



UL 2416

STANDARD FOR SAFETY

Audio/Video, Information and
Communication Technology Equipment
Cabinet, Enclosure and Rack Systems

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UL Standard for Safety for Audio/Video, Information and Communication Technology Equipment Cabinet, Enclosure and Rack Systems, UL 2416

First Edition, Dated March 11, 2015

Summary of Topics

This revision of ANSI/UL 2416 dated October 2, 2020 includes the following:

- **Modified definition of Enclosure;** [4.5](#)
- **Updated references for spacings;** [6.10.1](#)
- **Refinement of effectively grounded marking requirement;** [7.4.3](#), [7.4.4](#)
- **Revision of Functional Earthing (Grounding) marking;** Section [7.5](#)
- **Clarification on reference to UL 62368-1 for Indoor Locations;** [9.1.3.1](#)
- **Additional UL 62368-1 alternative for Outdoor Enclosures;** [9.1.4.1](#)
- **Clarification on condensation and drain holes;** [10.2.3.5](#)
- **Editorial revision of ITE (Computer) Room application requirement;** [12.3.1](#)
- **Refinement of Openings in Vertical Surfaces Requirements to promote consistent application;** Section [12.5.2](#)
- **Clarification on treatment of pryout holes;** [12.5.3.4](#)
- **Clarification on allowed application of Bottom Opening requirements to promote consistent application;** [12.5.4.1](#), [12.5.4.3](#), [12.5.4.4](#), [12.5.4.5](#)
- **Clarification on Overcurrent Protection;** [13.4.1](#)
- **Clarification on application of Temperature Test;** [15.3.1](#), [15.3.2](#)
- **Clarification on Installation Markings;** [16.4.4](#)
- **Clarification on Installation Instructions;** [16.7.8](#)
- **Miscellaneous Updates to UL 2416 to address areas needing further refinement;** [3.56](#)
- **Additional option for enclosure venting of battery compartments;** [13.5.2.1A](#)
- **Clarification on Battery Supply Performance;** [13.7.2](#), [13.7.3](#)

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated June 12, 2020, July 31, 2020, and August 21, 2020.

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UL 2416

**Standard for Audio/Video, Information and Communication Technology
Equipment Cabinet, Enclosure and Rack Systems**

First Edition

March 11, 2015

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The most recent designation of ANSI/UL 2416 as an American National Standard (ANSI) occurred on September 28, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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INTRODUCTION

1 Scope

1.1 This Standard covers requirements for Audio/Video, Information and Communication Technology Equipment Cabinet, Enclosure and Rack Systems. For the purpose of this Standard 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 Standard 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 the Standard for Heating and Cooling Equipment, UL 1995, and the Outline of Investigation for Drop-Out Ceilings Installed Beneath Automatic 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 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 References

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

- 3.2 The standards specified in [3.3](#) – [3.56](#) contain provisions, which, through referenced in this Standard, constitute provisions of this Standard.
- 3.3 The National Electrical Safety Code, ANSI/IEEE C2. See [6.2.8](#).
- 3.4 Safety glazing materials used in buildings – safety performance specifications and methods of test, ANSI Z97.1. See [9.3.3](#).
- 3.5 The Standard Test Method for Surface Burning Characteristics of Building Materials, ASTM E84. See [12.2.1](#).
- 3.6 The Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, ASTM A90/A90M. See [B1.4](#) and [B1.5](#).
- 3.7 The Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source, ASTM E162. See [12.2.1](#).
- 3.8 The Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for, ASTM A568/A568M. See [B1.4](#) and [B1.5](#).
- 3.9 Mechanical Structural Issues, ATIS 0600006. See [11.1.7.2](#).
- 3.10 Temperature, Humidity, and Altitude Requirements for Network Telecommunications Equipment Utilized in Outside Plant Environments, ATIS 0600010.01. See [15.3.1](#).
- 3.11 Network Equipment – Earthquake Resistance, ATIS 0600329. See [11.1.7.2](#).
- 3.12 The Code of Federal Regulations (CFR), Title 21. See [16.6.1](#), [16.6.3](#), [16.6.6](#), and [16.6.7](#).
- 3.13 Telcordia Generic Requirements for Electronic Equipment Cabinets, GR-487-CORE. See [10.2.4.1](#) and [10.2.5.3](#).
- 3.14 Generic Requirements for Fiber Optic Splice Closures, GR-771-CORE. See [12.6.1](#).
- 3.15 Telcordia Generic Requirements for Optical Network Unit (ONU) Closures and ONU Systems, GR-950-CORE. See [10.2.5.3](#).
- 3.16 Graphical symbols for use on equipment, IEC 60417. See [7.5.1](#) and [Figure 7.1](#).
- 3.17 Safety of laser products – Part 1: Equipment classification and requirements, IEC 60825-1. See [16.6.3](#), [16.6.4](#), [16.6.6](#), and [16.6.7](#).
- 3.18 The National Electrical Code (NEC), ANSI/NFPA 70. 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](#).
- 3.19 The Standard for the Fire Protection of Information Technology Equipment, NFPA 75. See [12.3.1](#) – [12.3.3](#).
- 3.20 The Standard for Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits, UL 5C. See [12.1.8](#).
- 3.21 The Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50. See [6.4.3](#), [9.1.3.1](#), [9.1.3.2](#), [9.1.4.1](#), [9.2.5](#), and [9.3.3](#).

- 3.22 The Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E. See [9.1.4.1](#), [9.2.5](#), and [10.2.4.1](#).
- 3.23 The Standard for Flexible Cords and Cables, UL 62. See [6.6.2](#).
- 3.24 The Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94. See [12.5.1.1](#) and [12.6.1](#).
- 3.25 The Standard for Grounding and Bonding Equipment, UL 467. See [7.1.2](#), [7.1.7](#), and [7.2.5](#).
- 3.26 The Standard for Wire Connectors, UL 486A-486B. See [6.5.8](#).
- 3.27 The Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E. See [6.5.7](#) and [6.5.8](#).
- 3.28 The Standard for Attachment Plugs and Receptacles, UL 498. See [6.6.2](#) and [6.7.1](#).
- 3.29 The Standard for Industrial Control Equipment, UL 508. See [6.6.3](#), [6.7.2](#), and [6.10.1](#).
- 3.30 The Standard for Industrial Control Panels, UL 508A. See [6.5.8](#), [9.1.3.1](#), [9.1.3.2](#), and [9.1.4.1](#).
- 3.31 The Standard for Metallic Outlet Boxes, UL 514A. See [6.4.3](#) and [12.5.1.5](#).
- 3.32 The Standard for Conduit, Tubing, and Cable Fittings, UL 514B. See [6.3.2](#) and [12.5.1.5](#).
- 3.33 The Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C. See [6.3.9](#), [6.3.12](#), and [6.4.3](#).
- 3.34 The Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D. See [12.5.1.5](#).
- 3.35 The Standard for Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings, UL 651. See [12.5.1.5](#).
- 3.36 The Standard for Test for Surface Burning Characteristics of Building Materials, UL 723 (see [12.2.1](#)), or the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C (see [9.3.4.4](#) and [12.5.1.1](#)).
- 3.37 The Standard for Electrochemical Capacitors, UL 810A. See [13.1.2](#).
- 3.38 The Reference Standard for Service Equipment, UL 869A. See [6.10.6](#).
- 3.39 The Standard for Emergency Lighting and Power Equipment, UL 924. See [13.1.2](#).
- 3.40 The Standard for Marking and Labeling Systems, UL 969. See [16.1.5](#).
- 3.41 The Standard for Terminal Blocks, UL 1059. See [6.5.7](#).
- 3.42 The Standard for Surge Protective Devices, UL 1449. See [6.10.4](#).
- 3.43 The Standard for Fire Tests of Through-Penetration Firestops, UL 1479. See [12.4.3.3](#).
- 3.44 The Standard for Lithium Batteries, UL 1642. See [13.1.2](#).

- 3.45 The Standard for Household, Commercial, and Institutional-Use Carts, Stands and Entertainment Centers for Use with Audio and/or Video Equipment, UL 1678. See [11.4.1](#).
- 3.46 The Standard for Plugs, Receptacles and Cable Connectors of the Pin and Sleeve Type, UL 1682. See [6.6.2](#).
- 3.47 The Standard for Uninterruptible Power Systems, UL 1778. See [13.1.2](#) and [13.7.2](#).
- 3.48 The Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications, UL 1973. See [13.1.2](#).
- 3.49 The Standard for Standby Batteries, UL 1989. See [13.1.2](#).
- 3.50 The Standard for Cable Routing Assemblies and Communications Raceways, UL 2024. See [12.1.8](#).
- 3.51 The Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces, UL 2043. See [12.4.1](#) and [12.4.3.3](#).
- 3.52 The Standard for Household and Commercial Batteries, UL 2054. See [13.1.2](#).
- 3.53 The Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications, UL 2271. See [13.1.2](#).
- 3.54 The Standard for Batteries for Use in Electric Vehicles, UL 2580. See [13.1.2](#).
- 3.55 The Outline of Investigation for Modular Data Centers, UL 2755. See [9.5.1](#) and [9.5.2](#).
- 3.56 The Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1. See [7.1.4](#), [8.2.3](#), [9.1.3.1](#), [9.1.4.1](#), [9.4](#), [12.1.1](#), [12.1.5](#), [12.3.1](#), [12.5.4.2](#), [13.5.2.1](#), [13.7.3](#), [15.3.1](#), [15.3.2](#), [15.4.1](#), and [15.5.2](#).

4 Glossary

4.1 For the purpose of this Standard the following definitions apply. Also reference the National Electrical Code, NFPA 70, Article 100.

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;
- c) The Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E; and
- d) The Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

the terms and definitions in those standards are applicable.

4.2 **ACCESORY** – 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;
- h) Power distribution equipment,

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 parts involving a risk of electric shock or personal injury, to minimize the risk of fire due to 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 Standard 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 Standard, and other than as indicated in [5.2](#), a component or subassembly used in a product covered by this shall comply with the requirements for that component or subassembly. See Appendix for a list of standards covering components and subassemblies used in the products covered by this.

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 Standard or
- b) Is superseded by a requirement in this Standard.

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 Enclosure systems intended for fixed installation or permanent connection to the building structure that require a branch-circuit supply 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) that require a branch-circuit supply 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 that requires a branch-circuit supply 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 intended to be connected 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 intended to be connected 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:

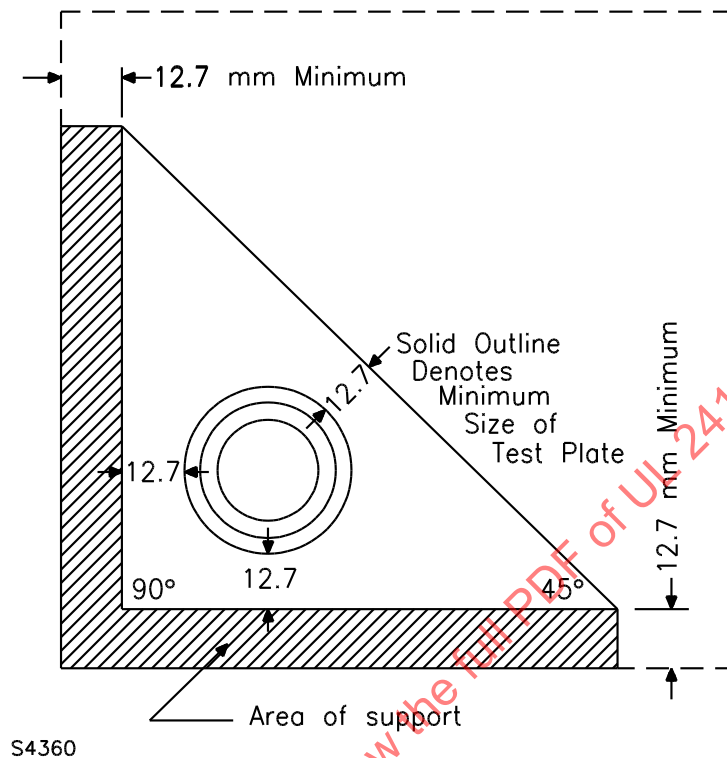
- a) The material can be readily removed, using ordinary care, to provide an opening of the required size without damaging the remainder of the enclosure or any outer rings and
- b) The strength of any remaining rings will withstand the loading test specified in [6.3.6.3\(b\)](#).

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
- 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 ^a	Conduit trade size	Bending moment for metallic conduit ^b	
		N-m	(pound-inches)
Horizontal	All	33.9	(300)
Vertical	1/2 – 3/4	33.9	(300)
	1 and larger	67.8	(600)

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

^b 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:

- Be located so that the connections may be readily inspected after the enclosure system is installed;
- Permit the connection to be introduced and connected easily; and
- 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:

- The Standard for Metallic Outlet Boxes, UL 514A;
- The Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C; or

- c) The Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, 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 mm²) 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 mm²) or smaller wire, and not less than 1.27 mm (0.050 inch) thick for a wire larger than 14 AWG (2.1 mm²). 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 mm²) or smaller conductor, or a 3.5 mm diameter (No. 6) screw for securing a 14 AWG (2.1 mm²) 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 A strain relief shall be provided on the cord to prevent stress and strain on internal wiring connections. If strain relief is provided as part of an internal assembly, at the point at which the cord passes through the enclosure wall, a suitable bushing or equivalent 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 No. 1: A strain relief means that complies with the Standard for Industrial Control Equipment, UL 508.

Exception No. 2: A strain relief means that is provided as part of a certified assembly.

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 6.3](#) or [Table 6.4](#) 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 6.3
Ampacity of flexible cord

Conductor size, AWG	Amperes	
	Two conductors	Three conductors ^a
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

^a 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 for 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 6.4
Ampacity of portable power cable

Conductor size, AWG	Number of current-carrying conductors		
	1	2	3 ^a
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

^a 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 Services, 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 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 Equipment Connected to the Supply Side of Service Disconnect, 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 Spacings, Section 37, or Clearance and Creepage Distances, Section 40 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 Spacings, 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 the requirements for miscellaneous devices in 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 Premises Circuits Not Leaving the Building, 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 Resistance of earthing conductors and their terminations, 2.6.3.4 of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1 Clause 5.6.6 – Resistance of the protective bonding system. 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 mm²). 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 mm²) 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:

- a) Entrance Cable Bonding and Grounding, 770.100;
- b) Cable and Primary Protector Bonding and Grounding, 800.100;
- c) Bonding Conductors and Grounding Electrode Conductors – Receiving Stations, 810.21;
- d) Cable Bonding and Grounding, 820.100;
- e) Cable, Network Interface Unit, and Primary Protector Bonding and Grounding, 830-100; or
- f) ONT and Optical Fiber Cable Grounding, 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 mm²). 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

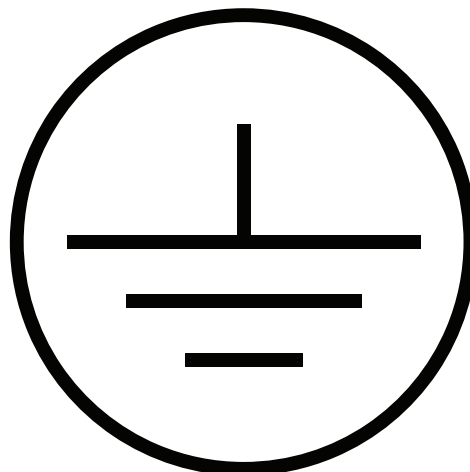
7.3.1 A pressure wire connector intended for connection of a field-installed equipment grounding conductor shall be marked in accordance with [7.3.3](#).

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 mm²) 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".

The symbol shall be applied to all parts that are not effectively bonded to the protective earthing terminal.

A single marking may identify several or groups of parts, provided these parts are located near each other.

7.4.4 A list of parts, or groups 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 (earthing)

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

- a) The equipment is marked with the symbol, IEC 60417-6092 (2013-03).

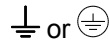


- b) Wiring terminals to be used only for the connection of functional grounding shall be marked with the symbol, IEC 60417-5018 (2011-07).



- c) Wiring terminals to be used only for the connection of grounding shall not be marked with the symbol, IEC 60417-5017 (2006-08) or with the symbol, IEC 60417-5019 (2006-08). However,

these symbols may be used for a wiring terminal provided on a pre-selected component (for example, a terminal block) or subassembly.



d) For the connection of a functional grounding conductors, the color combination green-and-yellow shall not be used;

e) 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

f) 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](#).

7.5.2 Deleted

8 Separation of Circuits

8.1 General

8.1.1 Enclosure systems shall be constructed to accommodate the separation of circuits as required by ANSI/NFPA 70, National Electrical Code.

Note: See 770.133 of ANSI/NFPA 70 for Optical Fiber Cables, 800.133 for Communications Cables, 810.18 and 810.70 for Antenna Lead-In Conductors, 820.133 for Coaxial Cables and 830.133 for Network Powered Broadband Communications Cables.

8.1.2 Field-wiring terminals and external circuit connectors for Class 2, Class 3, or communication cables shall not be in a wiring compartment, box, or other area with conductors or terminals for other circuits. Field installed conductors shall be secured so that they cannot contact uninsulated live parts, field-installed wiring, and factory installed wiring of any other circuit.

Exception No. 1: This requirement does not apply if a solid (unpierced) partition, permanently secured in place, is provided to separate field-installed conductors from field- and factory-installed conductors and live parts of any other circuit.

Exception No. 2: In units for which field connections for some applications are different from the connections for other applications, a removable solid partition or a permanent partition in which there are holes for the passage of conductors may be used. Instructions for use of a removable or pierced partition are to be a permanent part of the unit.

Exception No. 3: Instead of a partition, a wiring diagram may be provided on or with the unit if provision is made for routing all conductors, if such routing is clearly and completely shown by the diagram, and if complete wiring instructions accompany the diagram.

Exception No. 4: Separation of some field-installed conductors from others and from uninsulated live parts connected to different circuits can be accomplished by arranging the location of openings in the enclosure for the various conductors (with respect to the terminals or other uninsulated live parts) so that there is no likelihood that the conductors or parts of different circuits can be intermingled. If no more openings than are necessary are provided in the enclosure for wiring of the unit and each opening is opposite a set of terminals, it is to be assumed in determining compliance with the requirement for the separation of terminals that conductors entering the enclosure through any such opening will be connected only to the terminals opposite that opening. If more openings than are necessary are provided in the enclosure for

wiring the unit, it is to be assumed in determining compliance with the requirement for the separation of terminals that conductors will enter the enclosure through openings that are not opposite the terminals to which they are intended to be connected and will touch insulated conductor and uninsulated live parts of circuits other than their own.

8.1.3 In determining whether a unit complies with these requirements the unit is to be wired in the manner in which it would be wired in the field. A reasonable amount of slack is to be left in each conductor within the enclosure, and not more than average care is to be used in stowing the slack in the compartment.

8.1.4 Where permitted by ANSI/NFPA 70, National Electrical Code, cables containing different circuits may not require separation in an enclosure or wiring compartment provided that all cables are suitable for the highest class of circuit involved. If this provision in ANSI/NFPA 70 is required to comply with the separation of circuits criteria, a marking shall be provided adjacent to the wiring terminals indicating that all field wired cables are to comply with the requirements for highest class circuit involved.

8.2 Interruption of non-current carrying metallic members of optical fiber cable

8.2.1 An insulating joint or equivalent device used to comply with 770.93(B) of ANSI/NFPA 70, National Electrical Code shall comply with [8.2.2](#) and [8.2.3](#).

8.2.2 An insulating joint or equivalent device shall be rated for the rms voltage it is intended to isolate. Standardized ratings of 2.5 kV, 8 kV, 15 kV or 20 kV shall be used unless there is a need for more specific or alternate ratings based on the anticipated distribution system voltage. The isolation rating shall be marked on the enclosure system near the insulating joint or equivalent device where visible to an installer. The isolation information shall also appear in the installation instructions.

Note: Typical distribution voltages on joint use poles are 2.4/4.16 kV, 7.2/12.47 kV, 7.62/13.2 kV, 7.97/13.8 kV, 14.4/24.94 kV and 19.92/34.5 kV. Only phase-to-ground voltages are considered for this requirement.

8.2.3 The isolation provided by an insulating joint or equivalent device between the noncurrent carrying metallic members of optical fiber cables and circuits, accessible dead metal parts (grounded or ungrounded) or other surfaces (conductive or non-conductive) that may be contacted shall withstand an electric strength test of 2 X the rated isolation voltage. Electric strength tests shall be performed in accordance with Electric Strength, 5.2 of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or Electric Strength Test, 5.4.9, of the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1. For this test, the insulating joint or equivalent device shall be wired with a min. 24 AWG (0.21 mm²) uninsulated wire routed anywhere within the enclosure system that non-current carrying metallic members of optical fiber cables may be routed during installation of the cable, taking into account any wire routing diagrams or instructions that may be provided.

9 Construction Details

9.1 General construction

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

9.1.2 An ENCLOSURE shall:

- a) Completely enclose all equipment and components that may be housed in it. See Accessibility, [9.4](#) and

b) Provide a fire enclosure for all equipment and components that may be housed in it. See Fire Resistance Criteria, Section [12](#).

9.1.3 Indoor locations

9.1.3.1 An enclosure system intended only for indoor locations shall comply with the requirements in:

- a) Clause 4, Physical requirements, of 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;
- c) The Standard for Industrial Control Panels, UL 508A;
- d) The Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1. (Appropriate parts of Clauses 5 – -10 may be applicable based on the specific hazard involved.)

9.1.3.2 An ENCLOSURE intended only for indoor locations that is designated by a type number for enclosures for indoor locations, (Types 1, 2, 5, 12, 12K, and 13) shall comply with the construction requirements in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50 or the Standard for Industrial Control Panels, UL 508A. An enclosure system that is for indoor locations and is not marked with a type number does not need to comply with UL 50 or UL 508A but shall comply with [9.1.3.1](#).

9.1.4 Outdoor locations

9.1.4.1 An ENCLOSURE intended for outdoor locations shall comply with the requirements in this Standard for enclosures. Additionally, the ENCLOSURE shall comply with one of the following:

- a) Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50;
- b) Enclosure requirements in Sections 62 – 64 of the Standard for Industrial Control Panels, UL 508A;
- c) Annex Y, Construction requirements for outdoor enclosures, of UL 62368-1, Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements.

Exception: A sheet metal enclosure need not comply with Thickness, 6.4.1, and 6.4.2.3 and 6.4.2.5, covering fasteners, of UL 50, if it complies with the Impact test for outdoor enclosures, [9.1.5](#). The general requirement of [9.1.1](#) still applies.

9.1.5 Impact test for outdoor enclosures

9.1.5.1 Only where required by the Exception to [9.1.4.1](#), an outer enclosure shall not sustain any mechanical damage that would affect the structural or environmental integrity of the enclosure, result in the reduction of electrical spacings, produce any other condition that might increase the risk of fire, electric shock, or injury to persons, or affect the function of critical subassemblies such as heat exchangers when subjected to the following impact test.

9.1.5.2 The equipment shall be subjected to an impact on any surface that may be exposed to a blow during normal use or during installation. The impact is to be applied by means of a smooth, solid, sphere as indicated below. The sphere is to fall freely from rest (by dropping or as a pendulum) through the

vertical distance specified to obtain the desired required impact force. When the test is used in place of the requirements in 6.4.2.3 and 6.4.2.5 of the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, the joint in question shall be subjected to the impact.

9.1.5.3 For an enclosure having a volume less than 0.2265 m^3 (8 ft^3) the impact is to be 13.6 J (10 foot-pounds) produced by dropping a steel sphere, 50.8 mm (2 inches) in diameter and weighing .535 kg (1.18 pounds), from a height of 2.6 m (102 inches).

9.1.5.4 For an enclosure having a volume of 0.2265 m^3 (8 ft^3) or more, the impact is to be 136 J (100 foot-pounds) produced by dropping a hard rubber ball (such as a bowling ball), approximately 21.6 cm (8-1/2 in) in diameter and weighing approximately 7.3 kg (16 lb.), from a height as needed to produce the required impact force. [1.9 meters (6.25 ft.) is needed for a 7.3 kg (16 lb.) ball].

9.1.5.5 The impact shall not cause any of the conditions described in [9.1.4.1](#) to occur.

9.1.5.6 In general, the test may be conducted at any ambient temperature within the range of $10 - 40^\circ\text{C}$ ($50 - 104^\circ\text{F}$). For outdoor applications, enclosures with non-metallic surfaces are to be cooled to minus 29°C (minus 20°F) and maintained at that respective temperature for 8 hours. The samples are to be tested within 10 minutes following removal from the cold chamber.

9.1.6 For flammability requirements, refer to Fire Resistance Criteria, Section [12](#).

9.2 Corrosion

9.2.1 Ferrous metal parts shall be protected against corrosion by galvanizing, plating, painting, enameling, or other equivalent means when the malfunction of such parts is likely to result in a risk of fire, electric shock or injury to persons. Magnets are not required to have corrosion protection.

9.2.2 Metal shall be used in combinations that are galvanically compatible.

9.2.3 Hinges and other attachments shall be resistant to corrosion.

9.2.4 A nonmetallic enclosure shall be judged on the basis of the effect of exposure to ultraviolet light and water.

9.2.5 A metallic enclosure shall be protected against corrosion as specified in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, and the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, or Appendix [B](#).

9.3 Glass windows

9.3.1 Glass windows not more than 102 mm (4 in) in any dimension (including the diagonal) and shall not be less than 1.40 mm (0.055 in) thick

9.3.2 Glass windows not more than 929 cm^2 (144 in^2) in area and having no dimension (including the diagonal) greater than 304.8 mm (12 in), shall not be less than 2.92 mm (0.115 in) thick.

9.3.3 Glass used to cover an area larger than 929 cm^2 (144 in^2) or greater than 304.8 mm (12 in) in any dimension shall be of a nonshattering or tempered type that, when broken, shall conform to the performance specifications in Safety glazing material used in buildings – safety performance specifications and methods of test, ANSI Z97.1, and shall:

a) For an EQUIPMENT CABINET, not be less than 3.175 mm (1/8 in) thick and withstand a 3.4 J (2.5 ft-lb) impact or for glass less than 3.175 mm thick withstand an impact of 6.8 J (5 ft-lbs) when tested in accordance with the impact test of [9.3.4](#); or

b) For an ENCLOSURE, withstand an impact of 6.8 J (5 ft-lbs) when tested in accordance with the impact test of [9.3.4](#) and the Crushing resistance test in 8.10 of the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50.

9.3.4 Glass window impact test

9.3.4.1 In accordance with [9.3.3](#), each window sample shall be subjected to a single impact of the value specified in [9.3.3](#) (a) or (b).

9.3.4.2 The specified impact is to be produced by dropping a steel sphere, 50.8 mm (2 inches) in diameter, and weighing 0.535 kg (1.18 lb.) mass from the height necessary to produce the specified impact. For surfaces other than the top on an enclosure, either the sample could be supported on the side and subjected to the ball impact mentioned above, or the steel sphere is to be suspended by a cord and swung as a pendulum, dropping through the vertical distance necessary to cause it to strike the surface with the specified impact.

9.3.4.3 There shall be no cracking or breaking to the extent that a piece is released or dropped from its normal position.

9.3.4.4 Glass used as part of the enclosure system shall be reliably secured in such a manner that it cannot be readily displaced in service. A glass window shall be secured to the enclosure by mechanical means, such as mechanical fasteners. When an adhesive is used to secure a glass window to the enclosure, the assembly shall comply with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

9.4 Accessibility

9.4.1 To reduce the likelihood of unintentional contact by a user that may involve a risk of electric shock from an uninsulated live part, a hazardous energy level, or injury to persons from a moving part, an opening in an enclosure system shall not allow the part to be contacted (accessed) by the probe illustrated in [Figure 9.1](#). In addition an ENCLOSURE shall not permit access to any such parts that may be part of user installed equipment.

Exception: For contact with moving parts of electric fans, the probe shown in the Probe for fan impellers and other moving parts of stationary fans and fans intended to be permanently connected electrically, Figure 8.2 in the Standard for Electric Fans, UL 507 is applicable. The probes of [Figure 9.1](#) and the Jointed test probe for equipment not likely to be accessible to children, Figure V.2 of the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1 may be used as an alternative if agreeable to the manufacturer.

9.4.2 The probe specified in [9.4.1](#) shall be applied in any possible configuration; and, if necessary, the configuration shall be changed after insertion through the opening.

9.4.3 The probe specified in [9.4.1](#) shall be applied with a force not to exceed 10 N (2.2 lbs). The probe is to be used to determine the accessibility provided by an opening, and not as an instrument to determine the strength of a material.

9.4.4 The probe specified in [9.4.1](#) is to be inserted as described in [9.4.2](#) into all openings, including those in the bottom of the unit. The unit is to be moved in whatever way necessary to make the entire bottom accessible for insertion of the probe.

Exception: For a floor-standing unit, the probe is to be inserted into all openings in the bottom that are accessible without tipping, turning over, or otherwise moving the unit from its intended installed position.

9.4.5 In a Service access areas, uninsulated live parts involving the risk of electric shock, parts involving hazardous energy, or parts involving injury to persons from a moving part shall be located or guarded so that accidental contact or shorting across different circuits, for example by tools or test probes used by service personnel, is unlikely. Parts in a Class 2 or Low voltage limited energy circuits need not be located or guarded from accidental contact by service personnel.

9.4.6 With respect to hazardous parts that have the potential to cause personal injury, these parts shall be so arranged, enclosed or guarded as to reduce the risk of injury to persons according to [9.4.1](#) for a user and [9.4.5](#) for service persons. In addition to rotating and moving parts such as blowers and fans, examples of parts and areas that need to be considered are lift-up awning type doors or panels and pinch points around heavy swing out doors or frames that have sufficient momentum to severely injure a person.

9.4.7 Enclosure systems may be evaluated for installation in a restricted access location, such as a dedicated equipment room or telecommunication equipment closet, where access to the entire equipment is limited to trained service personnel. Such enclosure systems are provided with a marking or installation instructions in accordance with [16.4.2](#). The accessibility requirements for service access areas apply to such equipment except that for hazardous moving parts the requirements for user access shall apply.

9.5 Large enclosure systems

9.5.1 Large enclosure systems less than or equal to 1.8 m (6 ft.) that can be entered by service personnel shall be constructed so that there is ample working space and illumination around equipment. The requirements in Section 8, Working Space, and 6.15, Lighting, of the Outline of Investigation for Modular Data Centers, UL 2755 shall apply.

9.5.2 Enclosure systems larger than 1.8 m (6 ft.) intended for use as a modular data center (MDC) housing information technology equipment (ITE) and various ITE support equipment shall, in addition to the requirements in this outline, comply with the applicable requirements of the Outline of Investigation for Modular Data Centers, UL 2755. This requirement also applies to other large enclosure systems intended for uses similar to MDCs where more than occasional service, maintenance and upgrading of the installed equipment is expected.

Note: Generally it is expected that for this type of enclosure system service personnel will be present on a fairly regular basis even though it is not considered an "occupied space" for personnel.

9.5.3 Enclosure systems larger than 1.8 m (6 ft.) intended for applications where service personnel are expected to enter the enclosure for only occasional service and maintenance operations shall, in addition to the requirements in this outline, comply with the following requirements of the Outline of Investigation for Modular Data Centers, UL 2755:

- a) 6.15, Lighting (if provided)

- b) 6.16, Emergency Lighting (if provided)
- c) 6.17, Intrusion alarms (if provided)
- d) Section 8, Working Space
- e) 10.3.1 – 10.3.4, Installed Equipment
- f) 11.4, Doors
- g) 11.5.1, Slip resistant Floors
- h) 12.2.1 – 12.2.4, Exit Doors
- i) 13.1.2, Smoke/fire detection/protection (if provided)

In addition, there shall be one entrance to and egress from the working space not less than 610 mm (24 in.) wide and 2.0 m (6 1/2 ft) high at each end of the working space.

Exception: Where the location permits a continuous and unobstructed way of egress travel, a single entrance to the working space shall be permitted.

Note: An example of such an enclosure system would be an enclosure systems intended to house communications equipment located at a cell site.

10 Environmental Considerations

10.1 Indoor locations

10.1.1 An enclosure system intended only for indoor locations that is designated by a type number for enclosures for indoor locations, (Types 1, 2, 5, 12, 12K, and 13) shall comply with the environmental requirements in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, applicable to an enclosure of the type number or numbers with which it is marked.

Note: Enclosure systems that are for indoor locations and are not marked with a type number do not need to comply with UL 50E.

10.2 Outdoor locations

10.2.1 General

10.2.1.1 ENCLOSURES intended for outdoor locations shall comply with the requirements in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E applicable to the enclosure type and are identified by the type designation. For example, "Type XXX__ Enclosure", or equivalent.

Exception: An ENCLOSURE may be identified as "raintight" or "rainproof" without a type designation if it complies with the requirements of [10.2.3](#).

10.2.1.2 An enclosure provided with multiple compartments is permitted to be evaluated to different outdoor enclosure type requirements when the compartments are completely separated by a wall or barrier and the compartments are rated Type 3, 3R, 3RX, 3S, 3SX, 3X, 4, 4X, 6, or 6P.

10.2.1.3 An enclosure system having multiple compartments shall have each compartment subjected to the tests applicable to the type with which it is marked. The internal barrier between compartments is not

required to be directly subjected to these tests. Any joints and gasket materials between compartments shall be subjected to the environmental tests which are the most severe for either compartment.

10.2.1.4 If rain enters the enclosure during testing of a ventilated Type 1, 2, or 3R enclosure, a marking shall be provided to indicate the area in which live parts may or may not be installed.

10.2.2 For enclosures other than Type 1, conduit openings and fittings shall comply with the requirements specified in 19.1 and 19.4 of the Standard for Industrial Control Panels, UL 508A.

10.2.3 Raintight and rainproof ENCLOSURES

10.2.3.1 When subjected to the Rain Test, described in [10.2.4](#), an ENCLOSURE designated as:

- a) "Raintight" shall be constructed so that rain does not enter the ENCLOSURE
- b) "Rainproof," shall be constructed so that rain will not interfere with the operation of the apparatus or result in wetting of live parts, wiring or equipment within the ENCLOSURE.

10.2.3.2 A gasket used to make an ENCLOSURE raintight or rainproof shall be tested as specified in [10.2.5](#).

10.2.3.3 An opening for conduit in a raintight ENCLOSURE shall either be threaded, or accommodate a specific hub complying with the requirements for such devices.

10.2.3.4 An opening for conduit in a rainproof ENCLOSURE shall either:

- a) Be threaded or
- b) Accommodate a specific hub complying with the requirements for such devices unless the opening is located wholly below the lowest terminal lug or other live part within the enclosure. There shall be provision for drainage of the enclosure if a knockout or unthreaded hole is provided other than in the bottom.

10.2.3.5 Where necessary, the ENCLOSURE shall be provided with drain holes to control the accumulation of moisture due to:

- a) Entrance of water through openings and
- b) Condensation, when this is likely to occur.

Note: Condensation is considered not likely to occur if the equipment is constantly energized or is actively heated from within.

10.2.4 Rain test

10.2.4.1 An ENCLOSURE identified as "raintight" or "rainproof" and not designated by the type number from the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E shall be exposed to a rain test (water spray) as described in [10.2.3.2](#) – [10.2.3.5](#) and comply with the criteria in [10.2.3.1](#).

Exception: The rain intrusion test (R3-217) in Telcordia Technologies Generic Requirements for Electronic Equipment Cabinets, GR-487-CORE, may be used in place of the rain test for ENCLOSURES designated as "raintight" or "rainproof".

Note: Equipment designated by a type number from UL 50E is tested in accordance with that standard and therefore does not require this specific rain test.

10.2.4.2 A raintight or rainproof ENCLOSURE is to be mounted as in actual service. Unspecified lengths of conduit are to be attached with normal torque and without a pipe thread compound. At each unthreaded wiring opening, a locknut and bushing are to be used. The unattached end of each conduit is to be covered to prevent entry of water during the test. Openings intended for the entry of Class 2 and communications wiring in low-voltage circuits are to be sealed in accordance with the manufacturer's instructions. If no instructions are provided they shall not be sealed. Openings in the bottom need not be closed.

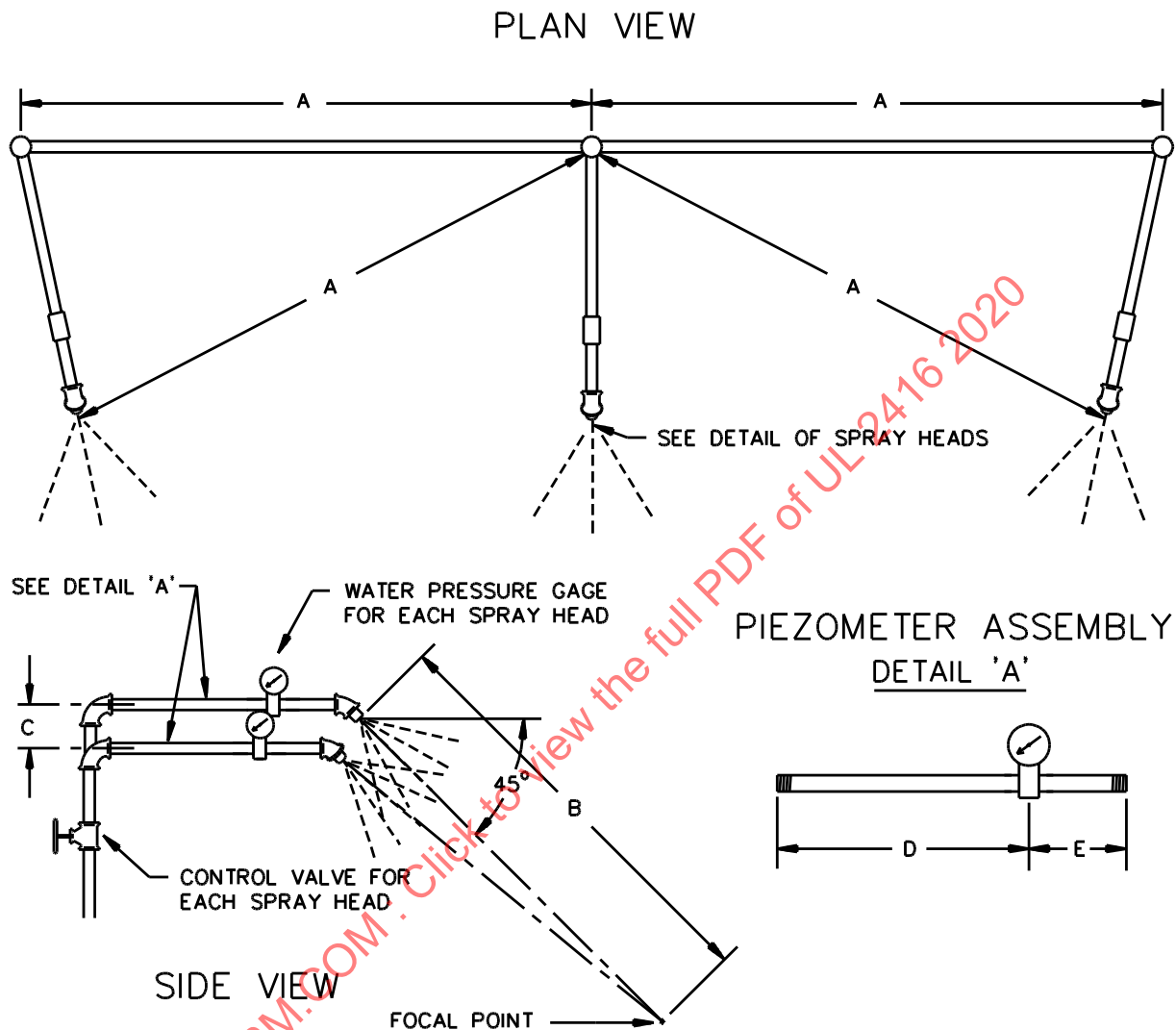
10.2.4.3 The enclosure system is to be operated so that it is tested under the normal conditions evaluated most likely to cause the entrance of water. It may be necessary:

- a) To operate the equipment under various modes of operation and in different mounting positions or operating handle positions (if applicable);
- b) To energize the equipment if more adverse conditions could result; or
- c) To take into account any orientations of use permitted in the installation or operating instructions.

10.2.4.4 Each exposure is to be for 1 hour. If more than one exposure is required, the equipment is to be reconditioned, if necessary, prior to the second and each subsequent exposure so that the results of the test will not be adversely affected by prior exposures.

10.2.4.5 The water spray test apparatus shall consist of at least three spray heads mounted in a water supply pipe rack as shown in [Figure 10.1](#). Spray heads shall be constructed in accordance with the details shown in [Figure 10.2](#). The water pressure for all tests is to be maintained at 34.5 kPa (5 psi) at each spray head. The equipment is to be brought into the focal area of the three spray heads in such position and under such conditions that the greatest quantity of water will enter the equipment. The spray is to be directed at an angle of 45 degrees to the vertical toward the device.

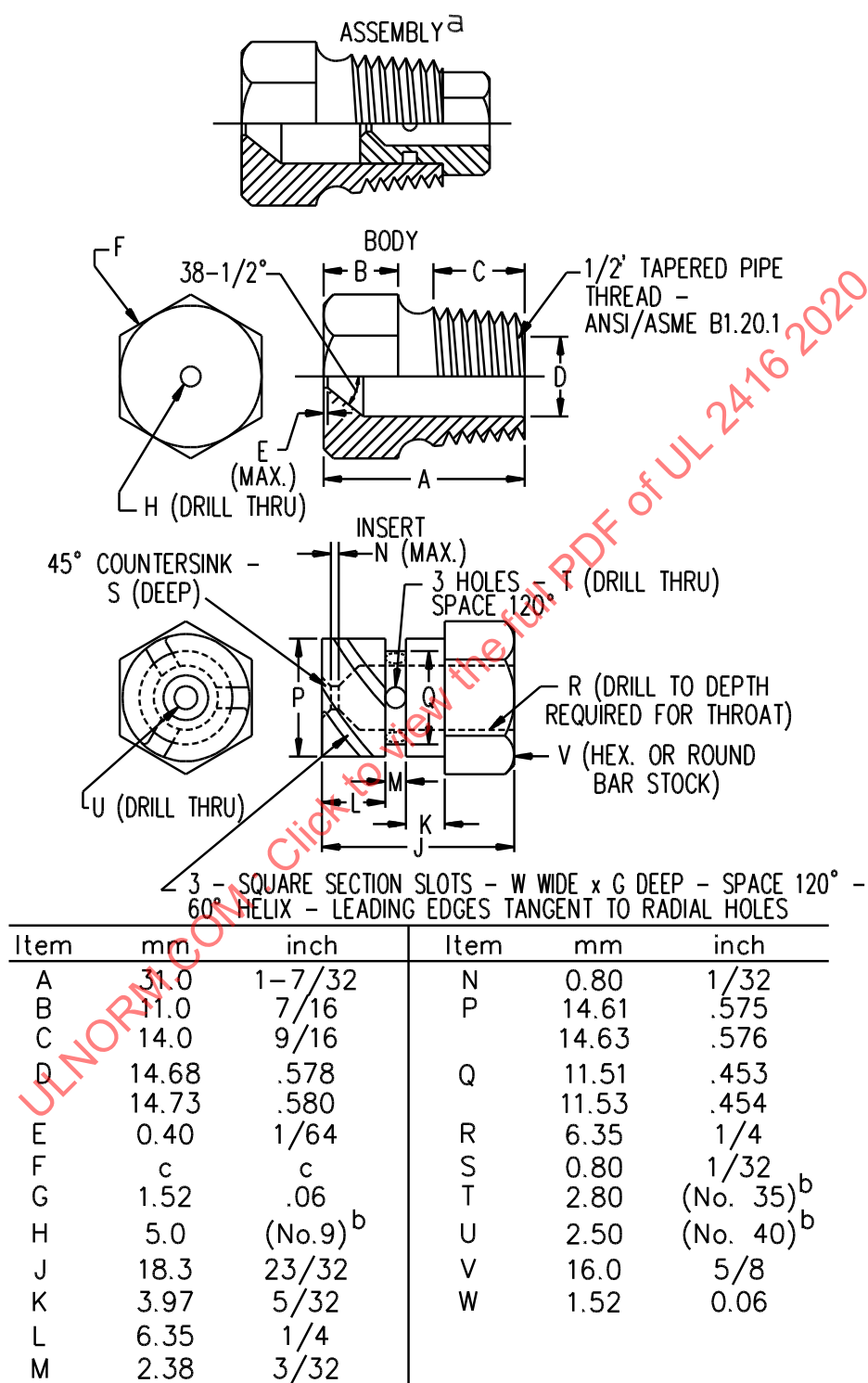
Figure 10.1
Rain-test spray head piping



Item	mm	inch
A	710	28
B	1400	55
C	55	2-1/4
D	230	9
E	75	3

RT101F

Figure 10.2
Rain-test spray head



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

^b ANSI B94.11M Drill Size

^c Optional - To serve as a wrench grip.

10.2.4.6 At the conclusion of each test, the outside of the ENCLOSURE is to be wiped dry. The ENCLOSURE is then to be opened for inspection.

10.2.5 Requirements for gaskets and seals

10.2.5.1 A gasket, seal and gasket/seal adhesive relied upon to comply with the requirements for raintight or rainproof equipment shall be constructed of material that is resistant the conditions it is likely to be exposed to in use and will adequately maintain its properties over its expected lifetime.

Note: Equipment designated by a type number from the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E is evaluated in accordance with that standard and therefore does not require a special evaluation of the gaskets.

10.2.5.2 Compliance is checked by testing in accordance with the Standard for Seals and Gaskets, UL 157, using the following parameters:

a) Tensile Strength and Ultimate Elongation

The gasket material shall have an initial tensile strength as indicated in Tests for property profile information, Table 4.1 of UL 157 for the specific material involved. For other materials the gasket material shall have an initial tensile strength of 8274 kPa (1200 psi). The gasket material shall have and an initial elongation of greater than 300 percent. No minimum values are specified if the material complies with the compression set requirements. After the air-oven aging test, the tensile strength and elongation properties of the material shall be at least 60 percent of the as-received samples.

b) Compression Set

For materials that do not meet the minimum initial tensile strength and elongation properties given above, the gasket material shall have an as-received compression set of no more than 40 percent.

c) Air-Oven Aging (Accelerated Aging)

Samples of the gaskets shall be conditioned in an air circulating oven maintained at 100°C for a period of 168 hours. As an alternative, the conditioning may be performed at 90°C for 720 hours. After conditioning, the samples shall show no signs of deterioration, deformation, melting, cracking or hardening of the gasket material. The tensile strength and elongation properties of the material shall be at least 60 percent of the as-received samples.

10.2.5.3 A material that does not comply with the values stated above may be tested in accordance with one of the following requirements (a) or (b) to determine the suitability of the gaskets.

a) Telcordia Technologies Generic Requirements for Electronic Equipment Cabinets, GR-487-CORE

- 1) Oven Aging (R3-26 [20])
- 2) Thermal Shock (Section 3.20)
- 3) Rain Intrusion (Section 3.31.2)

The rain test described in Raintight and rainproof ENCLOSURES, [10.2.3](#) may be used in place of the rain intrusion test.

b) Telcordia Technologies Generic Requirements for Optical Network Unit (ONU) Closures and ONU Systems, GR-950-CORE

- 1) Accelerated Thermal Aging (Section 5.6.2)
- 2) Temperature and Humidity (Section 5.6.4)
- 3) Water-Spray Test Procedure (Section 5.6.6.2.4)

The rain test described in Raintight and rainproof ENCLOSURES, [10.2.3](#) may be used in place of the water spray test procedure.

After the completion of the tests, the equipment shall comply with the criteria in [10.2.3.1](#) for “raintight” or “rainproof” enclosures.

10.2.5.4 A gasket or seal that may be exposed to direct sunlight shall be made of UV resistant material.

Note: A gasket “sandwiched” between panels or a door and the main enclosure, and similar constructions, are not considered to be exposed to direct sunlight.

11 Structural Considerations

11.1 Loading

11.1.1 Each enclosure system shall be rated for a maximum load carrying capability. For a system that is provided with a fixed configuration of shelves and mounting brackets, it is acceptable for the individual load ratings of the shelves and mounting brackets to serve as the maximum load rating for the system.

11.1.2 An enclosure system intended to support and provide a fastening arrangement for overhead cable distribution systems shall be designed to support to a load of 45 Kg (99.2 pounds). This may be included in the overall load rating or identified as a separate cable load rating. The cable load shall be included in the tests specified below.

11.1.3 An enclosure system shall be tested to ensure that it can handle its maximum rated load without collapse or stress failure of the frame. Stress failures include bent or twisted uprights, buckled flanges, torsional twist of the frame, permanent distortion of the base, broken welds or signs of permanent structural plastic deformation. Slight temporary distortion of the frame is acceptable if the frame parts have not experienced stress failures. This shall be determined by **any one** of the following tests described in [11.1.4 – 11.1.8](#). If the enclosure system is intended to handle a specified load (which may be the same or less than its full rated load) on parts such as temporary shipping brackets, casters, or the like, then it shall also be tested in this configuration with the “rated load” identified in the tests replaced by the “specified load.”

11.1.4 Loading test 1 (4X rated load)

11.1.4.1 This is one (1) of five (5) alternative tests used to evaluate the load handling capability of an enclosure system. See [11.1.3](#).

11.1.4.2 The enclosure system shall be mounted as intended and loaded with simulated loads representing four times the maximum load rating of the system for a period of one minute. The load shall be evenly distributed within the system unless specific instructions are provided for alternate loading arrangements. A system with a fixed configuration of shelves and brackets that are individually rated shall be loaded with simulated loads representing four times the maximum load rating of each shelf and bracket. The test is performed with any panels or doors both opened and closed.

Note: An example of a specific loading arrangement would be an enclosure system that is designed to handle a battery load representing a significant portion of the load rating at the bottom of the enclosure. The test is performed with any panels or doors both opened and closed.

11.1.4.3 This test need not be performed on an enclosure system that complies with the “Strength of mounting” requirements in [11.5](#) if the testing is representative of the requirements of [11.1.4](#).

Note: For example, a complete enclosure subjected to the mounting test with at least a rated load on each of its supporting surfaces is considered to comply with this test.

11.1.5 Loading test 2 (lateral forces)

11.1.5.1 This is one (1) of five (5) alternative tests used to evaluate the load handling capability of an enclosure system. See [11.1.3](#).

11.1.5.2 The enclosure system shall be mounted as intended and loaded with simulated loads representing the maximum load rating of the system. The load shall be evenly distributed within the system unless specific instructions are provided for alternate loading arrangements. A system with a fixed configuration of shelves and brackets that are individually rated shall be loaded with simulated loads representing the maximum load rating of each shelf and bracket.

11.1.5.3 Compliance is checked by the tests described in [11.1.5.4](#) and [11.1.5.5](#). Each test is conducted separately but shall be performed on the same fully loaded sample. If necessary, the unit shall be secured to the floor to prevent it from tipping over during the tests. The tests shall be performed with any doors both opened and closed.

11.1.5.4 Tilt test. The enclosure system shall be tilted to an angle of 10 degrees from its normal upright position and held in this position for a period of 1 minute. The test shall be repeated for all four positions (front, back, side1, side2).

Exception: If the system construction and loading are symmetrical, the test may be performed on either the front or the back and either side 1 or side 2 (two tests instead of four).

11.1.5.5 Push force test. While in its normal position on a flat surface, a force equal to 20 percent of the weight of the fully loaded enclosure system, but not more than 250 N (56.2 lbf), is applied in any direction except upwards, at a height not exceeding 2 m (78.74 in) from the floor. The force is applied to the front, back and each side of the system, each for a period of 1 minute.

Exception: If the system construction and loading are symmetrical, the test may be performed on either the front or the back and either side 1 or side 2 (two tests instead of four).

11.1.6 Static load test 1

11.1.6.1 This is one (1) of five (5) alternative tests used to evaluate the load handling capability of an enclosure system. See [11.1.3](#).

11.1.6.2 Static load tests shall be performed on the enclosure system by applying a horizontal force as close as practicable to the top of the enclosure equal to two times the total weight of the loaded system.

Note: The total weight of the system includes the weight of the system itself, the maximum rated load and rated cable weight, if applicable.

11.1.6.3 The unit shall be tested without equipment, blank panels, or any other reinforcement mounted to upright rails. Doors and side panels provided with the enclosure system are to be left in place for the tests.

11.1.6.4 The enclosure system shall be secured at the base by using the recommended mounting pattern and number of bolts. The horizontal static force shall be applied as close to the top of system as practicable using a measurable load application method to plus or minus 5 percent tolerance. Two

separate horizontal static load tests are required; one on the front to back axis and one on the side-to-side axis.

11.1.6.5 The measured horizontal deflection shall not exceed 50 mm (2.0 inches) when measured at greatest deflection point and the system shall recover to within 5 mm (0.2 inches) upon removal of the force.

11.1.7 Static load test 2

11.1.7.1 This is one (1) of five (5) alternative tests used to evaluate the load handling capability of an enclosure system. See [11.1.3](#).

11.1.7.2 Frames with a maximum rated load of 204 kg (450 lbs) shall comply with the frame work performance tests in the Standard for Mechanical Structural Issues, ATIS 0600006.

11.1.8 Seismic tests

11.1.8.1 This is one (1) of five (5) alternative tests used to evaluate the load handling capability of an enclosure system. See [11.1.3](#).

11.1.8.2 The enclosure system shall be loaded with simulated loads representing the rated load of the system. The loads shall be mounted as they would be normally distributed in the system. The system shall be rigidly secured at the base to a seismic table using the recommended mounting pattern and number of bolts.

11.1.8.3 Tests shall be completed in accordance with the Standard for Network Equipment-Earthquake Resistance, ATIS 0600329, Category F. Closed systems shall be tested with doors and side panels in place. Equipment with optional doors or panels shall be tested with the doors or panels both on and off.

11.2 Fixed shelf and mounting bracket loading

11.2.1 Each shelf and mounting bracket shall be rated for a maximum load carrying capability and shall be tested to ensure that it can handle its maximum rated load without collapse or permanent damage that results in a risk of injury to persons.

11.2.2 The shelf or mounting bracket shall be loaded for a period of 5 minutes with the following load:

- a) Four times (4X) the maximum load rating when the supporting surface is rated for loads of 45.36 kg (100 pounds) or less or
- b) Two times (2X) the maximum load rating plus 90.72 kg (200 lbs) (2 X [max load rating]+ 90.72 kg (200 lbs)) when the supporting surface is rated for loads greater than 45.36 kg (100 pounds). A specified load rating greater than 45.36 kg (100 pounds) shall be not less than 47.6 kg (105 pounds).

The load shall be evenly distributed unless specific instructions are provided for alternate loading arrangements.

11.2.3 Shelves and brackets that have been tested with 4X their rated load during other testing or with their rated load as part of the Seismic Tests in [11.1.8](#) need not be subjected to the test of [11.2.2](#).

11.3 Slide/rail systems for shelves and brackets

11.3.1 General

11.3.1.1 For shelves and brackets provided with slide/rails allowing installed equipment to slide away from the enclosure system for installation, service, maintenance and the like, the slides/rails shall be adequate for the rated load of the shelf or bracket. This section specifies requirements for the slide-rail assembly to reduce the likelihood of injury by retaining the equipment in a safe position and not allowing the slide-rails to buckle, means of attachment to break, or the slide rail assembly or equipment to slide past the end of the slide-rail assembly.

Note: Slide/rails include bearing slides, friction slides or other equivalent mounting means.

11.3.1.2 Slide/rails shall have end stops that prevent the equipment from unintentionally sliding off the mounting means in either direction.

11.3.2 Mechanical strength test, variable force

11.3.2.1 The slide-rail shall be installed in an enclosure system with the equipment, or equivalent load setup in accordance with the manufacturer's rating and instructions. With the equipment in its extended position, a force in addition to the weight of the equipment or rated load is to be applied downwards through the center of gravity for 1 min by means of a suitable test apparatus providing contact over a circular plane surface 30 mm (1.18 in) in diameter. If applying this force could damage the equipment, a metal plate or other means of distributing the force may be placed under the test apparatus. The total force shall be calculated based on the mass of the slide-rail mounted equipment or rated load of the slide-rail system plus an additional mass as determined below.

Note: This additional force is intended to take into account other items or devices that may be stacked on top of the installed rack mounted equipment while in the extended position during installation of other equipment.

a) For slide-rail mounted equipment where the slide-rails are mounted horizontally on each side of the equipment, the total force applied to the slide-rails shall be equal to the greater of the following two values:

1) 150 percent of the slide-rail mounted equipment mass or rated load plus 330 N (74.2 lbf) and

2) 150 percent of the slide-rail mounted equipment mass or rated load, plus an additional mass, where the additional mass is equal to the slide-rail mounted equipment mass or rated load or 530 N (119 lbf), whichever is less.

b) Where the slide-rails are mounted vertically on the top and bottom of the equipment in the rack, the total force applied to the slide-rails shall be 150 percent of the equipment mass or rated load, with a minimum force of 250 N (56.2 lbf) and a maximum force of 530 N (119 lbf).

c) If the supporting surface is intended to be a shelf, then the distribution of force over a metal plate under the test apparatus does not apply. The manufacturer shall state the maximum load that is intended to be placed on the shelf in order to determine the force that needs to be applied to the shelf. An instructional safeguard shall be provided on the shelf to indicate the maximum weight that can be added to the shelf. The force test shall be conducted at 125 percent of the maximum weight stated by the manufacturer. The force is to be applied directly by means of the test apparatus providing contact over a circular plane surface 30 mm (1.18 in) in diameter.

11.3.3 Mechanical strength test, 250 N, including end stops

11.3.3.1 The slide-rail mounted equipment is installed in an enclosure system in accordance with the manufacturer's instructions. A 250 N (56.2 lbf) static force is applied to the slide-rail assembly or mounted equipment, in every direction except upward to include the most unfavorable position of the slide-rail mounted equipment, for a period of 1 min. The force is applied to the slide-rail mounted equipment in its fully extended (service) position as well as its normally recessed (operating) position by means of a suitable test instrument providing contact over a circular plane surface 30 mm in diameter. The force is applied with the complete flat surface of the test instrument in contact with the equipment. The test instrument need not be in full contact with uneven surfaces (for example corrugated or curved surfaces).

11.3.4 Compliance – For the tests described in [11.3.2](#) and [11.3.3](#), the equipment and its associated slide-rail system shall remain secure during the tests. One complete cycle of travel on its slide-rails after completion of each test shall be performed. If the mounting means is not able to perform one complete cycle without binding, a force of 100 N (22.5 lbf) shall be applied horizontally to the front of the equipment at its center point with the intent to completely retract the equipment into the rack. Should the equipment fail to fully retract, the mounting means shall not bend or buckle to any extent that could introduce an injury. End stops shall retain the equipment in a safe position and shall not allow the equipment to slide past the end of the slide-rails.

11.4 Equipment intended to be moved during use

11.4.1 An enclosure system that is more than 1 m (39.4 in) above the floor and that is intended to be moved during use, or is provided with a dynamic load rating shall be tested in accordance with Dynamic tip stability test for tall institutional carts and stands, 16.4 of the Standard for Household, Commercial, and Institutional-Use Carts, Stands and Entertainment Centers for Use with Audio and/or Video Equipment, UL 1678.

Note: A dynamic load rating is for enclosure systems that are intended to be moved in use, not just provided with casters for shipping, handling or moving into place by trained installers.

11.4.2 The enclosure system shall be loaded with simulated loads representing the maximum dynamic load rating of the enclosure system. The load shall be evenly distributed within the system unless specific instructions are provided for alternate loading arrangements. A system with a fixed configuration of shelves and brackets that are individually rated shall be loaded with simulated loads representing the maximum load rating of each shelf and bracket.

11.4.3 Supporting surfaces of a shelf that may be located more than 1 m (39.37 in) above the floor and used in equipment intended to be moved during use shall be provided with a means to restrict a product from sliding off the surface. A minimum 3.2 mm (1/8 in) high lip or rail or the equivalent on sides of the supporting surface where installed equipment might slide off meets the intent of the requirement. Other constructions are permitted. Friction shall not be the sole means of restricting a product from sliding off a supporting surface. The top of an enclosure system is not considered a supporting surface or shelf within the meaning of this requirement unless it is specified as such by the manufacturer.

11.5 Strength of mounting

11.5.1 The mounting means of an enclosure system intended to be mounted on a wall, pole, strand, ceiling or similar location shall be suitable for the application and shall not become damaged or physically unstable to likely create a risk of injury.

Note: The mounting means includes any part of the enclosure system that supports the enclosure and installed equipment when mounted. Examples are brackets, clips, enclosure frames and panels with mounting holes, hinges for swing-out units and the like.

11.5.2 The mounting means of an enclosure system intended to be mounted on a wall, pole, strand, ceiling or similar location shall be loaded for a period of five minutes with the following loads:

- a) Four times (4X) the combined weight of the product plus its maximum load rating (4 X [Product weight + rated load]) when the enclosure system is rated for loads of 45.36 kg (100 pounds) or less or
- b) Two times (2X) the combined weight of the product plus its maximum load rating plus 90.72 kg (200 pounds) (2 X [Product weight + rated load] + 90.72kg (200 lbs) when the enclosure system is rated for loads greater than 45.36 kg (100 pounds). A specified load rating greater than 45.36 kg (100 pounds) shall be not less than 47.6 kg (105 pounds).

There shall be no malfunction of or damage to the mounting bracket, its securing means, or that portion of the product to which it is attached.

11.5.3 To determine whether a product complies with this requirement, it is to be mounted in accordance with the installation instructions provided by the manufacturer – on a surface of the construction specified using the parts (bolts, washers, spring nuts, unistruts channels, etc.) or mounting hardware provided with or specified for the equipment. If no surface construction is specified, nominal 9.5 mm (3/8-in) thick plasterboard (dry wall) on nominal 5.1 by 10.2 cm (2 by 4 in) wood studs spaced on 406- mm (16-in) centers is to be used as the supporting surface. The mounting parts are to be used as specified in the instructions, and, if not otherwise indicated, the securing screws are to be located between the studs and secured in the plasterboard.

11.5.4 An adjustable product is to be adjusted to the position that will give the maximum projection from the wall. Equipment with slide out shelves or rails or compartments that may be opened or moved to access, add or retrieve information or products shall be placed and tested in their most unfavorable position, shifting the center of gravity of the equipment farther away from the rear panel or the wall.

11.5.5 The force is to be applied through the use of weights or other convenient means that can distribute the force uniformly on the enclosure and its mounting means. The force is to be applied during a 5- to 10-second interval, until the specified load is applied to the mounting system. The load is to be maintained for 5 minutes. Longer application times are permitted as long as the full weight is maintained for the 5-minute period. The product and mounting system are to remain in place with no damage, breakage or rupturing of the support system.

11.5.6 An enclosure system with a swing-out design, intended to be in the open position only during installation of equipment and occasional servicing, may be tested using the following alternative procedure:

- a) The enclosure system shall comply with the test and compliance criteria of [11.5.5](#) using a minimum load of (2 X [Product weight + rated load]). The load shall be applied with the enclosure system in a closed position then the assembly swung out from the closed to open position, and held in its open position for a minimum of one minute. The product and mounting system are to remain in place with no damage, breakage or rupturing of the support system.
- b) The enclosure system shall comply with the test and compliance criteria of [11.5.5](#) in its normal operating (closed) position. The product and mounting system are to remain in place with no damage, breakage or rupturing of the support system.
- c) The enclosure system shall comply with the test criteria of [11.5.5](#) with the enclosure system in the open position. There is no catastrophic failure of the mounting means or load bearing parts of the enclosure system.

Note: Catastrophic failure means the enclosure system or load bearing parts falling off the wall or other support surface or the introduction of other risks of mechanical hazards or personal injury.

11.5.7 The load capacity of mounting fasteners is dependent on the type of structure and material employed at the installation. If the instructions for the securement of the equipment to the mounting structure rely on the use of mechanical building codes for the selection of the appropriate fasteners, the instructions shall include the load capacity (pull out and shear force) for each mounting fastener. The appropriate load capacities shall be determined by loading the equipment as indicated above and using load washers or other measuring apparatus or by using appropriate calculations. Where more than two fasteners are specified, shear force shall be determined by using only two fasteners.

11.5.8 An enclosure system intended to be mounted on a wall, pole, strand, ceiling or similar location shall be provided with installation instructions and the parts needed to mount the product as instructed unless the parts are readily available to the installer. Parts not provided shall be described in detail in the instructions with a warning that no substitutions shall be permitted.

11.6 Strength of handles and lifting hardware

11.6.1 Handles and lifting hardware used to support or carry an enclosure system shall withstand a force of four times the combined weight of the product plus its rated pre-installation load ($4 \times [\text{system weight} + \text{rated pre-installation load}]$) without damage or deformation to the handle or hardware, its securing means, or that portion of the enclosure to which the handle or hardware is attached.

Note: For this requirement, the load calculation should only include the weight of the enclosure system plus any additional hardware or equipment that is or may be installed in the enclosure during shipping and handling, prior to installing or mounting. If necessary, instructions shall include any hardware or equipment shipped with the enclosure that should not be installed until after the enclosure is properly mounted.

11.6.2 Carrying Handles – For carrying handles, the load is to be uniformly applied over a 76-mm (3 in) width at the center of the handle, without clamping. The load is to be started at zero and gradually increased so that the test value is attained in 5 to 10 seconds; the test value is to be maintained for 1 minute. If a product has more than one handle and cannot be carried by one handle, the load is to be distributed between the handles. The distribution of the load is to be determined by measuring the percentage of the product weight sustained by each handle with the product in the normal carrying position. If a product is furnished with more than one handle and can be carried by only one handle, each handle is to withstand the total load.

11.6.3 Lifting Hardware – For lifting hardware, details for attaching lifting lines, etc. shall be clearly specified in the installation instructions. The lifting hardware shall be positioned such that the equipment can be moved in a balanced, level and stable manner. The force is to be applied through the use of weights or other convenient means that can distribute the force uniformly on the enclosure and its mounting means. As an alternative, the enclosure can be bolted to the floor and a lifting force applied. The force is to be increased until the total load is applied to the lifting hardware. The force is to be maintained for 1 minute.

11.7 Safety strap attachment – pole mounted/aerial equipment

11.7.1 If a pole mounted/aerial enclosure system is provided with an attachment point for a personnel safety strap, the equipment mounting means and the attachment point shall be capable of supporting 2268 kg (5000 lbs.) without cracking, breaking or any permanent deformation of the attachment point, enclosure components or the enclosure or safety strap attachment mounting means.

11.7.2 The enclosure system shall be mounted in accordance with the manufacturer's installation instructions. A suitable safety strap shall be secured to the attachment point with a suitable snap-hook or D-ring and the load is to be gradually increased so that the test value of 2268 kg (5000 lbs.) is attained in 5 to 10 seconds. The test weight is to be maintained for a period of 1 minute.

11.8 Reserved for future use

11.9 Stability

11.9.1 Under conditions of normal use, enclosure systems shall not become physically unstable to the degree that they could become a hazard to an operator or to a service person.

11.9.2 Compliance is checked by the tests described in [11.9.3](#) and [11.9.4](#), where relevant. During the tests, the enclosure system shall be loaded with a load that represents the most disadvantageous condition from the minimum to the maximum loading specified in the manufacturer's instructions. The enclosure system shall be configured in a manner producing the most disadvantageous condition but consistent with any manufacturer's instructions for load placement. All castors and jacks, if used in a normal installation, are placed in their most unfavorable position, with wheels and the like locked or blocked. Enclosure systems that may be installed with either wheels/casters or jacks shall be tested with both configurations. If the castors are intended only to transport the unit to a fixed installation location, and if the installation instructions require jacks to be lowered after installation, then the jacks (and not the castors) are used in this test; the jacks are placed in their most unfavorable position, consistent with reasonable leveling of the unit. If the loading tests described in [11.1.5](#) (Loading test 2) were performed and are representative of the stability tests described below then the tests need not be repeated.

Note: If there is no specified minimum load in the manufacturer's instructions then the minimum load is taken as no load other than the minimum configuration as noted on the configuration list, or diagram of the components, and assemblies marking on the unit.

11.9.3 An enclosure system having a mass of 7 kg (15.43 lbs.) or more shall not fall over when tilted to an angle of 10 degrees from its normal upright position. Doors, drawers, etc., are closed during this test. An enclosure system provided with multi-positional features shall be tested in the least favorable position permitted by the construction.

11.9.4 A floor-standing enclosure system having a mass of 25 kg (55.12 lbs.) or more shall not fall over when a force equal to 20 percent of the weight of the unit, but not more than 250 N (56.2 lbf), is applied in any direction except upwards, at a height not exceeding 2 m (78.74 in) from the floor. Doors drawers, slide rails, etc. which may be opened or moved for servicing by the operator or by a service person are placed in their most unfavorable position. For non-operator servicing, placement shall be consistent with the manufacturer's instructions.

12 Fire Resistance Criteria

12.1 General

12.1.1 ENCLOSURES shall meet the criteria for fire enclosures in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950- 1, as follows:

- a) The bottom enclosure or internal barriers or baffles in accordance with Bottoms of fire enclosures, 4.6.2 of UL 60950-1;
- b) Top and side openings in accordance with Top and side openings, 4.6.1 of UL 60950-1 for fire enclosures;
- c) Doors or covers in accordance with Doors or covers in fire enclosures, 4.6.3 of UL 60950-1 for fire enclosures; and
- d) Materials in accordance with Materials for fire enclosures, 4.7.3.2 of UL 60950-1.

Alternatively, ENCLOSURES shall meet the criteria for fire enclosures in 6.4.8, Fire enclosures and barriers, in the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

The unit shall also comply with other criteria in this section that may be applicable to the particular type of enclosure system and installation.

Note: For example, the flammability requirements for large surfaces in [12.2](#) may apply.

Exception: Decorative materials that are outside of the fire enclosure and separated from the interior of the ENCLOSURE by metal or 5VA rated material that would serve to minimize the effects of an internal fire on the material may be rated minimum HB. Other criteria in this section that may be applicable still apply.

12.1.2 Non-metallic outer parts of EQUIPMENT CABINETS that form more than 50 percent of the area of any surface shall be min. V-1. Other non-metallic outer parts may be rated min. HB. These parts shall comply with other criteria in this section that may be applicable to the particular type of system and installation.

Exception: Parts separated from the interior of the EQUIPMENT CABINET by metal or 5VA rated material that would serve to minimize the effects of an internal fire on the material may be rated minimum HB. Other criteria in this section that may be applicable still apply.

12.1.3 Enclosure systems housing protectors or protection ground connections installed in accordance with Articles:

- a) 770, Optical Fiber Cables and Raceways;
- b) 800, Communications Circuits;
- c) 810, Radio and Television Equipment;
- d) 820, Community Antenna Television and Radio Distribution Systems; or
- e) 830, Network-Powered Broadband Communications Systems

of ANSI/NFPA 70, National Electrical Code shall be rated 5VA and comply with other criteria in this Section that may be applicable to the particular type of system and installation.

12.1.4 Enclosure systems housing only non-electrical parts such as splices, passive splitters, etc. for optical fiber cable shall be min V-1 and shall comply with other criteria in this section that may be applicable to the particular type of system and installation.

Note: For example, the fire stop requirements in Enclosure systems intended to be installed in air-handling spaces, [12.4](#), may apply.

12.1.5 Materials used in an enclosure system with a bottom enclosure or internal barriers or baffles complying with Bottoms of fire enclosures, 4.6.2 of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, shall comply with Materials for components and other parts inside fire enclosures, 4.7.3.4 of UL 60950-1.

Alternatively, materials used in an enclosure system with a bottom enclosure or internal barriers or baffles shall comply with the criteria in 6.4.8, Fire enclosures and barriers, in the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

Enclosure systems without such a bottom enclosure or intermediate baffle shall have minimum V-1 or HF-1 materials for internal parts.

Note: ENCLOSURES require compliance with 4.6.2 of UL 60950-1 or 6.4.8 of UL 62368-1 for bottom enclosures. See [12.1.1\(a\)](#)

12.1.6 For Enclosure systems, it is permissible to use laminated or unlaminated wood or wood-based materials as an enclosure, structural, decorative or internal part. The material shall comply with the appropriate flammability requirements. Compliance is checked by inspection of the construction and the relevant material data and, where required by [12.1.7](#) or otherwise determined to be necessary, by testing.

Note: Constructions of hardwood, plywood and dense particle board or press wood at least 12.5 mm (approx. 1/2 in.) thick, which would obviously comply with the flammability requirements may be accepted without test. Less substantial constructions, use of unknown or untested laminates, etc. should be tested.

12.1.7 Testing or verification of the required material properties is required for wood or wood based materials for the following:

- a) [12.2](#) – Flammability requirements for large surfaces;
- b) [12.4](#) – Enclosure systems intended to be installed in air-handling spaces;
- c) [12.5](#) – In-wall mounted Enclosure systems;
- d) [12.6](#) – Fire stop requirements.

12.1.8 Cable management systems provided as part of an enclosure system shall comply with at least one of the flammability requirements or tests in the Standard for Surface Raceways and Fittings for Use with Data, Signal, and Control Circuits, UL 5C, or the Standard for Cable Routing Assemblies and Communications Raceways, UL 2024. This requirement applies whether the cable management system is located inside or outside of an ENCLOSURE, an EQUIPMENT CABINET or a RACK.

12.2 Flammability requirements for large surfaces

12.2.1 An external surface of combustible material that has an individual or a mechanically contiguous surface area of 0.93 m² (10 ft²) or more, or a single dimension greater than 1.80 m (6 ft.) shall have a flame spread rating of 200 or less when tested in accordance with either:

- a) The Standard for Tests for Surface Burning Characteristics of Building Materials, UL 723, or the Standard Test Method for Surface Burning Characteristics of Building Materials, ASTM E 84 or
- b) The radiant panel furnace method in the Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source, ASTM E 162. The flame spread rating as determined by this method is the average value based on tests of six samples representative of the wall thickness used.

If two sides of a single piece are exposed, only the larger side is to be considered in computing the area.

12.2.2 A material with a flame spread rating higher than 200 may be used as the exterior finish or covering on any portion of the enclosure, guard or cabinet if the flame spread rating of the combination of the base material and finish or covering complies with the flame spread requirements.

12.3 ITE (computer) room applications

12.3.1 Enclosure systems intended to be used or installed in ITE (computer) rooms in accordance with the Standard for the Protection of Information Technology Equipment, NFPA 75, shall be constructed in such a way that by limiting combustible materials and the use of enclosures fire is not likely to spread beyond the unit. The system shall comply with all of the following:

- a) The bottom enclosure or internal barriers or baffles in accordance with Bottoms of fire enclosures, 4.6.2 of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1.
- b) Top and side openings in accordance with Top and side openings, 4.6.1 of UL 60950-1.
- c) Doors or covers in accordance with Doors or covers in fire enclosures, 4.6.3 of UL 60950-1.
- d) Materials in accordance with Materials for fire enclosures, 4.7.3.2 of UL 60950-1.
- e) Flammability requirements for large surfaces, [12.2](#), for flammability requirements for large surfaces with a flame spread rating of 50 instead of 200.

Alternatively, ENCLOSURES shall meet the criteria for fire enclosures in 6.4.8, Fire enclosures and barriers, in the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

12.3.2 Equipment complying with the requirements in this section may be identified as suitable for use in ITE (computer) rooms in accordance with the Standard for the Protection of Information Technology Equipment, NFPA 75.

12.3.3 EQUIPMENT CABINETS and RACKS that comply with the material requirements in [12.3.1](#) (d) and (e) but do not meet the fire enclosure requirements in [12.3.1](#) (a) – (c) with respect to the containment of fire may be marked “Materials suitable for installation in ITE (computer) rooms in accordance with the Standard for the Protection of Information Technology Equipment, NFPA 75.”

Note: When used in computer rooms these types of EQUIPMENT CABINETS and RACKS are intended to house or mount certified equipment that is provided with its own fire enclosure.

12.4 Enclosure systems intended to be installed in air-handling spaces

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

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

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

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

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

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

b) There shall be a maximum of five openings in any one side or end of the enclosure and the total area of all openings shall not be more than 1.3 cm² (0.2 in²); and

c) There shall be a maximum of 15 openings in the enclosure and the total area of all openings shall not be more than 3.2 cm² (0.5 in²).

12.4.3 Markings and instructions

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

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

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

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

12.5 In-wall mounted enclosure systems

12.5.1 General

12.5.1.1 Enclosure systems intended to be built-in or mounted in such a way that any part of the enclosure that may be located behind the finished wall material, such as enclosures intended to be mounted between studs, shall:

a) Be constructed of metal or

b) Be constructed of material that complies with the 127 mm (5 inch) flame testing in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or is classed as 5VA by the five inch burning test described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

12.5.1.2 Any part of the enclosure that may be located inside a wall or behind the finished wall material shall have minimal openings that could permit the emission of flame, molten material or the like from the enclosure.

12.5.1.3 A ventilating opening provided in an in-wall mounted enclosure system shall not vent into the concealed space where the spread of a fire can occur undetected. A ventilating opening shall not be located in a mounting surface of an enclosure.

12.5.1.4 Other openings in a built-in enclosure system shall be limited in number and of such dimensions that fire and products of combustion passing through the openings are not likely to ignite material on the outside of the enclosure.

12.5.1.5 A plate or plug for an unused conduit opening or other hole in an enclosure that does not meet the criteria in [12.5.1.1](#) shall comply with:

- a) The Standard for Metallic Outlet Boxes, UL 514A;
- b) The Standard for Conduit, Tubing, and Cable Fittings, UL 514B;
- c) The Standard for Cover Plates for Flush-Mounted Wiring Devices, UL 514D; or
- d) The Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings, UL 651.

Such a plate or plug shall be securely mounted.

12.5.1.6 Where the equipment has two or more possible operating orientations, opening properties apply to each possible orientation.

12.5.2 Openings in vertical surfaces

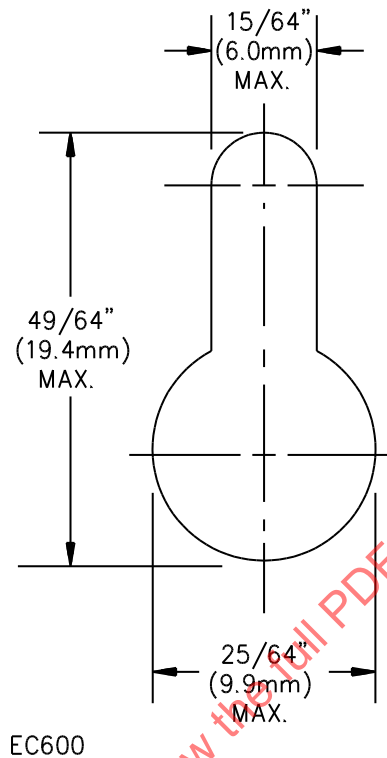
12.5.2.1 An enclosure system for building in shall have no open holes located behind the finished wall material on vertical surfaces, except if they meet the following provisions:

- a) The size and number of openings in a vertical surface are not restricted if they comply with the requirements for top openings described in 12.5.3, with the surface tested in a horizontal position.
- b) For escape of air or drainage of paint during a painting process, not more than four holes 3.2 mm (1/8 in) or less in diameter are permitted located as close to the corners of the enclosure as possible.
- c) For drainage in a rainproof enclosure, a single opening is permitted that shall not exceed 6.4 by 6.4 mm (1/4 by 1/4 in).
- d) For mounting miscellaneous components inside the enclosure, four unused holes are permitted. The largest dimension of each opening shall not be more than 4.8 mm (3/16 in).
- e) For mounting of the enclosure inside the wall, the following allowances are permitted.
 - 1) For enclosures with a maximum dimension of 305 mm (12 in), four of the holes may be keyhole slots having the configuration illustrated in [Figure 12.1](#). The dimensions specified in [Figure 12.1](#) may vary if the area is equivalent.
 - 2) For enclosures having a maximum dimension of 457 mm (18 in), four holes may be provided.
 - 3) For enclosures having a maximum dimension of more than 457 mm (18 in) but less than 1.2 m (48 in), six holes may be provided.
 - 4) For enclosures with a maximum dimension of 1.2 m (48 in) or more, eight holes may be provided.

For [12.5.2.1](#) (e) (2) through (e) (4), the dimensions are not specified, but shall be appropriate for the enclosure dimensions and configurations as determined by the manufacturer.

12.5.2.2 A pryout hole or slot may be provided in a knockout for 25.4 mm (1 in) or smaller trade size conduit. Openings outlining the pryout hole, and slots inside the knockout, are not considered for purposes of [12.5.2.1](#).

Figure 12.1
Keyhole slot



12.5.2.3 Deleted

12.5.2.4 Deleted

12.5.3 Top openings

12.5.3.1 Top openings shall comply with the test described in [12.5.3.2](#) – [12.5.3.3](#).

12.5.3.2 The test is conducted using the needle-flame burner as specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, for the 12 mm flame testing apparatus placed vertically in a draft-free location. The distance between the inner side of the top openings and the center of the burner tube is 7 mm ±1 mm (approx. 0.276 in). The sample is placed in its normal operating position. The top openings are covered with a single layer of cheesecloth. The flame is applied for a period of 1 min.

12.5.3.3 The cheesecloth shall not ignite. In case of openings having different dimensions, the test shall be conducted on one opening of each group of the top openings with the same dimensions.

12.5.3.4 A pryout hole or slot may be provided in a knockout for 25.4 mm (1 in) or smaller trade size conduit. Openings outlining the pryout hole, and slots inside the knockout, are not considered for purposes of [12.5.3.1](#).

12.5.4 Bottom openings

12.5.4.1 The bottom of an enclosure system intended to be built-in or mounted in such a way that any part of the enclosure is located behind the finished wall material shall prevent the emission of flame, molten material and the like.

12.5.4.2 Compliance is checked by inspection and, where necessary, by the hot flaming oil test of Clause A.3 of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1 or Clause S.3 of the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1. When conducting the hot flaming oil test on In-wall mounted enclosure systems, the “pattern of openings” shall mean the entire enclosure bottom.

12.5.4.3 The following constructions are considered to satisfy the requirement without test:

- a) No opening in the bottom of the enclosure;
- b) Openings that do not exceed 3 mm (0.12 in) in any dimension, or 1 mm (0.04 in) in width regardless of length;
- c) Openings in the bottom of any size under an internal barrier, screen or the like, which itself complies with these requirements;
- d) Baffle plate construction as illustrated in [Figure 12.2](#);
- e) Metal bottoms of an enclosure conforming to the dimensional limits of any line in [Table 12.1](#); and

Metal bottom screens having a mesh with nominal openings not greater than 2 mm (0.079 in) between center lines and with wire diameters of not less than 0.45 mm (17.7 mils).

Figure 12.2
Bottom panel baffles

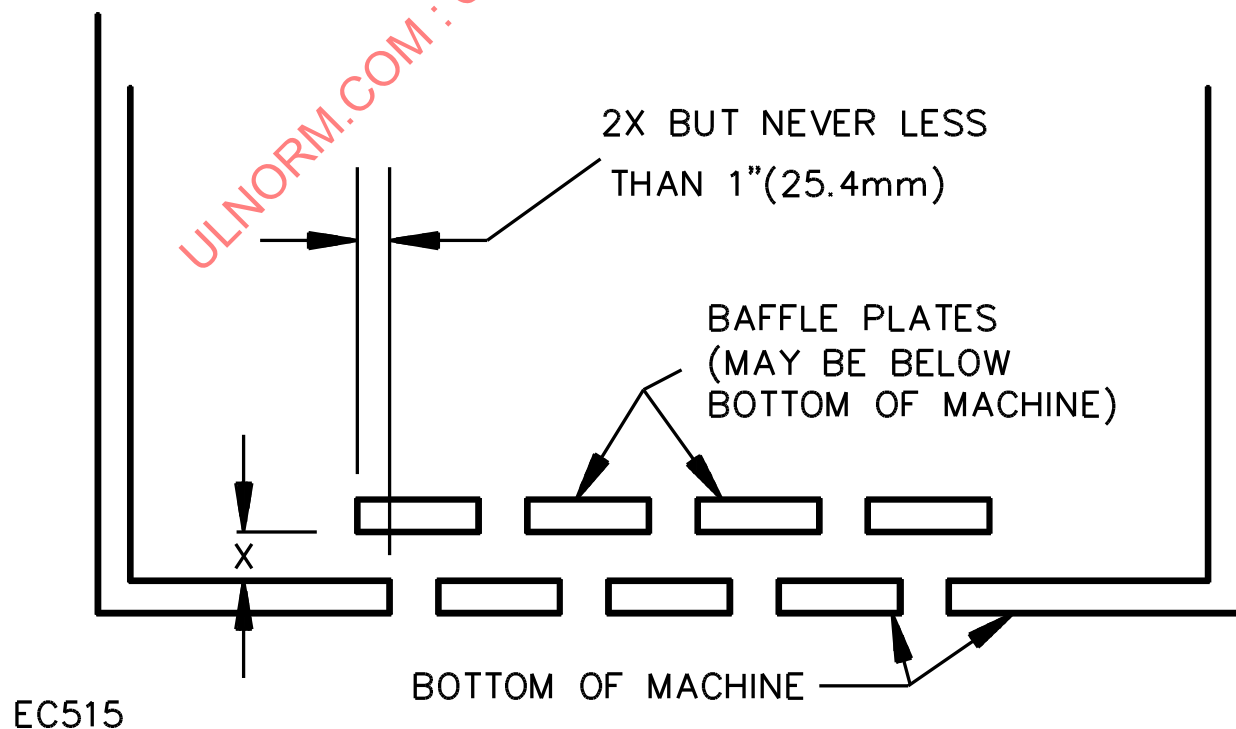


Table 12.1
Size and spacing of openings in metal bottoms of fire enclosures

Applicable to circular holes			Applicable to other shaped openings	
Metal bottom minimum thickness	Maximum diameter of holes	Minimum spacing of holes center to center	Maximum area	Minimum spacing of openings border to border
mm	mm	mm	mm ²	mm
0.66	1.1	1.7	1.1	0.56
0.66	1.2	2.3	1.2	1.1
0.76	1.1	1.7	1.1	0.55
0.76	1.2	2.3	1.2	1.1
0.81	1.9	3.1	2.9	1.1
0.89	1.9	3.1	2.9	1.2
0.91	1.6	2.7	2.1	1.1
0.91	2.0	3.1	3.1	1.2
1.0	1.6	2.7	2.1	1.1
1.0	2.0	3.0	3.2	1.0

12.5.4.4 A pryout hole or slot may be provided in a knockout for 25.4 mm (1 in) or smaller trade size conduit. Openings outlining the pryout hole, and slots inside the knockout, are not considered for purposes of [12.5.4.1](#).

12.5.4.5 Other openings associated with knockouts and pryouts, such as openings for mounting of boxes to the bottom enclosure with the knockout removed, shall comply with the test in [12.5.4.2](#) or the construction in [12.5.4.3](#).

Compliance with [12.5.4.2](#) may include use of outlet bushings and fittings in accordance with UL 514A, Metallic Outlet Boxes, or UL 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, or similar.

Compliance with [12.5.4.2](#) may include use of factory-installed tape or similar barrier to cover such openings if the bottom openings with tape in place comply with [12.5.4.2](#) and the component used is determined suitable for the application, such as compliance with a UL tape standard UL 181A, Closure Systems for Use With Rigid Air Ducts or UL 181B, Closure Systems for Use With Flexible Air Ducts and Air Connectors.

12.5.5 Markings and instructions

12.5.5.1 An enclosure system that by construction appears to be intended for in-wall mounting and that is not investigated in accordance with the requirements for In-Wall Mounted Enclosure Systems shall be marked "CAUTION – Not Suitable for In-Wall Mounting."

12.5.5.2 An enclosure system intended for in-wall mounting that is provided with knockouts or removable panels shall be provided with instructions that require any punched openings to be sealed with a suitable plug and any covers or panels to be replaced and secured.

12.6 Fire stop requirements

12.6.1 An enclosure system intended to be mounted on a building or similar structure that is provided with unlisted underground or outside plant construction cable or inner-duct (i.e. cable stubs) or that are intended for use with such cables, shall be constructed to minimize the risk of propagating flame from the

cables to the supporting surface or other combustible material that may be in contact with the enclosure. This necessitates that the enclosure material resist burn-through or be provided with a suitable barrier or bushing that serves as a fire stop where the cable or inner-duct enters the enclosure. In order to meet this requirement, such Enclosure Systems shall meet one of the following criteria:

- a) The enclosure shall be constructed of metal with minimal openings that could permit flames or molten material to exit the enclosure. (See [12.5](#)).
- b) The enclosure shall be constructed of material rated 5VA when tested as described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, with minimal openings that could permit flames or molten material to exit the enclosure. (See [12.5](#)).
- c) Where the cable enters the enclosure, be provided with a tight fitting bushing constructed of metal, a material rated 5VA or a material rated V-0, V-1, V-2, or 5-VA when tested as described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, used as a fitting, an insulating bushing, or a throat liner that is fitted into a bushing or similar cable entry opening in a material constructed of metal or a material rated 5VA.
- d) The cable and bushing mounted to the enclosure shall be tested in accordance with the Cable Burn/Fire Stop Test in [12.6.2](#).
- e) The enclosure and cabling shall comply with the Horizontal and Vertical Fire Test described in GR-771-CORE, Generic Requirements for Fiber Optic Splice Closures, "Fire Resistance".

For hollow core cables or assemblies where innerduct is used and not completely filled, the options described in (c) and (d) above shall not be permitted without the use of listed fire stopping material applied to the inner cable/innerduct openings. Instructions shall be provided with reference to the instructions marked on the enclosure system in the cable entry area. 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.

12.6.2 Cable burn/fire stop test

12.6.2.1 When a finished product sample is tested as described in [12.6.2.2](#) – [12.6.2.8](#), it shall comply with the following:

- a) The finished product material shall not:
 - 1) Openly flame for more than one minute after the final application of the test flame or
 - 2) Be consumed.
- b) There shall not be an opening in the material such that a 6.4 mm (1/4 in) diameter rod passes through after the material has returned to ambient temperature. The rod shall be applied without force.
- c) There shall not be a visible flame on the surface of the sample opposite the surface to which the test flame has been applied.
- d) There shall not be glowing or burning particles during the test.

12.6.2.2 Two samples shall be used for this test. One shall be tested as received, one shall be tested after being conditioned for 168 hours at a temperature of $90 \pm 1^{\circ}\text{C}$ ($194 \pm 2^{\circ}\text{F}$) in a full-draft air-circulating oven that has been preheated at full draft. Minimum 30.5 cm (12 in) cable stubs shall be provided.

12.6.2.3 The apparatus for this test shall consist of a test chamber of sheet metal 305 mm wide x 356 mm deep x 610 mm high (12.0 in wide x 14.02 in deep x 24.02 in high) open at the top and front. When the

fitting is too large to be tested in this chamber, a chamber with proportionately larger dimensions shall be used.

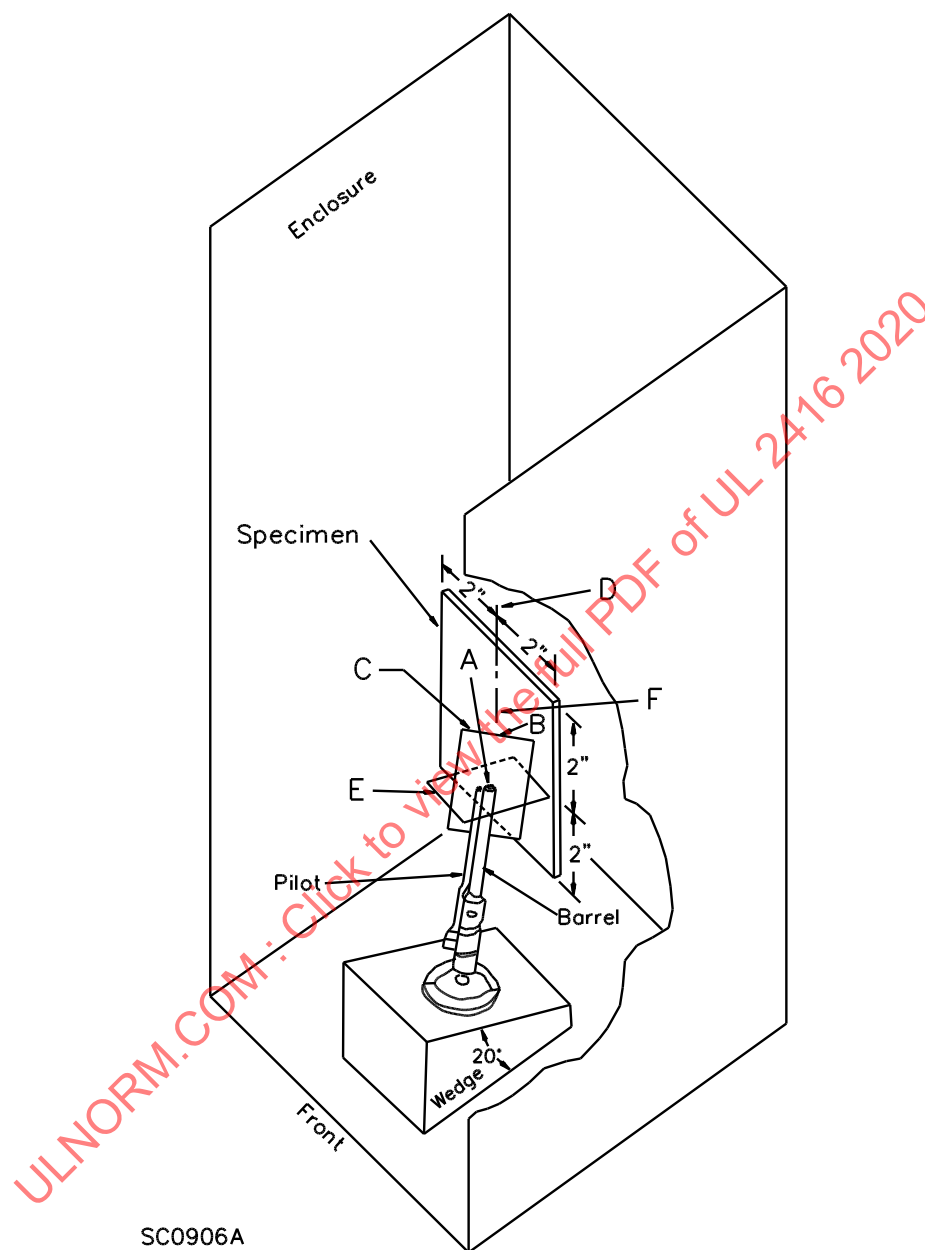
12.6.2.4 Each sample shall be secured with its vertical axis in the center of the enclosure and with both axes parallel to the back of the enclosure.

12.6.2.5 A Tirrill gas burner to which a gas pilot light is attached shall supply the test flame. The barrel of the burner shall extend 102 mm (4 in) above the air inlets and its inside diameter shall be 9.5 mm (3/8 in). While the barrel is vertical, the overall height of the flame shall be adjusted to 127 mm (5 in). The blue inner cone shall be 38 mm (1-1/2 in) high. Without disturbing the adjustments for the height of the flame, the valves supplying gas to the burner and pilot flames shall be closed.

12.6.2.6 A wedge to which the base of the burner is secured shall be provided for tilting the barrel 20 degrees from the vertical, while the longitudinal axis of the barrel remains in a vertical plane. The burner shall be secured to the wedge and the assembly shall be placed in an adjustable jig that is attached to the floor of the enclosure. The jig shall be adjusted laterally (see [Figure 12.3](#)) to place the longitudinal axis of the barrel in the same vertical plane as the vertical axis of the sample. The plane shall be parallel to the sides of the enclosure.

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Figure 12.3
Flammability test apparatus and sample dimensions



SC0906A

Notes:

Units for the values specified are: 102 mm (4 in); 50.8 mm (2 in); 38.1 mm (1-1/2 in).

C is the vertical plane parallel to the sides of the enclosure and containing the vertical axis of the sample and the longitudinal axis of the barrel.

D is the vertical axis of the sample in the center of the enclosure and parallel to the back of the enclosure.

E is the plane of the tip of the barrel.

F is the longitudinal axis of the barrel.

12.6.2.7 The jig shall also be adjusted toward the rear or front of the enclosure (see [Figure 12.3](#)) to position point A 38.1 mm (1-1/2 in) from point B at which the extended longitudinal axis of the barrel meets the front surface of the sample. Point A is the intersection of the longitudinal axis of the barrel with the plane of the tip of the barrel. Point B is the point at which the tip of the inner blue cone touches the finished sample at the spot where the cable enters through the bushing.

12.6.2.8 The gas shall be 37 MJ/m³ (993.04 Btu/ft³) at normal pressure [76 – 127 mm (3 – 5 in) of water]. The valve supplying gas to the pilot shall be opened and the pilot flame lit. The valve supplying gas to the burner shall be opened to apply the flame to the sample automatically. This valve shall be held open for 15 seconds and then closed for 15 seconds. This procedure shall be repeated four times for a total of five applications of flame to the plaque or finished sample.

13 Battery Supplies and Ventilation

13.1 General

13.1.1 A battery supply provided as part of an enclosure system shall comply with the requirements in [13.1](#) – [13.7](#).

13.1.2 If a discreet uninterruptible power system (UPS) is provided as part of an enclosure system, the UPS and its included batteries shall comply with the Second and Fourth Editions of the Standard for Uninterruptible Power Systems, UL 1778.

13.2 Batteries

13.2.1 A battery provided as part of an enclosure system shall comply with the applicable requirements for batteries in the:

- a) Standard for Emergency Lighting and Power Equipment, UL 924;
- b) Standard for Standby Batteries, UL 1989;
- c) Standard for Household and Commercial Batteries, UL 2054;
- d) Standard for Batteries for Use in Electric Vehicles, UL 2580;
- e) Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications, UL 2271;
- f) Standard for Lithium Batteries, UL 1642; or
- g) Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications, UL 1973.
- h) Electrochemical capacitors shall comply with the Standard for Electrochemical Capacitors, UL 810A.

Exception: Batteries and electrochemical capacitors that are part of certified equipment and included in the certification do not require any further investigation.

13.2.2 A battery that requires the addition of water shall employ a means to determine the fluid level.

13.3 Battery mounting

13.3.1 A battery shall be so located and mounted that the terminals of cells will be prevented from coming into contact with terminals of adjacent cells, or with metal parts of the battery compartment, as the result of shifting of the battery.

13.3.2 The battery chamber shall facilitate the safe installation, inspection, and replacement of the batteries.

13.3.3 A metal case or container of a battery shall be insulated or spaced away from contact with uninsulated live parts such contact may result in a short circuit.

13.3.4 An enclosure or compartment housing batteries employing metal containers or cases that are conductively connected to a battery electrode shall be such that the batteries are insulated or spaced from each other, or otherwise physically arranged, to prevent short-circuiting of part or all of the battery supply after installation.

13.3.5 To reduce the risk of leakage of the electrolyte as a result of damage to the battery case by a battery mounting means, a battery mounting means shall not cause undue stress to the battery case.

13.3.6 A battery mounting means that consists of a bracket, strap, or the like that extends around the top and/or sides of the battery shall not cause undue compression to the walls of the battery. The types of brackets or straps indicated in (a) – (c) are considered acceptable. Other constructions may be accepted if they are determined to be equivalent:

- a) A bracket or strap constructed of a non-rigid polymeric material;
- b) A metal bracket or strap with a flexible, foamed material or the like between the bracket or strap and the battery walls; and
- c) A metal bracket, which when tightened as intended, provides a clearance, minimum not specified, between the bracket and the battery walls.

13.3.7 When determining the adequacy of the clearance for the mounting means the following factors shall be taken into consideration:

- a) Dimensional tolerances of the bracket and overall dimensions of the battery case;
- b) The overall dimensions of the battery may increase slightly after use; and
- c) The need for a restraining means for use during shipping if the clearance of the mounting means permits excessive movement of the battery.

13.4 Overcurrent protection

13.4.1 The battery supply circuit shall be provided with acceptable rated dc overcurrent protection to reduce the risk of fire and electric shock resulting from overload or short-circuit conditions. The protective device shall be located adjacent to the battery connecting means before any component which may fall short-circuited such as capacitors, solid-state devices, or the like.

Wiring between the battery supply connecting means and the first overcurrent protection device shall be provided with spacings for General industrial control equipment as shown in UL 508 Table 37.1 Minimum acceptable spacings.

Note: Wiring between the battery supply connecting means and the first overcurrent protection device that complies with above spacings is considered to have required protection against faults.

13.5 Enclosure, vented batteries

13.5.1 General enclosure construction

13.5.1.1 Vented batteries shall be contained in a separate enclosure or compartment from arcing parts, such as the contacts of switches, circuit breakers, and relays, nor shall the enclosure or compartment vent into closed spaces where such parts are located. This requirement does not apply to valve-regulated batteries.

13.5.1.2 Vented batteries may be contained in the overall compartment of the enclosure system provided that a barrier, partition, or the equivalent is used to inhibit the passage of hydrogen gas from the battery area to the area of the enclosure containing the electronic components, switches, contactors, and controls.

13.5.1.3 The interior of a metallic enclosure or compartment housing a vented battery shall be protected by two coats of acid (or alkali, as applicable) resistant paint, two coats of enamel individually baked on, or the equivalent.

13.5.1.4 A polymeric enclosure or compartment housing a vented battery, such as a lead-acid storage battery, shall be constructed of materials resistant to corrosion by acids or alkalis, as applicable.

13.5.1.5 The enclosure or compartment housing a vented battery shall be constructed so that spillage or leakage of the electrolyte from one battery will be contained within the enclosure and prevented from:

- a) Reaching the outer surfaces of the enclosure where contact with the user is possible;
- b) Contaminating adjacent electrical components or materials; and
- c) Bridging required electrical spacings.

13.5.1.6 For outdoor equipment, the enclosure or compartment housing a battery shall minimize the entry of water and prevent water from getting onto the posts or terminals of the battery. The enclosure or compartment shall have drain holes for water drainage.

13.5.2 Enclosure venting

13.5.2.1 The enclosure or compartment housing a vented battery or a valve regulated battery, where gassing is possible during heavy discharge, overcharging, or similar type of normal or abnormal usages, shall be vented. The means of enclosure venting shall provide airflow throughout the compartment in order to reduce the buildup of pressure or accumulation of an explosive gas mixture, such as hydrogen-air, involving a risk of injury to persons. A gas mixture is lighter than air (such as hydrogen-air), may necessitate locating ventilation openings in the uppermost portions of the battery enclosure or compartment where such a gas mixture may accumulate.

Note: Examples of battery technologies that may vent hydrogen under either normal or abnormal conditions include lead acid batteries and large Ni-Cad batteries.

13.5.2.1A As an alternative to [13.5.2.1](#), requirements for enclosure venting may comply with the Risk of Explosion from Lead Acid and NiCd Batteries requirements in Clause M.7, and the Protection Against Internal Ignition from External Spark Sources of Batteries with Aqueous Electrolyte requirements in Clause M.8 of the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1.

13.5.2.2 Arcing parts, such as the contacts of switches, circuit breakers, and relays, shall not be located in the enclosure or compartment housing a vented battery, nor shall the enclosure or compartment vent into closed spaces where such parts are located. For purposes of this requirement, fuses and connectors do not contain arcing parts. Battery or compartment monitoring sensors (such as temperature sensors and the like) may be located in the enclosure or compartment.

13.5.2.3 The venting means shall prevent hydrogen concentrations in excess of 2 percent by volume. If the adequacy of the ventilation required in is not obvious, a determination shall be made by measurement of gas concentration. (A lead-acid battery at full charge, when most of the charging energy goes into gas, will generate approximately 1 cubic foot of hydrogen gas per cell for each 63 ampere-hours of input).

13.6 Heaters and temperature controls

13.6.1 Temperature controls for heaters used to maintain the operating temperature range of a battery or battery compartment during cold ambient conditions shall be positioned such that they monitor the battery or battery compartment temperature and are minimally affected by the outside ambient to prevent thermal runaway. For example, temperature controls or regulators should normally be located away from outside vents and not mounted on the outer walls of an enclosure where thermal conductivity may render them ineffective.

13.7 Battery supply performance

13.7.1 Except as described in the Exception to [13.2.1](#), [13.7.2](#) and [13.7.3](#), batteries and battery supplies shall comply with [13.7.4](#) – [13.7.13](#) as applicable.

13.7.2 A discrete battery supply (i.e. not part of other equipment) shall comply with the performance requirements of the Standard for Uninterruptible Power Supply Equipment, UL 1778 (2nd edition), or the Standard for Uninterruptible Power Systems, UL 1778 (5th edition).

13.7.3 A battery supply that is integral to equipment that complies with the requirements in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, is considered to comply with [13.7.4](#) – [13.7.13](#).

13.7.4 Equipment containing batteries shall be designed to reduce the risk of fire, explosion and chemical leaks under normal conditions and after a single fault in the equipment, including a fault in circuitry within the equipment battery pack. The design or instructions shall reduce the likelihood of reverse polarity installation if this would create a hazard.

13.7.5 Battery circuits shall be designed so that:

- a) The output characteristics of a battery charging circuit are compatible with its rechargeable battery; and
- b) For non-rechargeable batteries, discharging at a rate exceeding the battery manufacturer's recommendations, and unintentional charging, are prevented; and
- c) For rechargeable batteries, charging and discharging at a rate exceeding the battery manufacturer's recommendations, and reversed charging, are prevented.

Note: Reversed charging of a rechargeable battery occurs when the polarity of the charging circuit is reversed, aiding the discharge of the battery.

13.7.6 Compliance is checked by inspection and by evaluation of the data provided by the equipment manufacturer and battery manufacturer. When appropriate data is not available, compliance is checked by

the following tests. However, batteries that are inherently safe for the conditions given are not tested under those conditions. Consumer grade, non-rechargeable carbon-zinc or alkaline batteries are considered safe under short-circuiting conditions and therefore are not tested for discharge; nor are such batteries tested for leakage under storage conditions.

13.7.7 The battery used for the following tests is either a new non-rechargeable battery or a fully charged rechargeable battery as provided with, or recommended by the manufacturer for use with, the equipment.

13.7.8 Overcharging of a rechargeable battery – the battery is charged under each of the following conditions in turn.

a) The battery charging circuit is adjusted with the battery disconnected to give 106 percent of the rated output voltage of the charger, or the maximum charging voltage available from the charger (without simulation of faults), whichever is the higher attainable value. The battery is then charged for 7 h.

b) The battery charging circuit is adjusted, with the battery disconnected, to 100 percent of the rated output voltage of the charger. The battery is charged while briefly subjected to the simulation of any single component failure that is likely to occur in the charging circuit and that results in overcharging of the battery. To minimize testing time, the failure is chosen that causes the highest overcharging current. The battery is then charged for a single period of 7 h with that simulated failure in place.

13.7.9 Unintentional charging of a non-rechargeable battery. The battery is charged while briefly subjected to the simulation of any single component failure that is likely to occur in the charging circuit and that would result in unintentional charging of the battery. To minimize testing time, the failure is chosen that causes the highest charging current. The battery is then charged for a single period of 7 h with that simulated failure in place.

13.7.10 Reverse charging of a rechargeable battery. The battery is reverse charged while briefly subjected to the simulation of any single component failure that is likely to occur in the charging circuit and that would result in reverse charging of the battery. To minimize testing time, the failure is chosen that causes the highest reverse charging current. The battery is then reverse charged for a single period of 7 h with that simulated failure in place.

13.7.11 Excessive discharging rate for any battery. The battery is subjected to rapid discharge by open-circuiting or short-circuiting any current-limiting or voltage-limiting components in the load circuit of the battery under test.

Note: Some of the tests specified can be hazardous to the persons carrying them out; all appropriate measures to protect personnel against possible chemical or explosion hazards should be taken.

13.7.12 These tests shall not result in any of the following:

- a) Chemical leaks caused by cracking, rupturing or bursting of the battery case;
- b) Spillage of liquid from any pressure relief device in the battery, unless such spillage is contained by the equipment without risk of damage to the insulation persons;
- c) Explosion of the battery, if such explosion could result in injury; or
- d) Emission of flame or expulsion of molten metal to the outside of the battery enclosure.

13.7.13 After completion of the tests, the equipment is subjected to the dielectric withstand tests of [15.4](#).

14 Product Assembly

Note: It is not the intent of this section to cover equipment that may be installed into an enclosure system by the end-user and that is not provided or specifically identified by the manufacturer as being part of the enclosure system.

14.1 General

14.1.1 A product shall be factory-built as a complete assembly and shall include all the essential components necessary for its intended function when installed (used) as intended.

14.2 Shipping unassembled

14.2.1 A product may be shipped from the factory unassembled, or disassembled to the degree necessary to facilitate shipment, if all of the following conditions are met:

- a) All of the parts shall be furnished by the manufacturer;
- b) All protective guards and other safety features shall be factory installed wherever possible;
- c) Upon assembly, grounding continuity shall be provided where required between the field assembled components;
- d) The product shall be constructed so that the field assembly can be accomplished without the necessity of drilling, cutting, threading, or any other alteration other than the attachment of field installed electrical conduit or raceway, and;
- e) The relationship between separate parts shall be established at the time of manufacture, and shall not be dependent upon installation personnel.

14.2.2 Detailed step-by-step installation instructions shall be provided. The instructions shall either be packed with the product or provided via a company website. If provided via a company website the following shall apply:

- a) A hardcopy notice shall be provided with the product alerting the user/installer of the need to access the company website, which includes the URL.
- b) The hardcopy notice shall include the signal word "IMPORTANT" and a statement "See Installation Instructions Before Installing Any Accessory Equipment", or similar wording.

14.2.3 Equipment intended to be shipped unassembled shall be subject to the Assembly and installation test in [15.6](#) to verify the design, construction, assembly and instructions.

14.2.4 Equipment that is designed to be gangable or bayed together in the field shall be evaluated as being shipped unassembled.

14.2.5 For enclosure systems that may be shipped either fully assembled or as a "kit", the "kit" version shall be identified by a unique type or model number, prefix, suffix or the like that differentiates it from the fully assembled version.

14.3 Drop shipment of sub-assemblies

14.3.1 Enclosure systems not intended for household use and shipped not fully configured may have sub-assemblies shipped for final assembly at the installation site if all of the following conditions are met:

- a) All of the assemblies shall be specified by the manufacturer and identifiable at the installation site as complying with the applicable requirements in the standard.

- b) The specific location of the assemblies in the cabinet shall be established by the manufacturer, and shall be described in the installation instructions or on the cabinet.
- c) Upon assembly, grounding continuity shall be provided, where required, between the field assembled components.
- d) The product shall be constructed so that the field assembly can be accomplished without the necessity of drilling, cutting, threading, or any other alteration other than the attachment of field installed electrical conduit or raceway.
- e) Electrical connections used to connect the field-installed components within the cabinet shall be accomplished by means of plugs and receptacles, or other means intended for the application.
- f) All protective guards and other safety features shall be factory-installed whenever possible.

14.3.2 Products covered by this section shall be provided with a marking describing the exact component assemblies that may be installed and their specific location within the cabinet. The marking shall be provided on the equipment cabinet or enclosure in a location that would be readily visible to installation personnel.

Exception: The required information may be provided in the installation instructions. If provided in the installation instructions, a marking shall be provided on the cabinet where it will be readily visible during installation indicating that the unit shall be configured only with those component assemblies specified in the installation instructions and mounted in the locations specified.

14.3.3 Sub-assemblies, intended to be assembled on-site in accordance with this section, shall be marked with the assembly manufacturer's company name or logo, and a part number (P/N) or other type designation.

14.3.4 Products intended to be assembled on-site in accordance with this section, and marked in accordance with the Exception to [14.3.2](#), shall be provided with instructions describing the exact component assemblies that may be installed and their specific location within the cabinet.

14.3.5 Equipment that includes drop-shipped sections shall be subject to the Assembly and Installation Test in [15.6](#) to verify the design, construction, assembly and instructions.

14.4 Accessory equipment and conversion units

14.4.1 The requirements in this sub-section are applicable to accessory equipment and conversion units intended to upgrade, change or modify the product function and/or construction.

14.4.2 For the purpose of these requirements, accessory equipment is defined as a kit or a piece of equipment intended to be attached or added to a product, and of such size that it may be marked for identification by a catalog number or its equivalent. Accessory equipment usually is dependent upon the basic or host product for mechanical support and/or electrical input, or both, and may or may not, by itself, perform a complete function.

14.4.3 Conversion units are intended to cover individual items of circuitry or components, that for reasons of improving or modifying the functions of a product, are added to the product subsequent to the time of initial assembly, and that lose their identity in the process. Conversion units are intended to be installed by qualified service personnel.

14.4.4 Accessory equipment and conversion units shall be constructed so that they can be added to a product without creating a risk of electric shock, fire, or injury to persons.

14.4.5 The installation of accessory equipment by a user shall be restricted to an arrangement that can be accomplished mechanically by means of basic tools and electrically by means of plug-in connections to receptacles available on the product or as a part of the building wiring.

14.4.6 The installation of accessory equipment by qualified service personnel or conversion units shall be such that:

a) The mechanical positioning can be accomplished by means of basic tools usually available at a product's installation site or by means of special tools provided by the manufacturer as part of the installation kit.

b) The electrical connections can be readily accomplished by making use, wherever possible, of existing terminals and connections in the product.

14.4.7 The requirement in [14.4.6](#) does not preclude the addition, removal, or rerouting of insulated conductors to accomplish the desired change as long as the alterations in the product's wiring can be accomplished by the use of materials and reference to instructions, both of which are furnished as part of the accessory-equipment kit and conversion-unit kit, and do not require the use of makeshift or substitute parts not intended to be used in the basic construction of the product.

14.4.8 All wiring provided as a part of an item of accessory equipment and conversion unit or related to its installation shall be rated for use at the highest voltage and temperature that can be encountered in the area in which the wire is to be installed.

14.4.9 Each piece of accessory equipment and each conversion unit shall be marked with the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified and with a distinctive catalog number or equivalent identification.

14.4.10 If the accessory equipment or conversion unit is supplied with power from the main unit or from a separate branch-circuit, the accessory and conversion unit shall be marked with an input rating.

14.4.11 Accessory equipment intended to be installed by a user shall be marked to indicate the product for which it is intended and shall include instructions on the equipment that will provide enough information to enable the accessory equipment to be mounted on and interconnected with the basic product as intended.

Exception: The information may be included in the user instructions packed with the product, provided the product is marked with the symbol  or the words, "See instruction manual," or the equivalent.

14.4.12 Accessory equipment intended to be installed by qualified personnel and conversion units shall include instructions either on, or packed with the equipment that will provide a step-by-step outline of the mechanical and electrical alterations that are necessary for determining and providing for acceptable installation and operation. Detailed instructions may be provided via a company website if all of the following conditions are met:

a) A hardcopy notice shall be provided with the product alerting the user/installer of the need to access the company website, which includes the URL.

b) The hardcopy notice shall include the signal word "IMPORTANT" and a statement "See Installation Instructions Before Installing Any Accessory Equipment", or similar wording.

14.4.13 Accessory equipment and conversion units shall be subject to the Assembly and installation test in [15.6](#) to verify the design, construction, assembly and instructions.

14.5 Special accessories

14.5.1 Special accessory equipment may be manufactured by a manufacturer for use in other than the original equipment manufacturer (OEM). Examples of such "Accessory" equipment include shelves or brackets for installation in a standard 19 inch rack.

14.5.2 The investigation of an Accessory includes consideration and evaluation, to the extent necessary, of the combination of the Accessory with all models of the specified equipment specifically covered by the scope of the use of the Accessory, including models currently in production and, if applicable, models no longer in production. The Accessory Applicant (Company A) is responsible for supplying the necessary samples of the specified equipment required for the investigation, as needed.

Exception: Accessories intended for use with generic configurations of enclosure systems may be evaluated based on limited performance testing if the standard Listing investigation of the generic ITE anticipated the installation of such accessories in/with it and sound engineering judgment can be substituted for specific investigation of the Accessory with every specified model. Hazard-based Safety Engineering (HBSE) analysis should be used, as applicable, to help identify hazards. Different criteria may be necessary in judging the acceptability of the instructions, hazard warnings and design features that are intended to reduce reasonably foreseeable hazards to an acceptable degree depending upon the intended use involved and the degree of training of the intended installer.

14.5.3 Where installation is likely by untrained or inexperienced persons, plug-in interconnections using attachment plugs and receptacles, and standard connectors are required. Installations requiring arrangements of components or wiring, cutting or splicing of existing wiring and soldering of connections generally are not permitted. The effect of errors and incorrect installation should be considered. Appropriate construction features or markings, if construction features are not feasible, should be provided to reduce all reasonably foreseeable hazards to an acceptable degree.

14.5.4 If the product is for commercial/industrial use only, complexity of product modification, and placement of more reliance on the skill of the installer may be possible. However, reliance on the skill of the installer shall be made only for products where it is reasonable to expect that the modification will be made by a qualified person.

14.5.5 The level of knowledge of the construction of the specified equipment and awareness of any problems in the Accessory equipment may be higher for a product that is intended for use with a generic type of ITE, e. g., PC. If the specified equipment is identified by generic or broad terminology, more uncertainty as to installation problems exists because of variations among the products within the generic category. Thus, if the specified equipment is identified by generic category, greater care is required to make the installer aware of the potential hazards and proper methods of hazard minimization.

14.5.6 Instructions should be understandable to the intended reader, including those involving installation by trained, qualified service persons. More detailed instructions may be required for less knowledgeable persons.

14.5.7 Installation instructions and markings should warn of all reasonably foreseeable hazards. Where untrained or inexperienced installers are likely to be involved, it may be necessary to observe untrained UL staff or others trying to follow the installation instructions so as to be able to identify hazards that may result from improper interpretation or failure to follow instructions.

14.5.8 For equipment for use with a generic type of enclosure system the Accessory marking shall include a statement to the effect "Use only with Listed ITC cabinet, enclosure or rack systems," or similar. This statement may be provided as either a marking or instruction.