connectors that comply with the Standard for Grounding and Bonding Equipment, UL 467, may be used for grounding and bonding connections.
- g) Cable fittings that comply with the Standard for Cable Assemblies and Fittings for Industrial Control and Signal Distribution, UL 2238, and have been evaluated for power circuits;

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- h) Cable fittings that comply with the Outline for Investigation for Multi-Point Interconnection Power Cable Assemblies for Industrial Machinery, UL 2237;
- i) The wiring terminals on a device may be used to connect the adjacent Multioutlet Assembly or raceway section;
- j) Other splice methods may be used provided they are investigated and found suitable for the intended use. When conductors pass through a joint between sections of a Multioutlet Assembly that are separable for shipping purposes, the joint or section shall comply with 8.1, Protection of wiring, while in the unassembled and assembled configuration.

6 Mounting

6.1 General

6.1.1 If the Multioutlet Assembly is designed to be secured to the mounting surface by fasteners extending from the inside, the arrangement shall not result in damage to the conductors or devices installed within the Multioutlet Assembly.

6.1.2 A keyhole slot, notch, or similar means for mounting, when provided, shall be located so that the supporting screws or the like cannot damage any electrical insulation or reduce spacings to uninsulated live parts.

6.1.3 A barrier that covers a mounting hole and forms part of the required enclosure shall comply with the Mounting Hole Barrier probe test. Refer to Section 16, Mounting Hole Barriers.

6.1.4 Mounting hardware shall either be packaged with the Multioutlet Assembly or fittings, or the installation instructions packaged with the Multioutlet Assembly or fittings shall specify the types of acceptable mounting hardware to be used. Refer to Installation Instructions, Section 34.

6.1.5 An adhesive strip, if provided on the Multioutlet Assembly, may serve only as a positioning aid during the installation process. The Multioutlet Assembly shall also have provisions for mechanical fastening as required in 6.1.1 and 6.1.4.

Exception: A Multioutlet Assembly intended only for class 2 circuits may be secured by adhesives.

6.1.6 Multioutlet Assemblies shall not rely on an outlet to support utilization equipment.

6.1.7 Multioutlet Assemblies shall be designed to be mounted in accordance with at least one of the methods noted in 6.2 – 6.4.

6.2 Surface mounted multioutlet assemblies

6.2.1 Provisions shall be made for attaching the Multioutlet Assembly to the mounting surface. Such means shall provide for securing the Multioutlet Assembly at intervals of not more than 1.22 m (4 ft).

6.2.2 A Multioutlet Assembly intended to be mounted on or into a work surface, shall be protected from liquid spillage in accordance with a, b or c below. A Multioutlet Assembly shall not be designed to orient a receptacle in a face up position on a work surface:

- a) When for use in a normally dry use work area surface (example: office desk) shall comply with Section 31, Spill Test, Method I, and shall be provided with installation instructions in accordance with 34.15;
- b) When for use in a work area that is directly adjacent to a lavatory (example: kitchen sink counter) shall comply with Section 31, Spill Test, Method II, and shall be provided with installation instructions in accordance with 34.15; or
- c) If the Multioutlet assembly only incorporates a GFCI receptacle and no other outlets, the assembly shall comply with the requirements for GFCIs in the Standard for Ground Fault Circuit Interrupters, UL 943.

6.2.3 If the deterioration or breakage of a gasket, or seal could affect the spill test, the gasket or seal shall be tested as specified in the Gasket and Seals Test, Section 33.

6.2.4 If a Multioutlet Assembly incorporates a gasket or seal that is in contact with a moving part, and the deterioration or breakage of the gasket or seal could affect the spill test, the assembly shall be subjected to the Cycle test, 33.2.

6.3 Suspended multioutlet assemblies

6.3.1 For a Multioutlet Assembly intended to be suspended, the installation instructions shall specify the maximum weight the system is intended to support. Refer to 34.14.

6.3.2 The maximum weight of any field installed accessory (Luminaires, Signs, etc.) shall be marked on the Multioutlet Assembly where visible during installation of the field installed accessory. Refer to 35.2.3.

6.3.3 The Multioutlet Assembly shall comply with the Suspended Load Test, Section 23.

6.4 Multioutlet assembly – power poles

6.4.1 Multioutlet Assembly Power Poles shall be provided with a means of securement near or at the base and near the top of the power pole assembly. Intermediate support shall be provided as required.

6.4.2 The Multioutlet Assembly Power Pole shall be provided with installation instructions, refer to Section 34, Installation Instructions.

7 Electrical and Fire Enclosures

7.1 General

7.1.1 Raceways and fittings that comply with the Standard for Surface Metal Raceways and Fittings, UL 5, or the Standard for Nonmetallic Surface Raceways and Fittings, UL 5A, comply with the enclosure requirements of Section 7, Electrical and Fire Enclosures.

7.2 Polymeric materials

7.2.1 The thickness of a nonmetallic part is not specified. The suitability of a nonmetallic part shall be determined by the applicable tests.

7.2.2 A nonmetallic part of a Multioutlet Assembly or Multioutlet Assembly fitting that serves as an enclosure, or provides direct or indirect support for an uninsulated live part, shall comply with the values specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

7.2.3 A nonmetallic material that does not serve as an enclosure or provide direct or indirect support for an uninsulated live part, but is used in a part or feature that can be removed without affecting the integrity of the installed Multioutlet Assembly or fittings, need not comply with this requirement.

7.3 Metallic materials

7.3.1 The minimum thickness of a metal cover of a Multioutlet Assembly or fitting shall comply with Table 7.1.

Exception: Multioutlet Assemblies with thinner metallic covers shall be limited to assemblies intended to enclose circuits operating at potentials of 300 volts or less between conductors and shall be marked in accordance with 35.1.18.

Table 7.1
Minimum nominal thickness of a metal cover of a Multioutlet Assembly or fitting

Potential between conductors (volts)	Steel, mm (in)	Aluminium, mm (in)
< 300	0.64 (0.025)	0.89 (0.035)
$300 \leq V \leq 600$	1.02 (0.040)	1.02 (0.040)

7.3.2 The metal base of a Multioutlet Assembly or fitting shall comply with Table 7.2 – 7.5, or be of material that provides equivalent protection for the wiring. Sections of reduced thickness may be suitable for facilitating break-offs. Break-offs shall not result in any sharp edges protruding into the interior of the Multioutlet Assembly or fitting. The cover of a Multioutlet Assembly or fitting shall be of metal as indicated above or shall be of nonmetallic material.

Table 7.2
Dimensions of raceway and fitting bases and covers for seven or fewer conductors not larger in cross-sectional area than 12 AWG (3.31 mm²)

Material	Minimum thickness at knock-outs and other points of connection for a wiring system,		Minimum thickness elsewhere than in break-off areas and at points of connection for a wiring system,		Maximum width of raceway,	
	mm	(in)	mm	(in)	mm	(in)
Steel	0.91	(0.036)	0.64	(0.025)	63.5	(2-1/2)
Aluminum	1.27	(0.050)	0.89	(0.035)	63.5	(2-1/2)

Table 7.3
Thickness of raceway and fitting bases and covers for conductors not larger in cross-sectional area than 6 AWG (13.30 mm²)

Material	Minimum thickness,	
	mm	(in)
Steel	0.91	(0.036)
Aluminum	1.27	(0.050)

Table 7.4
Thickness of raceway and fitting bases and covers for conductors that are larger in cross-sectional area than 6 AWG (13.30 mm²)

Material	Part	Minimum thickness,	
		mm	(in)
Steel	Base	1.35	(0.053)
	Cover	0.91	(0.036)
Aluminum	Base	1.88	(0.074)
	Cover	1.27	(0.050)

Table 7.5
Minimum thickness of parts that are cast of metal

Material	mm	(in)
Malleable iron	2.4	(3/32)
Iron other than malleable iron	3.2	(1/8)
Die-cast nonferrous:		
Part that is not ribbed or otherwise reinforced for mechanical strength	2.4	(3/32)
Part that is ribbed or otherwise reinforced for mechanical strength	1.6	(1/16)
Cast nonferrous other than die-cast	2.4	(3/32)

7.3.3 Inside and outside surfaces of each length of an iron or steel Multioutlet Assembly or fitting shall be cleaned of all scale and rust, have a smooth surface, and be in a condition that enables the protective coating to adhere.

7.3.4 The thickness of the finished product is to be measured with a round-nose micrometer calibrated to read to at least 0.01 mm (0.001 in). Measurements are to be made at five different locations on each specimen examined.

7.3.5 Other than as noted in 7.3.6, a knockout provided in a Multioutlet Assembly for a 1/2-in or larger trade-size conduit shall be surrounded on both the inside and outside surfaces by a concentric flat surface to permit installation of a locknut. The flat surface shall extend in all directions beyond the edge of the knockout for a distance not less than that specified in Table 7.6.

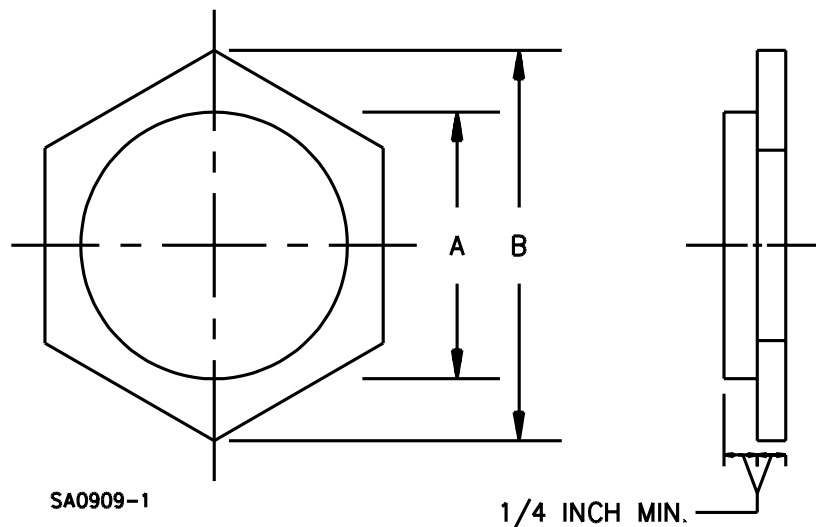
Table 7.6
Diameter of knockout and width of surrounding flat surface

Trade size of conduit,	Knockout diameter,		Minimum width of flat surface surrounding knockout,	
	mm ^a	(in)	mm	(in)
1/2	22.23	(0.875)	3.38	(0.133)
3/4	28.17	(1.109)	3.96	(0.156)
1	34.93	(1.375)	5.03	(0.198)
1-1/4	44.04	(1.734)	6.96	(0.274)

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

7.3.6 When the concentric flat surface required in 7.3.5 is not provided, the acceptability of the flat surface surrounding a knockout on both the inside and outside surfaces is able to be determined by application of a test gauge as illustrated in Figure 7.1 which has the dimensions specified in Table 7.7. To use the gauge, the knockout is to be removed and the appropriate trade size of test gauge is to be inserted in the resulting opening from either side of the Multioutlet Assembly. It is not prohibited that the gauge be offset from the center of the opening, and rotated so that the flat surface including all points of the hexagonal portion of the gauge will be in intimate contact with the surface of the Multioutlet Assembly. The test gauge is then to be inserted in the resulting opening from the opposite side of the Multioutlet Assembly with the same degree and position of offset from the center used on the other side. The flat surface, including all points of the hexagonal portion of the gauge, is to be in intimate contact with the surface of the Multioutlet Assembly as the gauge is rotated through an angle of at least 60 degrees. The test gauge is not to be canted or tilted to make the required contact with the surface of the Multioutlet Assembly.

Figure 7.1
Dimensions of test gauges for flat surfaces



A – Nominal diameter of conduit

B – Maximum diameter of locknut

Table 7.7
Dimensions of test gauges for flat surfaces surrounding knockouts

Trade size,	Nominal knockout diameter,		Nominal diameter of conduit,		Maximum diameter of locknut,	
	mm	(in)	mm ^a	(in)	mm ^b	(in)
1/2	22.23	(0.875)	21.34	(0.840)	28.96	(1.140)
3/4	28.17	(1.109)	26.67	(1.050)	36.07	(1.420)
1	34.93	(1.375)	33.40	(1.315)	44.96	(1.770)
1-1/4	44.04	(1.734)	42.16	(1.660)	57.94	(2.281)

^a Nominal outside diameter of rigid conduit. Tolerances for test gauge: ± 0.03 mm (0.001 in).
^b Maximum diameter of locknut. Tolerances for test gauge: plus 0.0254 mm (0.001 in), minus 0.000 mm/in.

7.3.7 When evaluating a Multioutlet Assembly for compliance with the requirement in 7.3.5, consideration is to be given to the clearances from adjacent knockouts and the sides of the Multioutlet Assembly, but it is not required that the Multioutlet Assembly be constructed so that conduit can be installed simultaneously in adjacent knockouts.

7.4 Protection against corrosion

7.4.1 Enclosures and fittings for use as a Multioutlet Assembly shall be protected against corrosion on all inside and outside surfaces, unless the metal is inherently resistant to ordinary dry location indoor atmosphere corrosion. The acceptability of corrosion protection shall be determined as described in the applicable requirements for protection against corrosion in the Standard for Surface Metal Raceways and Fittings, UL 5.

Exception: This requirement does not apply to field or factory cut edges or the edges of concentric knockouts.

7.4.2 Iron and steel parts, other than those described in 7.4.1, shall be provided with corrosion protection, such as enameling, galvanizing, powder coating, plating, or other equivalent means, if the malfunction of unprotected parts introduces a risk of fire, electric shock, or injury to persons.

7.5 Covers

7.5.1 A raceway shall be provided with a cover that is capable of being removed or opened if intended for the field installation of conductors or that has provision for the field installation or servicing of devices. Type A1, B and C Multioutlet Assemblies must meet this requirement.

7.5.2 Provision shall be made for securing the raceway cover to the base of a multi-piece Multioutlet Assembly at intervals of not more than 1.22 m (4 ft). A cover that is held in place by continuous grooves, flanges, or the like, shall securely fix the cover in place as noted in 7.5.3.

7.5.3 A cover that is held in place by continuous grooves, flanges, or the like, shall comply with the grounding and bonding impedance test with each coating system (paint coated, powder coated, zinc coated, etc.) used. A multi-channel Multioutlet Assembly shall comply with the grounding and bonding impedance test with all combinations of raceways specified in the installation instructions as assembled.

7.5.4 For Multioutlet Assemblies using conductors larger than 6 AWG (13.30 mm²), the Short Circuit Test, Section 27, shall be performed to determine whether the cover is secure.

7.6 Partitions

7.6.1 A partition shall comply with the same requirements as the enclosure of the Multioutlet Assembly. The compliance of the partition shall be determined with the base and cover assembled as intended.

7.6.2 A partition provided in a Multioutlet Assembly or fitting shall be secured. The partition shall have the strength required to support the maximum wire fill by weight in the intended installation orientation.

7.6.3 A partition in a multi-channel Multioutlet Assembly system shall not permit accidental or unintentional passage of circuit conductors between channels. A gap of any length, but not wider than 2.0 mm (0.080 in), shall be permitted.

7.6.4 If the company provides mechanical wire retainers, the gap shall be permitted to exceed 2.0 mm (0.080 in) but shall not exceed 3.2 mm (0.125 in). The companies recommended installation interval for the wire retainers shall be provided in the installation instructions. Refer to 34.12.

7.7 Mounting or support of luminaires (light fixtures), signs and accessories

7.7.1 A Multioutlet Assembly intended to support a surface mounted or suspended luminaire, sign, or accessory, shall comply with the mounting method or the means of support as described in the installation instructions for that component. The specific luminaire, sign, or accessory, that the Multioutlet Assembly is intended to support shall be specified. Refer to Section 34, Installation Instructions.

7.7.2 A Multioutlet Assembly luminaire, sign, or accessory support, shall be capable of supporting 4 times the weight of the luminaire, sign, or accessory in accordance with Section 13, Accessory Support.

8 Electrical Construction

8.1 Protection of wiring

8.1.1 The point where conductors pass through an opening in a wall, barrier, or enclosure, shall be free from sharp edges, burrs, and fins that are able to damage conductor insulation.

8.1.2 Conductors shall be provided with mechanical means to prevent the conductor from being pushed inside the enclosure and contacting:

- a) A lamp or heated surface;
- b) A sharp edge; or
- c) A moving part.

8.1.3 An insulating bushing shall be provided where conductors enter a pendant lampholder or at the base or stem of metal tubing.

8.1.4 Conductors that pass through tubing or contact the edge of a sheet-metal wall 1.07 mm (0.042 in) thick or less shall be reliably held away from the edges of the metal, be protected by a non-rubber bushing, be protected by a grommet, or protected by rolling the edge of the metal not less than 120 degrees.

8.1.5 When conductors pass through or contact the edges of sheet metal thicker than 1.07 mm (0.042 in), the metal shall be treated by reaming or the equivalent to remove burrs, fins, or sharp edges that are able to damage insulation.

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

8.1.7 Polymeric sleeving shall not be used for reducing the risk of cutting or abrasion of wiring. Fiberglass sleeving not less than 0.25 mm (0.010 in) thick is capable of being used to reduce the risk of cutting or abrasion of wire.

8.1.8 Fiberglass sleeving shall extend a minimum of 2.54 cm (1 in) to each side of the opening through which the conductor(s) pass. The sleeving shall be secured from movement along the conductor.

8.1.9 A bushing shall be securely held in place.

8.2 Grounding

8.2.1 A Multioutlet Assembly shall have provision for grounding all exposed non-current carrying conductive parts that may become energized. A part shall be considered capable of becoming energized if failure of electrical spacing, or insulation, or both, can result in a conductive connection to a current carrying part.

Exception No. 1: An exposed non-current carrying conductive part that may become energized, as described in (a) – (e), below need not comply with this requirement.

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

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

2) Electrically isolated from all electrical components.

b) A panel, cover, or other metal part that is isolated from all electrical components, including wiring, by a barrier of vulcanized fiber, varnished cloth, phenolic composition, or other moisture-resistant insulating material that is not less than 0.8 mm (1/32 in) thick and is secured in place.

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

d) A door or the like that can only become energized through a grounded part.

e) A small assembly screw that is separated from wiring and all uninsulated live parts.

Exception No. 2: An exposed non-current carrying conductive part that may become energized by only a Class 2 circuit or other circuit considered to exhibit an adequately reduced risk of electric shock and fire need not be grounded.

8.2.2 All non-current carrying conductive parts shall be bonded together and to the electrical supply equipment-grounding means in accordance with Bonding, 8.3.

8.2.3 Connection to the electrical supply equipment-grounding means shall be accomplished as follows:

a) The knockout or equivalent opening means in a metal enclosure intended to be connected to a metal-enclosed wiring system suitable for grounding, or

b) The equipment-grounding field-wiring terminal or lead.

8.2.4 An equipment-grounding conductor shall be:

- a) If insulated, provided with insulation having an outer surface that is green with or without one or more yellow stripes,
- b) Of a size acceptable for the application in accordance with Table 8.1, but shall not be required to be larger than the circuit conductors supplying the equipment.

Table 8.1
Minimum size of equipment grounding conductor

Rating of branch-circuit overcurrent-protective device to which the product is intended to be connected, amperes	Size of equipment-grounding conductor ^a			
	Copper		Aluminum	
	Wire, AWG	Equivalent cross-sectional area, kcmil (mm ²)	Wire, AWG	Equivalent cross-sectional area, kcmil (mm ²)
15	14	3987 (2.02)	12	6334 (3.21)
20	12	6334 (3.21)	10	10380 (5.261)
30	10	10380 (5.261)	8	16510 (8.367)
40	10	10380 (5.261)	8	16510 (8.367)
60	10	10380 (5.261)	8	16510 (8.367)

^a Where ungrounded conductors are increased in size, equipment grounding conductors shall be increased in size proportionately according to the circular mil area of the ungrounded conductor.

8.2.5 If more than one rating of branch-circuit overcurrent-protective device is involved, the size of an equipment-grounding conductor shall be based on the rating of the overcurrent-protective device that provides protection for that portion of the product connected to the equipment-grounding conductor. For example, if a motor circuit within a product is individually protected against ground faults by a branch-circuit overcurrent device of lesser rating than that of the overcurrent device used to provide overcurrent protection for the entire product, an equipment-grounding conductor for that motor circuit shall be sized on the basis of the rating of the overcurrent device protecting the motor circuit.

8.2.6 A terminal intended for the connection of an equipment grounding conductor shall be identified by:

- a) Use of a wire-binding screw with a green-colored head that is slotted or hexagonal, or both;
- b) Use of a threaded stud with a green-colored hexagonal nut;
- c) Use of a green-colored pressure-terminal connector;
- d) Being marked "G," "GR," "GND," "Ground," "Grounding," or the like;
- e) A marking on a wiring diagram provided on the product; or
- f) The grounding symbol illustrated in Figure 8.1 with or without the circle on or adjacent to the terminal or on a wiring diagram provided on the product.

Figure 8.1
Grounding symbol



8.2.7 A thread forming or sheet metal screw shall not be used to connect equipment-grounding conductors.

8.2.8 A grounding screw shall engage at least two full threads and shall be used in conjunction with upturned lugs, a cupped washer, or an equivalent method that is capable of retaining a 10 AWG copper conductor under the head of the screw.

8.2.9 A separable connection such as that provided in mating connectors and receptacles, shall be constructed so that the equipment-grounding connection connects before or at the same time mating supply-conductor terminals connect. During disconnection of mating connectors, the supply-conductor terminals shall disconnect before or at the same time the grounding-conductor terminal disconnects.

8.2.10 A ferrous metal part in a grounding path shall be protected against corrosion by powder coating, enameling, galvanizing, plating, or equivalent means.

8.2.11 A single opening in a wiring terminal intended for equipment-grounding connections shall not be used:

- a) For connection of more than one 8 AWG (8.4 mm²) copper or larger conductors, or
- b) For connection of more than three 10 AWG (5.3 mm²) copper or smaller conductors.

8.2.12 When installed as intended, an equipment-grounding terminal or terminal assembly shall:

- a) Provide a reliable bond to the Multioutlet Assembly enclosure; and
- b) Be such that the resistance of the connection between an installed equipment-grounding conductor and the frame or enclosure is not more than 0.005 ohm. Refer to the Electrical Resistance Test, Measured across joints, 25.2.

8.2.13 A set screw or other acceptable positive means of securement shall be provided for each connection between adjacent metal Multioutlet Assembly sections and between metal Multioutlet Assembly sections and fittings of a metal Multioutlet Assembly system.

Exception: Other methods of providing electrical continuity may be used when in compliance with the requirements in the Electrical Resistance Test, Measured across joints, 25.2.

8.2.14 The arrangement of grounding connections shall be that the disconnection or removal of a receptacle, switch, luminaire, sign, accessory, or other device will not interfere with the grounding continuity or bonding of any other portion of the Multioutlet Assembly not being serviced.

Exception: The grounding and bonding arrangement is not required to comply with 8.2.14 when the Multioutlet Assembly is factory assembled and provided with tamper resistant fasteners or a factory sealed enclosure system that does not allow for user servicing or maintenance. The Multioutlet Assembly shall be marked to inform the user that there are no user serviceable parts inside, refer to 35.1.16.

8.2.15 When one or more isolated ground outlets are used within the Multioutlet Assembly there shall be one ground terminal or conductor to bond the exposed non-current carrying conductive part that may become energized in accordance with 8.2.1.

8.3 Bonding

8.3.1 A conductor, including a strap, jumper, or similar part, that is used only for bonding shall:

- a) Be of copper, copper alloy, aluminum, or other material that has been investigated and found acceptable for use as an electrical conductor,
- b) Be protected from mechanical damage,
- c) Not be secured by a removable fastener used for any purpose other than bonding unless the bonding conductor is not likely to be omitted after removal and replacement of the fastener, and
- d) Have the flexibility needed to withstand mechanical stress due to vibration or flexing during use.

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

8.3.3 Bonding shall be by a positive means, such as by a clamp, rivet, bolt, screw, welded joint, or a soldered or brazed joint using materials having a softening or melting point higher than 454°C (850°F). Terminals complying with the requirements in the Standard for Electrical Quick-Connect Terminals, UL 310, are acceptable to connect bonding conductors in sizes 18 – 14 AWG copper under the following conditions:

- a) For conductor sizes 18 – 16 AWG copper, the minimum connector and tab width shall be 2.8 mm (0.110 in).
- b) For conductor size 14 AWG copper, the minimum connector and tab width shall be 6.4 mm (0.250 in).
- c) Quick-connect tabs shall not be less than 0.8 mm (0.032 in) thick.

8.3.4 A bonding screw shall engage at least two full threads and shall be used in conjunction with upturned lugs, a cupped washer, or an equivalent method that is capable of retaining a 10 AWG copper conductor under the head of the screw.

8.3.5 A bonding connection means shall penetrate nonconductive coatings, such as paint, powder coatings or vitreous enamel.

8.3.6 A metal-to-metal hinge-bearing member of a door or cover used as a means for bonding the door or cover shall be of the multiple-bearing-pin (piano) type.

8.3.7 When wiring devices are mounted to a metallic removable cover the cover shall remain bonded to the grounding conductor in accordance with 8.3.1 with the cover removed.

8.4 Electrical continuity

8.4.1 Electrical continuity shall be provided between all metal parts of a Multioutlet Assembly system while the parts are installed in the intended manner. Refer to the Electrical Resistance Test, Measured across joints, 25.2.

8.4.2 All metal parts of a Multioutlet Assembly system that are likely to become energized shall be bonded to ground. Mounting hardware that is not exposed after installation need not comply with this requirement.

8.4.3 The Maximum acceptable resistance of an individual section and fitting shall be as indicated in Table 8.2.

Table 8.2
Maximum raceway resistance

Material	Thickness of metal cover		Electrical resistance	
	mm	(in)	Ohms per meter	(Ohms per foot)
Steel	At least 0.64 but less than 0.91	(At least 0.025 but less than 0.036)	0.0272	(0.0083)
	At least 0.91	(At least 0.036)	0.115	(0.035)
Aluminum	At least 0.89 but less than 1.27	(At least 0.035 but less than 0.050)	0.0039	(0.0012)
	At least 1.27	(At least 0.050)	0.0020	(0.00060)

8.5 Wiring devices

8.5.1 A wiring device or device assembly shall be secured to the Multioutlet Assembly by more than one securement point such as two screws or two rivets.

8.5.2 A snap-fit or other non-positive means of securement may be used if the securement complies with the tests described in Section 14, Outlet Secureness.

8.5.3 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.

8.5.4 Multi-Point Interconnection Power Cable Assemblies for Industrial Machinery shall comply with the requirements in the Outline of Investigation for Multi-point Interconnection Power Cable Assemblies For Industrial Machinery, UL 2237.

8.5.5 Special purpose cable fittings for remote control, signaling and power circuits shall comply with the requirements in the Standard for Cable Assemblies and Fittings for Industrial Control and Signal Distribution, UL 2238.

8.5.6 Hospital grade convenience receptacles shall comply with the requirements for Hospital Grade Receptacles in the Standard for Attachment Plugs and Receptacles, UL 498. When utilized in a Multioutlet Assembly (Refer to 1.10) the Multioutlet Assembly shall be provided with installation instructions that specify that the Multioutlet Assembly shall not be installed in patient care areas. Refer to 34.4.

8.5.7 Pin and Sleeve outlet devices shall comply with the Standard for Plugs, Receptacles and Cable Connectors of the Pin-and-Sleeve Type, UL 1682.

8.5.8 Lampholders shall comply with Standard for Lampholders, UL 496, and shall be marked as indicated in 35.1.14 adjacent to the lampholder.

8.5.9 An outlet or receptacle shall be uniquely keyed by a physical or mechanical means to maintain correct polarity consistent with different voltages, frequencies, or types (AC or DC) within the same Multioutlet Assembly.

8.6 Switches and controls

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

- a) A switch that controls a single or duplex outlet shall be rated for the maximum voltage and current for that outlet configuration.
- b) A switch that controls multiple outlets shall be rated for the maximum voltage and current based on the voltage of the branch circuit and the overcurrent device supplying power to those outlets.

8.6.2 With reference to the requirement in 8.6.1, the current rating of a switch that controls an inductive load other than a motor, such as a transformer or an electric-discharge-lamp ballast, shall not be less than twice the rated full-load current of the transformer or ballast unless the switch has been investigated and found acceptable for the application.

8.6.3 A switch or an overcurrent-protective device shall be electrically connected to a terminal or lead intended for connection to ungrounded conductor(s) of the supply circuit.

8.6.4 A switch that controls an E11 (mini-can) lampholder or larger lamp shall be acceptable for use with tungsten-filament lamps.

8.6.5 A switch shall be securely mounted and shall be prevented from turning. The means for preventing the turning or shifting is to consist of more than friction between surfaces – for example, a properly applied lock washer is acceptable as the means for preventing a small stem-mounted switch or other device having a single-hole mounting means from turning.

Exception: A switch need not be prevented from turning provided:

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

b) The spacings are not reduced below the minimum required values if the switch rotates, the normal operation of the switch is by mechanical means rather than by direct contact by persons and rotation of the switch does not transmit strain to internal connections or splices.

8.6.6 A switch shall comply with the Standard for General-Use Snap Switches, UL 20, the Standard for Special-Use Switches, UL 1054, the Standard for Switches for Appliances – Part 1: General Requirements, UL 61058-1, or the Standard for Solid-State Controls for Appliances, UL 244A. Other switches may be used provided they are investigated and found suitable for the intended use. 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 the UL 244A requirements.

8.6.7 A switch having an identified "off" function shall be either:

- a) An air gap switching device having, in the "off" mode, an air gap between the line and load terminals; or
- b) A solid-state switching device having a maximum let-through current of 0.5 mA.

8.6.8 A switch as mentioned in 8.6.7(b) shall not be used to provide a disconnect function and shall be marked as indicated in 35.1.17.

8.7 Splices and connections

8.7.1 All splices and connections shall be mechanically secure and provide electrical continuity. A soldered connection shall be made mechanically secure before being soldered.

8.7.2 A splice shall be provided with insulation sufficient for the potential voltage of the circuit but not less than 300 V.

8.7.3 In determining if splice insulation consisting of fabric, thermoplastic, or other type of tubing is acceptable, consideration is to be given to such factors as its dielectric properties, heat- and moisture-resistant characteristics, and the like. Thermoplastic tape over a sharp edge is not acceptable.

8.7.4 Where stranded internal wiring is connected to a wire-binding screw, the construction shall be such that loose strands of wire will not contact:

- a) Other uninsulated live parts not always of the same polarity; or
- b) Dead metal parts.

8.7.5 Wire connectors providing a splice in a power circuit intended for field connection or disconnection shall comply with 5.3.

8.7.6 Wire connectors shall comply with the Standard for Wire Connectors, UL 486A-486B, the Standard for Splicing Wire Connectors, UL 486C, or the Standard for Electrical Quick-Connect Terminals, UL 310.

Exception: Connectors that comply with the Standard for Grounding and Bonding Equipment, UL 467, may be used for grounding and bonding connections.

8.7.7 Terminal Blocks shall comply with the Standard for Terminal Blocks, UL 1059.

8.8 Spacings

8.8.1 All components shall be reliably secured and prevented from shifting or movement by other than friction between surfaces. Components shall be mounted such that electrical spacings specified in this section are maintained.

8.8.2 Spacings at and within a component or device are judged based on the requirements for the component or device, and are not specified herein.

8.8.3 Spacings between adjacent components, between components and dead-metal parts, between components and the enclosure, and at field wiring terminals, shall be maintained as shown in Table 8.3.

Table 8.3
Minimum electrical spacings

Potential involved		Minimum Spacings, mm (in)							
		Rating, Volts							
		Class 2)		51 - 150		151 - 300		301 - 600	
		mm	(in)	mm	(in)	mm	(in)	mm	(in)
Between any uninsulated live parts and an uninsulated live part of opposite polarity or different circuit, uninsulated grounded part (other than enclosure) or exposed metal part	Through Air	3.2	(1/8)	3.2 ^a	(1/8)	6.4	(1/4)	9.6	(3/8)
	Over surface	6.4	(1/4)	6.4	(1/4)	9.6	(3/8)	12.7	(1/2)
Between any uninsulated live part and the walls of a metal enclosure including fittings for conduit or armored cable	Shortest distance	1.6	(1/16)	12.7	(1/2)	12.7	(1/2)	12.7	(1/2)

^a Spacings of field wiring terminals shall not be less than 6.4 mm (1/4 in)

8.8.4 In applying Table 8.3 it is to be assumed that:

- a) The voltage from a live part, other than the neutral, to grounded dead metal equals the line-to-line voltage of the system.
- b) The voltage from a neutral live part to grounded dead metal equals the line-to-neutral voltage of the system.
- c) Spacings are to be measured through joints in insulation materials unless the joint is sealed with an adhesive, cement, or the like, that complies with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.8.5 Spacings between multiple circuits shall be maintained based on requirements for the circuit with the highest voltage potential.

8.8.6 A barrier or liner of insulating material used in areas where spacings do not comply with the requirements in this standard shall be evaluated and determined to comply with the requirements for internal barriers outlined in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, and shall be secured in place. An adhesive used to position a barrier shall be investigated for the effects of temperature, humidity, and cyclic conditions outlined in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

8.9 Printed-wiring boards

8.9.1 A printed-wiring board shall comply with the requirements in the Standard for Printed-Wiring Boards, UL 796, and shall be classed V-0, V-1, or V-2 in accordance with the requirements in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

Exception: A printed wiring board containing only circuitry not exceeding Class 2 limits is not required to comply with this requirement.

8.9.2 A Multioutlet Assembly that has a grounding path through traces on a printed-wiring board shall comply with the Printed Wiring Board (PWB) Ground Path Test, Section 29.

8.9.3 All load-current-carrying circuit traces on a printed-wiring board shall comply with the Printed Wiring Board (PWB) Conductor Overcurrent Test, Section 30.

8.9.4 Spacings on a printed wiring board shall comply with the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840 or the minimum spacings of Table 8.3. The following parameters shall be used when applying UL 840:

- a) Pollution degree 2: For the purposes of compliance with the requirements for coatings of printed wiring boards used to achieve pollution degree 2 in accordance with UL 840, a coating that complies with the requirements for Conformal Coatings in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, is considered to be acceptable.
- b) Clearances for branch circuits shall be considered Overvoltage Category III.
- c) Clearances for controls connected to the branch circuit shall be considered Overvoltage Category II.

8.10 Field wiring connections

8.10.1 General

8.10.1.1 A Multioutlet Assembly shall have provisions for connection to at least one of the permanent wiring systems specified in the National Electrical Code, NFPA 70.

8.10.1.2 A Multioutlet Assembly shall be provided with wiring terminals or leads for the connection of conductors having an ampacity acceptable for the Multioutlet Assembly. Refer to Table 8.4.

Table 8.4
Ampacity of insulated conductors based upon conductor insulation rated for 60°C (140°F)

AWG or kcmil (mm ²)		Maximum Ampacity Rating, A
Minimum Copper Conductor Size	Aluminum or copper-clad aluminum	
14 AWG (2.1 mm ²)	12 AWG (3.3 mm ²)	15
12 AWG (3.3 mm ²)	10 AWG (5.3 mm ²)	20
10 AWG (5.3 mm ²)	8 AWG (8.4 mm ²)	30
8 AWG (8.4 mm ²)	6 AWG (13.3 mm ²)	40
6 AWG (13.3 mm ²)	4 AWG (21.2 mm ²)	55
4 AWG (21.2 mm ²)	2 AWG (33.6 mm ²)	70

8.10.1.3 A wiring compartment for field-wiring connections shall be of a volume that will accommodate the conductors having an ampacity acceptable for the Multioutlet Assembly and will accommodate the conduit and fittings sized for the wire in accordance with the National Electrical Code, NFPA 70, Article 314.

8.10.1.4 The location of a terminal box or compartment in which field wiring branch-circuit connections to a Multioutlet Assembly are to be made shall be such that the connections can be inspected without disturbing wiring after the Multioutlet Assembly has been installed as intended.

8.10.2 Wiring leads

8.10.2.1 AWG 14 (2.1 mm²) copper is the smallest conductor that is capable of being used for branch circuit wiring of a Multioutlet Assembly.

8.10.2.2 Field wiring leads provided for connection to the supply shall have an ampacity not less than that of the rating of the Multioutlet Assembly circuit. Refer to Table 8.4.

8.10.2.3 The free length of a field-wiring lead inside a Multioutlet Assembly shall be a minimum of 152 mm (6 inches) long.

8.10.2.4 An insulated conductor intended for the connection of a grounded supply conductor shall be uniquely identified. Identification that distinguishes each grounded conductor shall be one of the following:

- a) An outer covering of white, gray, white or gray with a colored stripe, or by three continuous white stripes on other than green insulation along its entire length; or
- b) Other and different means of identification that distinguishes each grounded conductor.

Exception: Grounded conductors are not required to be color coded where they are not accessible during intended use and maintenance of the system.

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

8.10.3 Wiring terminals

8.10.3.1 A field-wiring terminal is considered to be a terminal to which a conductor is intended to be terminated in the field.

8.10.3.2 A field-wiring terminal shall be restrained from turning or shifting in position by means other than friction between surfaces. This shall be accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug or offset, by a connecting strap or clip fitted into an adjacent part, or by some other equivalent method.

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

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

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

Exception No. 3: A device wiring terminal that has been separately investigated to the requirements for that device.

8.10.3.4 A wire-binding screw shall thread into metal.

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

8.10.3.6 A terminal plate formed from stock having the thickness specified in 8.10.3.5 may have the metal extruded at the tapped hole to provide two full threads for the binding screw.

8.10.3.7 Upturned lugs or a cupped washer shall be capable of retaining a supply conductor of the size specified in Table 8.4 under the head of the screw or washer.

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

8.10.3.9 Field wiring shall be reliably separated by barriers from internal wiring and internal components operating at a voltage potential less than the voltage potential of the field installed conductors unless all internal wiring and components are rated 600 Volts. For Multioutlet Assemblies marked in accordance with 35.1.13 all internal wiring and components shall be rated 300 Volts minimum.