

May 14, 2012

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UL 2416

OUTLINE OF INVESTIGATION  
FOR  
AUDIO/VIDEO, INFORMATION AND COMMUNICATION TECHNOLOGY  
EQUIPMENT CABINET, ENCLOSURE AND RACK SYSTEMS

Issue No. 1

May 14, 2012

*Summary of Topics*

*This is the First issue of the Outline of Investigation for Audio/Video, Information and Communication Technology Equipment Cabinet, Enclosure and Rack Systems, UL 2416, which covers cabinet, enclosure and rack/frame systems that are not complete equipment but include components and sub-assemblies that are intended to power, protect, heat, cool or otherwise support information technology (IT), telecommunications, audio/video or other similar equipment that will be installed at a later time.*

*The requirements of UL 2416 will become effective on May 14, 2015.*

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## INTRODUCTION

*The requirements of UL 2416 will become effective on May 14, 2015.*

### 1 Scope

1.1 This Outline of Investigation covers requirements for Audio/Video, Information and Communication Technology Equipment Cabinet, Enclosure and Rack Systems. For the purpose of this Outline, cabinet, enclosure and rack systems are all referred to as "enclosure systems".

1.2 Enclosure systems are not complete equipment but include components and sub-assemblies that are intended to power, protect, heat, cool or otherwise support information technology (IT), telecommunications, audio/video (A/V) and similar equipment that will be installed at a later time. They usually include mounting hardware, shelves or space for the installation of the additional equipment. These enclosure systems are intended to be used by manufacturers in the construction of complete A/V, IT and communications equipment, or by service providers and other qualified installers for the installation of network infrastructure equipment or communications and multi-media systems equipment.

1.3 This Outline of Investigation assumes that the final installation of equipment into the enclosure system will be performed by qualified service personnel in accordance with the applicable installation instructions, installation practices and national installation codes. As appropriate, this equipment should be installed in accordance with ANSI/NFPA 70, National Electrical Code (NEC), and/or the applicable sections of ANSI/IEEE C2, National Electrical Safety Code (NESC). Equipment intended for installation in information technology equipment (computer) rooms should be installed in accordance with NFPA 75, Standard for the Protection of Information Technology Equipment.

1.4 Enclosure systems by their very nature are intended to house equipment that is not specified by the enclosure system manufacturer and whose construction and characteristics are largely unknown. As such, in some cases these requirements include additional or supplementary safeguards beyond those normally required by general equipment standards where the final configuration is well defined and risks can be reduced to an acceptable level by a thorough evaluation of the design and testing.

1.5 These requirements do not cover enclosures for modular data centers. Equipment of this type shall be investigated under the requirements in the Outline of Investigation for Modular Data Centers, UL 2755.

1.6 These requirements do not cover exhaust chimneys and other air management systems that connect to environmental air systems in buildings. Equipment of this type shall be investigated under the requirements in Standard for Heating and Cooling Equipment, UL 1995, and Outline of Investigation for Drop Out Ceilings Installed Beneath Sprinklers, UL 723S.

Note: Environmental air systems include ducts specifically designed for environmental air and other spaces used for environmental air (plenums) that may not be specifically fabricated for environmental air-handling purposes but are used for air-handling purposes as a plenum. The space over a hung ceiling used for environmental air-handling purposes is an example of this type of other space.

1.7 It is the responsibility of the Authority Having Jurisdiction over the final installation to determine if the final configuration meets the necessary criteria for installation and use.

## 2 Units of Measurement

2.1 The values given in SI (metric) units shall be normative. Any other values in parentheses are explanatory or for informational purposes only.

## 3 References

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

3.2 The following standards contain provisions, which, through referenced in this Outline of Investigation, constitute provisions of this Outline.

- a) ANSI/IEEE C2, National Electrical Safety Code. See 6.2.8.
- b) ANSI Z97.1, Safety glazing materials used in buildings – safety performance specifications and methods of test. See 9.3.3.
- c) ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials. See 12.2.1.
- d) ASTM A90/A90M, Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings. See B1.4 and B1.5.
- e) ASTM E162, Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source. See 12.2.1.
- f) ASTM A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements. See B1.4 and B1.5.
- g) ATIS 0600006, Mechanical Structural Issues. See 11.1.7.2.
- h) ATIS 0600010.01, Temperature, Humidity, and Altitude Requirements for Network Telecommunications Equipment Utilized in Outside Plant Environments. See 15.3.1.
- i) ATIS 0600329, Network Equipment – Earthquake Resistance. See 11.1.7.2.
- j) Code of Federal Regulations (CFR), Title 21. See 16.6.1, 16.6.3, 16.6.6, and 16.6.7.
- k) GR-487-CORE, Telcordia Generic Requirements for Electronic Equipment Cabinets. See 10.2.4.1 and 10.2.5.3.
- l) GR-771-CORE, Generic Requirements for Fiber Optic Splice Closures. See 12.6.1.
- m) GR-950-CORE, Telcordia Generic Requirements for Optical Network Unit (ONU) Closures and ONU Systems. See 10.2.5.3.
- n) IEC 60417, Graphical symbols for use on equipment. See 7.5.1 and Figure 7.1.
- o) IEC 60825-1, Safety of laser products – Part 1: Equipment classification and requirements. See 16.6.3, 16.6.4, 16.6.6, and 16.6.7.

- p) ANSI/NFPA 70, National Electrical Code (NEC). See 6.3.1, 6.5.4, 6.8.1, 6.8.3, 6.9.1, 7.1.3, 7.2.1, 8.1.1, 8.1.4, and 12.4.3.2.
- q) NFPA 75, Standard for the Protection of Information Technology Equipment. See 12.3.1 – 12.3.3.
- r) UL 60950-1 , Information Technology Equipment – Safety – Part 1: General Requirements. See 7.1.4, 9.1.3.1, 12.1.1, 12.1.5, 12.5.4.2, 15.3.1, 15.3.2, 15.4.1, and 15.5.2.
- s) UL 50 Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations. See 6.4.3, 9.1.3.1, 9.1.3.2, 9.1.4.1, 9.2.5, and 9.3.3.
- t) UL 50E , Standard for Enclosures for Electrical Equipment, Environmental Considerations. See 9.1.4.1, 9.2.5, and 10.2.4.1.
- u) UL 62 , Standard for Flexible Cords and Cables. See 6.6.2.
- v) UL 94 , Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances. See 12.5.1.1 and 12.6.1.
- w) UL 467 , Standard for Grounding and Bonding Equipment. See 7.1.2, 7.1.7, and 7.2.5.
- x) UL 486A-486B , Standard for Wire Connectors. See 6.5.8.
- y) UL 486E , Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors. See 6.5.7 and 6.5.8.
- z) UL 498 Standard for Attachment Plugs and Receptacles. See 6.6.2 and 6.7.1.
- aa) UL 508 , Standard for Industrial Control Equipment. See 6.6.3, 6.7.2, and 6.10.1.
- bb) UL 508A , Standard for Industrial Control Panels. See 6.5.8, 9.1.3.1, 9.1.3.2, and 9.1.4.1.
- cc) UL 514A , Standard for Metallic Outlet Boxes. See 6.4.3 and 12.5.1.5.
- dd) UL 514B , Standard for Conduit, Tubing, and Cable Fittings. See 6.3.2 and 12.5.1.5.
- ee) UL 514C , Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers. See 6.3.9, 6.3.12, and 6.4.3.
- ff) UL 514D , Standard for Cover Plates for Flush-Mounted Wiring Devices. See 12.5.1.5.
- gg) UL 651 , Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings. See 12.5.1.5.
- hh) UL 723 , Standard for Test for Surface Burning Characteristics of Building Materials (see 12.2.1), or UL 746C , Polymeric Materials – Use in Electrical Equipment Evaluations (see 9.3.4.4 and 12.5.1.1).
- ii) UL 810A Standard for Electrochemical Capacitors. See 13.1.2.
- jj) UL 869A , Reference Standard for Service Equipment. See 6.10.6.

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- kk) UL 924 , Standard for Emergency Lighting and Power Equipment. See 13.1.2.
- ll) UL 969 , Standard for Marking and Labeling Systems. See 16.1.5.
- mm) UL 1059 , Standard for Terminal Blocks. See 6.5.7.
- nn) UL 1449 , Standard for Surge Protective Devices. See 6.10.4.
- oo) UL 1479 , Standard for Fire Tests of Through-Penetration Firestops. See 12.4.3.3.
- pp) UL 1642 , Standard for Lithium Batteries. See 13.1.2.
- qq) UL 1667 , Standard for Tall Institutional Carts for Use With Audio-, Video-, and Television-Type Equipment. See 11.4.1.
- rr) UL 1682 , Standard for Plugs, Receptacles and Cable Connectors of the Pin and Sleeve Type. See 6.6.2.
- ss) UL 1778 , Standard for Uninterruptible Power Systems. See 13.1.2 and 13.7.2.
- tt) UL 1973 , Outline of Investigation for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications . See 13.1.2.
- uu) UL 1989 , Standard for Standby Batteries. See 13.1.2.
- vv) UL 2043 , Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces. See 12.4.1 and 12.4.3.3.
- ww) UL 2054 , Standard for Household and Commercial Batteries. See 13.1.2.
- xx) UL 2271 , Outline of Investigation for Batteries for Use in Light Electric Vehicle (LEV) Applications. See 13.1.2.
- yy) UL 2580 , Outline of Investigation for Batteries for Use in Electric Vehicles. See 13.1.2.
- zz) UL 2755 , Outline of Investigation for Modular Data Centers. See 9.5.1 and 9.5.2.

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## 4 Glossary

4.1 For the purpose of this Outline of Investigation the following definitions apply.

Note: Unless otherwise stated, when applying clauses from other referenced standards, such as:

- a) The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1;
- b) The Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50; and
- c) The Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E,

the terms and definitions in those standards are applicable.

4.2 ACCESSORY – A part or combination of parts intended for installation in or connection to an enclosure system for the purpose of modifying or supplementing the functions of the product. It may be factory installed or intended for installation by the user or service personnel. Examples of accessories include:

- a) Shelves;
- b) Brackets,
- c) Fan trays;
- d) Temperature sensors,
- e) Monitoring equipment;
- f) Cable management;
- g) Extensions,

and the like.

4.3 BREAKOUT – A portion of a wall of a cast or molded enclosure so fashioned, usually by the use of one or more rings of reduced thickness of the wall material, that the material within the outer perimeter of the ring to be removed may be readily broken away at the time of installation in order to provide an opening similar to that provided by a knockout

4.4 ELECTRIC SHOCK, RISK OF – The risk that a person encounters when exposed to live uninsulated parts of a product which have a voltage and current sufficient to cause an electric shock. Generally, parts operating at voltages over 42.4 volts peak or 60 volts dc where wet contact is not likely to occur, and 21.2 volts peak or 30 volts dc where wet contact is likely to occur, are considered to pose a risk of electric shock.

4.5 ENCLOSURE (ALL CAPITAL LETTERS) – An enclosure system with doors, top, side and bottom panels constructed to provide a degree of protection to personnel against accidental contact with equipment, parts involving a risk of personal injury or energized parts, to minimize the spread of fire or flames from within and to provide a degree of protection to the enclosed equipment against physical damage or specified environmental conditions.

4.6 ENCLOSURE (NORMAL CASE LETTERS) – A general term referring to the overall structure and outer housing (panels, doors, etc.) of an enclosure system.

4.7 ENCLOSURE SYSTEM – A simplified term used in this Outline of Investigation for audio/video, information and communication technology equipment cabinet, enclosure and rack systems.

4.8 EQUIPMENT CABINET (ALL CAPITAL LETTERS) – A closed storage system with a surrounding case or housing that does not provide the degrees of protection of an enclosure. An EQUIPMENT CABINET is used to store or mount equipment that is provided with its own enclosure or may be used in place of an enclosure in a restricted access location that is limited to access by service personnel only. EQUIPMENT CABINETS are intended for indoor installation only.

4.9 EQUIPMENT FRAME (ALL CAPITAL LETTERS) – Same as RACK. See 4.15 for definition.

4.10 HAZARDOUS ENERGY LEVEL – Available power level of 240 volt-amperes or more, having a duration of 60 s or more, or a stored energy level of 20 J or more (for example, from one or more capacitors), at a potential of 2 volts or more

4.11 INDOOR LOCATIONS – Areas that are protected from exposure to the weather.

4.12 IN-WALL MOUNTED ENCLOSURE SYSTEM – An EQUIPMENT CABINET or ENCLOSURE that is intended for mounting in a wall (behind the finished wall), has provisions for mounting ears or flanges to facilitate mounting between wall studs, is provided with instructions for mounting in an unfinished wall cavity or by its appearance or design would otherwise lead a person to mount the system in a wall. The enclosure system is placed inside an unfinished wall cavity with at least some part of the enclosure system located behind the plane of the front wall of the wall cavity and in front of the plane of the rear wall of the wall cavity.

4.13 KNOCKOUTS – A portion of a wall of an enclosure system so fashioned that it may be removed readily by a hammer, screwdriver, and pliers at the time of installation in order to provide a hole for the attachment of an auxiliary device, railway, cable or fitting.

4.14 OUTDOOR LOCATIONS – Areas which are exposed to the weather.

4.15 RACK (ALL CAPITAL LETTERS) – An open frame mounting system, usually either in a two-post or four-post frame design that does not provide the degrees of protection of an enclosure. A RACK is used to store or mount equipment that is provided with its own enclosure or is intended for use only in restricted access locations limited to service personnel only. RACKS are intended for indoor installations only or in outdoor environments when installed in a suitably rated ENCLOSURE.

4.16 SERVICE EQUIPMENT – Equipment, usually consisting of a circuit breaker, switch, or fuses, and related accessories, located near the point of entrance of supply conductors to a building or other structure and intended to constitute the main control and means of cutoff of the supply.

4.17 USER INSTALLED EQUIPMENT – Equipment that is not included as part of the enclosure system but that may be installed by the user or final customer at a later date.

## CONSTRUCTION

### 5 Components and Subassemblies

5.1 In addition to complying with the requirements in this Outline of Investigation, and other than as indicated in 5.2, a component or subassembly used in a product covered by this Outline shall comply with the requirements for that component or subassembly. See Appendix A for a list of standards covering components and subassemblies used in the products covered by this Outline.

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

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this Outline of Investigation or
- b) Is superseded by a requirement in this Outline.

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

5.4 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.

### 6 Power Circuits

#### 6.1 General

6.1.1 The cross-sectional area of wires shall be adequate for the current they are intended to carry when the equipment is operating under maximum rated load such that the maximum permitted temperature of conductor insulation is not exceeded. All wiring (including busbars) used in the distribution of power shall be protected against overcurrent and short-circuit by suitably rated protective devices. Wiring not directly involved in the distribution path does not require protection if it can be shown that creation of hazards is unlikely (for example, indicating circuits).

6.1.2 Wireways shall be smooth and free from sharp edges. Wires shall be protected so that they do not come into contact with burrs, cooling fins, moving parts, etc., which could cause damage to the insulation of conductors. Holes in metal, through which insulated wires pass, shall have smooth well-rounded surfaces or shall be provided with bushings.

6.1.3 Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of:

- a) Excessive strain on wire and on terminal connections;
- b) Loosening of terminal connections; and
- c) Damage of conductor insulation.

6.1.4 Conductors shall be provided with a means (for example, barriers or fixing), or be so terminated, that they and their terminators (for example, ring terminals and flat quick-connect terminals) cannot, in normal use, become so displaced that spacings are reduced to less than the values specified in Spacings, 6.10. It is permitted to use soldered, welded, crimped, screwless (push-in) and similar terminations for the connection of conductors. For soldered terminations, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain the conductor in position.

## 6.2 Branch circuit connection

6.2.1 An enclosure system intended for fixed installation or permanent connection to the building structure shall be provided with a means for permanent connection to the branch-circuit supply. See Connections for wiring systems, 6.3, Field wiring compartments, 6.4 and Wiring terminals and leads, 6.5.

*Exception: Products may be cord-connected under the conditions specified in 6.2.4.*

6.2.2 Stationary enclosure systems (systems that are not fixed but are not easily moved) shall be provided with a means for permanent connection to the branch-circuit supply. See Connections for wiring systems, 6.3, Field wiring compartments, 6.4 and Wiring terminals and leads, 6.5.

*Exception: Products may be cord-connected under the conditions specified in 6.2.4*

6.2.3 Enclosure systems that are portable, easily moved or intended to be moved on a regular basis shall be provided with a length of flexible cord and an attachment plug for connection to the supply circuit. See Power supply cords, 6.6.

6.2.4 In determining whether or not it is acceptable to the compliance of cord and plug connection for stationary equipment, the decision should include consideration of whether:

- a) The cord connection of the equipment facilitates frequent interchange;
- b) The fastening means or mechanical connections are intended to permit removal for maintenance and repair; or
- c) All external connections to the equipment are by means of cord and attachment plug.

6.2.5 An in-wall mounted enclosure system intended for connection to a branch circuit shall have a means for permanent connection to the branch-circuit supply.

6.2.6 Connection to an AC mains supply

6.2.6.1 The connection of an enclosure system to the AC mains supply shall be made by means of one the following:

- a) Terminals for permanent connection to a building mains supply. See Connections for wiring systems, 6.3, Field wiring compartments, 6.4 and Wiring terminals and leads, 6.5.
- b) A hard-service non-detachable power supply cord that terminates in an attachment plug that is rated for the voltage and current involved. See Power supply cords, 6.6.
- c) A receptacle for the connection of a detachable power supply cord (appliance inlet). The arrangement shall be such that live parts shall not be exposed under any intended condition of use.

### 6.2.7 Connection to a DC mains supply

6.2.7.1 The connection of an enclosure system to a dc mains supply shall be made by means of one the following:

- a) Terminals for permanent connection to a building DC mains supply. See Connections for wiring systems, 6.3, Field wiring compartments, 6.4 and Wiring terminals and leads, 6.5.
- b) A non-detachable power supply cord that terminates in an attachment plug that is rated for the dc voltage and current involved. The plug shall not be of a configuration commonly used for ac systems. The plug shall be designed as to prevent reverse polarity connections if a hazard can be created by such a connection. See Power supply cords, 6.6.
- c) A receptacle for the connection of a flexible cord or cord set suitable for dc applications. The receptacle shall not be of a configuration commonly used for ac systems. The receptacle shall be designed as to prevent reverse polarity connections if a hazard can be created by such a connection. The arrangement shall be such that live parts shall not be exposed under any intended condition of use.

6.2.8 Enclosure systems intended for installation on the network side of the subscriber demarcation point and intended to be installed and maintained by telecommunications companies, CATV companies, and similar network communications companies shall be permitted to be provided with a wiring system conforming to generally-accepted utility installation practices for the type of equipment and service involved. This equipment is intended to be installed in accordance with the applicable sections of ANSI C2, National Electrical Safety Code.

## 6.3 Connections for wiring systems

6.3.1 A unit intended for permanently-connected branch circuit power shall have a provision for the connection of one of the applicable wiring systems in accordance with ANSI/NFPA 70, National Electrical Code. The equipment shall be provided with cable entries, conduit entries, knock-outs, or glands that allow connection of the appropriate types of cables or conduits.

6.3.2 Openings in an enclosure for conduit or threaded connectors shall be of such sizes and so located that the conduit can be readily inserted and shall permit the proper seating of a conduit bushing or locknut (see Appendix D for knockout dimension information). All openings provided for conduit connections in the field shall be of standard dimensions. When provided, conduit fittings shall comply with the Standard for Conduit, Tubing, and Cable Fittings, UL 514B.

6.3.3 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.

6.3.4 Knockouts shall be so formed that they are capable of being readily removed but will not drop out during ordinary handling. Multiple ring knockouts shall have sufficient strength to meet the test requirements of 6.3.6.

6.3.5 Breakouts shall be so formed that:

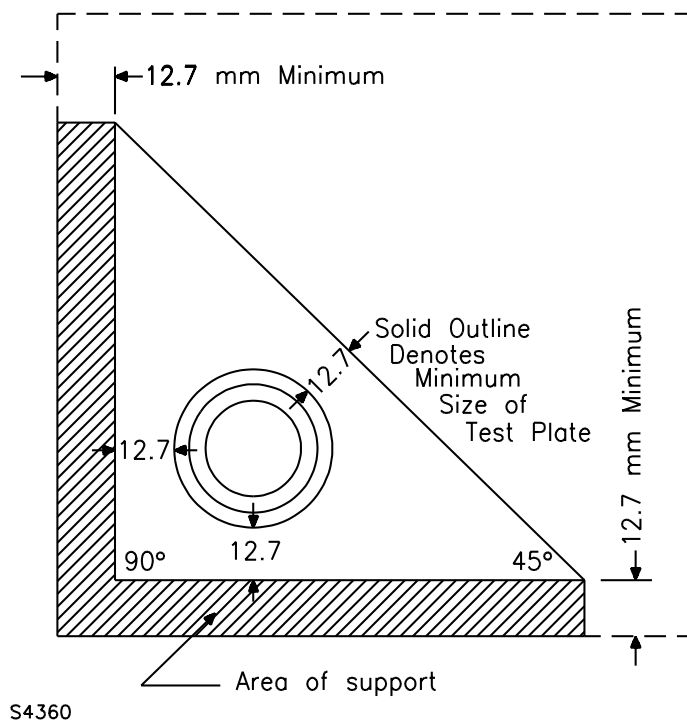
- a) The material can be readily removed, using ordinary care, to provide an opening of the required size without damaging the remainder of the enclosure or any outer rings and
- b) The strength of any remaining rings will withstand the loading test specified in 6.3.6.3(b).

6.3.6 Multiple knockouts test

6.3.6.1 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.

6.3.6.2 Samples for testing shall be in the form of either complete enclosures or sample plates that fulfill the requirements of Figure 6.1.

**Figure 6.1**  
**Diagram of test plate**



6.3.6.3 With a sample enclosure securely held or a test plate supported as in Figure 6.1, 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

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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.

#### 6.3.7 Threaded openings

6.3.7.1 A threaded hole for the connection of conduit that is tapped all the way through an enclosure shall be provided with not less than three full threads, except as permitted by 6.3.7.2. The construction shall be such that a conduit bushing can be properly attached as intended.

6.3.7.2 Two full threads shall be acceptable if the threaded opening complies with the Metallic enclosure threaded opening test, 6.3.8.

6.3.7.3 If the threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or the like, there shall not be less than five full threads in the metal.

6.3.7.4 The inlet hole shall:

- a) Be smooth and rounded to afford protection to the conductors equivalent to that provided by a standard conduit bushing and
- b) Have an internal diameter approximately the same as that of the corresponding trade size of rigid conduit.

#### 6.3.8 Metallic enclosure threaded opening test

6.3.8.1 A threaded hole for the connection of conduit (see Threaded openings, 6.3.7) shall be subjected to the Torque test in 6.3.8.2 and the Bending moment test in 6.3.8.3. Threads shall not strip and the walls of the enclosure shall not fracture.

6.3.8.2 With conduit installed and the enclosure rigidly mounted, the tightening torque shall be applied for 5 minutes as specified in Table 6.1.

**Table 6.1**  
**Tightening torque**

| Trade size of conduit | Tightening torque |                           |
|-----------------------|-------------------|---------------------------|
|                       | N-m               | torque N-m (pound-inches) |
| 3/4 and smaller       | 90.4              | (800)                     |
| 1, 1-1/4, and 1-1/2   | 113.0             | (1000)                    |
| 2 and larger          | 181.0             | (1800)                    |

6.3.8.3 With conduit installed and the enclosure rigidly mounted, a bending moment of 68 N·m (600 pound-inches) shall be applied to its axis. The lever arm shall be measured from the wall of the enclosure to the point of application of the force.

6.3.9 A polymeric enclosure intended for use with rigid nonmetallic conduit – glued, threaded, or the like shall comply with the applicable requirements for the Standard for Non-Metallic Outlet Boxes, Flush-Device Boxes and Covers, UL 514C.

6.3.10 A polymeric enclosure intended for connection to a rigid metallic conduit system shall comply with the requirements in 6.3.11.

6.3.11 Polymeric enclosures – rigid metallic conduit connection test

6.3.11.1 Criteria – A polymeric enclosure intended for connection to a rigid metallic conduit system shall not pull apart or sustain damage such as cracking and breaking as a result of the pullout, torque, and bending procedures described in 6.3.11.2 – 6.3.11.4. If breakouts are incorporated in the enclosure, they shall remain in place following the procedure described in 6.3.11.5.

*Exception: An enclosure that is provided with a separate hub assembly and that has instructions stating that the hub is to be connected to the conduit before being connected to the enclosure need not be subjected to the torque test in 6.3.11.3.*

6.3.11.2 Pullout – The enclosure shall be suspended by a length of rigid conduit installed in one wall of the enclosure or mounted as intended in service and a pulling force of 890 N (200 pounds) shall be applied for 5 minutes to a length of conduit in the opposite wall.

6.3.11.3 Torque – The enclosure shall be securely mounted as intended in service. A torque in accordance with Table 6.1 shall be applied to a length of installed conduit in a direction tending to tighten the connection. The lever arm shall be measured from the center of the conduit.

*Exception: An enclosure that is intended to be connected at the end of a run of conduit and has only one 3/4 maximum trade size opening for the connection of conduit, need only be subjected to a tightening torque of 22 N·m (200 pound-inches).*

6.3.11.4 Bending – A 3.0 meter minimum (9 feet – 10-7/64 inch) length of conduit of the intended size shall be installed:

- a) In a hub or an opening if provided as part of the enclosure or

- b) If a hub or opening is not provided, in the center of the largest unreinforced surface intended for the connection of conduit.

The enclosure shall be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. The test shall be terminated once the deflection of the conduit end exceeds 255 mm (10 inches). If a weight is necessary to cause the conduit end to deflect, the test shall be terminated once the deflection of the conduit end exceeds 255 mm (10 inches) or once a bending moment as specified in Table 6.2 is achieved.

For the SI system of units, the magnitude of the weight shall be determined from the equation:

$$W = (0.1 M - 0.5 CL)/L$$

in which,

*W and C are measured in kilograms;*

*M is in Newton-meters; and*

*L is in meters.*

For inch-pound units, the magnitude of the weight shall be determined from the equation:

$$W = (M - 0.5 CL)/L$$

in which,

*W is the weight, in pounds, to be hung at the end of the conduit;*

*L is the length of the conduit, in inches, from the wall of the enclosure to the point at which the weight is suspended;*

*C is the weight of the conduit, in pounds; and*

*M is the bending moment required, in pound-inches.*

**Table 6.2**  
**Bending moment**

| Normal mounting plane of enclosure surface <sup>a</sup> | Conduit trade size | Bending moment for metallic conduit <sup>b</sup> |                |
|---------------------------------------------------------|--------------------|--------------------------------------------------|----------------|
|                                                         |                    | N-m                                              | (pound-inches) |
| Horizontal                                              | All                | 33.9                                             | (300)          |
| Vertical                                                | 1/2 – 3/4          | 33.9                                             | (300)          |
|                                                         | 1 and larger       | 67.8                                             | (600)          |

<sup>a</sup> If the enclosure surface may be installed in either a horizontal or a vertical plane, the vertical bending moment value shall be used.

<sup>b</sup> For an end of line enclosure as defined in the Exception to 6.3.11.3, the bending moment shall be 17.0 N-m (150 pound-inches).

6.3.11.5 Breakouts – A breakout shall be subjected to a force of 89 N (20 pounds) applied at right angles by means of a mandrel with a 6.4 mm (1/4 inch) diameter flat end. The mandrel shall be applied at the point most likely to cause movement of the breakout.

6.3.12 A clamp provided in an enclosure and intended for securement of nonmetallic-sheathed cable shall comply with the applicable requirements for the Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C.

6.3.13 For an enclosure system where it is intended that an opening for conduit will be punched or drilled in the field during installation, a permanent marking on the enclosure, a template, detailed instructions, a full-scale drawing furnished with the equipment or the like, shall identify the appropriate locations.

6.3.14 With regard to the requirement in 6.3.13 any operations related to the required cutting or drilling in the enclosure system shall not have the potential to damage electrical or mechanical components and wiring within the enclosures. Means shall be provided so that an opening for conduit can be made without subjecting internal parts to any contamination resulting from the presence of metallic particles. Spacings not less than the minimum required by this outline shall be provided between uninsulated live parts and a conduit bushing installed at any specified location likely to be used during installation.

## 6.4 Field wiring compartments

6.4.1 A field-wiring compartment in which branch circuit connections are to be made shall:

- a) Be located so that the connections may be readily inspected after the enclosure system is installed;
- b) Permit the connection to be introduced and connected easily; and
- c) Permit the connection of the supply wires after the enclosure system is fixed to its support.

6.4.2 An outlet box, terminal box, wiring compartment, or similar component, in which connections to the power unit circuit are made in the field shall be free from any sharp edge including screw threads, a burr, a fin, a moving part, or similar component that may abrade the insulation on conductors, or otherwise damage the wiring.

6.4.3 The outlet box, terminal box, wiring compartment, or similar component, in which connections to the power unit circuit are made in the field shall comply with:

- a) The Standard for Metallic Outlet Boxes, UL 514A;
- b) The Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C; or
- c) The Standard for Enclosures for Electrical Equipment, UL 50.

6.4.4 The wiring compartment for the supply connections shall not occupy the same space for any of the Class 2, communications or other low voltage or signal wiring. Also see Separation of Circuits, Section 8.

## 6.5 Wiring terminals and leads

6.5.1 A lead or a terminal, such as a pressure wire connector or wire-binding screw, shall be provided for connection of each conductor intended to be installed in the enclosure in the field.

6.5.2 Terminals and leads for branch circuit connections shall be located in proximity to each other and to the grounding terminal.

6.5.3 A field wiring terminal or lead shall be located so that:

- a) It is accessible for examination after the wiring and enclosure system are installed; and
- b) Connection is able to be tightened or wires removed without loosening any screws that secure internal (factory) wiring, bus bars, or components.

6.5.4 A field-wiring terminal, or lead, shall be sized in accordance with ANSI/NFPA 70, National Electrical Code for the connection of conductors as appropriate for the branch circuit specified. In calculating the appropriate branch circuitry, 125 percent of the rated current of the enclosure system shall be used.

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

6.5.6 A field wiring terminal shall be for use with copper or aluminum conductors or both and marked with one of the following:

- a) "Use Copper Conductors Only" or "CU" for terminals intended for connection only to copper wire;
- b) "Use Aluminum Conductors Only" or "AL" for terminals evaluated only for connection to aluminum wire;
- c) "Use Copper or Aluminum Conductors", "Use Copper, Copper-Clad Aluminum, or Aluminum Conductors" or AL-CU" or "CU-AL" for terminals evaluated for connection to copper and aluminum or copper-clad aluminum wire; or
- d) "Use Copper or Copper-Clad Aluminum Conductors" or "CC-CU" or "CU-CC" for terminals evaluated for connection to copper and copper-clad aluminum wire.

6.5.7 A field wiring terminal block shall comply with the Standard for Terminal Blocks, UL 1059 and be suitable for field wiring using the applicable wire gauge specified in the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E.

6.5.8 A pressure wire connector of a component other than a terminal block shall:

- a) Comply with the Standard for Wire Connectors, UL 486A-486B or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E and
- b) Have electrical spacings at field wiring terminals that comply with, Spacings, Section 10 of the Standard for Industrial Control Panels, UL 508A.

6.5.9 A wire-binding screw may be employed at a wiring terminal intended for connection of a 10 AWG (5.3 mm<sup>2</sup>) or smaller conductor only.

6.5.10 A wire binding screw, other than one on a terminal block or a component, shall comply with the following:

- a) A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.76 mm (0.030 inch) thick for a 14 AWG (2.1 mm<sup>2</sup>) or smaller wire, and not less than 1.27 mm (0.050 inch) thick for a wire larger than 14 AWG (2.1 mm<sup>2</sup>). There shall be at least two full threads in the plate

*Exception: Two full threads are not required if fewer threads result in a secure connection in which the threads will not strip upon application of a 2.3 N·m (20 pound-inch) tightening torque.*

- b) A terminal plate formed from stock having the required thickness specified in (a) is able to have the metal extruded at the tapped hole for the binding screw to provide two full threads;

- c) A wire-binding screw shall thread into metal;

- d) A wire-binding screw shall be 4.2 mm diameter (No. 8) or larger screw for securing a 10 AWG (5.3 mm<sup>2</sup>) or smaller conductor, or a 3.5 mm diameter (No. 6) screw for securing a 14 AWG (2.1 mm<sup>2</sup>) conductor only.

- e) Upturned lugs, a cupped washer, or the equivalent shall be provided to hold the wire in position. Upturned lugs or cupped washers shall be capable of retaining the conductor under the head of the screw or washer.

6.5.11 The free length of a lead inside an outlet box or wiring compartment shall be at least 152 mm (6 inches) and shall not exceed 610 mm (24 inches) in length if the lead is for field connection to an external circuit.

## 6.6 Power supply cords

6.6.1 An enclosure system intended to be portable or as free-standing stationary equipment and having no provisions for conduit or permanent connection to a building, is permitted to be cord-connected to the supply.

6.6.2 The cord shall be a hard-service or junior hard-service flexible cord that:

- a) Complies with the Standard for Flexible Cords and Cables, UL 62 and
- b) Terminates in an attachment plug that complies with the Standard for Attachment Plugs and Receptacles, UL 498, or the Standard for Plugs, Receptacles and Cable Connectors of the Pin and Sleeve Type, UL 1682, and is rated for the voltage involved.

6.6.3 At the point at which the cord passes through the enclosure wall, a strain relief bushing shall be provided to prohibit cord abrasion. The strain relief bushing shall comply with the Standard for Conduit, Tubing, and Cable Fittings, UL 514B.

*Exception: A strain relief means that complies with the Standard for Industrial Control Equipment, UL 508.*

6.6.4 The cord shall comply with the Standard for Flexible Cords and Cables, UL 62, and be one of the following types: S, SE, SEO, SEOO, SJ, SJE, SJEO, SJEOO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, STOO, or portable power cable Type G, PPE, or W power cable.

6.6.5 A cord, used on equipment having a:

- a) Type 3, 3R, 3S, 4, 4X, 6, or 6P enclosure shall be marked:
  - 1) "Outdoor",
  - 2) "W;"
- b) Type 6 or 6P enclosure shall be marked "water resistant;" and
- c) Type 12, 12K, or 13 enclosure shall be oil resistant and designated by the letter "O" in the cord type (such as SO, SJO, or STO).

6.6.6 The required conductor size of a cord shall be determined by:

- a) Calculating the required ampacity by multiplying the rated current times 125 percent and
- b) Determining minimum conductor size from Table 7.1 or Table 7.2 having a corresponding ampacity that is not less than (a).

6.6.7 Power supply cords are not permitted where they may be concealed by walls, floors, or ceilings or located above suspended or dropped ceilings.

**Table 7.1**  
**Ampacity of flexible cord**

| Conductor size, AWG | Amperes        |                               |
|---------------------|----------------|-------------------------------|
|                     | Two conductors | Three conductors <sup>a</sup> |
| 18                  | 10             | 7                             |
| 16                  | 13             | 10                            |
| 14                  | 18             | 15                            |
| 12                  | 25             | 20                            |
| 10                  | 30             | 25                            |
| 8                   | 40             | 35                            |
| 6                   | 55             | 45                            |
| 4                   | 70             | 60                            |
| 2                   | 95             | 80                            |

<sup>a</sup> Where more than three current-carrying conductors are provided, the ampacity of each of the conductors shall be 80 percent of these values for 4 – 6 conductors; 70 percent of these values for 7 – 9 conductors; 50 percent of these values for 10 – 20 conductors; 45 percent of these values for 21 – 30 conductors; 40 percent of these values for 31 – 40 conductors; and 35 percent of these values for 41 or more conductors.

**Table 7.2**  
**Ampacity of portable power cable**

| Conductor size, AWG | Number of current-carrying conductors |     |                |
|---------------------|---------------------------------------|-----|----------------|
|                     | 1                                     | 2   | 3 <sup>a</sup> |
| 8                   | 60                                    | 55  | 48             |
| 6                   | 80                                    | 72  | 63             |
| 4                   | 105                                   | 96  | 84             |
| 3                   | 120                                   | 113 | 99             |
| 2                   | 140                                   | 128 | 112            |
| 1                   | 165                                   | 150 | 131            |
| 1/0                 | 195                                   | 173 | 151            |
| 2/0                 | 225                                   | 199 | 174            |
| 3/0                 | 260                                   | 230 | 201            |
| 4/0                 | 300                                   | 265 | 232            |
| 250                 | 340                                   | 296 | 259            |
| 300                 | 375                                   | 330 | 289            |
| 350                 | 420                                   | 363 | 318            |
| 400                 | 455                                   | 392 | 343            |
| 500                 | 515                                   | 448 | 392            |

<sup>a</sup> Where more than three current-carrying conductors are provided, the ampacity of each of the conductors shall be: 80 percent of these values for 4 – 6 conductors; 70 percent of these values for 7 – 9 conductors; 50 percent of these values for 10 – 20 conductors; 45 percent of these values for 21 – 30 conductors; 40 percent of these values for 31 – 40 conductors, and 35 percent of these values for 41 or more conductors.

## 6.7 Receptacles

6.7.1 A general-use grounding type receptacle and a multi-pin type receptacle shall comply with the Standard for Attachment Plugs and Receptacles, UL 498.

6.7.2 A multi-pin receptacle mounted through an enclosure wall shall additionally:

- a) Be provided with a metal housing or comply with the polymeric enclosure requirements in the Standard for Industrial Control Equipment, UL 508 and
- b) Be a female type.

6.7.3 A general use receptacle shall be marked with an ampere rating and this rating shall be included in the overall rating of the enclosure system.

## 6.8 Service equipment

6.8.1 For an enclosure system that is designed such that it may be powered from a separate electrical service, the service equipment for control and protection of services and their installation shall comply with Article 230 of ANSI/NFPA 70, National Electrical Code. The service equipment and their arrangement and installation shall permit the installation of the service entrance conductors in accordance with Article 230 of ANSI/ NFPA 70.

6.8.2 Service equipment shall be certified and marked as being suitable for use as service equipment. Refer to the Reference Standard for Service Equipment, UL 869A. See Appendix A for other appropriate standards.

6.8.3 Service disconnects shall be operable without exposing the operator to uninsulated live parts. No equipment shall be connected to the supply side of the service disconnecting means, except as permitted in 230.82 of ANSI/NFPA 70, National Electrical Code.

## 6.9 Premises wiring

6.9.1 Cables external to an enclosure system that may be installed in buildings (i.e. facility wiring that may be run in walls or ceilings, attached to the building structure, through walls, doors or other openings, etc.) shall comply with the appropriate article in ANSI/NFPA 70, National Electrical Code, for the installation, cable and circuit under consideration.

## 6.10 Spacings

6.10.1 Electrical spacings shall comply with Section 36, Spacings, or Section 39, Clearance and Creepage Distances, of the Standard for Industrial Control Equipment, UL 508. Spacings at and within a subassembly, component or device shall be investigated based on the requirements for that subassembly, component or device.

6.10.2 Indoor enclosure systems covered under this outline are normally considered to be Overvoltage Category II. Indoor enclosure systems that may be installed as part of the building installation in the direct line of the source of power to the load equipment shall be evaluated for Overvoltage Category III.

6.10.3 The Overvoltage Category of outdoor enclosure systems is considered to be one of the following:

- a) If powered via the normal building installation wiring, Overvoltage Category II;
- b) If powered directly from the mains distribution system, Overvoltage Category III;
- c) If at, or in the proximity of, the origin of the electrical installation, Overvoltage Category IV.

Note 1: An example of an Overvoltage Category III enclosure system is an outdoor enclosure powered by a separate pedestal that contains the service equipment.

Note 2: An example of an Overvoltage Category IV enclosure system is an outdoor enclosure that contains service equipment and is powered directly by a service drop.

6.10.4 It is permitted to include components within enclosure systems that reduce the Overvoltage Category. Components used to reduce the Overvoltage Category shall comply with the requirements for the Standard for Surge Protective Devices, UL 1449. Suitability of the component for the application shall be determined for the intended installation. (For example, some devices are suitable for installation on the load side of the service entrance only, and some are suitable for use with cord-connected equipment only.) The equipment shall be evaluated for the rated impulse withstand voltage specified in the Standard for Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment, UL 840.

6.10.5 Indoor enclosure systems anticipated to be installed in a clean environment such as an office or an information technology room are evaluated for Pollution Degree 2. Outdoor enclosure systems and systems for use in industrial and similar environments are evaluated for Pollution Degree 3.

6.10.6 The spacings in equipment used as service equipment shall comply with Section 10 of the Reference Standard for Service Equipment, UL 869A.

## 7 Grounding

### 7.1 Equipment grounding conductor and grounding continuity

7.1.1 An enclosure system shall be provided with a field wiring lead or terminal, such as a pressure wire connector or wire-binding screw, for the connection of an equipment grounding conductor.

Note: In some standards this terminal may also be referred to as a protective earthing terminal (PET).

7.1.2 The equipment grounding lead or terminal shall have electrical continuity with all metal parts of the enclosure system by means of metal-to-metal contact or by means of internal bonding conductors. The bonding shall be by a positive means, such as by clamping, riveting, brazing, welding or making a bolted or screwed connection. Other methods are permitted if they have been evaluated and found to be suitable for maintaining continuity between parts. See Section 11 of the Standard for Grounding and Bonding Equipment, UL 467. The bonding connection shall penetrate nonconductive coatings, such as paint, or such parts shall be paint-free (masked). Parts requiring continuity to the equipment grounding conductor include, but are not limited to, structural members, exterior doors and panels, various metal members, vertical mounting rails, bottom front and bottom rear rails, raceways and conduit, lacer bars for wiring, and the like.

*Exception No. 1: The following small metal parts need not be grounded:*

- a) A metal part, such as an adhesive-attached metal-foil marking, a screw, or a handle that is located on the outside of an ENCLOSURE or EQUIPMENT CABINET and isolated from electrical components and wiring by grounded metal parts so that it is not likely to become energized*
- b) A small internal assembly screw, or other small fastener such as a rivet, a handle for a pull-out disconnect switch, or a magnet or armature of a relay or contactor.*

*Exception No. 2: As permitted by Parts not required to be grounded, 7.4.*

7.1.3 Parts facilitating the grounding of coaxial shields in accordance with 840.101 of ANSI/NFPA 70, National Electrical Code, require continuity to the equipment grounding conductor. See also 7.1.4.

7.1.4 Bonding conductors and combinations of conductive parts used for grounding continuity shall be evaluated in accordance with 2.6.3.4 of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, for protective bonding conductors. For systems without a mains supply, the protective current rating is assumed to be 20 amperes or as specified by the manufacturer, whichever is greater.

7.1.5 The equipment grounding conductor connection shall be located or protected such that the lead, terminal or installed equipment grounding conductor will not be disturbed or damaged by the installation of equipment or wiring in the field.

7.1.6 A free lead for connection of an equipment grounding conductor shall not be smaller in size than the line and neutral conductors and not smaller than 14 AWG (2.1 mm<sup>2</sup>). A terminal shall be suitable for the connection of an equipment grounding conductor that is not smaller than the line and neutral conductors and is not smaller than 14 AWG.

Note: Some industry requirements, such as GR-487-CORE, require a connection for a minimum 6 AWG (13.3 mm<sup>2</sup>) or equivalent grounding conductor.

7.1.7 A terminal for connection of an equipment grounding conductor shall comply with:

- a) The requirements for a field wiring terminal in accordance with Connections for wiring systems, 6.3 or
- b) The Standard for Grounding and Bonding Equipment, UL 467.

7.1.8 A field wiring terminal or lead for connection to an equipment grounding conductor, a bonding conductor or a grounding electrode conductor is not required to be installed in the enclosure system if the equipment is provided with a grounding kit or a grounding lug complying with this section and the unit is provided with the marking and instructions in accordance with 7.3.5.

## 7.2 Bonding conductor and grounding electrode conductor

7.2.1 An enclosure system that may be used for the connection of a bonding conductor or a grounding electrode conductor for bonding and grounding in accordance with 770.100, 800.100, 810.21, 820.100, 830-100 or 840.100 of ANSI/NFPA 70, National Electrical Code, shall be provided with a field wiring lead or terminal, such as a pressure wire connector or wire-binding screw, for the connection of a bonding conductor or a grounding electrode conductor.

Note: Examples of enclosure systems that may be used for this purpose include optical fiber splice closures, network interface device (NID) closures, optical network units (ONU) and the like.

*Exception No. 1: A polymeric enclosure system intended only for connection to nonconductive optical fiber cable from the network need not be provided with a lead or terminal for the connection of a bonding conductor or a grounding electrode conductor if it is marked in accordance with 7.3.6.*

*Exception No. 2: A polymeric enclosure system intended only for connection to optical fiber cable from the network need not be provided with a lead or terminal for the connection of a bonding conductor or a grounding electrode conductor if it is intended to interrupt the non-current carrying metallic members of the cable by an insulating joint or equivalent device as permitted by 770.93(B) of ANSI/NFPA 70, National Electrical Code. The insulating joint or equivalent device shall comply with 8.2, Interruption of non-current carrying metallic members of optical fiber cable.*

7.2.2 The lead or terminal shall have electrical continuity with all metal parts of the system in accordance with 7.1.2 and 7.1.3.

7.2.3 The lead or terminal shall be located or protected such that the lead, terminal or installed bonding conductor or grounding electrode conductor will not be disturbed or damaged by the installation of equipment or wiring in the field.

7.2.4 A free lead for connection of an equipment grounding conductor shall not be smaller in size than the line and neutral conductors and not smaller than 14 AWG (2.1 mm<sup>2</sup>). A terminal shall be suitable for the connection of an equipment grounding conductor that is not smaller than the line and neutral conductors and is not smaller than 14 AWG.

Note: Some industry requirements, such as GR-487-CORE, require a connection for a minimum 6 AWG or equivalent bonding conductor or a grounding electrode conductor.

7.2.5 A terminal for connection of a bonding conductor or a grounding electrode conductor shall comply with the requirements in the Standard for Grounding and Bonding Equipment, UL 467.

### 7.3 Grounding – identification and markings

7.3.1 A pressure wire connector intended for connection of a field-installed equipment grounding conductor shall be marked in accordance with 7.3.3.

7.3.2 A wire-binding screw terminal intended for connection of a field-installed equipment grounding conductor not larger than 10 AWG (5.3 mm<sup>2</sup>) shall be colored green or marked in accordance with 7.3.3.

7.3.3 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; or
- b) Use of a threaded stud with a green-colored hexagonal nut; or
- c) Use of a green-colored pressure-terminal connector; or
- d) Being marked "G," "GR," "GND," "Ground," "Grounding," or the like; or
- e) A marking on a wiring diagram provided on the product; or
- f) The grounding symbol illustrated in Figure 7.1 on or adjacent to the terminal or on a wiring diagram provided on the product.

**Figure 7.1**  
**Grounding symbol (IEC Publication 60417-5019)**



7.3.4 The lead or terminal for the equipment grounding conductor shall not be identified for the connection of an aluminum conductor.

7.3.5 If a field wiring terminal for an equipment grounding conductor is not installed in the equipment as shipped, the equipment shall be marked stating which pressure wire connector or component terminal kits are acceptable for use with the equipment. This information may be provided in the instruction manual if the enclosure is marked with the word "Ground" or "Grounding" or the grounding symbol in Figure 7.1 and the words "See instruction manual," or the equivalent. The symbol ▲ may be used in place of the reference to the instruction manual as long as its meaning is described in the instruction manual. The equipment instructions shall provide details regarding the proper installation of the equipment grounding terminal.

7.3.6 If a lead or terminal for the connection of a bonding conductor or a grounding electrode conductor is not provided as permitted by the Exception to 7.2.1, a marking shall be provided on the unit stating that only nonconductive optical fiber cable shall be used and that there is no provision for the connection of a bonding conductor or a grounding electrode conductor.

#### 7.4 Parts not required to be grounded

7.4.1 For an EQUIPMENT CABINET or RACK intended to mount only enclosed equipment, parts such as shelves, side rails, slide rails and blank interior panels are not required to be grounded. Structural parts such as the support frame, exterior panels, doors, lacer bars for wiring, raceways and cross bars are required to be grounded in accordance with Equipment grounding conductor and grounding continuity, 7.1.

7.4.2 If all metal parts are not effectively grounded, the EQUIPMENT CABINET or RACK shall be marked in accordance with 7.4.3 and provided with instructions in accordance with 7.4.4.

7.4.3 If all metal parts are not effectively grounded, the EQUIPMENT CABINET or RACK shall be marked with the symbol  and the following marking: "WARNING not all parts are effectively grounded". In addition the symbol shall be applied to all parts that are not effectively bonded to the protective earthing terminal.

7.4.4 A list of parts not effectively grounded shall be provided in the instruction manual with instruction stating the following or equivalent wording: "The following parts are not effectively bonded to the protective earthing terminal: \_\_\_\_\_." along with instructions on how to effectively bond them if required for the final installation.

#### 7.5 Functional grounding

7.5.1 A functional grounding terminal or connector may be provided that does not comply with the requirements for the connection of an equipment grounding conductor if all of the following are met:

- a) Wiring terminals to be used only for functional grounding shall not be marked or otherwise identified either on the enclosure, on schematics or in the instructions by any of the methods described in Grounding – identification and markings, 7.3;

Note: Other markings, such as one of the Symbols 5018 or 5020 of IEC 60417, Graphical symbols for use on equipment, if appropriate, are permitted

- b) For the connection of a functional grounding conductors, the color combination green-and-yellow shall not be used;
- c) The instructions shall clearly state that the functional grounding terminal is only for functional grounding use (such as EMI) and shall not be used for the connection of an equipment grounding conductor; and
- d) The equipment also complies, with the one of the requirements for the connection of an equipment grounding conductor, a bonding conductor or a grounding electrode conductor as required in Equipment grounding conductor and grounding continuity, 7.1 or Bonding conductor and grounding electrode conductor, 7.2.