UL 1203

STANDARD FOR SAFETY

ExplosionProof and Dust-IgnitionProof Electrical Equipment for Use in Hazardous (Classified) Locations

UL Standard for Safety for ExplosionProof and Dust-IgnitionProof Electrical Equipment for Use in Hazardous (Classified) Locations, UL 1203

Sixth Edition, Dated July 10, 2023

Summary of Topics

This revision of ANSI/UL 1203 dated May 30, 2024 adds a marking for component enclosures that have been tested for explosion pressure and propagation effects of short-circuit testing with circuit breakers; 59.23 and 59.24

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

The new requirements are substantially in accordance with Proposal(s) on this subject dated February 2, 2024 and April 26, 2024.

No Text on This Page

JULY 10, 2023
(Title Page Reprinted: May 30, 2024)

ANSI/UL 1203-2024

UL 1203

Standard for ExplosionProof and Dust-IgnitionProof Electrical Equipment for Use in Hazardous (Classified) Locations

First Edition – January, 1987
Second Edition – July, 1994
Third Edition – September, 2000
Fourth Edition – September, 2006
Fifth Edition – November, 2013

Sixth Edition

July 10, 2023

This ANSI/UL Standard for Safety consists of the Sixth Edition including revisions through May 30, 2024.

The most recent designation of ANSI/UL 1203 as an American National Standard (ANSI) occurred on May 30, 2024. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

No Text on This Page

CONTENTS

PART II – DUST-IGNITIONPROOF EQUIPMENT

CONSTRUCTION

PERFORMANCE

PART III – MANUFACTURING AND PRODUCTION TESTS

PART IV – MARKINGS AND INSTRUCTIONS

PART V – INDUSTRIAL CONTROL EQUIPMENT

CONSTRUCTION

PERFORMANCE

MARKINGS

PART VI – SWITCHES

CONSTRUCTION

RATINGS

MARKING

PART VII – CIRCUIT BREAKERS

CONSTRUCTION

MARKINGS

PART VIII – OUTLET BOXES AND FITTINGS

PERFORMANCE

PART IX – RECEPTACLE-PLUG COMBINATIONS

INTRODUCTION

CONSTRUCTION

PLUG

PLUG AND RECEPTACLE FOR FLAMMABLE ANESTHETIZING LOCATIONS

PERFORMANCE

ANNEX B (normative) – ALTERNATIVE EXPLOSION TESTS

ANNEX C (normative) – CELLS AND BATTERIES

No Text on This Page

INTRODUCTION

1 Scope

1.1 These requirements cover explosionproof and dust-ignitionproof electrical equipment for installation and use in hazardous (classified) locations, Class I, Division 1, Groups A, B, C, and D, and Class II, Division 1, Groups E, F, and G, in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements also cover explosionproof electrical equipment for installation and use in Class I, Zone 1, Groups IIA, IIB, and IIC hazardous (classified) locations and dust-ignitionproof equipment for use in Zone 20, 21, and 22 locations.

1.3 These requirements also cover explosionproof electrical equipment that has been investigated for use in one or more specific gas or vapor atmospheres with or without additional Class I Groups. See 59.6.

1.4 These requirements do not cover equipment for use in hazardous (classified) locations specifically covered in a separate standard.

1.5 These requirements cover equipment for use under the following atmospheric conditions:

a) A minimum ambient temperature of minus 60 °C (minus 76 °F);

b) An oxygen concentration not greater than 21 % by volume; and

c) A nominal barometric pressure of one atmosphere.

1.6 Equipment covered by this standard shall also comply with the applicable requirements for similar equipment for use in ordinary unclassified locations.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this Standard shall comply with the requirements for that component.

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

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

b) Is superseded by a requirement in this standard.

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

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.5 Enclosures containing cells or batteries shall comply with Annex C.

3 Units of Measurement

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

4 Referenced Publications

4.1 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.

4.2 The following publications are referenced in this Standard:

ASME B1.1, *Unified Inch Screw Threads (UN and UNR Thread Form)*

ASME B1.20.1, *Pipe Taper (NPT) Thread*

ASME B46.1, *Surface Texture*

ASTM B858-06, *Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys*

ASTM E11, *Specification for Wire Cloth and Sieves for Testing Purposes*

ASTM E28, *Test Method for Softening Point by Ring-and-Ball Apparatus*

ASTM 1056, *Specification of Flexible Cellular Materials – Sponge or Expanded Rubber*

ASTM D256, *Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics*

ASTM D395, *Test Methods for Rubber Property – Compression Set*

ASTM D790, *Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

ASTM E28, *Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus*

ISO 965-1, *General Purpose Metric Screw Threads – Tolerances – Part 1*

ISO 965-3, *General Purpose Metric Screw Threads*

NFPA, Health Care Facilities

UL 20, *General-Use Snap Switches*

UL 50, *Enclosures for Electrical Equipment, Non-Environmental Considerations*

UL 50E, *Enclosures for Electrical Equipment, Environmental Considerations*

UL 98, *Enclosed and Dead-Front Switches*

UL 157, *Gaskets and Seals*

UL 429, *Electrically Operated Valves*

UL 486E, *Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors*

UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures*

UL 508, *Industrial Control Equipment*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 969, *Marking and Labeling Systems*

5 Enclosure Types

5.1 An enclosure that is intended for use in other environmental conditions shall also comply with the applicable requirements for each enclosure type, for example Type 3, 4X, or 6, specified in UL 50E.

5.2 A Type 3, 3R, 3S, 4, 4X, 6, or 6P enclosure is not prohibited from being marked "Raintight" when no water enters the enclosure or "Rainproof" when no water enters the enclosure at a point higher than the lowest live part. Compliance with these requirements shall be determined by the applicable tests in UL 50E.

6 Class I, Zone and Group Equivalency

6.1 Class I, Zone 1, Group IIA

6.1.1 Explosionproof electrical equipment intended to be marked in accordance with 59.4 shall comply with all the requirements for explosionproof electrical equipment for use in Class I, Group D hazardous (classified) locations.

6.2 Class I, Zone 1, Group IIB

6.2.1 Explosionproof electrical equipment intended to be marked in accordance with 59.5 shall comply with all the requirements for explosionproof electrical equipment for use in Class I, Group C hazardous (classified) locations.

6.3 Class I, Zone 1, Group IIC

6.3.1 Explosionproof electrical equipment intended to be marked in accordance with 59.7 shall comply with all the requirements for explosionproof electrical equipment for use in both Class I, Group A and Class I, Group B hazardous (classified) locations.

6.4 Zone 20 and Zone 21

6.4.1 Dust-ignitionproof electrical equipment intended to be marked in accordance with 59.10 shall comply with all the requirements for dust-ignitionproof electrical equipment for use in Class II, Division 1 hazardous (classified) locations.

7 Glossary

7.1 For the purpose of this Standard, the following definitions apply.

7.2 AXIAL JOINT SECTION – The portion of a flat, labyrinth, or rabbet joint that is parallel to the axis of the parts forming the joint.

7.3 CEMENTED JOINT – A joint which relies upon a cement or other similar compound to prevent the propagation of an explosion to a surrounding atmosphere by filling all voids between the mating parts

forming the joint, such that no flamepath exists. Intended for joints which are not disturbed after assembly. See 10.2.

7.4 CLEARANCE, AXIAL – The clearance between parts forming the axial joint section.

7.5 CLEARANCE, DIAMETRICAL – The clearance between two parts measured as the difference in the diameters.

7.6 CLEARANCE, RADIAL – The clearance between parts forming the joint section radiating from the axis or center.

7.7 FLAMEPATH – The joint formed upon assembly of parts that are intended to arrest the flame and vent hot gases produced when an ignition of an explosive atmosphere takes place within an explosionproof enclosure.

7.8 INTERNAL LENGTH OF JOINT – The distance from the innermost point to the outermost point of the joint formed upon assembly of the parts comprising that joint.

7.9 LABYRINTH JOINT – A joint consisting of an arrangement of mating steps, grooves or collars consisting of two or more axial sections having one radial section between each axial section, or two or more radial sections with one axial section between each radial section, whereby the flame path changes direction more than twice.

7.10 RABBET JOINT – A rabbet joint consists of an axial section and a radial section that form a right angle, whereby the flamepath must change direction. A rabbet joint is also known as a spigot joint.

7.11 RADIAL JOINT SECTION – The portion of the joint that is perpendicular to the axis of the parts forming the joint.

7.12 SEALED JOINT – A joint where a sealing material applied to a joint surface does not increase the maximum clearance between joint surfaces beyond the dimensions specified in this Standard. See 10.3.1, 16.5, and 16.6.

7.13 SHAFT PATH – A path formed upon assembly of a shaft and shaft opening in an enclosure.

7.14 STRAIGHT OR FLAT JOINT – A joint where, upon assembly of the parts forming the joint, a straight flame path in a single plane is formed.

7.15 TEST FACTOR – A factor of safety imposed upon a test condition.

7.16 THREADED JOINT – A joint formed upon assembly of two mating threaded sections.

7.17 BLANKING ELEMENT – Fitting intended to close unused field wiring entries. These fittings can also be referred to as close-up plugs.

7.18 THREAD ADAPTER – Fitting intended to allow a threaded fitting or conduit to be installed in an opening with a different thread. These fittings may be NPT-NPT, NPT-Metric, or Metric-Metric.

PART I – EXPLOSIONPROOF EQUIPMENT

CONSTRUCTION

8 Enclosure Material

8.1 The enclosure housing the electrical components, except those portions for viewing or light transmission, shall be made of iron, steel, copper, brass, bronze, or aluminum or aluminum alloys containing a minimum of 80 % aluminum, or shall be made of nonmetallic material which complies with the requirements in Section 33, Non-Metallic Enclosure Materials Tests. A metal such as zinc or zinc alloy, or magnesium or magnesium alloy, shall not be used.

8.2 Copper and copper alloys shall not be used for the enclosure of a device for use in Class I, Group A locations containing acetylene unless it is coated with tin, nickel, or other coating that has been determined to comply with the requirements or by limiting the maximum copper content of the alloy to 30 %.

8.3 A part for viewing or light transmission shall be made of glass or similar material.

9 Enclosure Thickness

9.1 Except as noted in 9.3 and 9.4, the minimum thickness of the metal enclosure walls shall be in accordance with Table 9.1.

9.2 A machined or a threaded joint in the walls of a cast-metal enclosure shall be not less than the minimum thickness specified in Table 9.1 through the overlap.

Table 9.1
Thickness of Metal for Enclosure

External enclosure dimensions				Minimum thickness, inch (mm)					
Length or diameter		Area of any one surface		Cast brass, bronze, copper, malleable iron		Cast iron and aluminum[a]		Sheet steel	
inches	(mm)	in^2	(dm^2)						
22	(559)	480	(31)	0.093	(2.36)	0.125	(3.18)	0.067	(1.70)
30	(762)	620	(40)	0.093	(2.36)	0.125	(3.18)	0.093	(2.36)
60	(1524)	1500	(97)	0.125	(3.18)	0.187	(4.75)	0.125	(3.18)
Over 60	(over 1524)	Over 1500	(over 97)	0.187	(4.75)	0.250	(6.35)	0.187	(4.75)

[a] Includes sand-cast, permanent-mold, and die-cast aluminum and sheet aluminum.

9.3 A component that closes an opening in the enclosure, such as a Bourdon tube, flexure tube, bellows, or diaphragm, and a nonmagnetic section of the enclosure required for proper operation of a magnetically operated part shall have a minimum wall thickness as specified in Table 9.1 unless:

a) The thinner component is shielded from any electrical component that is subject to arcing by an insulation barrier at least 0.028 inch (0.71 mm) thick or a grounded metal barrier of such construction that an arcing fault between the electrical component and the barrier will prevent the arc from reaching the thinner section of the enclosure, or other equivalent means. Overcurrent protection, when provided in the circuit, shall be evaluated. An insulating material barrier, when provided, shall be evaluated with respect to moisture absorptive properties, combustibility, resistance to distortion at temperatures to which it will be subjected, and thermal aging in accordance with UL 746C;

b) Internal wiring is secured or mounted such that it does not contact the thinner component;

c) Mechanical protection is provided, such as by location within the equipment, to reduce the risk of mechanical damage to the thinner component, except for a component such as a flexure tube where such protection is unable to be obtained; and

d) The thinner component is formed of stainless steel, brass, or other corrosion-resistant metal which complies with these requirements.

9.4 The minimum thickness of an enclosure shall be as specified in Table 9.1 unless:

a) The construction is such that the enclosure is protected against arcing as described in 9.3 (a) and (b); or

b) The available energy of circuits inside the enclosure is limited, such as a Class 2 or Class 3 circuit, so that any arcing that occurs within the enclosure does not cause burnthrough of the enclosure or raise the temperature of the enclosure at any point to a temperature in excess of the minimum ignition temperature for any material in any of the hazardous location groups for which the equipment is being investigated; or

c) A combination of (a) and (b).

Exception No. 1: The minimum thickness requirements of Table 9.1 do not apply when the thickness is at least:

a) 0.093 inch (2.36 mm) for cast brass, bronze, copper, or malleable iron;

b) 0.125 inch (3.18 mm) for cast iron or aluminum; or

c) 0.067 inch (1.70 mm) for sheet steel.

Exception No. 2: The minimum thickness requirements of Table 9.1 do not apply when the thinner enclosure wall or walls are protected against mechanical damage by:

a) The construction of the device; or

b) Installation of the device when installed as intended.

10 Joints in Enclosures

10.1 General

10.1.1 Joints in an enclosure shall comply with the applicable requirements in 10.1.2 – 10.6.3.1, and Section 21, Explosion Tests.

Exception: This requirement does not apply to joints that comply with the requirements in Annex A, Alternative Joints in Enclosures, and Annex B, Alternative Explosion Tests.

10.1.2 A joint in an enclosure shall be of the metal-to-metal, metal-to-glass, metal-to-polymeric, polymeric-to-polymeric, or polymeric-to-glass type. The joint surface shall have an arithmetical average roughness of not more than 250 microinches (0.0064 mm), in accordance with ASME B46.1.

10.1.3 A joint shall be continuous and without interruption by an O-ring groove or the like.

10.2 Cemented joints

10.2.1 When a part that is not intended to be removed after assembly, and that is not required to be opened to install or service the equipment is cemented with a cemented compound, the compound shall comply with the following as applicable:

a) Epoxy and RTV silicone rubber shall resist solvent action in compliance with Section 34, Chemical Resistance Tests on Sealing and Cementing Compounds;

b) RTV silicone rubber shall resist aging in accordance with the air-oven aging test method found in 41.3;

c) Plaster-based cements shall resist moisture in compliance with Section 89, High Humidity Tests; and

d) Comply with the requirements of 25.2, without loosening or cracking, or showing other signs of deterioration.

10.2.2 The length of the compound seal shall be either the minimum length of joint required for an unsealed joint, or 5/8 inch (15.9 mm), whichever is less.

10.2.3 The seal shall contain no voids between the mating parts forming the joint.

10.2.4 The sealing compound shall not be relied upon for mechanical security of the joint.

10.3 Joints with flamepaths Class I, Groups A, B, C, and D

10.3.1 A sealing material applied to a joint surface in accordance with Exception No. 1 to 16.4 shall not increase the maximum clearance between joint surfaces beyond the dimensions specified in this Standard.

10.3.2 A polymeric-to-polymeric joint shall be of the labyrinth or threaded type, and shall comply with the requirements in Section 33, Non-Metallic Enclosure Materials Tests.

10.3.3 The free-internal volume is determined to be the total internal volume of an electrical enclosure minus the volume of internal components. The volume of potting compounds is not used in the determination of the free-internal volume.

Exception No. 1: Potting compounds used for factory-installed lead wire seals, coil encapsulation, or coil insulation are to be used in the determination of the free-internal volume.

Exception No. 2: Potting compounds are to be used in determining the free-internal volume when the compounds:

a) Have been investigated to determine that they will withstand exposure to the flammable vapors involved in that they will remain in place inside the enclosure; and

b) Are free of voids.

10.3.4 A feeler gauge utilized to measure the clearances specified in these requirements is to be 1/8 to 1/2 inch (3.2 to 12.7 mm) wide, with a 1/2-inch-wide gauge preferred. The width of the joint is to be measured with the parts forming the joint assembled in the most unfavorable position.

10.3.5 A gasket shall not be employed in a metal-to-metal, metal-to-polymeric, or polymeric-to-polymeric joint. A gasket that is adjacent to a joint and does not increase the clearance, nor decrease the length of the joint specified in this Standard for the Group and type of joint, meets the intent of this requirement.

10.3.6 A gasket functioning as an active member in the flamepath is not prohibited from being employed in a metal-to-glass, polymeric-to-metal or polymeric-to-glass joint when the gasket complies with the requirements in 10.3.7 – 10.3.10. The maximum clearance between the gasket and the metal, polymeric, or glass shall not be more than that specified in this Standard for the Group and type of joint.

10.3.7 The use of a gasket functioning as an active member in the flamepath shall be limited to a joint that is not disturbed during the installation or intended servicing of the equipment.

10.3.8 A gasket functioning as an active member in the flamepath shall be a metal-covered type, formed from polytetrafluoroethylene, or other material that has been investigated and found capable of being used for the application. See 27.1. A metal-covered gasket in a metal-to-glass or polymeric-to-glass joint shall be mechanically attached to the glass. There shall be no overlapping of the metal covering the gasket on the joint surfaces.

10.3.9 When a gasket of polytetrafluoroethylene or similar material is used, it shall be installed in such a manner as to reduce the occurrence of cold flow of the gasket material.

10.3.10 A material that upon aging readily hardens or adheres to a joint surface, or both, is not to be used as a gasket material. A gasket, functioning as an active member in the flamepath, which is attached by an adhesive or a cement does not comply with this Standard.

10.3.11 A joint of the labyrinth type shall comply with the requirements in 21.26.

10.3.12 A labyrinth joint shall consist of not less than 3 adjacent segments where the path changes direction not less than 2 times.

10.4 Class I, Groups C and D locations

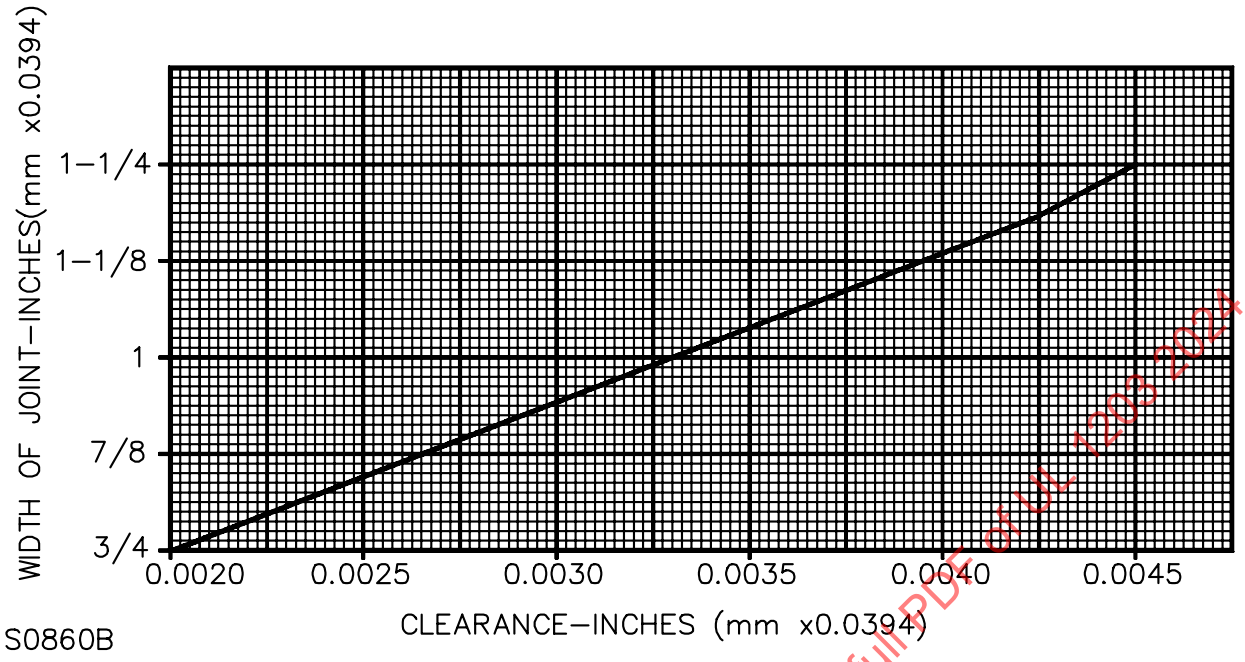
10.4.1 General

10.4.1.1 Except as indicated in 10.4.1.2 – 10.4.1.5 and 10.4.2.1, the width of a joint and the clearance, when assembled, shall be as specified in Figure 10.1. The width of the joint shall not be less than 3/4 inch (19.1 mm).

10.4.1.2 A rabbet joint is not prohibited from having a diametrical clearance at the axial section of not more than twice the clearance specified in 10.1 when neither the axial nor the radial section of the joint is less than 1/16 inch (1.6 mm) wide.

Figure 10.1

Relation Between Clearance and Width of Joint



10.4.1.3 An enclosure having a free-internal volume of not more than 300 cubic inches (4.92 dm^3) is not prohibited from having a 1/2 inch (12.7 mm) wide rabbet joint or a 3/8 inch (9.5 mm) wide flat joint when details comply with (a) or (b), respectively.

a) One-half-inch-wide rabbet joint (see Figure 10.2).

1) Neither the axial nor the radial section of the joint is less than 3/64 inch (1.2 mm) wide;

2) The diametrical clearance of the axial section and the clearance of the radial section is not more than 0.002 inch (0.05 mm); and

3) The joint width measured from the inside of the enclosure to the nearest edge of each bolt clearance hole and elsewhere is not less than 1/2 inch (12.7 mm).

b) Three-eighths-inch-wide flat joint (see Figure 10.3).

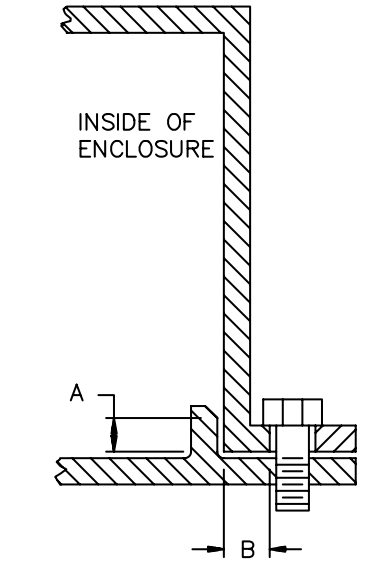
1) The clearance between the joint surfaces is less than 0.0015 inch (0.038 mm) or such that a 0.0015-inch feeler gauge will not enter the joint more than 1/8 inch (3.2 mm) at any point;

2) The thickness of the cover at the joint width is not less than 3/8 inch (9.5 mm), unless stiffened or reinforced material less thick has been found to be capable of being used when judged with respect to opening of joint clearance under internal pressures; and

3) The joint width measured from the inside of the enclosure to the nearest edge of each bolt clearance hole is not less than 3/8 inch (9.5 mm).

Figure 10.2

Rabbet Joint

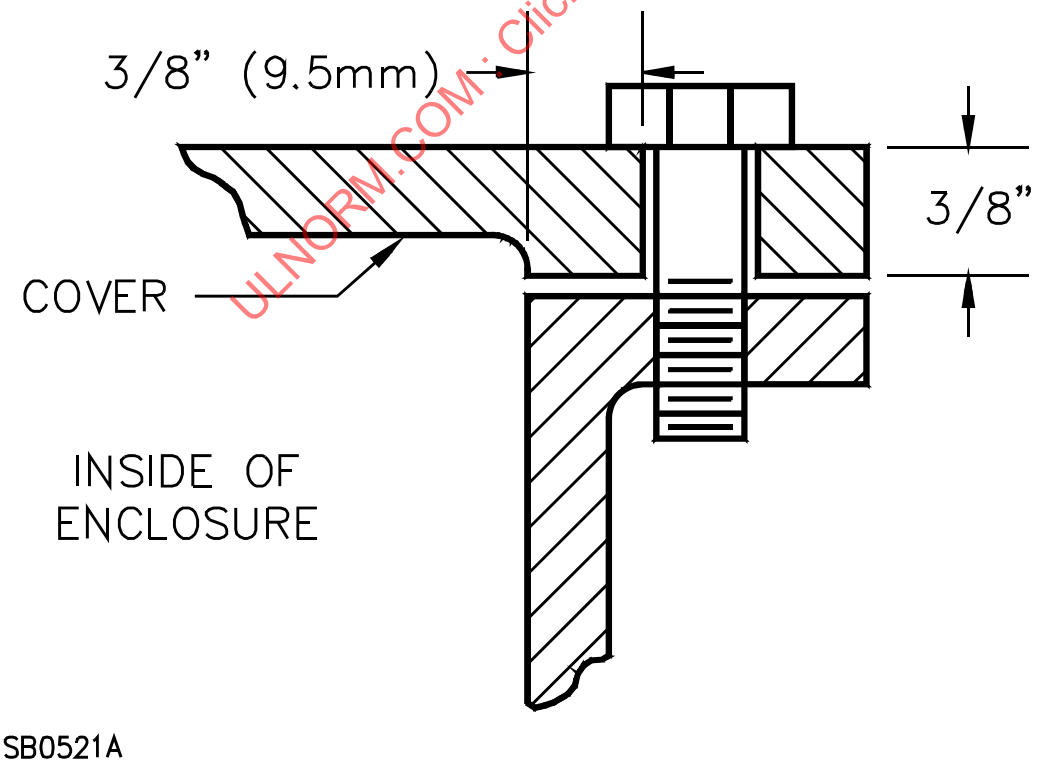


A + B = 1/2 inch (12.7 mm) for Class I, Groups C and D enclosures having free internal volume not more than 300 cubic inches (4.92 dm^3)

A + B = 7/8 inch (22.2 mm) for Class I, Group B enclosures having free internal volume not more than 100 cubic inches (1.64 dm^3)

Figure 10.3

3/8-inch (9.5-mm) Wide Flat Joint



10.4.1.4 The width of a joint in an enclosure having a free internal volume of not more than 6 cubic inches (0.1 dm^3) shall not be less than 1/4 inch (6.4 mm). For an enclosure for Group C locations, the clearance between the joint surfaces shall not be more than 0.004 inch (0.10 mm). For an enclosure for Group D locations, the clearance between the joint surfaces shall not be more than 0.006 inch (0.15 mm).

10.4.1.5 An enclosure shall be permitted to contain a venting section for the purpose of relieving internal explosion pressures. When the maximum explosion pressure developed during the explosion tests does not exceed 5 psig (34.5 kPa), a joint in a vented enclosure shall be permitted to have a width of not less than 1/4 inch (6.4 mm), and a clearance of not more than 0.005 inch (0.13 mm). A venting section shall afford protection against propagation of flame.

10.4.1.6 A 3/4 inch (19.1 mm) or wider joint shall not have an interruption, such as a groove for an O-ring, unless:

a) The interruption has a maximum cross-sectional area of 0.05 $inch^2$ (32.3 mm^2);

b) The joint width from the inside of the enclosure to the inner edge of the interruption is more than 1/2 inch (12.7 mm); and

c) The balance of the required minimum joint width is provided from the outer edge of the interruption, to the outside of the enclosure.

10.4.2 Labyrinth joints, Groups A, B, C, and D

10.4.2.1 A joint of the labyrinth type shall comply with the requirements in 21.26.

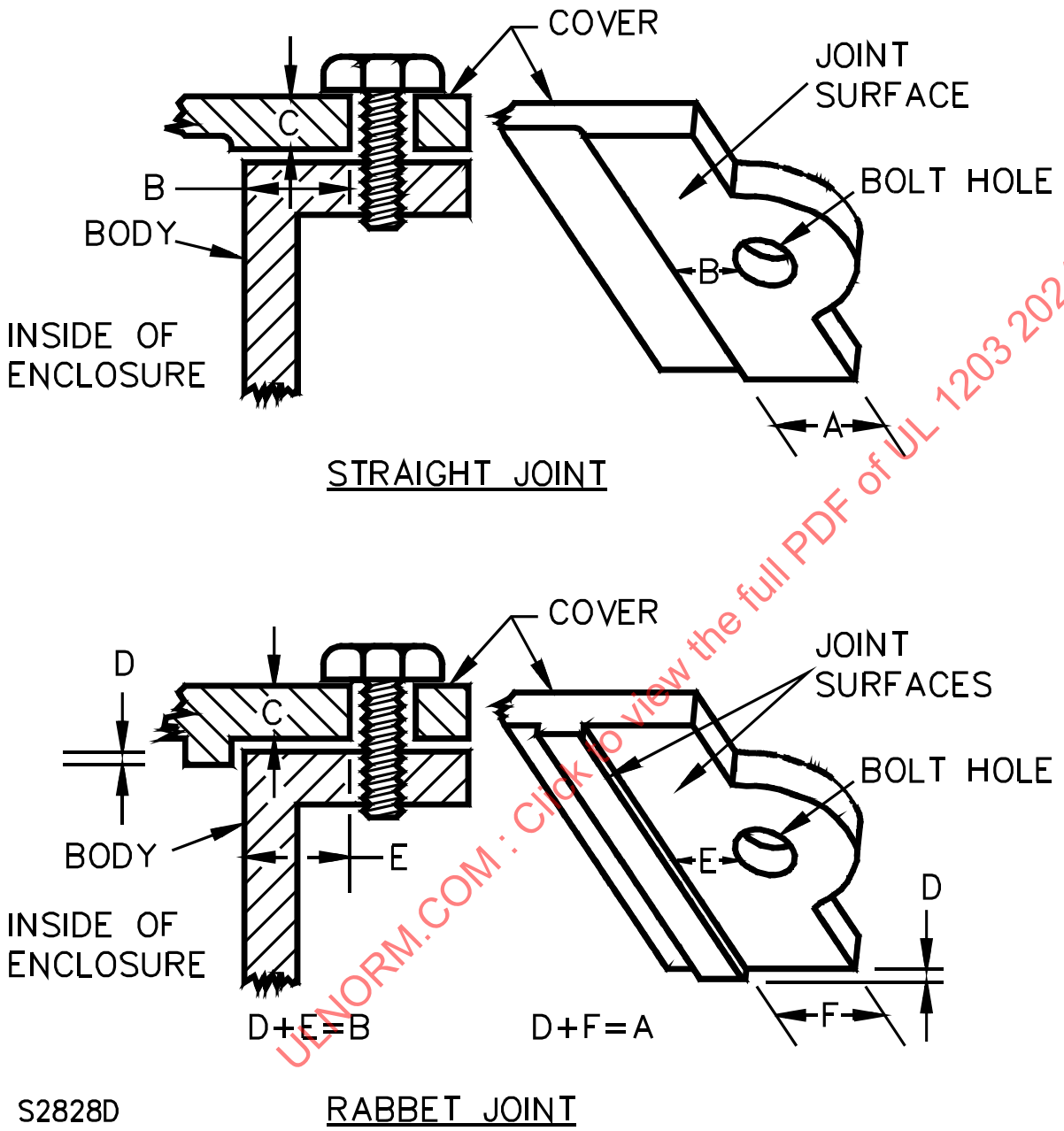
10.4.2.2 A labyrinth joint shall consist of not less than 3 adjacent segments where the path changes direction not less than 2 times.

10.4.3 Bolts in joint width

10.4.3.1 A bolt shall be permitted to be located in a 3/4 inch (19.1 mm) or wider joint when the distance from the inside of the enclosure to the nearest edge of the clearance hole for the bolt is not less than 1/2 inch (12.7 mm), and the diametrical clearance between the bolt and the clearance hole is not more than 0.045 inch (1.14 mm), measured over the shank or the major diameter of the threads, for a length of not less than one-half the required width of joint specified in Figure 10.1. The distance from inside the enclosure to the edge of the nearest clearance hole is measured with the cover in the most unfavorable position. See 10.4.3.4 and Figure 10.4.

Figure 10.4

Bolts in Joint Width



A = Required minimum width of joint (see Figure 10.1)

B = Minimum distance from inside enclosure to bolt clearance hole

C = One-half of required minimum width of joint

D = One part of rabbet joint

E = Second part of rabbet joint to bolt clearance hole

F = Second part of rabbet joint elsewhere

10.4.3.2 All bolt holes in a joint width shall be bottomed or the bolts or screws for fastening a cover shall each engage at least five full threads in a tapped hole.

10.4.3.3 A bolt in a joint width is not prohibited from being provided with a lock washer.

10.4.3.4 The requirements in 10.4.3.1 and 10.4.3.2 apply, in general, to machine screws having a round cross section. Screws that form their own machine-type thread and have been investigated for securing enclosure parts are not prohibited from being located in the joint width when they comply with the requirements in 10.4.3.1 and 10.4.3.2, except for measurement of the bolt clearance. In determining the clearance between a thread-forming screw and its clearance hole, the bolt dimension to be used is the minimum dimension of the cross section over the threads.

10.4.4 Cylindrical joints Groups A, B, C, and D

10.4.4.1 A flamepath having a cylindrical cross-section shall have a length of not less than 1 inch (25.4 mm). The diametrical clearance (difference in diameters) shall not be greater than 0.0033 inch (0.083 mm). The diametrical clearance of a path longer than 1-1/4 inch (31.8 mm) shall not be greater than 0.0045 inch (0.114 mm). For flamepath lengths greater than 1 inch (25.4 mm) but less than 1-1/4 inch (31.8 mm) the clearance shall be as given in Figure 10.1.

10.5 Class I, Group B locations

10.5.1 General

10.5.1.1 The width of a joint in an enclosure having a free internal volume of not more than 30 cubic inches (0.5 dm^3) shall not be less than 3/8 inch (9.5 mm). At a bolt hole, the width shall be measured from the inside edge to the nearest edge of the bolt clearance hole. The cover thickness at the joint flange shall not be less than 3/8 inch. The clearance between the joint surfaces shall be less than 0.0015 inch (0.038 mm) or such that a 0.0015 inch feeler gauge will not enter the joint more than 1/8 inch (3.2 mm) at any point. See Figure 10.3.

10.5.1.2 The width of a joint in an enclosure having a free internal volume of not more than 6 cubic inches (0.1 dm^3) shall not be less than 5/16 inch (7.9 mm) with a clearance between joint surfaces of not more than 0.002 inch (0.05 mm) or 3/8 inch (9.5 mm) with a clearance between joint surfaces of not more than 0.004 inch (0.10 mm). The cover thickness at the joint flange is not prohibited from being less than 3/8 inch.

10.5.2 The width of a joint in an enclosure having a free internal volume of more than 30 cubic inches (0.5 dm^3) and not more than 100 cubic inches (1.6 dm^3) shall not be less than 5/8 inch (15.9 mm). At a bolt hole, the width is to be measured from the inside edge to the nearest edge of the bolt clearance hole. The clearance between the joint surfaces shall be less than 0.0015 inch (0.038 mm) or such that a 0.0015-inch feeler gauge will not enter the joint more than 1/8 inch (3.2 mm) at any point. A rabbet joint shall have a total width of not less than 7/8 inch (22.2 mm), with neither section of joint being less than 3/8 inch (9.5 mm) wide. The diametrical clearance at the axial section of joint shall not be more than 0.0025 inch (0.064 mm), and the clearance at the radial or clamped section of joint shall not be more than 0.0015 inch. See Figure 10.2.

10.5.3 The width of a joint in an enclosure having a free internal volume of more than 100 cubic inches (1.64 dm^3) and not more than 350 cubic inches (5.7 dm^3) shall not be less than 1 inch (25.4 mm). At a bolt hole, the width shall be measured from the inside edge to the nearest edge of the bolt clearance hole. The clearance between the joint surfaces shall not be more than 0.0015 inch (0.038 mm).

10.5.4 Bolts in joint width

10.5.4.1 A bolt shall be permitted to be located in the joint width of an enclosure having a free internal volume (air volume) of more than 100 and not more than 350 cubic inches (1.6 – 5.7 dm^3) when it complies with the requirements in 10.5.4.2 and 10.5.4.3.

10.5.4.2 A bolt is not prohibited from being located in a 1 inch (25.4 mm) or wider joint when the distance from the inside of the enclosure to the nearest edge of the clearance hole for the bolt is not less than 55/64 inch (21.8 mm), and the diametrical clearance between the bolt and the clearance hole is not more than 0.045 inch (1.14 mm), measured over the shank or the major diameter of the threads, for a length of not less than one-half the required width of joint. The distance from inside the enclosure to the edge of the nearest clearance hole is measured with the cover in the most unfavorable position. See 10.5.4.5 and Figure 10.4.

10.5.4.3 All bolt holes in a joint width shall be bottomed or the bolts or screws for fastening a cover shall each engage at least five full threads in a tapped hole.

10.5.4.4 A bolt in a joint width is not prohibited from being provided with a lock washer.

10.5.4.5 The requirements in 10.5.4.1 – 10.5.4.3 apply, in general, to machine screws having a round cross section. Screws that form their own machine-type thread and have been investigated for securing enclosure parts are not prohibited from being located in the joint width when they comply with the requirements in 10.5.4.1 – 10.5.4.3, except for measurement of the bolt clearance. In determining the clearance between a thread forming screw and its clearance hole, the bolt dimension to be used is the minimum dimension of the cross section over the threads.

10.6 Threaded joints

10.6.1 Class I, Groups A, B, C, and D

10.6.1.1 The thread pitch in threaded joints shall not be finer than 32 threads per inch (0.79 mm pitch).

10.6.1.2 A joint of the serrated type with thread contour shall not have more than 20 serrations per inch (1.27 mm pitch) and shall have not less than 5 fully engaged and tightly clamped serrations.

10.6.1.3 All unused threaded openings through the walls of an explosionproof enclosure shall be closed by a device or a threaded plug. The joint formed, upon assembly, shall comply with 10.6.2.1.

10.6.1.4 For joints formed by a screw in a through hole securing a part, the screw shall be secured against removal by a lock nut, a lock washer, peening, staking, welding, or other mechanical means.

10.6.1.5 A thread locking compound shall be subjected to a special investigation.

10.6.1.6 Tapered threaded joints shall comply with Table 10.1.

Table 10.1
Tapered Threaded Joints

Pitch	≥ 0.9 mm
Threads provided on each part	≥ 5[b]
Threads engaged	c
On male threaded fittings with a shoulder or interruption, a thread length not less than the L4 dimension defined by ASME B1.20.1 shall be provided between the face of the shoulder and the end of the fitting thread.	
[a] Internal and external thread shall have the same nominal size, cone angle and thread form. [b] Threads shall conform to NPT requirements of ASME B1.20.1, and shall be made up wrench tight. [c] Adjustment of gauging practices is required to achieve the required engagement of threads. See Section 14, Supply Connections.	
Note: Gauging of female threads in IEC 60079-1 is flush to plus 2 turns of the plug gauge.	

10.6.2 Class I, Groups A and B

10.6.2.1 A threaded joint shall comply with the following:

a) For standard tapered pipe threads, not less than 5 fully engaged threads shall be provided; or

b) For parallel threads not finer than 20 threads per inch (1.27 mm pitch) the minimum number of threads required shall be not less than specified in Table 10.2 for the class of fit; or

c) For parallel threads not finer than 32 threads per inch (0.79 mm pitch) and tested as described in Section 21, Explosion Tests, the minimum number of threads required shall be not less than specified in Table 10.3.

Table 10.2
Minimum Threaded Engagement

Class of fit / minimum tolerance class		Minimum number of fully engaged threads
ANSI[a]	ISO[b]	
3	–	6
2	–	7
1	–	8
–	(6g/6H)	5
[a] See ASME B1.1. [b] See ISO 965-1 and ISO 965-3.		

Table 10.3
Threads Required Based Upon Enclosure Volume

Free internal volume of enclosure	Minimum number of fully engaged threads	Minimum length of thread engagement
≤ 6.1 inch^3 (≤ 100 cm^3)	5	0.25 inch (6 mm)
> 6.1 inch^3 (> 100 cm^3)	6	0.3125 inch (8 mm)

10.6.3 Class I, Groups C, and D

10.6.3.1 A threaded joint shall be made up with the number of fully engaged threads specified in Table 10.4. Threads shall not be finer than specified in Table 10.4.

Table 10.4
Thread Engagement

Maximum diameter of threaded sections, inch (mm)	Maximum number of threads per inch (per 25.4 mm)	Minimum number of threads engaged
No limit	20	5
3/8 (9.5)	24	5
Over 3/8	24	6
Over 3/8	28	7
Over 3/8	32	8

11 Shaft Openings

11.1 General

11.1.1 Shaft openings in an enclosure shall comply with the applicable requirements in 11.1.2 – 11.3.5.2 and Section 21, Explosion Tests.

Exception: This requirement does not apply to joints that comply with the requirements in Annex A, Alternative Joints in Enclosures and Annex B, Alternative Explosion Tests.

11.1.2 A shaft opening in an enclosure shall be of the metal-to-metal, metal-to-polymeric, or polymeric-to-ceramic type. See 10.1.2 regarding the roughness of the surfaces forming the shaft path joints.

11.1.3 The requirements in 11.2.1 – 11.3.5.2 apply to shaft openings in electrical enclosures for Class I, Groups C and D locations.

11.1.4 Equipment for Class I, Group A or B locations having a free internal volume of 30 cubic inches (0.5 dm^3) or less and a shaft that rotates at less than 100 rpm shall comply with the requirements in 11.2.1.

11.1.5 A shaft path shall be continuous and without interruption by an O-ring groove or the like.

11.2 Non-rotating shafts and shafts rotating at a speed of less than 100 rpm

11.2.1 A shaft opening in an enclosure shall have a length of path of not less than 1 inch (25.4 mm). The diametrical clearance (difference in diameter of the shaft and the opening in the enclosure) shall be as specified in Figure 10.1. The diametrical clearance of a path longer than 1-1/4 inch (31.8 mm) shall not be more than 0.0045 inch (0.114 mm). See 11.2.2.

Exception: An opening for a shaft that is centered in the opening by bearings or an equivalent construction that prevents contact between the shaft and the shaft opening is not required to comply with the requirements in 11.2.1 and 11.2.2 when it complies with the requirements in 11.3.1.3 – 11.3.5.2.

11.2.2 A shaft opening in an enclosure having non-rotating shafts and shafts rotating at a speed of less than 100 rpm and a venting section is not prohibited from having a diametrical clearance of 0.005 inch

(0.13 mm) for a maximum length of 1/2 inch (12.7 mm) when the explosion pressure developed in the explosion tests does not exceed 5 psi (34.5 kPa).

11.2.3 A device having a free internal volume of 1.0 cubic inch (0.016 dm^3) or less may have a length of path of not less than 9/32 inch (7.1 mm) with a diametrical clearance of not more than 0.005 inch (0.127 mm).

11.2.4 A device having a free internal volume of 6.1 cubic inches (100 cm^3) or less and tested as specified in 21.33 may have a shaft opening with a length and diametrical clearance as follows:

Minimum length of path inch (mm)	Maximum diametrical clearance inch (mm)
0.24 (6.0)	0.004 (0.10)
0.49 (12.5)	0.006 (0.15)

11.3 Shafts rotating at a speed of 100 rpm or more

11.3.1 General

11.3.1.1 Other than as noted in 11.3.1.2, the path at the opening for a shaft that rotates at a speed of 100 rpm or more shall comply with the requirements in 11.3.1.3 – 11.3.1.4.

11.3.1.2 For products, such as telemetering equipment, having a shaft that does not transmit power, is not intended to bear a load, and is intended to rotate at 100 rpm or more, the path at the shaft opening is not prohibited from complying with the requirements in 11.2.1 and 11.2.2.

11.3.1.3 The paths at shaft openings specified in 11.3.1.4 – 11.3.3.4 and 11.3.4.1 – 11.3.5.2 shall be in addition to any protection offered by the ball bearings or the sleeve bearings on the shaft.

11.3.1.4 The length of a shaft opening or path shall be determined by measuring only the metal-to-metal path. Oil or grease grooves without any inlet or outlet openings comply with the intent of this requirement when their size does not affect the protective value of the total length of path. Such grooves are not to be used in measuring the effective metal path. A labyrinth, when of a substantial form of construction, is evaluated as equivalent in length to a straight metal path. Openings for oil or grease shall be located outside the path.

11.3.1.5 A device having a free internal volume of 1.0 cubic inch (0.016 dm^3) or less may have a length of path of not less than 9/32 inch (7.1 mm) with a diametrical clearance of not more than 0.005 inch (0.127 mm).

11.3.1.6 A device having a free internal volume of 6.1 cubic inches (100 cm^3) or less and tested as specified in 21.33 may have a shaft opening with a length and diametrical clearance as follows:

Minimum length of path inch (mm)	Maximum diametrical clearance inch (mm)
0.24 (6.0)	0.004 (0.10)
0.49 (12.5)	0.006 (0.15)

11.3.2 Free internal volume of enclosure 65 cubic inches (1.1 dm^3) or less

11.3.2.1 An enclosure for Class I, Group D locations having a free internal volume of 65 cubic inches (1.1 dm^3) or less shall have a shaft opening with a length of not less than 1/4 inch (6.4 mm) and a diametrical clearance between shaft and shaft opening of not more than 0.015 inch (0.38 mm).

11.3.3 Free internal volume of enclosure 350 cubic inches (5.7 dm^3) or less

11.3.3.1 Except as indicated in 11.3.3.3 and 11.3.3.4, an enclosure for Class I, Group D locations having a free internal volume more than 65 cubic inches (1.1 dm^3) and not more than 350 cubic inches (5.7 dm^3), and a length (circumference) of joint not more than 32 inches (813 mm), shall have a shaft opening with a length of not less than 1-1/2 inches (38.1 mm) and a diametrical clearance of not more than 0.025 inch (0.64 mm).

11.3.3.2 A shaft opening in an enclosure for Class I, Group C locations shall:

a) Comply with the requirements in 11.3.3.1; and

b) Be provided with a labyrinth flame path of at least 1/8 inch (3.2 mm), the offset being not less than 1/16 inch (1.6 mm) (difference in diameters at least 1/8 inch) through two 90° turns.

11.3.3.3 A larger clearance at a shaft opening is not prohibited when there is an increase in length of metal path of 1/4 inch (6.4 mm) per 0.002 inch (0.05 mm) increase in diametrical clearance.

11.3.3.4 A proportional decrease in length of 1/4 inch (6.4 mm) per 0.002 inch (0.05 mm) decrease in diametrical clearance is not prohibited when the metal path is not less than 1 inch (25.4 mm).

11.3.3.5 When the path specified in 11.3.3.1 – 11.3.3.4 is not provided in addition to the length of the sleeve bearing, the bearing shall have an overall length of not less than 1-1/4 inches (31.8 mm). The necessary oil openings and grooves are not prohibited from being provided in this 1-1/4 inch length of sleeve bearing, subject to tests. In addition, the flame path shall either be:

a) Around a radial shaft shoulder of not less than 1/8 inch (3.2 mm) with end play limited by means of spring washers, or the equivalent, to less than 0.002 inch (0.05 mm) for an enclosure for Class I, Group D locations; or

b) Through a labyrinth with an offset not less than 1/16 inch (1.6 mm) (difference in diameters at least 1/8 inch) through two 90° turns. The labyrinth shall have a diametrical clearance of not more than 0.020 inch (0.50 mm) through a length of not less than:

1) For an enclosure for Class I, Group D locations, 1/4 inch (6.4 mm); and

2) For an enclosure for Class I, Group C locations, 3/8 inch (9.5 mm).

11.3.4 Free internal volume of enclosure more than 350 cubic inches (5.7 dm^3) with internal length of joint of 90 inches (2.29 m) or less

11.3.4.1 An enclosure for Class I, Group D locations having a free internal volume more than 350 cubic inches (5.7 dm^3) and an internal length (circumference) of joint less than 90 inches (2.29 m) shall have a shaft path complying with Table 11.1.

Table 11.1
Length of Shaft Opening and Diametrical Clearance

Minimum length of shaft opening		Maximum diametrical clearance	
inches	(mm)	inch	(mm)
1-1/2	(38.1)	0.025	(0.64)
2-1/2	(63.5)	0.030	(0.76)

11.3.4.2 A shaft opening in an enclosure for Class I, Group C locations shall:

a) Comply with the requirements in 11.3.4.1; and

b) Be provided with a labyrinth path of at least 1/8 inch (3.2 mm), the offset being not less than 1/8 inch [difference in diameters at least 1/4 inch (6.4 mm)] through two 90° turns.

11.3.5 Internal length of joint more than 90 inches (2.29 m)

11.3.5.1 An enclosure having an internal length (circumference) of joint larger than 90 inches (2.29 m) shall have at least two sections of labyrinth shaft paths complying with the dimensions in Table 11.2.

Table 11.2
Length of Labyrinth Path and Diametrical Clearance

Total length of labyrinth path		Maximum diametrical clearance		No section less than	
inches	(mm)	inch	(mm)	inch	(mm)[a]
2	(50.8)	0.025	(0.64)	1/4	(6.4)
3	(76.2)	0.030	(0.76)	1	(25.4)

[a] The lengths of adjacent labyrinth path sections shall be on different diameters with an offset not less than 1/8 inch (3.2 mm) (difference in diameters at least 1/4 inch) through two 90° turns.

11.3.5.2 The minimum dimensions specified in Table 11.2 shall be provided with the shaft in any position permitted by the end play of the shaft. The two adjacent sections of the path shall not be more than 5/8 inch (15.9 mm) apart, at any position provided by end play.

12 Holes in Enclosures

12.1 Except as indicated in 12.4, a hole in an enclosure for securing a part:

a) Shall be bottomed and the thickness of the metal remaining shall comply with the minimum thickness requirements for the enclosure;

Exception: When the hole is closed with a screw, the enclosure shall have a minimum thickness of 0.0625 inch (1.59 mm) and withstand the Hydrostatic Pressure Test, Section 22.

b) Shall be closed by welding of the part in place; or

c) The screw securing the part shall engage at least five full threads and be secured against removal by a lock nut, a lock washer, welding, peening, or the equivalent. When a self-tapping screw is used, it shall have a minimum of five full threads engaged when seated. A screw shall not have more than 32 threads per inch (per 25.4 mm).

12.2 A metal pin or a part press-fitted through the wall of an enclosure shall engage for at least 3/8 inch (9.5 mm). Such a part shall be secured against removal by welding, peening, or equivalent mechanical securement.

12.3 Unless an attachment complies with the requirements in 12.1 or 12.2, holes in an enclosure for attachment of a nameplate shall be bottomed. The remaining thickness at the bottomed hole shall withstand the Hydrostatic Pressure Test, Section 22, and shall not be less than 1/16 inch (1.6 mm).

12.4 A tapped hole shall not be provided in a sintered-metal part employed as a venting section of an enclosure.

12.5 An open-type receptacle complying with the requirements in 10.6 and threaded into the enclosure, or a closure plug threaded into an opening in the enclosure for such a receptacle need not be secured against removal.

12.6 An open-type receptacle shall close the opening into which it is installed in a manner that complies with the requirements in this standard when installed in accordance with the manufacturer's instructions.

13 Drain and Breather Fittings in Enclosures

13.1 Drain and breather fittings shall:

a) Drain a liquid from the enclosure without removal of any part of the fitting;

b) Be located to reduce the risk of damage to the fitting; and

c) Be permanently attached to the enclosure unless trade size 1/2 or larger NPT threads are provided in accordance with 14.1.1.2.

13.2 The metal-to-metal joint between a drain fitting and the enclosure shall comply with the requirements specified for joints in the enclosure.

13.3 Drain and breather fittings supplied as a part of an explosionproof electrical enclosure shall comply with the requirements in Section 21, Explosion Tests and Section 22, Hydrostatic Pressure Test.

13.4 Drain and breather fittings intended to be installed in a supply connection opening in accordance with installation instructions for installation of the fitting shall comply with the requirements in Section 85, Explosion Test and Section 86, Hydrostatic Pressure Test.

14 Supply Connections

14.1 Fixed equipment conduit and cable entries

14.1.1 General

14.1.1.1 Equipment intended for permanent installation shall have provision for connection to threaded rigid metal conduit or other wiring methods in accordance with Article 501 in NFPA 70.

Exception: The equipment enclosure is not required to comply with this requirement when instructions are provided in accordance with 59.21.

14.1.1.2 NPT threaded entries shall be permitted and shall use a modified National Standard Pipe Taper (NPT) thread with thread form per ASME B1.20.1. Entries shall not be smaller than trade size 1/2 nor larger than trade size 6. Factory-threaded entries shall conform to ASME B1.20.1 except that entries shall

gauge from flush to plus 3-1/2 turns beyond the L-1 gauging notch in lieu of the minus 1 to plus 1 turns described in ASME B1.20.1. Supply connection threads shall comply with Section 21, Explosion Tests.

14.1.1.3 Each entry shall be provided with one of the following constructions:

a) A smooth and well-rounded integral conduit stop, having a throat or inner diameter as specified in Table 14.1;

b) A smooth and well-rounded inner end as shown in Figure 14.1; or

c) Threads not exceeding the maximum number specified in Table 14.2 for the conduit size, such that a conduit bushing is able to be installed on the end of the conduit after it is engaged with the entry threads.

Exception: The opening is not required to comply with this requirement when instructions are provided in accordance with 59.19.

14.1.1.4 Where a conduit stop (also known as an integral bushing) is not provided, the inner end of the entry shall be smooth and well-rounded. The dimensions of a conduit stop, if provided, shall be as shown in Table 14.1.

Table 14.1
Throat Diameter of Conduit Stop

Trade size of conduit		Throat diameter of conduit stop, inches (mm)			
Inches	(mm OD)	Minimum		Maximum	
1/2	(21.3)	0.560	(14.22)	0.622	(15.80)
3/4	(26.7)	0.742	(18.85)	0.824	(20.93)
1	(33.4)	0.944	(23.98)	1.049	(26.64)
1-1/4	(42.2)	1.242	(31.55)	1.380	(35.05)
1-1/2	(48.3)	1.449	(36.80)	1.610	(40.89)
2	(60.3)	1.860	(47.24)	2.067	(52.50)
2-1/2	(73.0)	2.222	(56.44)	2.469	(62.71)
3	(88.9)	2.761	(70.13)	3.068	(77.93)
3-1/2	(101.6)	3.193	(81.10)	3.548	(90.12)
4	(114.3)	3.623	(92.02)	4.026	(102.26)
5	(141.3)	4.542	(115.37)	5.047	(128.19)
6	(168.3)	5.458	(138.63)	6.065	(154.05)

Figure 14.1

Conduit Opening Without Conduit Stop

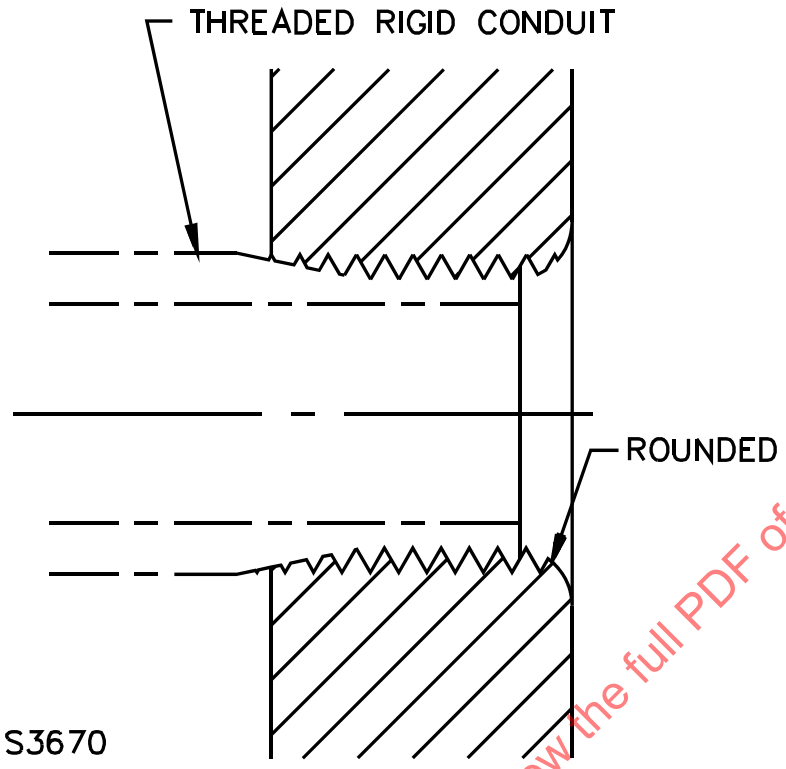


Table 14.2
Number of Threads in a Conduit Opening Without an Integral Stop

Trade size of conduit		Number of threads per inch (25.4 mm)	Maximum number of threads
inches	(mm OD)		
1/2	(21.3)	14	6
3/4	(26.7)	14	6
1	(33.4)	11-1/2	6
1-1/4	(42.2)	11-1/2	6
1-1/2	(48.3)	11-1/2	7
2	(60.3)	11-1/2	7
2-1/2	(73.0)	8	7
3	(88.9)	8	8
3-1/2	(101.6)	8	8
4	(114.3)	8	9
5	(141.3)	8	9
6	(168.3)	8	9

14.1.1.5 Metric threaded entries shall comply with the requirements in 10.6, Threaded Joints, and Section 21, Explosion Tests. Means shall be provided to minimize abrasion to conductor insulation.

14.1.1.6 Metric threaded entries shall have a permanent marking near the supply connection opening in accordance with 59.22.

Exception: Equipment which uses a thread type other than NPT or NPS is not required to have the marking in 59.22 when it is provided with an adapter to NPT or NPS thread form. The adapter shall comply with the applicable construction and performance requirements in Part VIII in this Standard.

14.1.1.7 When an integral conduit stop is provided, it shall be smooth and well-rounded, having a throat or inner diameter as specified in Table 14.1.

14.1.1.8 When an integral conduit stop is provided in the conduit opening of an enclosure for Class I, Group A or B locations, the threads shall be tapered 3/4 inch per foot (62.5 mm/m).

14.1.1.9 NPS threaded entries may be provided for an enclosure for Group C or D locations and shall use a National Standard Pipe Straight (NPS) thread per ASME B1.20.1 and shall include an integral bushing and shall provide five full threads. The dimensions of the integral bushing shall be as shown in Table 14.1.

14.1.1.10 When an integral conduit stop is not provided in a conduit opening, the threads shall be tapered 3/4 inch per foot (62.5 mm/m).

14.1.1.11 All openings for a power supply connection, except those required for installation, shall be furnished with metal close-up plugs engaging the opening in accordance with 10.6.

14.1.1.12 A supply connection hub not integrally cast with an enclosure shall:

a) Have a wall thickness before threading not less than that of the corresponding trade-size conduit;

b) Not depend upon friction alone to prevent it from turning, and

c) Comply with the Secureness Test on Supply Connection Hubs, Section 26.

14.1.1.13 Enclosures capable of being drilled and tapped in the field with supply connections shall have wall sections which are capable of accommodating the trade size openings that are added in the field. These enclosures shall be provided with field drilling and tapping instructions in accordance with 59.21.

14.1.1.14 Male NPT threaded fittings having a shoulder or other interruption that can interfere with thread engagement shall have a threaded length not less than the L4 dimension shown in ASME B1.20.1 when measured from the end of the fitting thread to the face of a shoulder or to an interruption.

14.1.1.15 Male NPT threaded fittings shall gauge ±1 turn of the ring gauge from being flush with the end of the thread in accordance with ASME B1.20.1.

14.1.1.16 A conduit hub not integrally cast with an enclosure shall:

a) Have a wall thickness before threading of not less than that of the corresponding trade-size conduit,

b) Not depend upon friction alone to prevent it from turning, and

c) Comply with the Secureness Test on Supply Connection Hubs, Section 26.

14.1.2 Conduit seals

14.1.2.1 A factory-installed conduit seal incorporated as part of the equipment shall:

a) Comply with the applicable requirements in 14.1.2.2, 14.1.2.3, and Section 24, Leakage Test on Factory-Installed Conduit Seals; and

b) Be marked in accordance with 59.15.

14.1.2.2 When a conduit seal is incorporated, the wires or conductors shall be securely held and tightly sealed where they pass into the enclosure. When a sealing compound or cement is used, it shall:

a) Provide a tight fit;

b) Neither soften nor crack under service conditions;

c) Be resistant to chemicals as required in Section 34, Chemical Resistance Tests on Sealing and Cementing Compounds;

d) Be resistant to moisture and aging in compliance with Section 89, High Humidity Tests; and

e) Not be less than 5/8 inch (15.9 mm) deep.

14.1.2.3 The sealing compound shall not flow or creep at the operating temperature of the device, and when it is of the softening type, have a softening point less than 93 °C (200 °F) as determined by ASTM E28.

14.1.2.4 When a nipple is used to retain the sealing compound for the lead wires of the device, the minimum depth of seal required is the internal diameter of the nipple, or 5/8 inch (15.9 mm), whichever is greater. Based on the compound, the size of the lead wires, and the construction of the sealing well, a greater depth of sealing compound shall be necessary to form a tight seal. Means shall be provided in the nipple to anchor the sealing compound.

14.1.3 Leads

14.1.3.1 A lead intended for the connection to the grounded conductor or terminal shall be finished to show a white or gray color and shall be distinguishable from the other leads.

14.1.3.2 The surface of an insulated lead intended solely for the connection to an equipment-grounding conductor or terminal shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

14.1.3.3 The requirements relating to color coding of a lead for identification do not apply to internal wiring that is not visible in a wiring compartment in which field connections are to be made.

14.1.3.4 The free length of a lead intended for connection to a device or an appliance shall have a minimum length as specified in (a) – (c), as applicable:

a) 6 inches (153 mm) when connections are intended to be made within an outlet box or within the equipment enclosure;

b) 18 inches (458 mm) when connections are not intended to be made within the valve enclosure; or

c) 24 inches (610 mm) plus the distance between the sealing fitting and the equipment enclosure that is specified in the marking when connections are not intended to be made within an outlet box or within the equipment enclosure, and the equipment is intended to have a sealing fitting installed.

14.1.4 Grounding

14.1.4.1 All equipment shall have provision for grounding all noncurrent carrying metal parts that are exposed, or that are capable of being contacted by persons during normal operation or adjustment of the equipment and that are capable of becoming energized, in accordance with the requirements in UL 508.

14.1.4.2 A supplemental external bonding terminal provided on the equipment shall have a terminal that is not identified as being intended for connection of the equipment grounding conductor by being:

a) Colored green;

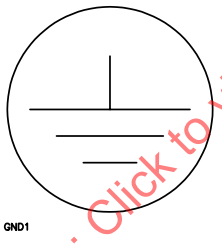
b) Marked with the letter or word "G", "GR", "GRD", "GROUND"; or

c) Marked with the symbol in Figure 14.2.

Exception: The external bonding terminal shall not be identified as an equipment grounding terminal unless instructions are included with the equipment indicating that the internal grounding terminal shall be used as the equipment grounding means and that the external terminal is only a supplemental bonding connection where local authorities permit or require such a connection.

Figure 14.2

Grounding-Terminal Symbol



(IEC PUBLICATION 417, SYMBOL 5019)

Symbol Definition – A terminal that must be connected to earth ground prior to making any other connections to the equipment.

14.1.4.3 When provided, the supplemental equipotential bonding connection facilities on the outside of electrical equipment shall provide effective connection of a conductor with a cross-sectional area of at least 4 mm^2 (10 AWG). Effective connection shall be verified by compliance with the pullout and secureness tests in UL 486E.

14.1.4.4 Fixed equipment employing a cord shall comply with the requirements described in 14.2, Cord-connected portable equipment.

14.2 Cord-connected portable equipment

14.2.1 General

14.2.1.1 External metal parts of portable equipment that are capable of being struck by or of striking against foreign objects shall be made of brass, bronze, or aluminum.

14.2.1.2 Portable equipment shall have provision for connection of flexible cord listed for extra-hard-usage, with a grounding conductor. The terminal enclosure shall be of a construction such that the cord is replaceable. The enclosure that contains the terminals for connection of the flexible-cord conductors shall completely enclose the terminals.

14.2.1.3 When a power-supply cord is provided, the insulation of the equipment-grounding conductor shall be green with or without one or more yellow stripes and no other conductor shall be so identified. The equipment-grounding conductor shall be connected to the grounding terminal of the equipment by means other than solder.

14.2.1.4 When provided, an attachment plug shall be of the grounding type, intended for use in the same hazardous location classes and groups as the equipment.

14.2.1.5 When a power-supply cord or attachment plug, or both, are not provided, the equipment shall be marked as indicated in 59.14.

14.2.2 Terminal enclosure

14.2.2.1 The terminal enclosure for terminals which are capable of turning, either at the screw end, at a head (wire-binding screw), or at a nut in contact with strands of the cord conductor shall:

a) Withstand the internal pressures resulting from explosions without bursting or loosening at joints;

b) Have metal-to-metal joints that comply with the requirements in Joints in Enclosures, Section 10; and

c) Withstand a hydrostatic pressure test or be determined to comply with the requirement by calculation as specified in 22.1.

14.2.2.2 The terminal enclosure shall be made of metal having a minimum thickness as specified in Table 9.1.

14.2.2.3 When each terminal is of a type that provides a minimum spacing of 3/16 inch (4.8 mm) shortest distance between terminals, is insulated, and does not have a screw end, a head (wire-binding screw), or a nut in contact with strands of the cord conductor, the terminals shall be enclosed, and the explosionproof construction specified in 14.2.2.1 is not required to be provided. The entrance for the power-supply cord is not prohibited from being closed with a molded-rubber or -neoprene bushing complying with the requirements in Accelerated Aging Test on Bushings, Section 29.

14.2.2.4 Where polarization of the supply is required, cord connectors shall have the terminal intended for connection to the grounded (white) conductor identified by a metal or metal coating substantially white in color, or by the word "white" or the letter "W" located adjacent to the identified terminal. When the terminal is not visible, the conductor entrance hole for the connection shall be colored white or marked with the word "white" or the letter "W".

14.2.3 Packing gland

14.2.3.1 A packing gland (stuffing box) shall be provided at the cord entrance to a terminal enclosure that is constructed as described in 14.2.2.1.

14.2.3.2 The packing material for the gland shall be polytetrafluoroethylene packing material, or a material having similar characteristics, having a minimum diameter or thickness of 3/32 inch (2.4 mm). The packing material shall completely surround the cord and provide a tightly compressed seal when the packing gland is assembled. The minimum depth of a tightly compressed seal shall be 5/8 inch (15.9 mm).

The construction and amount of packing shall be such that with the packing compressed, as intended, the compression nut still has a travel distance of at least 1/8 inch (3.2 mm) without interfering with parts other than packing material. The compression nut shall be mechanically secured against loosening by means of a setscrew or the equivalent.

14.2.3.3 The diametrical clearance between the outer jacket of the power-supply cord and the surrounding cavity for packing material shall not exceed three times the diameter of the packing material. At each end of the cavity for the packing material, the diametrical clearance between the opening in the gland parts and the outer jacket of the cord shall not exceed:

a) 1/16 inch (1.6 mm) for packing material less than 1/4 inch (6.4 mm) in diameter; or

b) 3/16 inch (4.8 mm) for packing material 1/4 inch (6.4 mm) in diameter or larger.

14.2.3.4 All metal surfaces of the gland and terminal enclosure adjacent to the cord shall be smooth and have rounded edges.

14.2.3.5 When a packing gland must be disassembled to replace the power-supply cord, instructions shall be provided for each device covering the intended assembly of the packing gland to the equipment. See 59.13.

14.2.4 Cord clamp

14.2.4.1 A positive mechanical cord clamp shall be provided so that the power-supply cord is capable of being readily replaced and strain is prevented at cord connections within the terminal enclosure when subjected to the Strain-Relief Test, Section 30. When the cord clamp is threaded to the terminal enclosure, it shall form a tight engagement or shall be secured against turning or loosening by means of a setscrew or the equivalent. The clamp shall be smooth and free from sharp edges that are capable of damaging the jacket of the flexible cord.

14.2.4.2 The cord clamp shall be in addition to the packing gland.

14.2.5 Bonding – Portable equipment

14.2.5.1 Except as indicated in 14.2.5.2, all dead metal parts of portable equipment shall be electrically bonded to the terminal for connection of the grounding conductor of the power-supply cord. See Electrical-Resistance Test, Section 28.

14.2.5.2 A dead metal part that does not become energized, such as a nameplate, is not required to be bonded when an investigation shows that after such a part has been electrostatically charged, the accumulation does not arc to a grounded probe.

14.2.5.3 A terminal for the connection of an equipment-grounding conductor shall have a permanent identification that is readily recognizable during installation and that is one of the following:

a) A terminal screw that is not readily removable and that has a green-colored head that is hexagonal, slotted, or both;

b) A hexagonal green-colored nut that is not readily removable from a threaded terminal stud;

c) A visible pressure terminal connector that has a green-colored body or appendage that is not readily removable from the connector;

d) A concealed pressure terminal connector identified in accordance with 14.2.5.4; or

e) The letter or word "G," "GR," "GRD," "GND," "Ground," "Grounding," "Green", or by the symbol in Figure 14.2, distinctively marked immediately adjacent to the terminal at least 1/16 inch (1.6 mm) high.

14.2.5.4 When a pressure terminal connector at the equipment-grounding terminal is located within an insulating body and is not visible, the wire-entrance hole for a connection to that terminal shall be identified by one of the following:

a) A distinct green-colored area immediately adjacent to the wire-entrance hole; or

b) The letter or word, "G," "GR," "GRD," "GND," "Ground," "Grounding," "Green", or by the symbol in Figure 14.2, distinctively marked immediately adjacent to the wire-entrance hole at least 1/16 inch (1.6 mm) high.

14.2.5.5 A readily removable (not staked or otherwise held captive) part of an equipment-grounding terminal, such as a setscrew or a clamping member, shall not be colored green or otherwise identified as part of the grounding terminal when the part is capable of being interchanged with a similar part of another terminal on the device.

14.2.5.6 When provided, the grounding member of the attachment plug and the grounding conductor of the power-supply cord and dead metal parts of portable equipment required to be bonded in accordance with 14.2.5.1 shall be electrically connected as determined by test.

14.2.5.7 External bonding terminals, where provided, shall comply with 14.14.2.

14.2.5.8 When the terminal for the equipment grounding conductor is readily removable, the area adjacent to the terminal shall be marked in accordance with 14.2.5.4.

15 Protection Against Corrosion

15.1 All enclosures of ferrous-metal other than stainless steel shall comply with the applicable requirements for indoor corrosion protection as is found in UL 50E, except at joint surfaces and conduit threads. Joint surfaces and conduit threads are not prohibited from being electroplated.

15.2 Brass, copper, or lead alloy (terne) coatings do not meet the intent of the requirement for coating ferrous-metal parts as protection against corrosion.

15.3 Enclosures made of the following materials are usable for indoor locations without additional corrosion protection:

a) Copper, aluminum, or stainless steel;

b) Bronze or brass containing no less than 80 % copper; and

c) Non-metallic materials.

15.4 For enclosures with dissimilar metals, the effects of galvanic action shall be evaluated.

15.5 Fasteners, or any other part serving to complete or maintain the integrity of the explosionproof enclosure, shall be resistant to corrosion and shall comply with the same requirements as the enclosure.

15.6 Except for flamepaths, both the inside and the outside surfaces of an explosionproof enclosure made of ferrous-metal other than stainless steel shall be protected against corrosion by plating, galvanizing, or painting, or other equivalent means. Enclosures constructed from other metals shall be permitted to be similarly protected.

15.7 A zinc coating on an exterior surface shall have an average thickness not less than 0.0005 inch (0.013 mm) and a minimum thickness not less than 0.0004 inch (0.0102 mm). A zinc coating on an interior surface shall have an average thickness not less than 0.00015 inch (0.0038 mm) and a minimum thickness not less than 0.0001 inch (0.0025 mm).

Exception No. 1: The thickness on interior surfaces not able to be contacted by a 0.75 inch (19.1 mm) diameter ball is not evaluated and the presence of a coating is to be determined by visual inspection.

Exception No. 2: For the surfaces of cast-iron or malleable-iron enclosure materials, the thickness is not evaluated and the presence of a coating is to be determined by visual inspection.

Exception No. 3: Threaded surfaces of tapped holes are not required to be coated.

15.8 Ferrous flamepath surfaces shall be protected against deterioration from corrosion by coating with a corrosion inhibiting material as specified in Section 16, Materials Applied to Joint Surfaces, or by electroplating. The metal plating thickness shall not exceed 0.0003 inches (0.008 mm).

15.9 Non-ferrous metallic flamepath surfaces are not prohibited from being coated as specified in Section 16, Materials Applied to Joint Surfaces, or electroplated. The metal plating thickness shall not exceed 0.0003 inches (0.008 mm). Aluminum flamepath surfaces that are corrosion protected by anodizing comply with the intent of this requirement.

16 Materials Applied to Joint Surfaces

16.1 A corrosion-inhibiting grease, such as petrolatum or soap-thickened mineral oils are usable on the metal joint surfaces before assembly.

16.2 The grease shall be of a type that does not:

a) Harden because of aging;

b) Contain an evaporating solvent; and

c) Cause corrosion of the joint surfaces.

16.3 A corrosion inhibiting, non-drying, thickened mineral oil-based sealant that does not contain metal particles shall be permitted to be applied to threaded joints.

16.4 Paint or a sealing material shall not be applied to the contacting surfaces of a joint.

Exception No. 1: This requirement does not apply to sealing material that is applied to the contacting surfaces of a joint that is not intended to be and is not required to be opened to install or service the equipment when the application of the material complies with the requirements in 10.3.1 and 21.22.

Exception No. 2: This requirement does not apply to metallic paint or other non-insulating coating that is applied to a threaded joint surface or a threaded conduit opening that, with the paint or coating applied:

a) Prevents the passage of flame, hot particles, or sparks capable of igniting the surrounding atmosphere during the explosion tests, see 21.11; and

b) Complies with the requirements in 28.2.1 – 28.2.3.

16.5 A sealing material applied to a joint surface in accordance with Exception No. 1 to 16.4 shall not increase the maximum clearance between the joint surfaces beyond the dimensions specified in this Standard.

16.6 When a sealing material is applied to a joint surface in accordance with the Exception No. 1 to 16.4, explosion tests are to be conducted both with and without the sealing material in place.

16.7 When a device is intended to be provided with a metallic paint or other non-insulating coating on a threaded joint surface or on a threaded conduit opening in accordance with Exception No. 2 to 16.4, the explosion tests are also to be conducted on a sample provided with such coating.

17 Devices Having Coated Threaded Joint Surfaces

17.1 The resistance of the grounding path at threaded joint surfaces on which a metallic paint or non-insulating coating has been applied shall not exceed 0.003 ohm.

17.2 A direct- or alternating-current of 50 amperes is to be passed between the two points, one on each of the two parts that comprise the joint, and the resulting drop in voltage potential is to be measured between these points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

18 Porosity in Enclosure Materials

18.1 Porosity not in a joint surface shall not be more than 3/32 inch (2.4 mm) wide and shall not be more than 1/16 inch (1.6 mm) deep. The minimum thickness of the wall from the bottom of a hole to the opposite surface shall not be less than 1/8 inch (3.2 mm), and shall not be affected by porosity holes.

18.2 Porosity in the joint surface greater than 1/64 inch (0.4 mm) wide shall be included in the measurement of the joint width. Holes in the joint surface shall not be more than 1/16 inch (1.6 mm) wide and shall not be more than 1/16 inch (1.6 mm) deep, and the specified minimum width of the joint, not including the holes, shall be provided.

19 Polymeric Enclosures

19.1 An enclosure made of a rigid polymeric material shall have mechanical strength and durability equivalent to a comparable metal enclosure. The enclosure shall be formed so that operating parts are protected against damage, and shall resist the abuses that are encountered during installation and normal use and service.

19.2 Explosionproof electrical enclosures made of rigid polymeric material shall comply with the requirements of Sections 8, 10 – 17, 20, 21, 22, 32, and 33.

19.3 Explosionproof electrical enclosures made of rigid polymeric material shall comply with the requirements in UL 50.

19.4 When a polymeric enclosure is utilized as an insulating material in connection with a live part, the polymeric material shall be rated for the intended use as an insulator. See UL 746C.

19.5 A polymeric enclosure shall be provided with means of maintaining continuity of the grounding system between grounded rigid metal conduit and dead metal parts within the enclosure that are capable of becoming energized, without relying on the dimensional stability of the polymeric material. An example of this means is a bonding jumper.

PERFORMANCE

20 Temperature Test

20.1 Under operating conditions, equipment shall not attain a temperature at any point on the exterior surface that exceeds:

a) 100 °C (212 °F); or

b) The maximum operating temperature or operating temperature class (T Code) marked on the equipment. See 59.3(i).

20.2 When the equipment is intended for use in an ambient temperature of 40 °C (104 °F) or less, the test is to be conducted at an ambient of 40 °C. When the equipment is for use in an ambient higher than 40 °C, the test is to be conducted at the higher ambient.

20.3 The operating temperature or operating temperature class shall be based on operation in an ambient as specified in 20.2. The temperature class, when provided, shall be in accordance with Table 59.1. For equipment intended and marked for use where Class I and Class II conditions exist simultaneously, the marked operating temperature or operating temperature class is to be based on the temperature attained during the test with dust blanket. See 44.10.

20.4 Temperatures are to be measured by thermocouples consisting of wires not larger than 24 AWG (0.21 mm^2) and not smaller than 30 AWG (0.05 mm^2).

20.5 Thermocouples are to be located at various points on the outside of the equipment enclosure.

20.6 A thermocouple junction and the adjacent thermocouple lead wires are to be securely held in thermal contact with the surface of the material, the temperature of which is being measured. Methods of obtaining adequate thermal contact include:

a) Drilling a small, bottomed hole in the metal, inserting the thermocouple junction and securing it in place by prick-punching the metal adjacent to the drilled hole; or

b) Placing the thermocouple junction against the surface being measured and securing it in position with a mixture of sodium silicate (water glass) and kaolin.

21 Explosion Tests

21.1 Equipment for use in Class I locations shall comply with the applicable requirements in Section 10, Joints in Enclosures, and 21.2 – 21.29.

Exception: This requirement does not apply to equipment for use in Class I locations that comply with the requirements in Annex A, Alternative Joints in Enclosures, and Annex B, Alternative Explosion Tests.

21.2 Equipment for use in Class I locations shall be subjected to a series of tests conducted in the presence of the specific gas- or vapor-air mixtures over the range of flammable or explosive concentration to determine:

a) The maximum explosion-pressure effects of the gas- or vapor-air mixtures over the test range specified in Table 21.3;

b) The maximum propagation effects of the gas- or vapor-air mixtures as specified in Table 21.3; and

c) That an electrical mechanism having contacts does not fail mechanically or electrically in the presence of explosive atmospheres when such tests are required. See 21.5 – 21.7.

21.3 During the explosion tests, the enclosure shall:

a) Prevent the passage of flame and sparks capable of igniting the surrounding atmosphere; and

b) Withstand the internal pressure from the explosions without bursting or loosening of the joints in the enclosure.

21.4 In addition to complying with the requirements in 21.2, 21.3, and 21.7, there shall be no mechanical damage to the electrical mechanism or mechanisms.

21.5 Except as indicated in 21.6, 21.7, and 21.10, tests are to be conducted under stalled-rotor-load conditions. Equipment that is not subject to stalled-rotor-load conditions is to be tested with the maximum electrical test load required for the electrical mechanism when used in ordinary locations.

21.6 Tests for Class I, Groups A or B equipment that is intended for connection to a circuit with a maximum available short circuit current of 10,000 rms symmetrical amperes are to be conducted using a spark plug to ignite the flammable mixture, and by using the arc of the contacts under stalled-rotor-load conditions. Equipment that is not subject to stalled-rotor-load conditions is to be tested with the maximum electrical test load required for the electrical mechanism when used in ordinary locations. For equipment employing a circuit breaker, tests are to be conducted under short-circuit conditions.

Exception: A snap switch not larger than 2 inch^2 (13 cm^2) on any side that is rated not more than 240 V, 20 A, 2 hp is usable in Class I, Group A or B locations without tests conducted using the arc of the contacts when:

a) The explosionproof enclosure has been found by test to be capable of use in such locations; and

b) The switch mechanism has been found by test to meet the requirements for ordinary locations for use at the corresponding rating.

21.7 For Class I, Group C or D locations, equipment intended for connection to a circuit with a maximum available short-circuit current of 10,000 rms symmetrical amperes is to be subjected to spark plug ignition tests with the intended electrical mechanisms in place. In addition, such equipment for Class I, Group C locations rated over 125 volts is to be subjected to explosion tests to determine that electrical mechanisms having contacts does not fail electrically when operated at maximum rated voltage and a load of nominally 10 amperes or rated current at maximum rated voltage, whichever is lower. The load characteristics are to be the same as the load characteristics required for ordinary-location use when the equipment is subjected to an endurance test. The application of an equivalent load is capable of being used to comply with this requirement.

Exception: A snap switch not larger than 2 inch^2 (13 cm^2) on any side that is rated not more than 240 V, 20 A, 2 hp is usable in Class I, Group C or D locations without tests conducted using the arc of the contacts when:

a) The explosionproof enclosure has been found by test to be capable of use in such locations; and

b) The switch mechanism has been found by test to meet the requirements for ordinary locations for use at the corresponding rating.

21.8 Equipment rated more than 200 horsepower (149.2 kW output) shall be evaluated for connection to a circuit with an available short-circuit current of more than 10,000 rms symmetrical amperes.

21.9 For equipment rated for connection to a circuit with an available short-circuit current of more than 10,000 rms symmetrical amperes, tests are to be conducted under short-circuit conditions. Tests are also to be conducted using a spark plug to ignite the flammable mixture.

21.10 For Class I, Groups A, B, C, or D locations, equipment having an internal fuse shall be subjected to explosion tests using a spark plug to ignite the flammable mixture, and by overload and short-circuit tests to determine the electrical and pressure effects resulting from rupture of the fuse.

Exception: Equipment using cartridge fuses filled with noncombustible granular material need not be subjected to overload and short circuit tests in the presence of explosive atmospheres if the product is marked in accordance with the requirements of 59.25.

21.11 When equipment is intended to be provided with a metallic paint or other non-insulating coating on a threaded joint surface or on a threaded conduit opening, the explosion tests are also to be conducted on a sample provided with such coating. See Exception No. 2(a) to 16.4.

21.12 For the explosion tests, the enclosure is to be installed in a test chamber that has inlet and outlet connections to the lines carrying the explosive mixture. The enclosure subjected to tests is to be tapped with threaded holes for connection to the inlet or outlet lines carrying the explosive mixture, attachment of explosion pressure-recording devices, and spark plugs for ignition. The explosive mixture is to be prepared by auxiliary equipment capable of maintaining predetermined concentrations of the mixture.

21.13 When lengths of conduit are required to be connected to the equipment for the explosion tests (see 21.17, the conduit is to be used for inlet or outlet connection to the line carrying the explosive mixture. A spark plug is to be located in the conduit length a maximum of 4 inches (10.2 cm) from the outer end.

21.14 The explosive mixture is to be allowed to flow into the enclosure being subjected to explosion tests and into the test chamber until all of the original air has been displaced. The mixture within the enclosure being subjected to tests is then to be ignited either by arcs produced by operation of the electrical mechanism or by a spark plug.

21.15 A series of at least ten tests is to be conducted on each device over the flammable range shown in Table 21.3. Because of the wide range of flammability for hydrogen 15 or more tests is to be conducted in order to cover the flammable range and determine the maximum explosion pressure. An enclosure having a venting section is to be subjected to an additional series of ten explosion tests with 75 % of the venting area sealed.

21.16 Electronic waveforms recorded from pressure sensing devices are to be smoothed using either a 2-kilohertz filter or a computer simulation of a 2-kilohertz filter.

21.17 Equipment is to be tested with lengths of conduit as specified in Table 21.1 when:

a) It has no current-interrupting contacts, or all current-interrupting contacts hermetically sealed (see 21.27) against the entrance of gases or vapors or immersed in oil; and

b) It is intended for connection to 1-1/2 inch (48.3 mm OD) and smaller trade sizes of conduit.

Exception: Equipment intended to have sealing fittings attached is not required to be tested with lengths of conduit when it is marked in accordance with 59.17.

Table 21.1
Lengths of Rigid Metal Conduit for Explosion Tests

Class I hazardous location Groups	Trade size of conduit inch (mm OD)	Conduit length
A, B, C	Less than 2 (60.3)	5, 10, and 15 feet (1.5, 3.0, and 4.6 m)
D	Less than 2 (60.3)	2 feet (0.6 m)

21.18 With reference to 21.17, a hermetically sealed construction is one in which the seal is made by fusion such as soldering, welding, or brazing, or the fusion of glass to metal.

21.19 Equipment having a factory-installed conduit seal is to be subjected to explosion tests on each side of the seal. Lengths of conduit, as specified in Table 21.2, are to be connected to the conduit side of the seal.

Exception: Explosion tests on the conduit side of the seal are not required when the equipment is subjected to the hydrostatic pressure test required by the Exception to 22.2.

Table 21.2
Lengths of Rigid Metal Conduit for Explosion Tests on Conduit Seals

Class I hazardous location Groups	Trade size of conduit, inch (mm OD)	Conduit length
A, B, C	All	5, 10, and 15 feet (1.5, 3.0, and 4.6 m)
D	Less than 2 (60.3)	2 feet (0.6 m)
D	2 (60.3) or over	5, 10, and 15 feet (1.5, 3.0, and 4.6 m)

21.20 Gaskets that are provided in addition to the required joints are to be removed for the explosion tests.

21.21 Potting compound, except as used for factory-installed lead wire seals, coil encapsulation, or coil insulation, is to be removed for the explosion tests.

21.22 When a sealing material is applied to a joint surface in accordance with Exception No. 1 to 16.4, the explosion tests are to be conducted both with and without the sealing material in place.

21.23 Equipment for Class I, Group A or B locations, or both, that has flat or rabbet type joints is to be tested with the joints reduced to 75 % of the minimum production joint width and the joints shimmed to give a clearance of 50 % more than the maximum production clearance.

21.24 Equipment for Class I, Group A or B locations, or both, that has threaded joints, serrated joints, or both is to be tested with an engagement of 75 % of the total number of engaging threads or engaging serrations to be used. The lateral clearance at the threaded or serrated joints is to be the maximum obtainable in production equipment, including maximum manufacturing tolerances.

21.25 Equipment for Class I, Group A or B locations, or both, that has a free internal volume greater than 30 cubic inches (0.5 dm^3) and has a shaft passing through the enclosure is to be tested with the metal-to-metal shaft path reduced to 75 % of the total path length.

21.26 Equipment with a labyrinth joint is to be tested with the joint reduced to 75 % of the total joint width and the joint clearance increased by 50 %.

21.27 A threaded polymeric-to-polymeric joint is to be tested with a thread engagement of 75 % of the minimum number of intended engaging threads.

21.28 The explosive mixtures to be used in the explosion tests are as specified in Table 21.3.

Table 21.3
Explosive Mixtures for Explosion Test

Class I hazardous location Group	Material	Flammable range, percent by volume
A	Acetylene	5.0 – 20.0
B	Hydrogen	15.0 – 35.0
C	Ethylene	4.0 – 9.0
D	Propane	3.0 – 7.0

21.29 For explosionproof equipment specified and marked for use at ambient temperatures lower than minus 25 °C (minus 13 °F), the explosion tests shall be determined by one of the following methods:

a) For explosionproof equipment specified and marked for use at ambient temperatures lower than minus 25 °C (minus 13 °F), the explosion tests shall be performed at the minimum ambient specified, ±5 °C (±9 °F). When the ambient specified is such that common materials within the Group are not flammable, a test temperature shall be specified that represents the minimum temperature at which the test gasses shown in Table 21.3 remain gasses, or

b) For equipment for use in Group C or D classified locations, rated not less than minus 60 °C (minus 76 °F), not subject to pressure piling, and determined to comply with the flame propagation requirements in 21.3(b), the equipment shall alternatively be subjected to the hydrostatic pressure test using the test factors for low ambient rated equipment found in Table 22.1, based upon room ambient explosion pressure tests, or

c) The reference pressure shall be determined at room ambient temperature (T_a) using the defined test mixture(s), but at increased pressure. The absolute pressure of the test mixture (P) shall be calculated by the following formula, using T_a in °C:

$$P = 100\left[\frac{293}{(T_a,\ \text{min} + 273)}\right]\ (kPa)$$

or

$$P = 14.6959\left[\frac{293}{(T_a,\ \text{min} + 273)}\right]\ (psi)$$

21.30 For explosionproof equipment specified and marked for use at ambient temperatures greater than 60 °C (140 °F), flame propagation tests shall be conducted under one of the following conditions:

a) At a temperature not less than the specified maximum ambient temperature; or

b) At normal ambient temperature using the defined test mixture at increased pressure according to the factors in Table 21.4; or

c) At normal atmospheric pressure and temperature, but with the test gap increased by the factors noted in Table 21.4.

These tests are in addition to the explosion tests required to determine compliance with 21.2 and 21.3(a).

21.31 All test sample joints are to be based upon the manufacturers maximum specified gap, and tested with not greater than 115 % of the minimum specified joint length. Specially prepared test samples having modified joint lengths, gaps and engagements shall be employed. For Groups A, B, or A and B, test factors per 21.23 and 21.26 are also required to be introduced into the test pressure or test gap in addition to the test factors above by multiplying the test factor of 21.23 or 21.26, as applicable, by the test factor of Table 21.4.

Table 21.4
Test Factors to Increase Pressure or Joint Test Gap

Temperature up to °C	Groups A & B 27.5% H_2 7.5% C_2H_2	Group C 37% H_2	Group D 55% H_2	Minimum number of tests[1]
60	1.00	1.00	1.00	5
70	1.11	1.04	1.05	5
80	1.13	1.05	1.06	5
90	1.15	1.06	1.07	5
100	1.16	1.06	1.08	5
110	1.18	1.07	1.09	5
120	1.20	1.08	1.10	5
130	1.22	1.09	1.11	5

[1] The tests are carried out five times with each test mixture. For equipment intended for Group B, only the test with the hydrogen-air mixtures is required.

21.32 A polymeric enclosure or a polymeric enclosure part that forms a portion of an explosionproof joint shall be subjected to the following series of explosion tests:

a) At least 100 tests on an enclosure with joints as described in 21.23 – 21.27, as applicable.

b) At least ten tests conducted at the minimum ambient temperature if less than minus 25 °C (minus 13 °F).

c) At least ten tests on an enclosure that has been subjected to 33.3.3.

d) At least ten tests on selected enclosures that have been subjected to the Chemical compatibility by complete end product tests, 33.3.

e) For a device intended for outdoor use, at least ten tests on an enclosure that has been subjected to the Resistance to Ultraviolet Light and Water Tests in UL 746C.

21.33 A device as specified in 11.2.4 and 11.3.1.6 shall be:

a) Tested with the diametrical clearance of the shaft path increased by 50 % if the device is intended for use in Class I, Group A or B locations; and

b) Subjected to five explosion tests in addition to those specified elsewhere in this section using the explosive mixture specified in Table 21.5.

Table 21.5
Explosive Test Mixture for Additional Tests on Enclosure With Free Internal Volume of 6.1 cubic inches (100 cm^3) or Less

Enclosure for Class I hazardous location Group	Explosive test mixture
A	Acetylene, 7.5 ±1 %
B	Hydrogen, 27 ±1 %
C	Hydrogen, 37 ±1 %
D	Hydrogen, 55 ±1 %

22 Hydrostatic Pressure Test

22.1 An electrical enclosure shall withstand for 10 seconds, without rupture or permanent distortion, a hydrostatic test pressure based on the maximum internal explosion pressure developed during the explosion tests. The safety factor applied shall be as given in Table 22.1.

Exception No. 1: The hydrostatic pressure test is not required to be performed when material strength calculations indicate a factor of safety based on the maximum internal explosion pressure. The safety factor shall be as specified in Table 22.1.

Exception No. 2: When the production-line hydrostatic pressure test specified in Section 58, Hydrostatic Pressure Test, is conducted, the pressure for the hydrostatic test is not required to exceed:

a) 2.25 times the maximum internal explosion pressure, and more than 345 kPa (50 psig) when the maximum pressure rise takes place in more than 5 milliseconds; or

b) 3 times the maximum internal explosion pressure, and more than 345 kPa (50 psig), when the maximum pressure rise takes place in less than 5 milliseconds.

Table 22.1
Safety Factors for Determining the Strength of an Enclosure

Enclosure material or part	Test factor for hydrostatic pressure test for ambient to –25 °C[d]	Test factor for hydrostatic pressure test for ambient to °C[a]			Test factor for calculations to –25 °C
		–40 °C	–50 °C	–60 °C	
Cast metal	4	6	6	6.5	5
Non-metallic other than glass	4	c	c	c	4
Glass	4	6	6	6.5	c
Fabricated steel and aluminum	3[b]	4.5	4.5	4.8	4
Cover bolts or screws	3	4	4.5	4.8	3

[a] For equipment in accordance with 21.29(b), where the equipment is not subject to pressure piling.

[b] The enclosure shall withstand a hydrostatic pressure of at least twice the maximum internal explosion pressure without permanent distortion and at least three times the maximum internal explosion pressure without rupture.

[c] Undefined.

[d] Applies to equipment tested in accordance with 21.29 (a) and (c).

22.2 A conduit seal in factory-sealed equipment shall withstand for 10 seconds, without rupture or permanent distortion, a hydrostatic test pressure of four times the maximum explosion pressure obtained on each side of the seal. When excessive leakage results in the inability of the test apparatus to maintain

the required pressure in a test of a seal for 2.0 inch (60.3 mm OD) or larger trade-size conduit with wires sealed in place, equipment with a seal but without wires is to be used.

Exception: Equipment having a factory-installed conduit seal that is not subjected to explosion tests on the conduit side of the seal as described in the Exception to 21.19 shall withstand without rupture or permanent distortion the applicable hydrostatic test pressure specified in Table 22.2.

Table 22.2
Hydrostatic Pressures for Factory-Installed Conduit Seals

Conduit trade size		Required hydrostatic pressure for Class I hazardous locations psig (MPa)			
inches	(mm OD)	Group A	Group B	Group C	Group D
1/2 – 2	(21.3 – 60.3)	6000 (41.4)	6000 (41.4)	1200 (8.3)	600 (4.1)
2-1/2 – 6	(73.0 – 177.8)	4000 (27.6)	4000 (27.6)	1200 (8.3)	600 (4.1)

22.3 The hydrostatic test pressure for an enclosure with a venting section is to be based on the maximum explosion pressure obtained with 75 % of the vented section sealed.

22.4 The hydrostatic pressure is to be applied at a rate of 100 – 600 psig (690 – 4137 kPa) per minute until the required internal pressure is reached. Gaskets or other means are not prohibited from being used to prevent leakage of water during application of pressure.

23 Dynamic Pressure Test

23.1 For explosionproof enclosures not subject to pressure piling and intended for routine testing during production, the Dynamic Pressure Test shall be permitted as an alternative to the Hydrostatic Pressure Test, Section 22. The dynamic tests shall be carried out in such a way that the maximum pressure to which the enclosure is subjected is 1,5 times the reference pressure.

23.2 The test shall be made once except for Group A or Group B, in which case the test shall be made three times with each gas mixture as follows:

– Group D: 4,6 ± 0,3 % propane

– Group C: 8 ± 0,5 % ethylene

– Group B: 31 ± 1 % hydrogen

– Group A: 14 ± 1 % acetylene

23.3 Following the test, there shall be no permanent deformation or damage and joints shall not be permanently enlarged.

24 Leakage Test on Factory-Installed Conduit Seals

24.1 A factory-installed conduit seal shall not provide for the passage of more than 0.007 cubic foot (0.20 dm^3) of air per hour at a pressure of 6 inches (152 mm) of water.

24.2 The test is to be conducted with wires sealed in place, using the maximum number and size of wires and wire insulation for which the seal is intended.

25 Tests for Glass Parts

25.1 Thermal-shock test

25.1.1 A glass part of an enclosure shall withstand, without cracking or breaking, the application of a cloth saturated with 10 °C (50 °F) water when the equipment reaches equilibrium temperatures at rated load in a 40 °C (104 °F) ambient, or at rated load at rated ambient if the rated ambient temperature is greater than 40 °C (104 °F).

25.1.2 Empty enclosures shall be tested as described in 25.1.1 with the glass at the maximum rated ambient temperature or at the maximum rated window surface temperature specified in the instructions provided with the enclosure, whichever is higher.

25.1.3 The test is to be performed five times and in each case the equipment is to reach thermal equilibrium before applying the wet cloth. The quantity of water involved must wet the surface completely.

25.2 Impact test

25.2.1 An inspection window shall withstand without cracking or breaking, the impact of a 4 pound (1.8 kg) weight falling through a distance of 6 inches (152 mm), (2.8 J). The weight is to have a hardened, spherical, steel surface, 1 inch (25.4 mm) in diameter. When a guard is provided to protect the window, the test shall be conducted both with and without the guard in place.

26 Secureness Test on Supply Connection Hubs

26.1 A conduit hub not integrally cast with a metal enclosure shall withstand the specified torque applied to a short length of threaded rigid metal conduit threaded into the hub of the enclosure in the intended manner, without turning in the enclosure and without stripping of any threads. The applied torque is specified in Table 26.1.

Table 26.1
Torque Requirements for Conduit Hubs

Conduit hub size		Applied torque	
inch	(mm OD)	pound·inches	(N·m)
1/2	(21.3)	800	(90)
3/4	(26.7)	800	(90)
1	(33.4)	1000	(113)
1-1/4	(42.2)	1000	(113)
1-1/2	(48.3)	1000	(113)
> 2	(> 60.3)	1600	(181)

27 Tests on Joint Gaskets

27.1 A gasket in a metal-to-glass joint shall be subjected to tests to determine the effects of solvent vapors, heat, aging, compression, distortion under conditions of use, and cold flow or creep when the gasket is of the elastomeric or thermoplastic type.

27.2 The means of securing the gasket to the cover or enclosure, the gasket construction, and the gasket material are to be investigated in determining the tests to be conducted.

28 Electrical-Resistance Test

28.1 Grounding-continuity of cord-connected equipment

28.1.1 The resistance of the grounding path between the terminal for connection of the grounding conductor of the power-supply cord and dead metal parts of portable equipment required to be bonded in accordance with 14.2.5.2 shall not exceed 0.1 ohm.

28.1.2 The resistance is to be determined by any convenient method except when results that do not comply with the requirement are recorded. Then either a direct- or alternating-current of 15 amperes is to be passed from the grounding terminal to each dead metal part required to be bonded in accordance with 14.2.5.1, and the resulting drop in potential is to be measured between these two points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

28.2 Equipment having coated threaded joint surfaces or conduit openings

28.2.1 The resistance of the grounding path at threaded joint surfaces or a threaded conduit opening on which a metallic paint or non-insulating coating has been applied shall not exceed 0.003 ohm.

28.2.2 A direct or alternating current of 50 amperes is to be passed between the two points specified in 28.2.3, and the resulting drop in potential is to be measured between these points. The resistance in ohms is to be determined by dividing the drop in potential in volts by the current in amperes passing between the two points.

28.2.3 For threaded joint surfaces, the voltage drop is to be measured between two points, one on each of the two parts of the equipment that comprise the joint. For a conduit opening, the voltage drop is to be measured between two points, one on the equipment adjacent to the opening and the other on a length of conduit connected to the opening, and located 1/16 inch (1.6 mm) from the equipment.

29 Accelerated Aging Test on Bushings

29.1 A molded-rubber or -neoprene bushing provided at the cord entrance to the terminal enclosure of portable equipment shall be exposed in an air oven for 70 hours at 100 °C ±2 °C (212 °F ±3.6 °F). See UL 157, for oven aging conditions for service temperatures exceeding 60 °C (140 °F). The bushing shall not have a change in hardness of more than ten numbers.

29.2 The complete molded-rubber or -neoprene bushing or representative material specimen is permitted to be tested. The hardness of the rubber or neoprene is to be determined as the average of five readings with a gauge such as a Rex hardness gauge or Shore durometer. The bushing is then to be exposed in an air oven for 70 hours at 100 °C ±2 °C (212 °F ±3.6 °F).

29.3 The bushing or specimen is to be removed from the oven and then cooled at room temperature for at least 4 hours. The hardness is to be determined again as the average of five readings. The difference between the original average hardness reading and the average reading taken after exposure in an air oven is the change in hardness.

30 Strain-Relief Test

30.1 Portable equipment is to be subjected to the strain-relief test described in 30.2 and 30.3. As a result of the test, there is to be no:

a) Displacement of more than 3/32 inch (2.4 mm) of the conductors, conductor insulation, or outer jacket of the flexible cord;

b) Damage to the cord insulation, such as a cut, rip, or tear; or

c) Damage to the equipment that results in non-compliance with the requirements in this standard.

30.2 The equipment is to be tested with each size of each type flexible cord marked on the equipment in accordance with 59.12. See 14.2.1.2. The cord is to be cut cleanly at a right angle to its major axis and installed in the equipment so that the end of the jacket is positioned as intended for the conductors to be connected to the terminals. However, there is to be no stripping of insulation and no connection to terminals. The flush position of conductor, insulation, fillers, and jacket is intended to provide an indicating means of cord displacement after the application of the test force.

30.3 The equipment is to be mounted in a fixed position and a direct pull is to be applied for 1 minute between the cord and the equipment. The force applied is to be 150 pounds (667 N) for equipment rated 30 amperes or less and 300 pounds (1334 N) for equipment rated more than 30 amperes.

31 Rough-Usage Test

31.1 Portable equipment not provided with a base or stand shall be subjected to a rough-usage test. The equipment, the terminal enclosure, and the cord clamp shall not be impaired nor shall threaded engagements be loosened.

31.2 The equipment is to be suspended in a vertical position, with cord clamp up, by means of flexible cord installed as intended. At a point 3 feet (0.91 m) from the cord clamp, the flexible cord is to be fastened to a screweye secured to a solidly mounted vertical board, 2 inches (50.8 mm) thick. The free end of the equipment is to be pulled away from the board and then caused to swing back against the board (or against a wooden block secured to the board) for 9000 times at a rate of approximately 50 times per minute. The horizontal swing distance is to be approximately 6 inches (152 mm).

31.3 Following the test, the equipment shall withstand for 1 minute, without breakdown, the application of a 60-hertz essentially sinusoidal potential of 1000 volts plus twice maximum rated voltage. The potential is to be applied between live parts and dead metal parts of the equipment.

32 Drop Test

32.1 Portable equipment shall be subjected to a drop test in which the equipment is dropped to a concrete floor ten times from a height of 3 feet (0.91 m). There shall be no loosening of the assembly or damage to parts.

32.2 For the first five drops, the equipment is to fall freely to replicate the effect of the equipment falling from a horizontal surface to the floor. In the remaining five drops, the equipment is to be held at various angles 3 feet (0.91 m) above the concrete floor and dropped.

33 Non-Metallic Enclosure Materials Tests

33.1 General

33.1.1 Non-metallic materials shall comply with the requirements in either 33.2 or 33.3, and shall comply with the requirements in 33.4.

33.1.2 Non-metallic electrical enclosures shall comply with the requirements in UL 50, Polymeric Enclosures/Parts, Polymeric Enclosure Rigid Metallic Conduit Connection Tests, and Polymeric Enclosure Bonding Test.

33.2 Chemical compatibility by material samples

33.2.1 Samples with like dimensions are to be prepared according to the requirements in ASTM D256, and \ASTM D790.

33.2.2 The values for the following physical properties are to be determined using as-received specimens and specimens that have been subjected to chemical exposure:

a) Resistance to impact in accordance with ASTM D256;

b) Flexural properties in accordance with ASTM D790; and

c) Changes in weight and dimensions.

33.2.3 For each of the following test chemicals, a set of three sets of 5 samples [5 specimens each for 33.2.2 (a) – (c)] shall be exposed to a 100 % saturated vapor in air of the chemical at 20 °C – 25 °C (68 °F – 77 °F) for a period of 7 days:

a) Acetic Acid (Glacial);

b) Acetone;

c) Ammonium Hydroxide (20 % by weight);

d) ASTM reference fuel C;

e) Diethyl Ether;

f) Ethyl Acetate;

g) Ethylene Dichloride;

h) Furfural;

i) n-Hexane;

j) Methyl Ethyl Ketone;

k) Methanol;

l) 2-Nitropropane; and

m) Toluene.

Exception: The manufacturer is not prohibited from marking specific chemical atmospheres in which the product is to be used and test for those chemical exposures only.

33.2.4 The physical property values after chemical exposure shall not be less than 85 % of the values determined using as-received samples for 33.2.2 (a) and (b).

Exception: A material that has values less than 85 % and not less than 50 % of the as-received values meets the intent of this requirement when it complies with the explosion and hydrostatic tests conducted on the complete sample subjected to the chemical exposure.

33.2.5 With regard to 33.2.2(c), shrinkage or weight loss shall not exceed 1 %.

Exception: A material whose shrinkage or weight loss exceeds 1 % of the as-received values meets the intent of this requirement when it complies with the explosion and hydrostatic tests conducted on the complete sample subjected to the chemical exposure.

33.2.6 A set of three complete enclosure samples shall be subjected to the following tests:

a) Accelerated aging as specified in 33.3.3; and

b) Flamepath erosion test as specified in 33.3.5.

33.3 Chemical compatibility by complete end product tests

33.3.1 Sixteen (16) complete samples are to be tested as specified in 33.3.2 – 33.4.3.5.

33.3.2 For each of the following test chemicals, one enclosure shall be exposed to a 100 % saturated vapor in air of the chemical at 20 °C – 25 °C (68 °F – 77 °F) for a period of 7 days:

a) Acetic Acid (Glacial);

b) Acetone;

c) Ammonium Hydroxide (20 % by weight);

d) ASTM reference fuel C;

e) Diethyl Ether;

f) Ethyl Acetate;

g) Ethylene Dichloride;

h) Furfural;

i) n-Hexane;

j) Methyl Ethyl Ketone;

k) Methanol;

l) 2-Nitropropane; and

m) Toluene.

Exception: The manufacturer is not prohibited from having an enclosure evaluated, and marked only for specific chemical atmospheres for which the product is intended.

33.3.3 Three separate enclosure samples are to be conditioned in an oven at a temperature (T_2) and for a length of time (D) determined in accordance with the following:

$$D = \frac{18262.5}{2^{(\Delta T/10)}}$$

$$T_2 = T_1 + 10\left(\frac{In\frac{18262.5}{D}}{IN2}\right)$$

in which:

D is the test time in days;

T_1 is the maximum temperature in °C obtained on the enclosure in a temperature test under normal operating conditions;

T_2 is the test oven temperature in °C;

ΔT is T_2 minus T_1.

Hygroscopic materials (most notably nylons) are not prohibited from being rehydrated in an ambient of 50 ±10 % Relative Humidity, 23 ±3 °C (73 ±5.5 °F) for 48 hours prior to materials testing. Either the test time in days (*D*) or the test temperature (T_2) is to be selected by the manufacturer based upon the aging properties of the material. The number of days (*D*) selected shall not be less than 30.

Exception: Aging less than 30 days, for polymers with known aging behavior (such as having an assigned Relative Temperature Index, RTI), meets the intent of this requirement. However, no test temperature shall be greater than 50 °C (122 °F) above the maximum temperature used to establish the RTI.

33.3.4 The three samples subjected to the accelerated aging test of 33.3.3 and each of the samples subjected to the solvent vapor exposure tests shall be individually subjected to the Hydrostatic Pressure Test, Section 22, based on the test pressure obtained during the explosion pressure tests conducted as described in Explosion Tests, Section 21.

33.3.5 Samples subjected to the solvent vapor exposure test of 33.3.2 or accelerated aging test of 33.3.3, shall exhibit no visual erosion of any flamepath when subjected to 100 additional flame propagation tests using the test method from Explosion Tests, Section 21.

33.4 Test for accumulation of static electricity

33.4.1 General

33.4.1.1 A nonmetallic external part with an area greater than 15.5 inch^2 (100 cm^2) shall comply with either the requirements in 33.4.2 or 33.4.3.

33.4.2 Method A

33.4.2.1 Any non-metallic surface with area greater than 15.5 inch^2 (100 cm^2) shall have a surface resistivity of 1 GΩ or less at 23 °C (73 °F) and 50 % relative humidity as defined by the material specifications or as determined by the test in 33.4.2.2.

33.4.2.2 The resistance is to be tested on the enclosure or on parts of the enclosure. Two parallel electrodes 0.04 inch (1 mm) in width, 4 inches (100 mm) in length, 0.4 inch (10 mm) apart are to be centered on a 6 by 2.4 inch (150 mm by 60 mm) sample. The sample is to be cleaned with distilled water, then with isopropyl alcohol, then once more with distilled water before being dried. Untouched by bare hands, it is to be conditioned for 24 hours at 23 °C (73 °F) and 50 % relative humidity. The test is to be carried out under the same conditions. A direct voltage of 500 ±10 Vdc is to be applied for one minute. The resistance is the quotient of the direct voltage applied at the electrodes to the total current flowing between them when the direct voltage has been applied for one minute.

33.4.3 Method B

33.4.3.1 A nonmetallic external part with an area greater than 15.5 inch^2 (100 cm^2) shall be subjected to the test specified in 33.4.3.2 – 33.4.3.5.

33.4.3.2 No sparks shall be observed when a grounded metal sphere is brought into gradual contact with the nonmetallic part, mounted as intended, after it has been electrostatically charged.

33.4.3.3 Three samples of the part are to be conditioned for at least 48 hours at a relative humidity of 25 ±10 %.

33.4.3.4 Immediately after removal from the low-humidity chamber, the samples are to be supported by means of insulators in a room having a relative humidity not more than 35 % and having all sources of light, other than electrical sparks, eliminated. An electrostatic charge is to be sprayed on non-conductive parts of the product using a Van de Graaf generator limited to 5000 volts.

33.4.3.5 A 3/8 inch (9.5 mm) diameter grounded metal sphere is to be brought into gradual contact with the non-conductive area of the sample.

34 Chemical Resistance Tests on Sealing and Cementing Compounds

34.1 A sealing material other than portland cement-based compounds and plaster-based materials which are used in Class I equipment shall be subjected to the tests described in 34.2 – 34.7 to determine its resistance to chemicals.

34.2 The resistance to crushing of the epoxy compound is to be determined on as-received specimens and specimens exposed to chemical vapors. The crushing force after exposure is to be at least 85 % of the value determined using as-received samples. In addition, changes in dimensions and weight after exposure are to be determined. Shrinkage or loss of weight of more than 1 % or an increase in weight or swelling that changes the intended properties of the sealing compound does not meet the intent of the requirement. See 34.8.

34.3 Cylindrical epoxy specimens 1/2 inch (12.7 mm) in diameter and 3/4 inch (19.1 mm) long are to be used for the tests. At least 81 specimens are required – six for each chemical and three for as-received tests. The samples shall be of uniform size and shape, having both ends perpendicular to the side of the cylinder.

34.4 The specimens are to be exposed for 168 hours (7 days) to saturated vapors in air of the chemicals specified in 33.2.3.

34.5 During and after the exposure, the specimens are to be observed for discoloration, swelling, crazing, cracking, leaching, or dissolving.

34.6 After the exposure, three specimens from each chemical exposure are to be weighed and measured immediately after removal from the chemical vapor.

34.7 The other three exposed specimens and the as-received specimens are to be placed between two parallel plates and crushed with a compression-testing machine having a crosshead speed of 0.1 inch (2.54 mm) per minute. The load is to be applied perpendicular to the axis of the cylindrical specimens and the compressive force required to crack and break the specimens is to be recorded.

34.8 As an alternative, tests to determine resistance of the epoxy compound to chemicals shall be conducted on a complete sample that incorporates the sealing compound as intended in the final

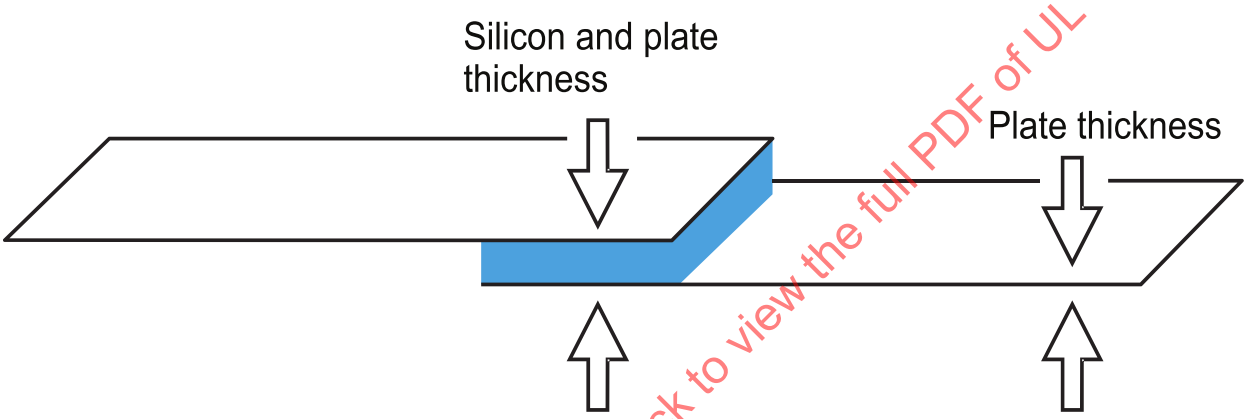
assembly, without cable or conductors. These tests are to consist of explosion and hydrostatic pressure tests in accordance with Section 21, Explosion Tests, and Section 22, Hydrostatic Pressure Test, on the complete sample after the sample has been exposed to the chemicals specified in 33.3.2. There shall be no flame propagation, rupture, cracking, breakage, or other damage to the sealing compound.

34.9 The adhesive bond strength of formed-in-place RTV silicone rubber is used as a measure of the retention of physical properties following conditioning. Shearing force is to be determined on as-received specimens and specimens exposed to chemical vapors. The shearing force after exposure is to be at least 50 % of the value determined using as-received samples.

34.10 At least 45 specimens are required – three for as-received tests three for each chemical and three for air-oven aging. The samples shall be in accordance with the form and dimensions of the test specimens that are specified in ASTM D 1002. See Figure 34.1.

Figure 34.1

RTV Silicone Rubber Lapshear Test Sample



su2145

34.11 Thirty-nine specimens (three specimens for each chemical) are to be exposed for 168 hours (7 days) to saturated vapors in air of the chemicals specified in 33.2.3.

34.12 Three specimens are to be placed in an air-oven for accelerated aging in accordance with the test method described in 41.3.3 through 41.3.5.

34.13 Following conditioning, each specimen is placed, in turn, in the grips of a tensile testing machine. The loading is applied to the specimen and continued to the shear point. The result is recorded for each specimen and the average value for each group of specimens is to be calculated. The average value for conditioned specimens shall not be less than 50 % of the average value for specimens as-received.

34.14 As an alternative, tests to determine resistance of the RTV silicone rubber to chemicals shall be permitted to be conducted on a complete sample that incorporates the sealing compound as intended in the final assembly. These tests are to consist of explosion and hydrostatic pressure tests in accordance with Section 21, Explosion Tests, and Section 22, Hydrostatic Pressure Test, on the complete sample after the sample has been exposed to the chemicals specified in 33.3.2. There shall be no flame propagation, rupture, cracking, breakage, or other damage to the sample.

PART II – DUST-IGNITIONPROOF EQUIPMENT

CONSTRUCTION

35 Enclosure

35.1 General

35.1.1 The enclosure shall prevent the entrance of dust. See Dust-Penetration Test, Section 43.

35.1.2 The enclosure construction shall comply with the requirements of 35.2 – 42.4 and the standards referenced in those sections.

35.1.3 The enclosure shall comply with the performance requirements of 43.1 – 56.3.

35.2 Material

35.2.1 The enclosure housing the electrical components, except those portions for viewing or light transmission, shall be made of iron, steel, copper, brass, bronze, or aluminum or aluminum alloys containing a minimum of 80 % aluminum, or shall be made of nonmetallic material which complies with the requirements in Section 45, Polymeric Enclosure Tests. A metal such as zinc or zinc alloy, or magnesium alloy shall not be used.

35.2.2 Dust-ignitionproof electrical enclosures made of a rigid polymeric material shall have mechanical strength and durability equivalent to a comparable metal enclosure. The enclosure shall be formed so that operating parts are protected against damage, and shall resist the abuses that are encountered during installation and normal use and service and shall not accumulate static electric charges. See UL 50 and the requirements of 33.4.

35.2.3 When a polymeric enclosure is utilized as an insulating material in connection with a live part, the polymeric material shall be rated for the intended use as an insulator. See UL 746C.

35.2.4 A polymeric enclosure shall be provided with means of maintaining continuity of the grounding system between grounded rigid metal conduit and dead metal parts within the enclosure that are capable of becoming energized, without relying on the dimensional stability of the polymeric material. An example of this means is a bonding jumper.

35.2.5 A part for viewing or light transmission shall be of glass or similar rigid material. Glass parts shall comply with Section 25, Tests for Glass Parts. A substitute for glass shall:

a) Withstand the maximum temperature of the equipment;

b) Have the required mechanical strength and stability; and

c) Comply with the requirements of Section 33, Non-Metallic Enclosure Materials Tests.

Polymeric materials for viewing or light transmission shall comply with Section 45, Polymeric Enclosure Tests.

35.3 Thickness

35.3.1 Except as indicated in 9.3 and 9.4, the minimum thickness of metal enclosure walls shall be as specified in Table 9.1.

35.3.2 The minimum thickness of polymeric enclosure walls shall be as specified for cast iron or aluminum in Table 9.1.

35.3.3 A machined or threaded joint in the walls of a cast-metal enclosure shall have at least the thickness specified in Table 9.1 through the overlap.

35.3.4 The minimum thickness of a viewing or light-transmission part is specified in Table 35.1.

Table 35.1
Thickness of Viewing or Light-Transmission Parts

Maximum length in any direction		Maximum exposed area		Minimum thickness	
inches	(mm)	$inch^2$	(cm^2)	inch	(mm)
4	(102)	16	(103)	0.125	(3.18)
12	(305)	144	(929)	0.187	(4.75)

36 Joints in Enclosures

36.1 The joints in the enclosure shall be of the metal-to-metal, metal-to-glass, metal-to-polymeric, polymeric-to-polymeric, or polymeric-to-glass type. The roughness of joint surfaces shall comply with the requirement in 10.1.2.

Exception: A glass part, such as a pilot light lens, is not prohibited from being sealed with a sealing compound that:

a) Is resistant to moisture and aging; and

b) Complies with the other test requirements in this Standard without loosening or cracking.

The length of compound seal shall not be less than the minimum length of joint required for an unsealed joint, or 5/8 inch (15.9 mm), whichever is less. The sealing compound shall not be relied upon for mechanical security of the joint.

36.2 A sealing material applied to a joint surface in accordance with Exception No. 2 to 42.4 shall not increase the maximum required clearance between the joint surfaces.

36.3 The width of the joint measured from the inside of the enclosure to the outside shall not be less than 3/16 inch (4.8 mm). The clearance at the joint shall not be more than 0.002 inch (0.05 mm) for a 3/16 inch wide joint and not more than 0.003 inch (0.08 mm) for a 1/4 inch (6.4 mm) wide joint. These specified widths shall be provided between the inside of the enclosure and the nearest edge of each bolt hole or other interruptions in the joint.

36.4 Threaded joints shall consist of at least three threads fully engaged. Screws shall not have more than 32 threads per inch (per 25.4 mm).

36.5 When a gasket is used in a joint, it shall be formed of polytetrafluoroethylene or a material having similar characteristics. The gasket shall not be made of plant-fiber sheet-packing material when the surface temperature to which the gasket is exposed exceeds 90 °C (194 °F). The gasket material shall be mechanically attached and protected from abuse. The width of gasket contact shall not be less than 3/16 inch (4.8 mm) at all points around the joint.

Exception No. 1: The gasket shall not be attached by an adhesive or cement unless aging tests on the construction show that the means of attachment does not deteriorate by compliance with thermal aging in 45.2.

Exception No. 2: A gasket that is secured in a joint not intended to be opened after the equipment is assembled is not required to be mechanically attached.

36.6 When a gasket of polytetrafluoroethylene or similar material is used, it shall be installed to reduce the risk of cold flow of the gasket material.

36.7 A material that upon aging either hardens or adheres to joint surfaces shall not be used as a gasket material.

37 Shaft Openings

37.1 A shaft opening in an enclosure shall be of the metal-to-metal type or metal-to-polymeric type. See 10.1.2 regarding the roughness of surfaces that form the shaft path.

37.2 Non-rotating shafts and shafts rotating at a speed of less than 100 rpm shall have a length of path of not less than 1/2 inch (12.7 mm). The maximum diametrical clearance between the shaft and shaft opening shall be:

a) 0.005 inch (0.13 mm) for a 1/2 inch (12.7 mm) length of path;

b) 0.008 inch (0.20 mm) for a 1 inch (25.4 mm) length of path; and

c) 0.011 inch (0.28 mm) for a 1-1/2 inch (38.1 mm) length of path.

Intermediate values are proportional.

Exception No. 1: An opening for a shaft that is centered in the opening by bearings or an equivalent construction that prevents contact between the shaft and the shaft opening is not required to comply with these requirements when it complies with the requirements in 37.3 – 37.5.

Exception No. 2: Equipment for use in Class II, Group F, Group G, or both locations, shall not have a longer path and greater clearances unless the construction complies with the Dust-Penetration Test, Section 43.

37.3 Shafts rotating at a speed of 100 rpm or more shall have a minimum length of path, as shown in segment 'B' in Figure 37.1, of 1/2 inch (12.7 mm). The maximum diametrical clearance between the shaft and shaft opening shall be:

a) 0.010 inch (0.25 mm) for a 1/2 inch (12.7 mm) length of path;

b) 0.016 inch (0.41 mm) for a 1 inch (25.4 mm) length of path; and

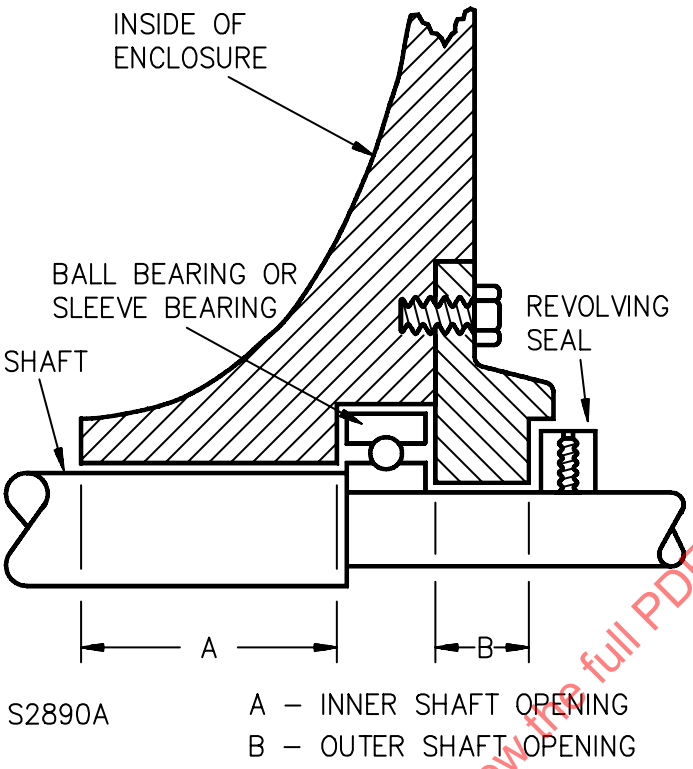
c) 0.022 inch (0.56 mm) for a 1-1/2 inch (38.1 mm) length of path.

Intermediate values are proportional. See Figure 37.1.

Exception: Equipment provided with an inner shaft opening (shown as segment 'A' in Figure 37.1 complying with the dimensions specified in 11.2.1 – 11.3.5.2 is not prohibited from having a shorter length of path and greater clearance at the outer shaft opening unless the construction complies with the Dust-Penetration Test, Section 43.

Figure 37.1

Shaft Openings



37.4 The dimensions of a shaft opening in an enclosure shall prevent the entry of dust into the bearings and the enclosure, as determined by visual examination following the Dust-Penetration Test, Section 43.

37.5 With reference to the requirement in 37.4, a revolving seal or slinger forming an additional labyrinth path at the shaft opening is not prohibited from being employed on equipment for use in Class II, Group E locations to prevent the entry of metal dust into the bearing. It shall be constructed of metal or of non-metallic material that has been determined to comply with the requirements for such material in this Standard.

37.6 When grooves are machined in the shaft path, the measurements shall be made overall without addition or subtraction of the grooves.

38 Holes in Enclosures

38.1 A hole in an enclosure for securing a mechanism shall be either:

a) Bottomed, and the thickness of the metal remaining shall comply with the minimum thickness requirements for the enclosure;

b) Closed by welding of the part in place; or

c) Secured by screws that engage at least three full threads and the screws are mechanically secured against removal. When a self-tapping screw is used, it shall have a minimum of three full threads engaged when seated. A screw shall have a maximum of 32 threads per inch (per 25.4 mm).

38.2 A metal pin or a part press-fitted through the wall of an enclosure shall engage for at least 3/16 inch (4.8 mm). Such a part shall be secured against removal by welding, peening, or the equivalent.

38.3 Unless attachment complies with the requirements in 38.1 or 38.2, holes in the enclosure for attachment of a nameplate shall be bottomed. The remaining thickness at the bottomed hole shall not be less than 1/16 inch (1.6 mm).

38.4 A tapped hole shall not be provided in a sintered-metal part employed as a venting section of an enclosure.

39 Drain and Breather Fittings in Enclosures

39.1 A drain fitting shall:

a) Drain a liquid from the enclosure without removal of any part of the fitting;

b) Be located or protected to prevent damage to the fitting; and

c) Be permanently attached to the enclosure.

Exception: A drain is not required to be permanently attached when it is installed in an opening intended for the attachment of conduit. See 40.1.1 – 40.1.12.

39.2 The metal-to-metal joint between a drain fitting and the enclosure shall comply with the requirements specified for joints in the enclosure.

39.3 A drain fitting shall prevent the entrance of dust to the inside of the enclosure. See Section 36, Joints in Enclosures.

39.4 A breather fitting shall comply with the applicable requirements in 39.1 – 39.3, and Section 43, Dust-Penetration Test.

40 Supply Connections

40.1 Fixed equipment

40.1.1 Equipment intended for permanent installation shall have provision for connection to threaded rigid metal conduit or other wiring methods in accordance with Article 502 in NFPA 70.

Exception: The opening is not required to comply with this requirement when instructions are provided in accordance with 59.21.

40.1.2 A conduit opening shall be provided with not less than 3-1/2 threads.

40.1.3 Each entry shall be provided with one of the following constructions:

a) A smooth and well-rounded integral conduit stop, having a throat or inner diameter as specified in Table 14.1;

b) A smooth and well-rounded inner end as shown in Figure 14.1; or

c) Threads not exceeding the maximum number specified in Table 14.2 for the conduit size, such that a conduit bushing is able to be installed on the end of the conduit after it is engaged with the entry threads.

Exception: The opening is not required to comply with this requirement when instructions are provided in accordance with 59.19.

40.1.4 Entries shall use a modified National Standard Pipe Taper (NPT) or National Standard Pipe Straight (NPS) thread. The pipe thread form shall comply with ASME B1.20.1. Entries shall not be smaller than trade size 1/2 nor larger than trade size 6 and shall provide for 3-1/2 full threads of engagement with a conduit or fitting gauging at L1-1 (1 turn large). NPT Threaded entries shall conform to ASME B1.20.1 except that entries shall gauge from flush to plus 3-1/2 turns beyond the L-1 gauging notch in lieu of the ±1 turns described in ASME B1.20.1.

40.1.5 Metric threaded entries shall comply with the requirements in 10.6. Means shall be provided to minimize abrasion to conductor insulation.

40.1.6 Metric threaded entries shall have a permanent marking near the supply connection opening in accordance with 59.22.

Exception: Equipment which uses a thread type other than NPT or NPS is not required to have the marking in 59.22 when it is provided with an adapter to NPT or NPS thread form. The adapter shall comply with the applicable construction and performance requirements Part VIII in this Standard.

40.1.7 When an integral conduit stop is provided, it shall be smooth and well-rounded, having a throat or inner diameter as specified in Table 14.1.

40.1.8 When an integral conduit stop is not provided in a conduit opening, the threads shall be tapered 3/4 inch per foot (62.5 mm/m).

40.1.9 All openings for connection to conduit, except those intended for installation, shall be furnished with metal plugs engaging not less than 3-1/2 full threads.

40.1.10 A supply connection hub not integrally cast with an enclosure shall:

a) Have a wall thickness before threading not less than that of the corresponding trade-size conduit;

b) Not depend upon friction alone to prevent it from turning; and

c) Comply with the Secureness Test on Supply Connection Hubs, Section 26.

40.1.11 Enclosures capable of being drilled and tapped in the field with supply connections shall have wall sections which are capable of accommodating the trade size openings that are added in the field. These enclosures shall be provided with field drilling and tapping instructions in accordance with 59.21.

40.1.12 A factory-installed conduit seal incorporated as part of the equipment shall:

a) Comply with the applicable requirements in 14.1.2.2, 14.1.2.3, and Section 24, Leakage Test on Factory-Installed Conduit Seals; and

b) Be marked in accordance with 59.16.

40.1.13 All wire leads, other than grounding leads, for connection of the equipment to the supply circuit shall not be less than 6 inches (152.4 mm) long.

40.1.14 A grounding lead, when provided, shall not be less than 6 inches (152.4 mm) long.

40.1.15 Grounding shall comply with the requirements in 14.1.4.1 – 14.1.4.3.

40.1.16 Male NPT threaded fittings shall gauge ±1 turn of the ring gauge from being flush with the end of the thread in accordance with ASME B1.20.1. Male NPT threaded fittings shall have a threaded length not less than the L4 dimension in accordance with ASME B1.20.1 from the end of the fitting to the face of a shoulder or to an interruption.

40.2 Cord-connected portable equipment

40.2.1 Cord-connected equipment shall comply with the requirements in 14.2.1.1 – 14.2.1.5 and 40.2.2 – 40.2.7.

40.2.2 Terminals that are intended to be connected by turning of a screw end, by a head (wire-binding screw), or by a nut in contact with strands of the cord conductor shall have a terminal enclosure that complies with the construction and performance requirements for dust-ignitionproof enclosures as given in Section 36, Joints in Enclosures, and Section 43, Dust-Penetration Test.

40.2.3 Metal or rigid polymeric parts of the terminal enclosure shall have a minimum thickness as specified in Table 9.1 and in 35.3.2.

40.2.4 When each terminal of a type that provides a spacing of at least 3/16 inch (4.8 mm) shortest distance between terminals, is insulated, and does not have a screw end, a head (wire-binding screw) or a nut in contact with strands of the cord conductor, the terminals shall be enclosed, and the dust-ignitionproof construction specified in 40.2.2 is not required to be provided. The entrance for the power-supply cord is not prohibited from being closed with a molded-rubber or neoprene bushing complying with the requirements in 29.1 and 29.2.

40.2.5 A packing gland (stuffing box) complying with the requirements in 14.2.3.2 – 14.2.3.5 shall be provided at the cord entrance to a terminal enclosure that is constructed in accordance with 40.2.2.

40.2.6 Cord-connected equipment shall be provided with a positive mechanical cord clamp complying with the requirements in 14.2.4.1 and 14.2.4.2.

40.2.7 Cord-connected equipment shall comply with the bonding requirements in 14.2.5.1 – 14.2.5.6.

41 Protection Against Corrosion

41.1 General

41.1.1 Corrosion protection shall comply with the requirements in 15.1, 15.2, and 41.1.2.

41.1.2 A joint surface, coated with a thin uniform baked enamel coating against which a gasket bears, and also intended to be opened during installation or normal use, shall comply with aging and compression tests. The results shall show that the enamel does not adhere to the gasket material and does not flake or peel off the joint surface.

41.1.3 The investigation is to include:

a) A review of information regarding properties of the gasket material;

b) A test to determine whether the gasket adheres to the joint surfaces after aging;

c) Determining whether compression set of the gasket (or alternative conditioning) adversely affects the integrity of the dusttight joint; and

d) An identification test for follow-up purposes.

41.2 Physical properties

41.2.1 Information relating to physical properties of the gasket material is to be reviewed to confirm that the material is suitable for use at the temperature to which it is subjected in service.

41.3 Accelerated air-oven aging test

41.3.1 The accelerated air-oven aging is intended to determine whether a gasket material transfers or adheres to the joint surfaces. The results are to be used in determining compliance with the requirements in 36.5, 36.7, and Exception Nos. 1 and 2 to 42.4.

41.3.2 The maximum temperature at the gasketed joint is to be determined by testing the fixture in air (that is, without dust blanket) at an ambient temperature of 40 °C (104 °F) or at rated ambient, whichever is higher.

41.3.3 The parameters for the accelerated air-oven aging are to be calculated using the maximum temperature measured at the gasketed joint. The calculations are to be based on testing for 50 years. For the purpose of calculations, the accelerated-aging period is not prohibited from being halved for each 10 °C (18 °F) increase in test temperature.

41.3.4 The test time and test temperature are to be calculated using the following formulas:

a) For test time:

$$D = \frac{18262.5}{2^{(\Delta T/10)}}$$

b) For test temperature:

$$T_2 = T_1 + 10\left(\frac{In\frac{18262.5}{D}}{IN2}\right)$$

in which:

D is the number of days for air-oven aging;

T_1 is the maximum temperature in °C at the gasketed joint, see 41.3.2;

T_2 is the air-oven aging test temperature in °C; and

ΔT is $T_2 - T_1$.

See 41.3.5.

41.3.5 For the calculation described in 41.3.4, either the test time (D) or the test temperature (T_2) is to be selected by the fixture manufacturer.

41.3.6 Two samples of the fixture housing with the gasketed joint assembly representative of production units are to be subjected to the air-oven aging. A third sample is to be provided for use as a control (as-received) sample for comparison with the samples subjected to the oven aging.

41.3.7 At the completion of the test, the samples are to be removed from the oven and allowed to cool to room temperature. The force required to separate the enclosure parts at the gasketed joint is then to be measured using tensile equipment employing a crosshead speed of 0.1 inch per minute (2.5 mm/min.) The force to separate the parts shall not exceed 100 pounds (44.8 N).

41.3.8 The samples subjected to the oven aging are also to be visually examined – see 41.3.9.

41.3.9 Among the factors that are to be investigated when determining the suitability of a gasketed assembly after oven aging are:

a) Deterioration of the materials used in the joint assembly;

b) Transfer of gasket material to a joint surface;

c) Transfer of paint to a gasket;

d) Peeling of paint from a painted joint surface;

e) Effectiveness of an adhesive used to secure a gasket;

f) The force required to separate a fixture at a gasketed joint – see 41.3.7; and

g) Other results that impair the dusttight construction of the fixture.

41.4 Compression set

41.4.1 General

41.4.1.1 It shall be determined whether compression set of a gasket adversely affects the dusttightness of a gasketed joint by:

a) Determining the percentage compression set as described in 41.4.2.1 – 41.4.2.4; or

b) Conditioning a sample fixture and then subjecting it to a dust-penetration test as described in 41.4.3.1 – 41.4.3.3.

41.4.2 Compression set determination

41.4.2.1 The percentage compression set shall be determined as described in 41.4.2.2 or 41.4.2.3 and shall not exceed 25 %.

41.4.2.2 The percentage compression set of closed-cell expanded rubber or open-cell sponge rubber is to be determined in accordance with Compression Set Under Constant Deflection in the ASTM D1056. The test time and temperature are to be determined using the formulae specified in 41.4.3.2.

41.4.2.3 The percentage compression set of an elastomeric material other than expanded or sponge rubber is to be determined by Method B of ASTM D395. The test time and temperature are to be determined using the formulae specified in 41.4.3.2.

41.4.2.4 The compression set is to be calculated using the following formula:

$$C = \frac{(t_0 - t_1)}{(t_0 - t_s)} \times 100$$

in which:

C is the compression set in percent;

t_o is the original thickness in inches;

t_1 is the thickness in inches after the specified recovery period; and

t_s is the thickness in inches of the spacer bar; that is the thickness of the compressed gasket.

41.4.3 Dust penetration

41.4.3.1 A sample fixture shall be conditioned as described in 41.4.3.2 and then subjected to the Dust-Penetration Test, Section 43.

41.4.3.2 The fixture assembled with all components required for conducting the dust-penetration test is to be conditioned in an air oven. The time and temperature for the conditioning are to be determined using the following formulas:

$$D = \frac{90}{2^{(x-1)}}$$

$$T_2 = T_1 + 10(X - 1)$$

in which:

D is the number of days for air-oven aging;

T_1 is the maximum temperature in °C at the gasketed joint – see 41.3.2;

T_2 is the air-oven aging test temperature in °C; and

X is any number from 1 to 5 selected by the fixture manufacturer. The same value is to be used in both equations.

41.4.3.3 After conditioning, the fixture is to be cooled to room temperature, and then, without disturbing the gasketed joints in the assembly, the fixture is to be subjected to the Dust-Penetration Test, Section 43.

41.5 Identification

41.5.1 The gasket material and the adhesive, when used, shall be subjected to qualitative pyrolytic-gas chromatographic analysis for follow-up identification purposes.

42 Materials Applied to Joint Surfaces

42.1 A corrosion inhibiting grease, such as petrolatum or soap-thickened mineral oils are usable on the metal joint surfaces before assembly.

42.2 The grease shall be of a type that does not:

a) Harden because of aging;

b) Contain an evaporating solvent; or

c) Corrode the joint surface.

42.3 A corrosion inhibiting, non-drying, thickened mineral oil-based sealant that does not contain metal particles shall be permitted to be applied to threaded joints.

42.4 Paint or a sealing material shall not be applied to the contacting surfaces of a joint.

Exception No. 1: A baked-enamel coating shall not be applied unless it complies with the requirements in 41.1.2.

Exception No. 2: A sealing material shall not be applied to the contacting surfaces of a joint that is not intended to be and is not required to be opened to install or service the equipment, unless the application of the material complies with 36.2 and 43.2.

Exception No. 3: A metallic paint or other non-insulating coating shall not be applied to a threaded joint surface or a threaded conduit opening unless the joint surface or opening, with the paint or coating applied, complies with the requirements in 28.2.1 – 28.2.3.

PERFORMANCE

43 Dust-Penetration Test

43.1 Equipment shall be subjected to the test described in 43.2 – 43.11. There shall be no entrance of dust into the enclosure.

Exception: Nonheat-producing equipment such as empty enclosures and equipment employing non-rotating shafts and non-power transmitting shafts less than 100 rpm and similar devices, are not required to be subjected to the dust-penetration test when all joints are of the threaded or ungasketed type complying with the applicable joint construction requirements in Table 43.1 and Table 43.2.

Table 43.1
Flat Joints and Rabbet Joints

Maximum joint clearance		Minimum joint width	
inches	(mm)	inches	(mm)
0.0015	(0.038)	3/8	(9.5)
0.0020	(0.050)	3/4	(19.0)
0.0033	(0.084)	1	(25.4)
0.0045	(0.114)	1-1/4	(31.8)

Table 43.2
Non-Rotating and Non-Power Transmitting Shafts Rotating Under 100 rpm

Maximum joint clearance		Minimum joint width	
inches	(mm)	inches	(mm)
0.0033	(0.084)	1	(25.4)
0.0045	(0.114)	1-1/4	(31.8)

43.2 When sealing material is applied to a joint surface in accordance with Exception No. 2 to 42.4, the test is to be conducted without the sealing material in place.

43.3 The equipment is to be installed in a test chamber of a size sufficient to prevent other than normal heating of the equipment and to provide free circulation of dust-air mixtures around the equipment.

43.4 The test chamber is to be provided with dust-air-inlet and -outlet connections and auxiliary apparatus for producing and circulating a dust-air atmosphere.

43.5 The equipment is to be operated at full-rated load or is to be equivalently heated in the dust-air atmosphere until equilibrium temperatures are attained, and is then cooled to ambient (room) temperature. The test is to be continued for at least six such heating and cooling cycles, covering at least 30 hours, while the equipment is continuously exposed to the circulating dust-air atmosphere.

43.6 Temperatures are to be measured by thermocouples as described in 20.4 – 20.6.

43.7 The ambient temperature in the test chamber is to be measured by at least two thermocouples located at different levels near the equipment being tested.

43.8 Grain dust consisting of wheat or corn dust, or both, that has passed through a USA Standard 150 Micron (100 mesh) wire cloth is to be used for the dust-air atmosphere for equipment that is for use in Class II, Group F, Group G, or both locations.

43.9 Magnesium dust, all of which has passed through a USA Standard 250 Micron (60 mesh) wire cloth, 66 % of which has passed through a 150 Micron (100 mesh) wire cloth, and 22 % of which has passed through a 75 Micron (200 mesh) wire cloth, is to be used for the dust-air atmosphere when the equipment is for use in Class II, Group E locations.

43.10 The wire cloth in 43.8 and 43.9 is to conform to the dimensional requirements of ASTM E11.

43.11 When the equipment is intended for Class II, Groups E and F, or Groups E, F, and G locations, penetration tests are to be conducted with magnesium dust.

44 Temperature Test with Dust Blanket

44.1 Heat producing equipment shall be subjected to a temperature test while blanketed with dust. The dust in contact with the enclosure shall not ignite or char, and the exterior temperatures shall not exceed maximum operating temperature or operating temperature class (T Code) marked on the equipment. The temperature measured shall be based on the ambient temperature described in 44.2.

44.2 When the equipment is intended for use in an ambient temperature of 40 °C (104 °F) or less, the test is to be conducted at an ambient of 40 °C. When the equipment is for use in an ambient higher than 40 °C, the test is to be conducted at the higher ambient.

44.3 The test is to be conducted in a test chamber as described in 43.3 and 43.4.

44.4 The equipment is to be installed in the test chamber and located so that the dust-air outlets do not discharge directly toward the equipment.

44.5 The temperature test is to be conducted with the equipment operated in the test chamber as specified in 44.6 with the dust atmosphere circulating until a stable blanket of dust has accumulated on the enclosure. The dust circulation is to be stopped and the test continued until equilibrium temperatures are attained.

44.6 The equipment is to be operated at full-rated load, or equivalent heating, and also under overload conditions when the equipment is of the type subject to overloading, such as motors or power transformers.

44.7 Temperatures are to be measured by thermocouples as described in 20.4 – 20.6.

44.8 The ambient temperature is to be measured by at least two thermocouples located at different levels near the equipment being tested, at a location that is not directly in a dust-air stream.

44.9 The temperature test is to be conducted with grain dust when the equipment is for Class II, Group F, Group G, Groups F and G, or Groups E, F, and G locations. The temperature test is to be conducted with magnesium dust when the equipment is intended for Class II, Group E locations only. See 43.10 and 43.11 for a description of each dust.

44.10 The exterior surface temperatures of equipment intended for use where Class I and Class II conditions are able to exist simultaneously shall not exceed:

a) 165 °C (329 °F) – For equipment for Class I and Class II, Group G, Groups F and G, or Groups E, F, and G; and

b) 200 °C (392 °F) – For equipment for Class I and Class II, Group E, Group F, or Groups E and F.

45 Polymeric Enclosure Tests

45.1 An enclosure made of a polymeric material shall be subjected to tests to determine that it is equivalent to comparable metal enclosures that have been found suitable for use in Class II hazardous locations.

45.2 A polymeric enclosure shall comply with the requirements in 33.3.3, Accelerated aging tests, 33.4, Tests for accumulation of static electricity, and UL 50.

45.3 A polymeric enclosure shall be such that the minimum widths of joints or shaft openings do not decrease nor the maximum clearances increase beyond those specified, under all conditions of use. In addition, tests shall show that no other adverse effects are expected to occur such as loosening of parts, reduction in electrical spacings, ignition of the polymeric material from an electrical arc, or accumulation of electrostatic charges.

45.4 Consideration is to be given to all variations in chemical composition, color percentage mix, or molecular weight.

46 Leakage Test on Factory-Installed Conduit Seals

46.1 A factory-installed conduit seal shall comply with the requirements in Leakage Test on Factory-Installed Conduit Seals, Section 24.

47 Tests for Glass Parts

47.1 A glass part of equipment shall comply with the requirements in Tests for Glass Parts, Section 25.

48 Secureness Test on Conduit Hubs

48.1 A conduit hub not integrally cast with a metal enclosure shall comply with the requirements in Secureness Test on Supply Connection Hubs, Section 26.

49 Tests on Joint Gaskets

49.1 A gasket in the required joint shall be subjected to tests to determine the effects of heat, aging, compression, distortion under conditions of use, and cold flow or creep for materials of the elastomeric or thermoplastic type. One means of evaluation is compliance with UL 157.

49.2 The means of securing the gasket to the cover or enclosure, the gasket construction, and the gasket material are to be used in determining the tests to be conducted.

50 Electrical-Resistance Test

50.1 Cord-connected equipment shall comply with the requirements in Electrical-Resistance Test, Section 28.

51 Accelerated-Aging Test on Bushings

51.1 A molded-rubber or -neoprene bushing provided at the cord entrance to the terminal enclosure of portable equipment shall comply with the requirements in Accelerated Aging Test on Bushings, Section 29.

52 Strain-Relief Test

52.1 Portable equipment shall comply with the requirements in Strain-Relief Test, Section 30.

53 Rough-Usage Test

53.1 Portable equipment shall comply with the requirements in Rough-Usage Test, Section 31.

54 Drop Test

54.1 Portable equipment shall comply with the requirements in Drop Test, Section 32.

55 Diaphragm Endurance Test

55.1 A sheet-metal diaphragm as described in 9.3 shall withstand 100,000 complete cycles of motion. Each complete cycle is to be conducted at a rate of 1 cycle per second through twice the distance the diaphragm travels in intended operation. Such operation shall not adversely affect the integrity of the diaphragm assembly.

56 Test for Secureness of Conduit Hubs

56.1 General

56.1.1 A conduit hub in a polymeric enclosure or a hub not integrally cast with a metal enclosure shall withstand the torque specified in Table 56.1 applied to a short length of rigid conduit threaded into the hub of the enclosure in the intended manner, without turning in the enclosure and without stripping of any threads.

Table 56.1
Tightening Torque for Conduit Hubs

Conduit hub trade-size		Tightening torque	
Inches	(mm O.D.)	Pound-inches	(N·m)
1/2 – 3/4	(21.3 – 26.7)	800	(90)
1 – 1-1/2	(33.4 – 48.3)	1000	(113)
2 and larger	(60.3)	1600	(181)

56.1.2 A conduit hub in a polymeric enclosure shall not pull apart or otherwise be damaged, such as by cracking or breaking, when subjected to the pullout and bending tests described in 56.2.1 and 56.3.1.

56.2 Pullout

56.2.1 The conduit hub in a polymeric enclosure is to 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 200 pounds (890 N) is to be applied for 5 minutes to a length of conduit installed in the opposite wall.

56.3 Bending

56.3.1 A length of rigid metal conduit at least 1 foot (305 mm) long of the intended size is to be installed in a conduit hub or opening in a polymeric enclosure. The enclosure is to be securely mounted as intended in service, but positioned so that the installed conduit extends in a horizontal plane. A weight is to be suspended from the end of the conduit to produce the bending moment specified in Table 56.2. The magnitude of the weight is to be determined from the equation:

$$W = \frac{M - 0.5CL}{L}$$

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.

For the SI system of units, the equation is:

$$W = \frac{0.1M - 4.9CL}{L}$$

in which:

W and *C* are measured in kilogram;,

M is in newton-meters; and

L is in meters.

Table 56.2
Bending Moment

Normal mounting plane of enclosure surface[a]	Conduit size inches	Bending moment Pound-inches[b]	(N·m)
Horizontal	All	300	(33.9)
Vertical	1/2 – 3/4	300	(33.9)
	1 – up	600	(67.8)

[a] If the enclosure surface is to be installed in either a horizontal or a vertical plane, the vertical bending moment value is to be used.

[b] The test procedure is allowed to be terminated prior to attaining the values specified if the deflection of the conduit exceeds 10 inches (255 mm) for a 10 foot (3.05 m) length of conduit.

PART III – MANUFACTURING AND PRODUCTION TESTS

57 Bonding Test on Cord-Connected Equipment

57.1 The manufacturer shall determine by a routine production-line test that the grounding member of the attachment plug, when provided, or the grounding conductor of the supply cord is electrically connected to dead metal parts of portable equipment required to be bonded in accordance with 14.2.5.1 or 40.2.7.

58 Hydrostatic Pressure Test

58.1 When the hydrostatic pressure test specified in Section 22, Hydrostatic Pressure Tests, is conducted in accordance with the Exception to 22.1, Exception No. 2, each explosionproof electrical enclosure shall withstand without rupture or permanent distortion, as a routine production-line test, the hydrostatic pressure specified in 58.2.

58.2 The hydrostatic pressure within each enclosure is to be raised to 1.5 times the maximum explosion pressure, and more than 50 psig (345 kPa). The pressure is to be applied for more than 10 seconds and less than 1 minute.

PART IV – MARKINGS AND INSTRUCTIONS

59 Details

59.1 These marking requirements apply to equipment covered in all Parts of this Standard. Product specific marking requirements found elsewhere in the standard are in addition to these requirements unless otherwise specified.

59.2 The markings shall be located so that they are visible after installation of the equipment.

59.3 The equipment shall be permanently marked as specified in (a) – (k) with a metal nameplate or plates mechanically attached, or shall be embossed, stamped, cast, or molded into the product, or shall be a nonmetallic pressure-sensitive label which complies with applicable sections of UL 969, and shall indicate the following as applicable:

a) The manufacturer's name or trademark;

b) The equipment identification;

c) Electrical ratings;

d) For devices with a rotating shaft, the maximum rpm at which the shaft is intended to rotate;

Exception: The rpm is not required to be marked on devices, such as a siren, where the maximum speed of the shaft is determined by an internal motor that is directly coupled to the shaft.

e) Designation of the hazardous location in which the equipment is intended to be used: for example, "Class ____, Group ____." Also see 59.18;

f) Enclosure-type designation. An enclosure that complies with the requirements for more than one type of enclosure is not prohibited from being marked with multiple designations;

Exception: The designation marking for Type 7 or 9 is not required to be marked.

g) The maximum ambient temperature rating, when other than 40 °C (104 °F), and/or the minimum ambient temperature rating when less than minus 25 °C (minus 13 °F).

h) A cautionary statement consisting of the word "CAUTION" and the following or equivalent wording: "To reduce the risk of ignition of hazardous atmospheres, disconnect the equipment from the supply circuit before opening. Keep assembly tightly closed when in operation.";

i) Maximum operating temperature or operating temperature class (T code) as specified in Table 59.1, when the operating temperature exceeds 100 °C (212 °F). This marking is to be based on the maximum temperature attained in the temperature tests. The operating temperature or temperature class shall be near the marking required by (e). It shall be identified as "Operating Temperature _____," or "Operating Temperature Code _____," or the equivalent; and

k) A device with a factory-installed seal shall be permanently marked "Leads Factory Sealed", or "Factory Sealed", or "Seal not Required", or the equivalent.

Table 59.1
Temperature Marking

Maximum operating temperature °C	(°F)	Operating temperature code or identification number
450	(842)	T1
300	(572)	T2
280	(536)	T2A
260	(500)	T2B
230	(446)	T2C
215	(419)	T2D
200	(392)	T3
180	(356)	T3A
165	(329)	T3B
160	(320)	T3C
135	(275)	T4
120	(248)	T4A
100	(212)	T5
85	(185)	T6

59.4 In addition to, or as an alternative to, the marking requirement in 59.3(e), equipment that has been investigated and found to comply with the requirements for Class I, Group D locations is not prohibited from being additionally or alternatively marked Class I, Zone 1, Group IIA.

59.5 In addition to, or as an alternative to, the marking requirement in 59.3(e), equipment that has been investigated and found to comply with the requirements for Class I, Group C locations is not prohibited from being additionally or alternatively marked Class I, Zone 1, Group IIB.

59.6 In addition to or as an alternative to, the marking requirement in 59.3(e), equipment that has been investigated and found to comply with the requirements for use in one or more specific gas or vapor atmospheres, is not prohibited from being additionally or alternatively be marked with those specific atmospheres. For example, "Class I, Group D plus epichlorohydrin" or "Class I, Zone 1, Group IIB plus hydrogen" or "For use in Class I, Division 1 atmospheres containing _____."

59.7 In addition to, or as an alternative to, the marking requirement in 59.3(e), equipment that has been investigated and found to comply with the requirements for both Class I, Group A, and Class I, Group B locations is not prohibited from being additionally or alternatively be marked Class I, Zone 1, Group IIC.

59.8 Equipment marked Group IIB is not prohibited from also being marked Group IIA.

59.9 Equipment marked Group IIC is not prohibited from also being marked Group IIA, Group IIB, or both Group IIA and Group IIB.

59.10 In addition to, or as an alternative to, the marking requirement in 59.3(e), equipment that has been investigated and found to comply with the requirements for Class II, Division 1 locations is not prohibited from being additionally or alternatively marked Zone 20, 21 or 22 (as applicable).

59.11 Unless the proper wiring connections are plainly evident, wiring terminals shall be marked, or the equipment shall be provided with a wiring diagram to indicate the connections. Equipment requiring the use of heater elements in the installation shall be provided with a heater table.

59.12 When a wiring diagram or heater table is required, each shall be secured to the device. The diagram or table shall not be a paper label unless it is:

a) Located within the enclosure where it is visible and legible on opening the enclosure; and

b) Protected against mechanical damage.

59.13 Portable equipment shall be marked with instructions regarding replacement of the power-supply cord. The instructions are to include the following, or equivalent information: "For replacement purposes, use __ AWG Type __ power-supply cord only." These instructions shall be legible and permanent in nature, and shall not be on a paper sticker unless located within the terminal compartment and protected against mechanical damage.

59.14 Cord-connected equipment employing a packing gland requiring dismantling during cord replacement shall be marked or provided with instructions regarding its installation and replacement.

59.15 Cord-connected equipment that is shipped without the flexible power-supply cord or the attachment fitting attached shall be provided with instructions regarding the installation of these components. These instructions shall be:

a) Provided as a permanent part of the equipment;

b) Contained on a removable tag secured to the equipment;

c) Provided in accordance with Section 60.

59.16 Equipment with a factory-installed conduit seal shall be marked "Leads factory sealed", or the equivalent. This information shall be provided as a permanent part of the equipment.

59.17 Equipment intended to have sealing fittings installed as specified in the Exception to 21.17 shall be permanently marked where readily visible during and after installation with the word "WARNING" and the following or the equivalent wording: "To reduce the risk of ignition of hazardous atmospheres, conduit runs must have a sealing fitting connected within 18 inches of the enclosure."

59.18 Equipment that has been tested and found to comply with the requirements for exposure to Class I and Class II location conditions at the same time shall be marked with the following or equivalent wording: "Intended for simultaneous use in Class I, Group ____ and Class II, Group ____ locations" together with the operating temperature or operating temperature class (T code).

59.19 In accordance with the Exceptions to 14.1.1.3 and 40.1.3, instructions to install a fitting providing a smooth, rounded inlet hole shall be provided when a conduit opening is not:

a) Provided with a conduit stop;

b) Well-rounded; or

c) Threaded as specified in Table 14.2.

59.20 When a manufacturer produces equipment at more than one factory, each unit shall have a distinctive marking to identify it as the product of a particular factory.

59.21 In accordance with 14.1.1.13 and 40.1.1, an enclosure shall be provided with instructions for drilling and tapping conduit openings. The instructions shall include the following information:

a) Maximum number of conduit openings;

b) Maximum and minimum trade size of conduit openings;

c) Location of conduit openings;

d) Type of conduit threads;

e) Gauging requirements for field-threaded entries shall conform to:

1) For NPT threaded entries, ASME B1.20.1 except that entries shall gauge from flush to plus 3-1/2 turns beyond the L-1 gauging notch in lieu of the minus 1 to plus 1 turns described in ASME B1.20.1;

2) Metric threaded entries shall have a thread tolerance class of 6H.

f) Other instructions necessary to provide for connection to threaded rigid metal conduit or cable sealing fittings in accordance with the requirements of this Standard.

59.22 Equipment having metric supply connection openings in accordance with 14.1.1.6 and 40.1.6 shall have a permanent marking which includes the supply connection thread size, and type, i.e. M20, M25, M50 etc.

59.23 A component enclosure that has been tested for explosion pressure and propagation effects of short-circuit testing with circuit breakers shall be marked with the word "CAUTION" and the following or equivalent wording: "To prevent external fire or explosion do not install switching equipment intended to interrupt more than _____ rms symmetrical amperes at _____ Volts A/C. Do not install equipment that will produce external surface temperatures exceeding the ignition temperature of the flammable or combustible materials which may surround this enclosure." and "Current-interrupting devices, such as switches, relays and circuit breakers, which may be installed in the enclosure may fail electrically or mechanically unless they have been investigated and found suitable for operation in the hazardous locations involved." The marking shall be readily visible during installation of the equipment and located

inside of the enclosure. The marking shall be permitted to be included on an adhesive or pressure sensitive label or the equivalent.

The blank space is to be marked "10,000" rms and “600” Volts unless the enclosure has been tested with representative equipment interrupting a higher current, in which case the higher current may be marked at the corresponding test voltage. Multiple ratings may be marked as applicable.

59.24 *Deleted*

59.25 Equipment that employs a cartridge fuse filled with noncombustible granular material in accordance with the Exception to 21.10 or B1.10 shall be marked, at a location visible when the fuse is being replaced, with the word "CAUTION " and the following or equivalent statement: "Risk of Ignition of Hazardous Atmospheres – Replace only with “x” fuse having the same voltage and current rating as the existing fuse." The manufacturer is to insert identification of the fuse filled with noncombustible granular material in the space marked "x ".

60 Installation Instructions

60.1 General

60.1.1 Explosionproof and dust-ignitionproof electrical equipment shall be provided with documentation that includes all the instructional material required by this standard.

60.2 Electronic medium for required instructions

60.2.1 The required instructional material of this standard may be provided by electronic media under the following conditions:

a) Where all required instructional material is provided by electronic media, there shall be marking on the equipment that contains the international symbol ⚠ (Reference No. 0434B of ISO 7000), along with the document number, revision level and location of the electronic documentation (e.g. URL, QRcode).

b) Where only some of the required instructional material is provided by electronic media and some is printed:

1) There shall be marking on the equipment that contains the international symbol ⚠ (Reference No. 0434B of ISO 7000), along with the document number, revision level and location of the electronic documentation (e.g. URL, QRcode); and

2) The printed instructions provided with the equipment shall clearly identify that additional information is available electronically, along with the document number, revision level and location of this electronic documentation (e.g. URL, QRcode).

Exception: For small electrical equipment where some or all of the instructional material is to be provided by electronic media, and where there is limited space for both the international symbol ⚠ (Reference No. 0434B of ISO 7000) and the document number, revision level and location of the electronic documentation (e.g. URL, QRcode):

a) The international symbol ⚠ (Reference No. 0434B of ISO 7000) shall be marked on the equipment; and

b) Printed instructions shall be provided with the equipment that, as a minimum, indicate the document number, revision level and location of the electronic documentation (e. g. URL, QRcode).

NOTE When electronic documentation is referenced either on the device or on the printed instructions, the location given can be the specific location for the required instructions (e. g. direct link to the specific instructions), or can be a more general location. (e.g. the URL for the overall manufacturer's website). It is the manufacturer's responsibility to assure that the location of the required instructions is accessible by the user.

60.2.2 Alternatively, the reference to the document number and revision level on the marking can be excluded if the location of the electronic documentation marked on the equipment (e.g. URL, QRcode) involves an electronic search feature that makes the required documentation available by entering specific information that is required to be marked on the equipment, such as any combination of model number, part number, serial number, date code, or other unique identifier.

60.2.3 Where a QRcode is used to provide the required instructional material, and the QRcode contains all required instructional material (as opposed to merely referencing a URL that contains required instructional material), a document number and revision level need not be indicated.

60.2.4 Where some or all of the required instructional material is provided by electronic media, the required instructional material shall be available in printed format upon request of the user.

NOTE 1 Where required instructional material, especially drawings, is provided in an electronic documentation format, consideration should be given by the manufacturer to its viewability and print capability by the user.

NOTE 2 While electronic medium is permitted for required instructions as part of standards supported by the NEC, CE Code and IECEx System, other constraints may apply in certain market places (e.g. the European Commission's Standing Committee for the ATEX Directive has taken the view that at least the safety related parts of the instructions in respect of ATEX should be supplied in paper form).

PART V – INDUSTRIAL CONTROL EQUIPMENT

61 General

61.1 Industrial control equipment shall comply with the applicable requirements of Part I – Part IV of this Standard in addition to the requirements in Part V.

61.2 Examples of industrial control equipment are:

a) Manual and magnetic starters and controllers.

b) Thermal- and magnetic-overload relays.

c) Pushbutton stations, including selector switches and pilot lights.

d) Control-circuit switches and relays.

e) Float-, flow-, pressure-, and vacuum-operated switches.

f) Resistors and rheostats.

g) Proximity switches.

h) Time-delay relays and switches.

i) Resistors and rheostats intended for industrial heating and lighting, including those for motor-generator fields.

j) Control devices intended for industrial heating and lighting.

k) Variable-voltage autotransformers.

61.3 These devices shall also comply with the applicable requirements in UL 508.

CONSTRUCTION

62 Holes in Enclosures

62.1 An open-type auxiliary device for use in a motor-control circuit (such as a pilot light, selector switch, or pushbutton) complying with the requirements in 62.2, threaded into an enclosure, or a closure plug threaded into an opening in the enclosure for such an auxiliary device, need not be secured against removal.

62.2 An open-type auxiliary device shall close the opening into which it threads in a manner complying with the requirements in this standard when installed in accordance with the manufacturer's installation instructions. If the construction is such that the enclosure of the auxiliary device requires a hydrostatic strength test or equivalent, the auxiliary device wiring terminals or leads shall be factory sealed.

Exception: A permanently mounted device shall have provision for connection to threaded rigid metal conduit, or other wiring methods in accordance with Article 501 in NFPA 70. This requirement does not apply to an open-type auxiliary device for use in a motor-control circuit (such as a pilot light, selector switch, or pushbutton) that:

a) Is intended to thread into an enclosure and close the opening into which it threads, and

b) Complies with the requirements in 62.2.

PERFORMANCE

63 No-Load Endurance Test

63.1 A manually-operated device provided with a metal-to-polymeric or polymeric-to-ceramic type shaft opening shall be subjected to the no-load endurance test specified in 63.2. There shall be no mechanical or visible damage to any of the parts.

63.2 The device shall be tested with shaft path surfaces having the maximum surface roughness to be provided in production. Following the test, the device shall comply with Explosion Tests, Section 21.

63.3 The device is to be operated in its intended manner. This test may be conducted manually or mechanically. The duration of the test is to be 10,000 cycles, at a rate not greater than 10 per minute. The rate of cycling is to be greater if agreeable to all concerned.

MARKINGS

64 Details

64.1 Unless the proper wiring connections are plainly evident, wiring terminals shall be marked, or the device shall be provided with a wiring diagram to indicate the connections. A device requiring the use of heater elements in the installation shall be provided with a heater table.

64.2 If a wiring diagram or heater table is necessary, each shall be secured to the device. The diagram or table may be on a paper label if it is:

a) Located within the enclosure where it is visible and legible on opening the enclosure, and

b) Protected against mechanical damage.

64.3 A magnetic motor controller enclosure shall be marked as required by 59.3, except that in place of the electrical ratings required by 59.3(c), the enclosure shall be marked to indicate the manufacturer, type, and ratings of the mechanism or mechanisms for which it is intended.

64.4 Except as noted in 64.5, the marking required by 64.3 shall be on the metal nameplate.

64.5 The information covering the mechanisms for which the enclosure is intended may be on a paper label cemented to the inside of the enclosure where it is readily visible if the nameplate bears a reference to the location of this information; for example, "For use only with mechanisms listed on inside of cover."

64.6 An open-type auxiliary device as described in 62.1, 62.2 and in the Exceptions to 62.2 shall be provided with instructions indicating that the device is to be installed in a threaded opening in an enclosure, the minimum number of threads to be engaged, and the type of threads required in the enclosure. These instructions are permitted to be in the form of a pressure-sensitive label.

64.7 The marking for an open-type auxiliary device for use in a motor-control circuit (such as a pilot light, selector switch, or pushbutton) complying with the requirement in 62.2 and intended for mounting within another enclosure, may be on an adhesive-backed label or equivalent secured to the auxiliary device.

PART VI – SWITCHES

65 General

65.1 Switches shall comply with the applicable requirements of Part I – Part IV of this Standard in addition to the requirements in Part VI.

65.2 Switches shall also comply with the applicable requirements for similar switches for use in unclassified locations.

65.3 These requirements cover snap and similar switches rated 60 amperes or less at 250 volts or less; 30 amperes or less at 600 volts or less; and 2 horsepower or less at 600 volts or less.

65.4 These requirements do not cover knife, enclosed, clock-operated, or magnetically-operated switches, or industrial control equipment such as auxiliary devices and magnetic or manual motor controllers.

CONSTRUCTION

66 Enclosure Thickness

66.1 A sheet-metal diaphragm that forms part of the enclosure of an electrical component may be less than 1/32 inch (0.8 mm) thick if:

a) A barrier of acceptable insulating material at least 1/32 inch thick is secured in place between the diaphragm and any electrical component that it encloses;

b) The diaphragm is located or enclosed so that it will be protected against unintentional mechanical damage;

c) The diaphragm is formed of an acceptable inherently corrosion-resistant sheet metal not less than 0.005 inch (0.127 mm) thick;

d) The diameter of the diaphragm is not greater than 1 inch (25.4 mm); and

e) The diaphragm assembly withstands the Explosion Tests, Section 21, Hydrostatic Pressure Test, Section 22, and Diaphragm Endurance Test, Section 55.

67 Mounting of Switch Mechanism

67.1 A switch mechanism operated by rotation of an integral shaft shall be secured so that the mechanism as a whole cannot turn.

68 Spacings

68.1 Except as specified in 68.2, the spacings shall comply with the spacing requirements for general-use switches for use in ordinary locations.

68.2 The spacing through air from each terminal to the enclosure walls shall not be less than 1/4 inch (6.4 mm).

69 Insulating Barrier or Liner

69.1 Except as noted in 69.2 – 69.4, an insulating barrier or liner that is used to provide spacings shall be of material acceptable for the application and shall not be less than 0.028 inch (0.711 mm) thick.

69.2 A barrier or liner that is used in conjunction with not less than one-half the required spacing may be less than 1/32 inch (0.80 mm) but shall not be less than 0.013 inch (0.330 mm) thick, if the barrier or liner is:

a) Of acceptable insulating material;

b) Resistant to moisture;

c) Of acceptable mechanical strength if exposed or otherwise likely to be subjected to mechanical damage;

d) Securely held in place; and

e) Located so that it will not be affected adversely by operation of the equipment in service – particularly arcing.

69.3 An insulating barrier or liner used as the sole separation between live parts and grounded parts or between live parts of opposite polarity, shall be of material acceptable for the mounting of uninsulated live parts and not less than 0.013 inch (0.330 mm) thick. Otherwise, a barrier shall be used in conjunction with at least a 1/32 inch (0.80 mm) air spacing.

69.4 An insulating material having a thickness less than that specified in 69.1 – 69.3 may be used if, upon investigation, it is found to be acceptable for the application and is equivalent to materials of the thickness contemplated in 69.1 – 69.3.

RATINGS

70 General

70.1 Other than noted in 70.2 and 70.4, a switch shall be rated in volts and amperes.

70.2 A switch may be rated in volts and horsepower with or without a current rating.

70.3 Except as noted in 70.4, the voltage rating shall be one or an appropriate combination of the voltage ratings specified in Table 70.1.

70.4 A switch not intended for general use may have a voltage rating other than specified in Table 70.1 in conjunction with an ampere, horsepower [not more than 2 horsepower (1.49 kW output)], or other acceptable load rating.

Table 70.1
Voltage Ratings

AC Voltage ratings	DC Voltage ratings
120 or 125	125
240 or 250	250
277	600
480	
600	

70.5 A switch may carry an additional "T" rating at 125 volts if the switch complies with the test requirements for a switch intended for the control of tungsten-filament lamps operating on direct current.

70.6 A switch may carry an additional "L" rating at 120 or 125 volts alternating current, if the switch complies with the test requirements for a switch intended for the control of tungsten-filament lamps operating on alternating current.

70.7 For two- and three-circuit switches (including fan-motor and double-throw switches), the ampere rating applies to the maximum current carried under any combination of circuits.

70.8 The horsepower rating of a switch intended for general use shall be 1/10, 1/8, 1/6, 1/4, 1/3, 1/2, 3/4, 1, 1-1/2, or 2 horsepower (0.07, 0.09, 0.12, 0.19, 0.25, 0.37, 0.56, 0.7, 1.1, or 1.49 kW output) or an appropriate combination of such values at different voltages.

70.9 The marked horsepower rating of a switch at any single voltage indicates that the switch is acceptable for that horsepower rating or less at that voltage only. If a switch is to be acceptable for any horsepower rating at another voltage, that horsepower and voltage rating is also to appear on the switch.

MARKING

71 Details

71.1 Each switch shall be marked with a metal nameplate indicating the following in addition to the requirements in Section 59, Details:

a) Electrical ratings (see also 70.9).

b) A cautionary statement: "CAUTION – To Reduce The Risk of Ignition Of Hazardous Atmospheres, Disconnect The Device From The Supply Circuit Before Opening. Keep Assembly Tightly Closed When In Operation ," or equivalent wording.

71.2 If a wiring diagram is necessary, it shall be secured to the switch. The diagram may be a paper label if it is located within the enclosure where it is visible and legible on opening the enclosure and it is protected from mechanical damage.

71.3 An alternating-current/direct-current switch provided with No. 6 (3.5 mm major diameter) wire-binding terminal screws having leads less than 0.296 inch (7.52 mm) in diameter shall be marked, where readily visible during installation, 12 AWG max or the equivalent.

71.4 A switch investigated for the control of tungsten-filament lamps on direct as well as alternating current shall be identified as such by means of the letter "T", which shall be a part of the marked electrical ratings and located to indicate that it applies only to the rating of 125 volts.

71.5 A switch investigated for the control of tungsten-filament lamps on alternating-current circuits only shall be identified as such by means of the letter " L", which shall be a part of the marked electrical ratings and located to indicate that it applies only to the rating for 120 or 250 volts alternating current.

71.6 A switch that is acceptable for use on alternating-current circuits only shall be identified as such by means of the letters "AC" or an acceptable frequency marking (for example, 60 hertz) or a phase marking, which shall be a part of the electrical ratings.

71.7 In accordance with the Exceptions to 14.1.1.3 instructions to install a fitting providing a smooth, rounded inlet hole shall be provided if a conduit opening is not:

a) Provided with a conduit stop;

b) Well-rounded; or

c) Threaded as specified in Table 14.2.

PART VII – CIRCUIT BREAKERS

72 General

72.1 Circuit breakers shall comply with the applicable requirements of Part I – Part IV of this Standard in addition to the requirements in Part VII.

72.2 These requirements cover circuit breakers specifically designed to provide service-entrance, meter-service, or branch-circuit protection for installation and use in hazardous (classified) locations, Class I, Division 1, Groups A, B, C, and D, and Class II, Division 1, Groups E, F, and G, in accordance with NFPA 70.

72.3 These requirements also cover explosionproof electrical equipment for installation and use in Class I, Zone 1, Groups IIA, IIB, and IIC hazardous (classified) locations.

72.4 These requirements also cover explosionproof electrical equipment for installation and use in Class I, Zone 1, Groups IIA, IIB, IIB plus Hydrogen, and IIC hazardous (classified) locations.

72.5 For the purpose of these requirements, the term circuit breaker covers the electrical mechanism together with an enclosure and the term circuit-breaker mechanism covers the electrical mechanisms only.

CONSTRUCTION

73 General

73.1 These requirements cover both circuit breakers and circuit-breaker enclosures other than as indicated in 75.23.

73.2 Circuit breakers for use in hazardous locations shall also comply with the applicable requirements in UL 489.

74 Wiring Space

74.1 The space within the enclosure of a circuit breaker shall be sufficient to provide ample room for the necessary wires and cables.

74.2 The terminal currents and conductor sizes are specified in Table 74.1.

Table 74.1
Terminal Current and Conductor Size

Terminal current in amperes[a]	Copper conductor			Aluminum or copper-clad aluminum conductor		
	Paralleled	Size[d]		Paralleled	Size[d]	
		60 °C (140 °F)	75 °C (167 °F)		60 °C (142 °F)	75 °C (167 °F)
15 or less	–	14 AWG[d]	14 AWG	–	12 AWG	12 AWG
20	–	12	12	–	10	10
25	–	10	10	–	10	10
30	–	10	10	–	8	8
40	–	8	8	–	6	8
50	–	6	6	–	4	6
60	–	4	6	–	3	4
70	–	4	4	–	2	3
80	–	3	4	–	1	2
90	–	2	3	–	1/0[c]	2
100	–	1	3	–	1/0[c]	1
110	–	1[b]	2	–		1/0
125	–	1/0	1	–		2/0
150	–		1/0	–		3/0
175	–		2/0	–		4/0
200	–		3/0	–		250 kcmil
225	–		4/0	–		300
250	–		250 kcmil	–		350
275	–		300	–		500
300	–		350	–		500
325	–		400	2		4/0 AWG
350	–		500	2		4/0
400	2		3/0 AWG	2		250 kcmil
450	2		4/0	2		300
500	2		250 kcmil	2		350
550	2		300	2		500
600	2		350	2		500
700	2		500	3		350

Table 74.1 Continued on Next Page

Table 74.1 Continued

Terminal current in amperes[a]	Copper conductor			Aluminum or copper-clad aluminum conductor		
	Paralleled	Size[d]		Paralleled	Size[d]	
		60 °C (140 °F)	75 °C (167 °F)		60 °C (142 °F)	75 °C (167 °F)
800	3		300	3		400
1000	3		400	4 or 3		350 or 600
1200	4 or 3		350 or 600	4		500
1400	4		500	5		500
1600	5		400 or	5		600
	4		600			
2000	6		400 or	6		600
	5		600			
2500	8		400,	8		600,
	7		500, or	7		750, or
	6		600	9		500
3000	9		400,	10		500,
	8		500, or	9		600, or
	7		600	8		750
4000	12		400,	13		500,
	11		500, or	12		600, or
	10		600	11		750

[a] For a terminal current other than specified, the next higher rating is to be used – for example, if rated 35 amperes, enter at 40 amperes.

[b] No. 1 Type RH, RHH, RHW, THW, THWN, or XHHW copper conductor may be used if the circuit breaker is so marked. See 75.16.

[c] No. 1 Type RH, RHH, RHW, THW, THWN, or XHHW aluminum conductor may be used if the circuit breaker is so marked. See 75.16.

[d] SI equivalents in mm^2 for AWG and kcmil wire are determined by the following formula:

mm^2= (CircularMils/1973.525)

74.3 With reference to the requirement in 74.1, the number of wires for which wiring space is to be provided is twice the number of circuit-breaker poles – the maximum number of wires involved when the wires enter the enclosure at the end opposite the end at which are located the terminals to which they will be connected. If a solid neutral terminal is supplied, wiring space for such wires will also be required. The provision of barriers to prevent the running of wires end-to-end is acceptable in lieu of the wiring space otherwise required provided that the barriers are riveted, welded, or otherwise secured in place to make their removal difficult.

74.4 If conduit openings are provided in a side wiring space, the width of such a space shall be adequate to accommodate (with respect to bending) the maximum size of wire for the application. For 8 AWG (8.4 mm^2) or larger wire sizes, reference may be made to Table 74.3 and Table 74.4.

Exception: Side wiring spaces of less width may be provided if conduit openings of sufficient size are properly located elsewhere, and if they can be used conveniently when the circuit breaker is wired as intended.

74.5 The clear wiring space at any point, independent of all projections, obstructions, or interference from moving parts of the operating mechanism, shall not be less in width nor in depth than the values specified in Table 74.2..

Table 74.2
Wiring Space

Maximum size of wire or cable involved AWG or kcmil (mm^2)		Minimum width and depth of wiring space inches (mm)		Minimum areas required for multiple wires based on factor of 2.5									
				Two Wires		Three Wires		Four Wires		Five Wires		Six Wires	
				$Inch^2$	mm^2	$Inch^2$	mm^2	$Inch^2$	mm^2	$Inch^2$	mm^2	$Inch^2$	mm^2
12 AWG	3.3	3/8	9.5	0.14	90	0.21	135	0.28	181	0.35	226	0.42	271
10	5.3	3/8	9.5	0.23	148	0.34	219	0.46	297	0.57	368	0.68	439
8[a]	8.4	1/2	12.7	0.43	277	0.64	413	0.85	548	1.07	690	1.28	826
6	13.3	5/8	15.9	0.62	400	0.93	600	1.24	800	1.55	1000	1.86	1200
4	21.2	3/4	19.1	0.80	516	1.20	774	1.60	1032	2.00	1290	2.40	1548
3	26.7	3/4	19.1	0.91	587	1.36	877	1.82	1174	2.27	1465	2.72	1755
2	33.6	7/8	22.2	1.03	665	1.55	1000	2.06	1329	2.58	1665	3.10	2000
1	42.4	1	25.4	1.36	877	2.04	1316	2.72	1755	3.40	2194	4.08	2632
1/0	53.5	1	25.4	1.55	1000	2.33	1503	3.10	2000	3.88	2503	4.66	3006
2/0	67.4	1	25.4	1.79	1155	2.68	1729	3.58	2310	4.47	2884	5.36	3458
3/0	85.0	1-1/8	28.6	2.08	1342	3.11	2006	4.16	2684	5.19	3348	6.22	4013
4/0	107.2	1-1/4	31.8	2.42	1561	3.63	2342	4.84	3123	6.05	3903	7.26	4684
250 kcmil	127.0	1-3/8	34.9	2.96	1910	4.44	2865	5.92	3819	7.40	4774	8.88	5729
300	152.0	1-1/2	38.1	3.42	2206	5.13	3310	6.84	4413	8.55	5516	10.26	6619
350	177.0	1-1/2	38.1	3.81	2458	5.72	3690	7.62	4916	9.53	6148	11.44	7381
400	203.0	1-5/8	41.3	4.18	2967	6.27	4045	8.36	5394	10.45	6742	12.54	8090
500	253.0	1-3/4	44.5	4.92	3174	7.38	4761	9.84	6348	12.30	7935	14.76	9523
600	304.0	1-7/8	47.6	5.97	3852	8.96	5781	11.94	7703	14.93	9632	17.92	11561
700	354.0	2	50.8	6.68	4310	10.02	6465	13.36	8619	16.70	10774	20.04	12929
750	380.0	2	50.8	7.04	4542	10.56	6813	14.08	9084	17.60	11355	21.12	13626
800	406.0	2-1/8	54.0	7.39	4768	11.09	7155	14.78	9535	18.48	11923	22.18	14310
900	456.0	2-1/4	57.2	8.09	5219	12.13	7826	16.18	10439	20.22	13045	24.26	15652
1000	506.0	2-1/4	57.2	8.77	5658	13.15	8484	17.54	11316	21.92	14142	26.30	16968
1250	633.0	2-1/2	63.5	11.03	7116	16.55	10677	22.06	14232	27.58	17794	33.10	21355
1500	760.0	2-3/4	69.9	12.74	8219	19.11	12329	25.48	16439	31.85	20548	38.22	24658
1750	886.0	2-7/8	73.0	14.45	9323	21.67	13981	28.90	18645	36.12	23303	43.34	27961
2000	1012.0	3-1/8	79.4	16.04	10348	24.06	15523	32.08	20697	40.10	25871	48.12	31045

[a] 8 AWG is the minimum size of wire to be considered if the device is marked "Suitable for Use As Service Equipment."

Table 74.3
Minimum Width of Gutter and Wire-Bending Space in inches (mm)

Size of wire		Wires per terminal (pole)									
AWG or kcmil	(mm^2)	1		2		3		4		5	
14 – 10	(2.1 – 5.3)	Not specified		–		–		–		–	
8 – 6	(8.4 – 13.3)	1-1/2	(38.1)	–		–		–		–	
4 – 3	(21.1 – 26.7)	2	(50.8)	–		–		–		–	
2	(33.6)	2-1/2	(63.5)	–		–		–		–	
1	(42.4)	3	(76.2)	–		–		–		–	
1/0 – 2/0	(53.5 – 67.4)	3-1/2	(88.9)	5	(127)	7	(178)	–		–	
3/0 – 4/0	(85.0 – 107)	4	(102)	6	(152)	8	(203)	–		–	
250	(127)	4-1/2	(114)	6	(152)	8	(203)	10	(254)	–	
300 – 350	(152 – 177)	5	(127)	8	(203)	10	(254)	12	(305)	–	
400 – 500	(203 – 253)	6	(152)	8	(203)	10	(254)	12	(305)	14	(356)
600 – 700	(304 – 355)	8	(203)	10	(254)	12	(305)	14	(356)	16	(406)
750 – 900	(380 – 456)	8	(203)	12	(305)	14	(356)	16	(406)	18	(457)
1000 – 1250	(507 – 633)	10	(254)	–		–		–		–	
1500 – 2000	(760 – 1010)	12	(305)	–		–		–		–	

Notes –

1) The table includes only those multiple-conductor combinations that are likely to be used. Combinations not mentioned may be given further consideration.

2) For circuit breakers rated 125 amperes or less, and marked to indicate use of both 60 °C and 75 °C wire, the wire bending space is based on the use of 60 °C (140 °F) insulated wire.

Table 74.4
Minimum Wire-Bending Space at Terminals in inches

Wire size		Wires per terminal (pole)[a]							
AWG or kcmil	(mm^2)	1		2		3		4 or more	
14 – 10	(2.1 – 5.3)	Not Specified		–		–		–	
8	(8.4)	1-1/2		–		–		–	
6	(13.3)	2		–		–		–	
4	(21.2)	3		–		–		–	
3	(26.7)	3		–		–		–	
2	(33.6)	3-1/2		–		–		–	
1	(42.4)	4-1/2		–		–		–	
1/0	(53.5)	5-1/2		5-1/2		7		–	
2/0	(67.4)	6		6		7-1/2		–	
3/0	(85.0)	6-1/2	(1/2)	6-1/2	(1/2)	8		–	
4/0	(107)	7	(1)	7-1/2	(1-1/2)	8-1/2	(1/2)	–	
250	(127)	8-1/2	(2)	8-1/2	(2)	9	(1)	10	
300	(152)	10	(3)	10	(2)	11	(1)	12	

Table 74.4 Continued on Next Page

Table 74.4 Continued

Wire size		Wires per terminal (pole)[a]							
AWG or kcmil	(mm^2)	1		2		3		4 or more	
350	(177)	12	(3)	12	(3)	13	(3)	14	(2)
400	(203)	13	(3)	13	(3)	14	(3)	15	(3)
500	(253)	14	(3)	14	(3)	15	(3)	16	(3)
600	(304)	15	(3)	16	(3)	18	(3)	19	(3)
700	(355)	16	(3)	18	(3)	20	(3)	22	(3)
750	(380)	17	(3)	19	(3)	22	(3)	24	(3)
800	(405)	18		20		22		24	
900	(456)	19		22		24		24	
1000	(507)	20		–		–		–	
1250	(633)	22		–		–		–	
1500	(760)	24		–		–		–	
1750	(887)	24		–		–		–	
2000	(1013)	24		–		–		–	

[a] Wire bending space shall be permitted to be reduced by the number of inches shown in parentheses under the following conditions:

1. Only removable wire connectors receiving one wire each are used, (there may be more than one removable wire connector per terminal).

2. The removable wire connectors can be removed from their intended location without disturbing structural or electrical parts other than a cover, and can be reinstalled with the conductor in place.

For SI units one inch = 25.4 mm

74.6 The clear wiring space, independent of all projections, obstructions, or interference from moving parts of the operating mechanism, shall be fully adequate for the wiring of the circuit breaker, and shall not be less in total area than 250 % of the total cross-sectional area of the maximum number of wires that may be used in such space.

74.7 Minimum values for some of the more common multiple-wire conditions are specified in Table 74.2.

74.8 To determine whether a wiring space complies with the requirements in 74.6, consideration is to be given to the actual size of the wires that will be used in the space; but it is to be assumed that wires smaller than 12 AWG (3.3 mm^2) will not be used. In computing the actual area of a wiring space, consideration is to be given to all the available space that may be used properly for the placement of wires.

74.9 The wire-bending space at the line and load terminals shall be as specified in Table 74.4 for the conductor size that corresponds with the maximum ampere rating of the circuit breaker.

74.10 The wire-bending space from a connector to any barrier or other obstruction that is part of a circuit-breaker enclosure shall be as specified in Table 74.3.

74.11 If a wire is restricted by barriers or other means from being bent in a 90° or S bend from the terminal to any usable location in the wall of the enclosure, the distance is to be measured from the end of the barrier or other obstruction to the wall of the enclosure.

74.12 The distance mentioned in 74.9 and 74.10 is to be measured in a straight line from the edge of the wire terminal closest to the wall in a direction perpendicular to the box wall or barrier. The wire terminal shall be turned so that the axis of the wire opening in the connector is as close to perpendicular to the wall of the enclosure as it can assume without defeating any reliable means provided to prevent its turning, such as a boss, shoulder, walls of a recess, multiple bolts securing the connector, or the like. A barrier, shoulder, or the like, is to be disregarded when the measurement is being made if it does not reduce the radius to which the wire must be bent. If a terminal is provided with one or more connectors for the connection of conductors in multiple, the distance is to be measured from the wire opening closest to the wall of the enclosure.

Exception: Side wire-bending space, such as at a neutral in a side gutter, may be measured in a straight line from the center of the wire opening in the direction the wire leaves the terminal.

74.13 The construction and arrangement of the operating mechanism and its relation to the wiring space shall be such that it will not damage wires that it may contact during operation of the breaker. Preferably, the operating mechanism should not touch any wires.

MARKINGS

75 Details

75.1 Each circuit breaker shall be marked with a metal nameplate indicating the following in addition to the requirements in Section 59, Details:

75.2 A circuit breaker shall indicate clearly whether it is open or closed.

75.3 A circuit breaker shall be marked with instructions for resetting the circuit breaker.

75.4 A two-pole circuit breaker that has been investigated and found acceptable for controlling a 3-phase circuit may be marked "1Φ-3 Φ".

75.5 A two-pole or a three-pole circuit breaker that is rated for use only on a three-wire, direct-current or single-phase alternating-current system having a grounded neutral shall be marked with a combination voltage rating, such as "125/250 volts" or "120/240 volts ac."

75.6 A three-pole circuit breaker that is rated for 250 volt dc use may be marked " 250 v dc" provided that it is clearly indicated that the rating applies to the use of at least two poles to control the circuit.

75.7 Any characteristic of a circuit breaker that may adversely affect its operation under certain conditions of use, such as that of polarity or position, shall be clearly indicated by a marking on the circuit breaker.

75.8 If any field-wiring terminal is marked to indicate that aluminum wire may be used at that terminal, such as by being marked with the symbol "AL," and if such marking is visible under the conditions specified in 75.14, the circuit breaker shall be marked in accordance with 75.9, 75.10, or 75.11, whichever applies. Also see 75.16.

75.9 If, because of wiring space or other factors, no terminal is acceptable for use with aluminum conductors, the circuit breaker shall be marked "USE COPPER WIRE ONLY," or equivalent wording.

75.10 If the wiring space and other factors are such that all terminals are acceptable for use with aluminum conductors as well as with copper conductors, the circuit breaker shall be marked "USE COPPER OR ALUMINUM WIRE," or equivalent wording.

75.11 If the wiring space and other factors are such that some terminals are acceptable for use with aluminum conductors as well as with copper conductors, while the remainder of the field-wiring terminals are acceptable for use with copper conductors only, the circuit breaker shall be marked "USE COPPER WIRE ONLY EXCEPT AT TERMINALS....." or equivalent wording. The marking shall positively identify the terminals that are acceptable for use with aluminum wire.

75.12 A circuit breaker shall be marked in a readily visible location with the required temperature rating for field-installed conductors if the wire-temperature rating required is higher than that marked on the circuit-breaker mechanism housed within the enclosure.

75.13 The word "terminal" as used in 75.8 – 75.11 signifies any terminal in the enclosure as well as the terminals of any circuit breaker mechanism or neutral assembly that is installed or intended to be installed in the enclosure.

75.14 The term "visible" as used in 75.8 signifies a marking that will be visible when the cover of the enclosure is removed. A marking on a separately supplied connector or on a connector or part thereof that is likely to be removed or displaced during the wiring operation is considered to be visible.

75.15 The characters in the markings described in 75.9 – 75.11 shall be legible and not less than 1/16 inch (1.6 mm) high.

75.16 A terminal intended to secure a field-installed 1 AWG (42.4 mm^2), Type RH, THW wire, or the like, mentioned in the notes to Table 74.1, shall be so identified in a readily visible location. The marking shall indicate the size and type of insulation of the conductor for which the terminal is intended, and if both copper and aluminum conductors are involved the marking shall clearly indicate "USE OF NO. 1 ALUMINUM LIMITED TO RH OR THW WIRE ONLY." Reference to other types of wire, as mentioned in the notes to Table 74.1, may be made in the marking.

75.17 The abbreviation "CU" for the word copper and "AL" for the word aluminum may be used in any required marking.

75.18 A circuit breaker acceptable for use as service equipment may be marked "Suitable for use as service equipment."

75.19 If a circuit breaker enclosure is marked "Suitable only for use as service equipment," the service disconnecting means for ungrounded conductors shall be marked “Service disconnect.”

75.20 The marking "Service disconnect" identifying the service disconnecting circuit breakers required by 75.21 is to appear on or adjacent to the circuit breaker handle.

75.21 A circuit breaker that has been found acceptable for use on circuits having high available fault currents may be marked with the current-interrupting rating or ratings for which it has been found acceptable. Each rating shall be given in rms symmetrical amperes at a given voltage rating. The marking shall be as follows:

"Current-Interrupting Rating(s)
Max RMS. Sym. Amperes . . ., Volts . . ."

75.22 A circuit breaker enclosure shall be marked as required by 75.1 – 75.21, except that in place of the electrical ratings – 59.3(c) and 75.4 – 75.7, 75.18, and 75.21 – the enclosure shall be marked to indicate the manufacturer, type, and maximum electrical ratings of the circuit breaker mechanism or mechanisms for which it is intended to be used and shall include the marking: "See additional marking on circuit breaker Mechanism," or equivalent wording.

75.23 Except as indicated in 75.24, the marking in 75.22 shall be on the metal nameplate.

75.24 The information covering the circuit breaker mechanisms for which an enclosure is intended to be used may be on a paper label secured to the inside of the enclosure where it is readily visible. The nameplate is then to bear a reference to the location of this information, for example, "For use only with circuit breakers listed on inside of cover."

75.25 A neutral assembly that is found to be acceptable for separate shipment shall comply with the following:

a) The neutral assembly shall be marked with its own ampere rating, its own catalog number or the equivalent, and the manufacturer's name or trademark; and

Exception: A neutral assembly need not be marked with its ampere rating provided that all enclosures in which it is to be used are marked with the neutral catalog number or the equivalent and the neutral ampere rating.

b) The circuit breaker or circuit breaker enclosure shall be marked with the catalog number of the neutral assembly and with an indication of the voltage ratings for which the neutral bus bar must be used.

PART VIII – OUTLET BOXES AND FITTINGS

76 General

76.1 General

76.1.1 Outlet boxes and fittings shall comply with the applicable requirements of Part I – Part IV of this Standard in addition to the requirements in Part VIII.

76.1.2 These requirements cover capped elbows, outlet boxes, conduit fittings for draining or venting, conduit fittings for sealing, conduit unions, cord connectors, flexible-connection fittings, mineral insulated cable fittings, blanking elements, thread adapters, and luminaire fittings of the adjustable, flexible, and rigid types.

76.2 Blanking elements

76.2.1 NPT blanking elements

76.2.1.1 NPT blanking elements shall comply with the following:

a) When made from materials other than stainless steel, thread shall conform to the NPT requirements of ASME B1.20.1;

b) When made from stainless steel, shall conform to the NPT thread form requirements of ASME B1.20.1, except that the male threads shall gauge with plus 1/2 to plus 1-1/2 turns beyond the L-1 gauging notch in lieu of the ±1 turns described in ASME B1.20.1;

c) The effective thread length shall not be less than the “L2” dimension;

d) On fittings with a shoulder or other interruption, a thread length not less than the L4 dimension defined shall be provided between the face of the shoulder and the end of the fitting thread; and

e) There shall be a provision for installation / removal using a tool.

76.2.2 Metric blanking elements

76.2.2.1 Metric blanking elements shall comply with the following:

a) The thread form for external threads shall have a tolerance Class of 6 g or better according to ISO 965-1 and ISO 965-3, and any chamfer or undercut shall be limited to a maximum axial length of 2 mm from both sides of the threaded part; and the threaded part shall comprise at least eight full threads. If the thread is provided with an undercut, then a non-detachable and non-compressible washer or equivalent device shall be fitted to ensure the required length of thread engagement;

b) A shoulder or interruption shall be included to preclude the blanking element from being threaded fully through the enclosure wall; and

c) There shall be a provision for installation / removal using a tool.

76.2.3 Thread adapters

76.2.3.1 Thread adapters shall comply with the following:

a) A male NPT thread;

1) Made from materials other than stainless steel, shall conform to the NPT requirements of ASME B1.20.1;

2) Made from stainless steel, shall conform to the NPT thread form requirements of ASME B1.20.1, except that the male threads shall gauge with plus 1/2 to plus 1-1/2 turns beyond the L-1 gauging notch in lieu of the ±1 turns described in ASME B1.20.1.

b) A female NPT thread;

1) Thread form shall conform to the NPT requirements of ASME B1.20.1;

2) Shall gauge with plus 1/2 to plus 3-1/2 turns beyond the L-1 gauging notch in lieu of the ±1 turns described in ASME B1.20.1; and

3) Effective thread length shall not be less than the “L2” dimension; and

c) Metric male threads shall have a tolerance Class of 6 g or better according to ISO 965-1 and ISO 965-3, and any chamfer or undercut shall be limited to a maximum axial length of 2 mm from both sides of the threaded part; and the threaded part shall comprise at least eight full threads. If the thread is provided with an undercut, then a non-detachable and non-compressible washer or equivalent device shall be fitted to ensure the required length of thread engagement, and a shoulder or interruption shall be included to preclude the blanking element from being threaded fully through the enclosure wall;

d) Metric female threads shall have a tolerance Class of 6H or better according to ISO 965-1 and ISO 965-3, and any chamfer or undercut shall be limited to a maximum axial length of 2 mm from the external wall surface; and the threaded part shall include at least five full threads; and

e) Threads shall be co-axial designs. Alternatively, other designs (such as elbow adapters) shall comply with all of the following:

1) When metric on the side with the male thread, incorporate an external locknut (to secure the adapter in the intended direction); and

2) The length and internal volume of thread adapters shall be minimized.

77 Material Thickness

77.1 A flexible fitting with thin corrugated-metal walls shall have an insulating inner liner to prevent electric arcs from burning through the walls. The insulating liner shall withstand arcing when tested as described in the Arcing Test, Section 92.

77.2 The flexible-metal tubing and reinforcing braid of a flexible fitting shall be soldered, brazed, or welded to the end connectors. Soft solders in flexible fixture fittings shall withstand the Endurance Load at Elevated Temperature Test, Section 95. The depth of a soft-solder seal between each end fitting and the flexible metal tubing shall not be less than 5/8 inch (15.9 mm).

77.3 A flexible fitting shall have approximately the same inside diameter as that of the corresponding trade size of conduit. The inside diameters of an end fitting and an insulating liner shall be approximately the same.

77.4 The minimum wall thickness of an outlet box or fitting shall not be less than that specified in Table 9.1.

Exception No. 1: A flexible fixture fitting need not comply with this requirement.

Exception No. 2: A flexible connection fitting need not comply with this requirement.

Exception No. 3: A mineral insulated cable fitting need not comply with this requirement.

Exception No. 4: The thickness at a bottomed hole in the enclosure need not comply with this requirement. See 12.2, 12.3, 38.2 and 38.3.

78 Supply Connections for Class I Locations

78.1 Supply connections for outlet boxes and fittings shall be constructed in accordance with Supply Connections, Section 14.

Exception: A box need not have provision for connection to conduit if instructions are provided in accordance with 102.13.

78.2 The hub of a fitting used for the support of a lighting fixture shall be provided with a setscrew to prevent turning of connected conduit that also supports the fixture. The setscrew shall be located to the outside of five full threads of the supply opening.

79 Supply Connections for Class II Locations

79.1 Supply connections for outlet boxes and fittings shall be constructed in accordance with Supply Connections, Section 40.

Exception: A box need not have provision for connection to conduit if instructions are provided in accordance with 102.13.

79.2 A conduit box or a fitting that is supported by conduit shall be provided with an opening having at least five full threads for attachment of the conduit.

79.3 A conduit box or a fitting that is not intended to be supported by conduit shall be provided with an opening having at least 3-1/2 threads for attachment of the conduit.

80 Fitting for Mineral Insulated Cable

80.1 A mineral insulated cable fitting shall be provided with male threads conforming to the requirements for male NPT threaded fitting in 14.1.1.4.

81 Conduit Fittings for Sealing

81.1 A conduit fitting for sealing shall be constructed to permit introduction of sealing compound to a depth equal to not less than the internal diameter of the conduit, but in no case to a depth less than 5/8 inch (15.9 mm). The construction of the device shall be such as to provide a tight seal and to retain the compound in place.

81.2 The intention of the requirement in 81.1 is to obtain at least a full 5/8 inch (15.9 mm) depth of sealing compound at any point between conduit openings. In fittings for vertical mounting, the required depth is to be measured between the top of the lower conduit stop and the lowest edge of the tapped opening for introducing the compound.

81.3 The sealing compound shall form a permanent seal under service conditions. The compound shall not be affected adversely by the hazardous vapors in which it is intended to be used.

81.4 A plug having at least five full tapered threads is considered satisfactory for closing the opening for introduction of the sealing compound.

82 Flexible Fittings

82.1 A flexible fitting shall have a length of flexible central section of not more than 36 inches (0.9 m).

82.2 A flexible fixture fitting shall be provided with a setscrew in a connector having internal conduit threads. The set screw shall be located outside of the conduit threads.

83 Mineral Insulated Cable Fittings

83.1 A fitting for mineral insulated cable shall be provided with means for sealing the end of the cable against moisture.

83.2 In addition to complying with the requirements for ordinary locations, a sealing compound shall not be affected adversely by the hazardous vapors in which it is intended to be used. See Section 100, Solvent and Water Condensate Exposure Test.

83.3 If the sealing compound is of the softening type, it shall have a softening point of not less than 93 °C (200 °F) as determined by the Standard Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

84 Cord Connectors for Mobile or Portable Equipment

84.1 General

84.1.1 These cord connectors are for use in making connections between a device for Class I, Groups A, B, C, and D or Class II, Groups F and G locations and multiple-conductor flexible cord with ground conductor listed for extra-hard-usage.

84.2 Terminal enclosure

84.2.1 Class I locations

84.2.1.1 The terminal enclosure shall be made of metal having a minimum thickness as specified in Table 9.1.

84.2.1.2 If each terminal is of a type that permits turning of a screw end, a head (wire-binding screw), or a nut in contact with the strands of the cord conductor, the terminal enclosure shall:

a) Withstand the internal pressures resulting from explosions without bursting or loosening at the joints;

b) Have metal-to-metal joints in accordance with 10.1.1 – 10.4.3; and

c) Withstand a hydrostatic test.

84.2.1.3 If each terminal is of a type that provides a spacing of at least 3/16 inch (4.8 mm) shortest distance between terminals, is insulated, and does not have a screw end, a head (wire-binding screw), or a nut in contact with the strands of the cord conductor, the terminals shall be enclosed, but the explosionproof construction specified in 84.2.1.2 need not be provided. The entrance for the power-supply cord may be closed with a molded-rubber bushing conforming to the Accelerated Aging of Bushing Test, Section 98.

84.2.1.4 With reference to the requirements in 84.2.1.2, the terminals may be of the pressure wire connector type where the wiring is clamped between two plates.

84.2.2 Class II, Groups F and G locations

84.2.2.1 A terminal enclosure shall be made of metal having a minimum thickness as indicated in Table 9.1.

84.2.2.2 If each terminal is of a type that permits turning of a screw end, a head (wire-binding screw), or a nut in contact with the strands of the cord conductor, the terminal enclosure shall:

a) Prevent the entrance of dust in grain dust-air atmospheres; and

b) Have metal-to-metal, gasketed, or threaded joints in accordance with 36.1 – 36.7.

84.2.2.3 If each terminal is of a type that provides a spacing of at least 3/16 inch (4.8 mm) shortest distance between terminals, is insulated, and does not have a screw end, a head (wire-binding screw), or a nut in contact with the strands of the cord conductor, the terminals shall be enclosed, but the dust-ignitionproof construction specified in 84.2.2.2 need not be provided. The entrance for the connection cord may be closed with a molded-rubber bushing conforming to the requirement in the Accelerated Aging of Bushing Test, Section 98.

84.2.2.4 With reference to the requirements in 84.2.2.3, the terminals may be of the pressure wire connector type where the wiring is clamped between two plates.

84.3 Insulating bases

84.3.1 A base or a body in or on which live metal parts are mounted shall be of porcelain, phenolic, urea, or cold molded composition or of another insulating material that has been investigated and found to have equivalent properties for the particular application.

84.3.2 Among the factors taken into consideration when judging the equivalency of a nonmetallic material are its:

a) Physical strength;

b) Resistance to impact;

c) Moisture absorptive properties;

d) Flammability;

e) Resistance to corrosion;

f) Resistance to solvents as covered in hazardous area group classification;

g) Resistance to accumulations of dangerous electrostatic charges; and

h) Resistance to distortion at temperatures to which the connector may be subjected under conditions of intended or abnormal use.

All of these factors are to be considered with respect to thermal aging.

84.3.3 Except for a raintight device, vulcanized fiber may be used for an insulating washer, a separator, and a barrier, but shall not be used as the sole support for live parts.

84.3.4 With respect to the requirement in 84.3.3, hard rubber is not acceptable.

84.4 Live parts

84.4.1 Ferrous materials, plain or plated, shall not be used for a part that is depended upon to carry current or for a wire-binding nut and screw.

Exception: Stainless steel may be employed for a part not subject to arcing, if it is found to be acceptable.

84.4.2 A live part shall be prevented from turning relative to the surface on which it is mounted if such turning would affect adversely the performance of the device.

84.4.3 Uninsulated live parts shall be secured in place so that a reduction in the spacings less than those specified in 84.8.1 is not likely.

84.5 Grounding

84.5.1 A cord connector shall have provisions for interconnection of the equipment grounding conductor to the grounding conductor of the power-supply cord.

84.5.2 Except for the metal housing, the grounding contact path shall be of copper or a copper base alloy. Also see 84.5.4.

84.5.3 A rivet, a bolt, or a clamp that is used to secure parts in the grounding path, but that is not an essential conductor in the grounding path, may be of steel or equivalent material.

84.5.4 A copper-base-alloy rivet that is used to hold parts in the grounding contact path together or that forms a part of the grounding path shall contain not less than 80 % copper.

84.5.5 Connections in the grounding contact path shall be secured by riveting, bolting, welding, or equivalent positive means.

84.6 Terminals

84.6.1 A cord connector shall be provided with suitable field-wiring terminals for the connection of conductors having an ampacity, in accordance with NFPA 70 not less than the current rating of the cord connector.

84.6.2 A field-wiring terminal intended solely for the connection of an equipment-grounding conductor shall be capable of securing a conductor of the size designated for the particular application, in accordance with NFPA 70. A connection that depends upon solder shall not be used.

84.6.3 Each field-wiring terminal shall be provided with a pressure wire connector acceptable for the size wire with which it is intended to be used.

84.6.4 Other forms of construction may be accepted if the ampacity and mechanical features are found to be equivalent to the connection described in 84.6.3.

84.6.5 A field-wiring terminal shall be prevented from any turning or shifting in position that may impair the assembly by means other than friction between surfaces. This may be accomplished by:

a) Screws or rivets;

b) Square shoulders or mortises;

c) A dowel pin, lug, or an offset;

d) A connecting strap or a clip fitted into an adjacent part; or

e) Some other equivalent method.

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

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

84.6.7 A terminal plate tapped for a wire-binding screw shall be of metal no less than 0.050 inch (1.27 mm) thick, except that a plate no less than 0.030 inch (0.76 mm) thick is acceptable if the tapped threads have two or more full threads in the metal, which may be extruded if necessary to provide the threads.

84.6.8 An upturned lug or a cupped washer shall be capable of retaining under the head of the screw or the washer a conductor of the size mentioned either in 84.6.1 [but not smaller than 14 AWG (2.1 mm^2)] or in 84.6.2, whichever is applicable.

84.6.9 A wire-binding screw shall thread into metal.

84.6.10 A field-wiring terminal intended for the connection of a grounded conductor shall be of, or plated with, a metal substantially white in color – such as nickel – and shall be distinguishable from the other terminals, or identification of that terminal shall be shown by some other means.

84.6.11 The terminal for the connection of an equipment-grounding conductor shall have a permanent identification that is recognizable during installation and that is one of the following:

a) A terminal screw that is not readily removable (staked or otherwise held captive) and that has a green-colored head that is hexagonal-shaped, slotted, or both;

b) A hexagonal green-colored nut that is not readily removable from a threaded terminal stud;

c) A visible pressure wire connector that has a green-colored body or an appendage that is not readily removable from the connector; or

d) A concealed pressure wire connector identified in accordance with 84.6.12.

84.6.12 If a pressure wire connector at the equipment-grounding terminal is located within an insulating body and is not visible, the wire-entrance hole for a connection to that terminal shall be identified by one of the following:

a) A distinct green-colored area immediately adjacent to the wire-entrance hole; or

b) The letter or word, G, GR, GRN, Ground, Grounding, or Green distinctively marked immediately adjacent to the wire-entrance hole in letters at least 1/16 inch (1.6 mm) high.

84.6.13 A readily removable (not staked or otherwise held captive) part of an equipment-grounding terminal, such as a setscrew or a clamping member, shall not be colored green or otherwise identified as part of the grounding terminal if the part may be interchanged with a similar part of another terminal on the device.

84.7 Leads

84.7.1 A lead intended for the connection to the grounded conductor or terminal shall be finished to show a white or gray color and shall be distinguishable from the other leads.

84.7.2 The surface of an insulated lead intended solely for the connection to an equipment-grounding conductor or terminal shall be green with or without one or more yellow stripes, and no other lead shall be so identified.

84.7.3 The free length of a lead intended for connection to a device or an appliance shall not be less than 6 inches (150 mm).

84.8 Spacings

84.8.1 Except as noted in 84.8.2, the spacings in a cord connector shall be in accordance with Table 84.1.

84.8.2 In measuring a spacing, an isolated dead metal part interposed between live parts of opposite polarity or between a live part and a grounded or exposed dead metal part is considered to reduce the spacing by an amount equal to the dimension of the isolated dead metal part in the direction of the measurement.

Table 84.1
Minimum Acceptable Spacings

Parts involved		Potential involved In volts, 0 – 600	
		inch	(mm)
Between any uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded dead-metal part other than the enclosure, or an exposed dead-metal part that is isolated (insulated).	Through air	3/16	(4.8)
	Over surface	3/16	(4.8)
Between any uninsulated live part and the walls of a metal enclosure	Shortest distance	1/4	(6.4)

84.8.3 Insulating barriers as described in 84.9.1 – 84.9.5 may be provided as part of or in lieu of the spacings specified in 84.8.1.

84.9 Insulating barrier or liner

84.9.1 An insulating barrier or a liner used as the sole separation between an uninsulated live part and a grounded dead metal part (including the enclosure) or between uninsulated live parts of opposite polarity, shall be of material acceptable for the mounting of an uninsulated live part and shall not be less than 0.028 inch (0.71 mm) thick.

84.9.2 Fiber not less than 0.028 inch (0.71 mm) thick may be used as the sole separation between the enclosure and an uninsulated metal part electrically connected to a grounded circuit conductor.

84.9.3 Except as noted in 84.9.4, an insulating barrier or a liner that is used in addition to an air space in place of the required spacing through air shall not be less than 0.028 inch (0.71 mm) thick. If the barrier or the liner is of fiber, the air space shall not be less than 1/32 inch (0.8 mm). If the barrier or the liner is of a material that is not acceptable for the support of an uninsulated live part, the air space provided shall be that required for the application.

84.9.4 A barrier or a liner that is used in addition to not less than one-half the required spacing through air may be less than 0.028 inch (0.71 mm) thick but shall not be less than 0.013 inch (0.33 mm) thick if the barrier or the liner is:

a) Of a material that is acceptable for the mounting of an uninsulated live part, or of fiber or similar material;

b) Of the necessary mechanical strength if exposed or otherwise likely to be subjected to mechanical damage;

c) Securely held in place; and

d) Located so that it will not be affected adversely by arcing or by operation of the equipment in service.

84.9.5 An insulating material having a thickness less than that specified in 84.9.1, 84.9.3, and 84.9.4 may be used, if upon investigation it is found to be acceptable for the particular application.

84.10 Seal

84.10.1 A seal shall be provided between the terminal end of the connector intended for the connection of the flexible cord and the end of the connector intended for connection to the portable or mobile equipment as indicated in 84.10.2 – 84.10.5.

84.10.2 A sealing compound or a cement used for the seal shall:

a) Not be less than 5/8 inch (15.9 mm) deep;

b) Neither soften nor crack under the service conditions;

c) Ensure a tight fit; and

d) Not be affected adversely by the hazardous vapors in which it is intended to be used.

84.10.3 A compound that contacts uninsulated live parts shall be of the nonconductive type.

84.10.4 The sealing compound shall neither flow nor creep at the operating temperature of the device. A sealing compound of the softening type shall have a softening point of not less than 93 °C (200 °F) as determined by the Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

84.10.5 In lieu of sealing compound, the seal may consist of explosionproof joints between the parts as specified in this standard. The joints may be metal-to-metal or metal-to-nonconductive material.

84.11 Packing gland

84.11.1 A packing gland (stuffing box) shall be provided at the cord entrance to the terminal enclosure if constructed as described in 84.2.1.2 or 84.2.2.2.

84.11.2 The packing material for the gland shall be polytetrafluoroethylene packing material having a diameter or thickness of not less than 3/32 inch (2.4 mm) or a material having similar characteristics. There shall be a sufficient amount of packing material to completely surround the cord and provide a tightly compressed seal when the packing gland is assembled. The depth of tightly-compressed seal shall be at least 5/8 inch (15.9 mm) if the terminal enclosure is constructed as described in 84.2.1.2 and at least 1/2 inch (12.7 mm) if the terminal enclosure is constructed as described in 84.2.2.2. The construction and amount of packing shall be such that, with the packing properly compressed, the compression nut still has a travel distance of at least 1/8 inch (3.2 mm) before interfering with parts other than packing material. The compression nut shall be mechanically secured against loosening.

84.11.3 The diametrical clearance between the outer jacket of the power-supply cord and the surrounding cavity for packing material shall not exceed three times the diameter of the packing material. At each end of the cavity for the packing material, the diametrical clearance between the openings in the gland parts and the outer jacket of the cord shall not exceed:

a) 1/16 inch (1.6 mm) for packing material less than 1/4 inch (6.4 mm) diameter; or

b) 3/16 inch (4.8 mm) for packing material 1/4 inch diameter or larger.

84.11.4 All metal surfaces of the gland and terminal enclosure adjacent to the cord shall be smooth and shall have well-rounded edges.

84.12 Cord clamp

84.12.1 A positive mechanical cord clamp shall be provided that permits the power-supply cord to be replaced, and prevents stress at cord connections within the terminal enclosure. A cord clamp that is threaded to the terminal enclosure shall form a tight engagement or shall be secured against turning or loosening by a setscrew or the equivalent. The clamp shall be smooth and free from sharp edges that may damage the jacket of the flexible cord.

84.12.2 The cord clamp shall be in addition to the packing gland.

84.13 Securement of threaded engagements

84.13.1 Threaded joints entering an explosionproof or dust-ignitionproof terminal enclosure of a cord connector shall be secured against loosening by a setscrew or the equivalent.

84.13.2 A setscrew or the equivalent shall also be provided to secure the connector to the portable or mobile equipment to which it is intended to be attached.

84.14 External metal parts

84.14.1 All external metal parts of a cord connector that may be struck by or strike against foreign objects shall be made of nonsparking material such as brass or aluminum.

PERFORMANCE

85 Explosion Test

85.1 Explosion testing performed on outlet boxes and fittings is performed in accordance with Section 21, Explosion Tests, except as specifically required in 85.2 – 85.6.

Exception No. 1: A conduit fitting for sealing, a conduit union, a conduit elbow, a blanking element, a thread adapter, and any other similar fitting, other than a flexible connection fitting or flexible fixture fitting, that does not increase the internal cross-sectional area of the conduit on which it is intended to be installed need not be subjected to explosion tests if:

a) The fitting is for use in Group C, Group D, or Groups C and D locations; or

b) The fitting is for use in Group A, Group B, or Groups A and B, locations and all joints are tapered, threaded type, with taper of 3/4 inch per foot (60 mm/m); and

c) The fitting is subjected to a hydrostatic pressure strength test in accordance with 86.1.1.

Exception No. 2: A flexible connection fitting or flexible fixture fitting need not be subjected to explosion tests if the fitting is subjected to a hydrostatic pressure strength test in accordance with 86.1.2.

85.2 Conduit lengths are to be connected to the box or the fitting. The lengths of conduit to be used shall be as indicated in Table 85.1.

Table 85.1
Lengths of Rigid Metal Conduit for Explosion Tests

Class I hazardous location Groups	Trade size of conduit, inch (mm OD)		Conduit length[a]
Sealing fittings, pull boxes, and unions			
A, B, C	All		5, 10, and 15 feet (1.5, 3.0, and 4.6 m)
D	Less than 2	(60.3)	2 feet (0.6 m)
D	2 or over	(60.3)	5, 10, and 15 feet (1.5, 3.0, and 4.6 m)
Conduit boxes[a] and other fittings			
A, B, C	Less than 2	(60.3)	5, 10, and 15 feet (1.5, 3.0, and 4.6 m)
D	Less than 2	(60.3)	2 feet (0.6 m)

Table 85.1 Continued on Next Page

Table 85.1 Continued

Class I hazardous location Groups	Trade size of conduit, inch (mm OD)	Conduit length[a]
A, B, C, D	2 or over (60.3)	18 inches (455 mm)
[a] Conduit boxes may be tested with shorter lengths of conduit if they are intended to have sealing fittings attached to conduit sizes less than 2 inches (60.3 mm outside diameter) and/or lengths less than 18 inches, and the box is marked as specified in 102.12.		

85.3 A fitting for draining or venting, or a fitting having special threaded joints, is to be tested with joints reduced 25 %.

85.4 The test setup for fittings for draining or venting is to be as illustrated in Figure 85.1 and as described below:

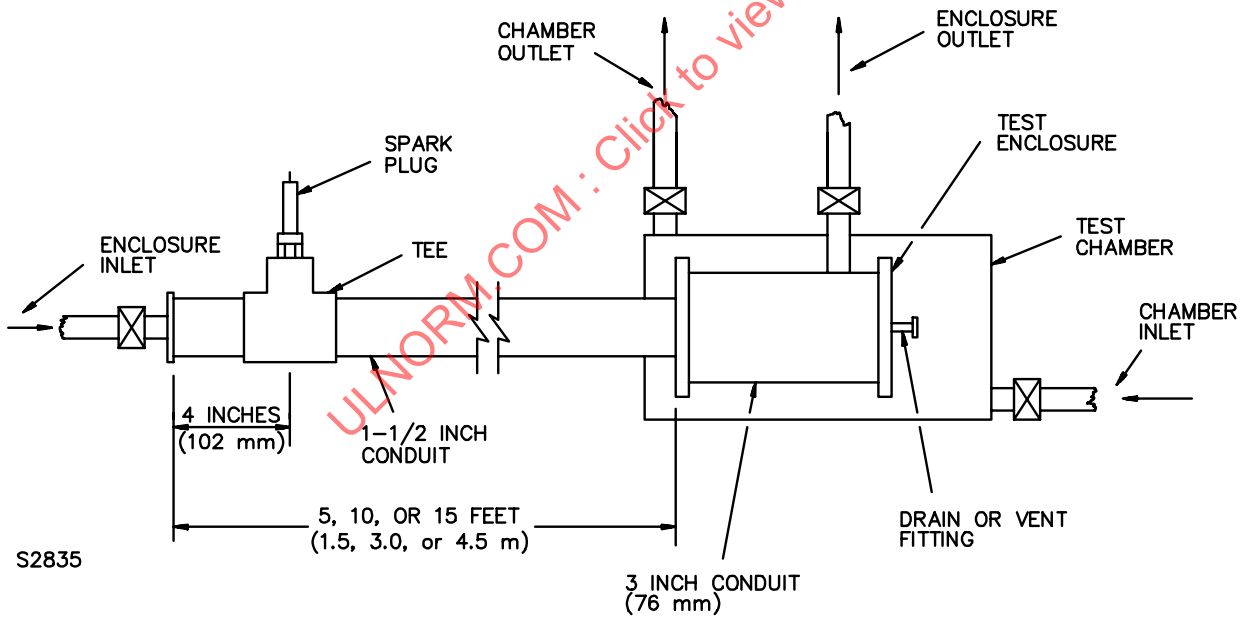
a) The drain or vent fitting is to be mounted in the center of a threaded pipe cap mounted on the end of a 6 inch (152.4 mm) length of a 3 inch trade size threaded rigid-steel conduit.

b) A 1-1/2 inch trade-size threaded rigid-steel conduit is to be attached to the center of a pipe cap threaded onto the other end of the 3 inch trade size conduit.

c) Three series of explosion tests are to be conducted using 5, 10, and 15 foot (1.5, 3.0, and 4.6 m) lengths of the 1-1/2 inch trade size rigid-steel conduit.

Figure 85.1

Test Setup



85.5 For mineral insulated cable fittings, the requirements in 85.2 – 85.6 apply except that the assembly subjected to the explosion tests shall be as specified in 85.6.

85.6 Short lengths of mineral insulated cable having end fittings assembled in accordance with the manufacturer's instructions are to be connected to two sample enclosures representative of explosionproof equipment. One enclosure is to have a free internal volume of 300 – 400 cubic inches (4.9 – 6.6 dm^3). The other enclosure is to have a free internal volume of 1800 – 2100 cubic inches (29.5 – 34.4 dm^3). Representative samples of the cable assemblies are to be installed in each of the enclosures. The inlet of the 300 – 400 cubic inch enclosure is to be provided with 5, 10, and 15 feet (1.5, 3.0, and 4.6 m) of 1-1/2 inch trade-size (48.3 mm outside diameter) conduit. The inlet of the 1800 – 2100 cubic inch enclosure is to be provided with 18 inches (455 mm) of 3 inch trade-size (88.9 mm outside diameter) conduit.

86 Hydrostatic Pressure Test

86.1 General

86.1.1 For a conduit fitting as described in Exception No. 1 to 85.1 that is not subjected to explosion tests, the hydrostatic test pressure is to be as specified in Table 86.2. For lower ambient temperatures below minus 25 °C, the test pressures are increased by the factors shown in Table 86.4.

86.1.2 For a flexible connection fitting or a flexible fixture fitting that is not subjected to explosion tests, the hydrostatic pressure is to be as specified in Table 86.3. There is to be no damage or leakage.

Table 86.1
Safety Factors for Determining the Strength of an Enclosure

Enclosure material or part	Safety factor for calculations	Safety factor for hydrostatic pressure tests
Cast metal	5	4
Fabricated steel	4	3[a]
Bolt	3	3

[a] The enclosure shall withstand a hydrostatic pressure of at least twice the maximum internal explosion pressure without permanent distortion and at least three times the maximum internal explosion pressure without rupture.

Table 86.2
Hydrostatic Pressures for Conduit Fittings for Sealing, Conduit Unions, Conduit Elbows, and Similar Fittings

Conduit trade size of fittings		Required hydrostatic pressure for Class I hazardous locations, psig (kPa)			
inches	(mm OD)	Group A	Group B	Group C	Group D
1/2	(21.3)	6000 (41,400)	6000 (41,400)	1200 (8280)	600 (4140)
3/4	(26.7)	6000 (41,400)	6000 (41,400)	1200 (8280)	600 (4140)
1	(33.4)	6000 (41,400)	6000 (41,400)	1200 (8280)	600 (4140)
1-1/4	(42.2)	6000 (41,400)	6000 (41,400)	1200 (8280)	600 (4140)
1-1/2	(48.3)	6000 (41,400)	6000 (41,400)	1200 (8280)	600 (4140)
2	(60.3)	6000 (41,400)	6000 (41,400)	1200 (8280)	600 (4140)
2-1/2	(73.0)	4000 (27,600)	4000 (27,600)	1200 (8280)	600 (4140)
3	(88.9)	4000 (27,600)	4000 (27,600)	1200 (8280)	600 (4140)
3-1/2	(101.6)	4000 (27,600)	4000 (27,600)	1200 (8280)	600 (4140)
4	(114.3)	4000 (27,600)	4000 (27,600)	1200 (8280)	600 (4140)
5	(141.3)	4000 (27,600)	4000 (27,600)	1200 (8280)	600 (4140)
6	(168.3)	4000 (27,600)	4000 (27,600)	1200 (8280)	600 (4140)

Table 86.3
Hydrostatic Pressures for Flexible Connection Fittings and Flexible Fixture Fittings

Conduit trade size of fittings		Required hydrostatic pressure for Class I hazardous locations, psig (kPa)			
inches	(mm OD)	Group A	Group B	Group C	Group D
1/2	(21.3)	2000 (13,800)	2000 (13,800)	1200 (8280)	600 (4140)
3/4	(26.7)	2000 (13,800)	2000 (13,800)	1200 (8280)	600 (4140)
1	(33.4)	3000 (20,700)	3000 (20,700)	1200 (8280)	600 (4140)
1-1/4	(42.2)	–	–	1200 (8280)	600 (4140)
1-1/2	(48.3)	–	–	1200 (8280)	600 (4140)
2	(60.3)	–	–	1200 (8280)	600 (4140)

Table 86.4
Additional Test Factor for Lower Ambient Temperature Below -25 °C

Fitting material	Additional test factor for hydrostatic test fittings rated for below -25 °C		
	-40 °C	-50 °C	-60 °C
Cast metal	1.5	1.5	1.625
Fabricated steel, stainless steel, or aluminium	1.125	1.125	1.2

86.1.3 A conduit fitting without a seal and the lead-wire seal in a conduit fitting for sealing shall withstand the required hydrostatic test pressure. See 88.3

Exception: If excess leakage occurs, resulting in the inability of the test apparatus to maintain the required pressure in a test of a 2 inch (60.3 mm outside diameter) or larger trade conduit fitting for sealing with wires sealed in the fitting, a fitting with a seal but without wires may be used.

86.1.4 The hydrostatic pressure test on the lead wire seal in a fitting is to be conducted on a seal prepared at room temperature, and on a seal prepared at the minimum temperature specified by the manufacturer in the installation instructions for the fitting or for the sealing compound.

86.1.5 A drain or vent fitting shall withstand for 1 minute without rupture or permanent distortion an internal hydrostatic test pressure as specified in Table 86.2.

86.2 Torque test for blanking elements

86.2.1 An NPT blanking element of each size shall be screwed into a steel test-block containing a threaded entry hole of size and form appropriate to the device under test. The sample shall be tightened to a torque at least equivalent to the appropriate torque given in Table 101.1 using a suitable tool. The test shall be deemed to be satisfactory if the correct thread engagement has been achieved and if, when dismantled, no damage invalidating the type of protection is found.

86.2.2 Metric blanking element of each size shall be screwed into a steel test-block containing a threaded entry hole of size and form appropriate to the device under test. The sample shall be tightened to a torque at least equivalent to the appropriate torque given in Table 86.5 using a suitable tool. The test shall be deemed to be satisfactory if the shoulder has not pulled fully into the thread.

Table 86.5
Tightening Torque Values, Metric

Thread size mm	Tightening torque blanking elements with shoulder Nm
< 16	3,5 *d*[a]
16	65
20	65
25	95
32	110
40	130
50	165
63	195
75	230
>75	3,5 *d*[a]

[a] The variable *d* is the major diameter of thread in millimetres.

86.3 Torque tests for thread adapters

86.3.1 A sample thread adapter of each size shall be screwed into a steel test-block, containing a threaded entry of size and form appropriate to the device under test. A steel or brass threaded plug of appropriate form and size shall be screwed into the female entry of the thread adapter.

86.3.2 The plug shall be tightened to a torque at least equivalent to the torque given in Table 101.1 or Table 86.5, based on the larger of the two threads on the adapter. The test shall be deemed to be satisfactory if no viable deformation to the thread adapter is found when the assembly is dismantled.

87 Dust Penetration Test

87.1 A box or fitting need not be exposed to the circulating dust-air atmosphere if all joints are of the threaded type, or are ungasketed and comply with the requirements in the Exception to 43.1.

87.2 For mineral insulated cable fittings, assemblies as described in 85.6 shall be used in the test, except that the lengths of inlet conduit shall be omitted.

88 Leakage of Sealing Fittings Test

88.1 A sealing fitting having wires sealed with compound provided with the fitting shall not permit the passage of more than 0.007 cubic foot (0.2 L) of air per hour at a pressure of 6 inches (152 mm) of water.

88.2 The test is to be conducted on seals prepared at room temperature and on seals prepared at the minimum temperature specified by the manufacturer in the installation instructions for the fitting or for the sealing compound.

88.3 The number and size of wires that are to be sealed in each sealing fitting shall be as specified in Table 88.1.

Exception: Other numbers and sizes of wires may be used if:

a) A cross section of the wires would fill more than 25 % but not more than 40 % of a cross section of the conduit for the fitting, and

b) They represent the range of wires specified in the instructions for the fitting.

Table 88.1
Number and Size Wires for Sealing Test

Conduit trade size of fittings		Number of wires[a]		Size of wires	
Inches	(mm OD)	TW	THHN	AWG or kcmil	(mm^2)
1/2	(21.3)	7	11	18	(0.82)
3/4	(26.7)	10	16	16	(1.3)
1	(33.4)	10	24	14	(2.1)
1-1/4	(42.2)	13	20	10	(5.3)
1-1/2	(48.3)	10	16	8	(8.4)
2	(60.3)	10	16	6	(13.3)
2-1/2	(73.0)	9	10	2	(33.6)
3	(88.9)	9	9	1/0	(53.5)
3-1/2	(101.6)	9	9	3/0	(85.0)
4	(114.3)	10	10	4/0	(107.2)
5	(141.3)	9	9	400	(203)
6	(168.3)	9	9	600	(304)

[a] Either Type TW or Type THHN wires may be used. Other wire types having external diameters equivalent to either the TW or THHN size specified may be substituted for these wires.

89 High Humidity Tests

89.1 Sample conduit fittings for sealing, conditioned as described in 89.2, shall be subjected to Hydrostatic Pressure Tests, Section 86, and Leakage of Sealing Fittings Test, Section 88.

89.2 Conduit fittings for sealing prepared in accordance with 88.2 and 88.3 are to be subjected to the following environmental conditioning:

a) 60 days at 60 °C (140 °F) and a relative humidity of 95 – 100 %

b) 60 days at 20 °C (68 °F) and relative humidity of 95 – 100 % with a 1 inch (25.4 mm) column of water maintained on the top of the seal.

90 Leakage of Mineral Insulated Cable Fittings Test

90.1 A fitting of each conduit size, having the maximum number of conductors to be used, shall be subjected to the test in 90.2.

90.2 A fitting for mineral insulated cable, assembled and sealed in accordance with the manufacturer's instructions, shall not permit the passage of more than 0.007 cubic foot (0.2 L) of air per hour at a pressure of 6 inches (152 mm) of water.

91 Electrical Resistance Test

91.1 Flexible fittings

91.1.1 A current of 50 amperes flowing through the connections between a flexible connection fitting or a flexible fixture fitting and conduit shall not result in a voltage drop of more than 150 millivolts. The voltage

drop is to be measured between two points, one on each section of conduit 1/16 inch (1.6 mm) from the fitting.

91.2 Boxes or fittings having coated threaded joint surfaces

91.2.1 A conduit box or fitting having threaded joint surfaces or conduit threads on which a metallic paint or noninsulating coating has been applied shall comply with the test described in 91.1.1, except that the voltage drop is to be measured as described in 91.2.2.

91.2.2 For a threaded joint, the voltage drop is to be measured between two points, one on each of the two parts of the box or fitting that comprises the joint. For a conduit opening, the voltage drop is to be measured between two points, one on the box or fitting adjacent to the opening and the other on a length of conduit connected to the opening, and located 1/16 inch (1.6 mm) from the box or fitting.

92 Arcing Test

92.1 A flexible connection fitting and a flexible fixture fitting shall be subjected to an arcing test in which the fitting is wired with one insulated copper wire sized in accordance with the value specified in the second column of Table 92.1. A 2 inch (51 mm) length of bare copper wire, sized in accordance with the value specified in the third column of Table 92.1, is to be spliced in the insulated conductor.

92.2 One sample fitting is to be tested with this bare copper wire located in the center of the fitting, and one sample is to be tested with the bare copper wire located near one end of the fitting. A 250-volt, direct-current voltage supply with series resistance in the line to limit the current flow to the value specified in the fourth column of Table 92.1 is to be used. The flexible metal tubing and reinforcing metal braid of the assembly is to be connected to the negative side of this circuit through a fuse, and the circuit is to be energized until arcing and burnout of the bare copper wire occurs. The size of the fuse is to be 6 amperes for 1/2, 3/4, and 1 inch trade size conduit, 15 amperes for 1-1/4 inch trade size conduit, and 30 amperes for 1-1/2 and 2 inch trade size conduit.

92.3 The grounding fuse shall not open, and the insulating inner liner in the fitting shall not burn through as a result of the test.

Table 92.1
Arcing Test on Flexible Fittings

Conduit trade size of fitting		Insulated conductor size		Bare copper wire size		Current, amperes
Inches	(mm OD)	AWG	(mm^2)	AWG	(mm^2)	
1/2	(21.3)	12	(3.3)	18	(0.82)	200
3/4	(26.7)	8	(8.4)	14	(2.1)	400
1	(33.4)	6	(13.3)	12	(3.3)	550
1-1/4	(42.2)	2	(33.6)	10	(5.3)	950
1-1/2	(48.3)	1/0	(53.3)	8	(8.4)	1250
2	(60.3)	4/0	(107.2)	6[a]	(13.3)	1950

[a] 8 AWG (8.4 mm^2) may be used if necessary to protect the test equipment.

93 Bending Test

93.1 A flexible connection fitting and a flexible fixture fitting shall be subjected to repeated bending by being moved back and forth over two pulleys. The fittings shall have a 36 inch (0.9 m) length of flexible center section. The two pulleys shall be mounted one above the other, but at opposite sides of the

plumbline. In the first half of the cycle, the flexible fitting shall bend first in one direction as it passes over the lower pulley and then in the opposite direction as it passes over the upper pulley. In the second half of the cycle the fitting shall be returned over the pulleys to the original vertical hanging position by a weight attached to the end of the fitting. The pull of the weight shall be sufficient to hold the flexible section of the fitting against the contour of the pulleys. The flexing or bending shall be conducted at the rate of approximately 4 cycles per minute for a total of 10,000 cycles.

93.2 The pulleys used in the test shall have a diameter that conforms to the minimum radius of bend to be specified by the manufacturer for the flexible fitting.

93.3 A flexible fitting shall withstand the bending test without physical damage to the inner flexible metal core and shall not leak when subjected to a 100 psig (690 kPa) internal air-pressure test.

93.4 To determine if a fitting complies with the leakage requirement in 93.3 following the test, the ends of the fitting are to be sealed. The fitting is then to be completely submerged in water in a horizontal position and an air pressure of 100 psig (690 kPa) is to be applied to the inside of the fitting. There is to be no leakage as evidenced by bubbles of air escaping from the fitting.

94 Vibration Test

94.1 A flexible connection fitting and a flexible fixture fitting shall show no damage of parts or loosening of assembly when subjected to the vibration test described in 94.2.

94.2 Two wires of the size specified in the second column of Table 92.1 shall be inserted in the fitting. The fitting, with a 90° bend of the minimum radius to be specified by the manufacturer, shall have one end mounted rigidly and the other end connected to the lower end of a vertical length of conduit about 26-1/2 inches (670 mm) long, the upper end of which is screwed into the threaded hub of a rigidly mounted frame. A horizontal rod shall be securely fastened to the vertical conduit at a point 4 inches (102 mm) above the lower end of the conduit in order to transmit a vibratory motion to the conduit from a motor-driven eccentric. The distance of horizontal movement in each of the back and forward directions of motion is to be 1/32 inch (0.8 mm) at a frequency of 2000 cycles per minute. The fitting is to be subjected to 35 hours of continuous vibration.

94.3 A fitting for mineral insulated cable shall show no damage or loosening of the assembly when subjected to a vibration test for 35 hours.

94.4 Representative samples of the fittings are to be assembled in accordance with the manufacturer's instructions to lengths of mineral insulated cable approximately 1 foot (305 mm) long. The torque used to assemble the fitting on the cable is to be as indicated in Table 94.1. The fitting-cable assemblies are to be installed in threaded openings of a conduit box. The conduit box is to be attached to the vibration equipment as indicated in 92.2 so that the samples are in a vertical position. The frequency and amplitude of the vibratory motion is to be as indicated in 94.2.

Table 94.1
Tightening Torque for Mineral Insulated Cable Fittings

Conduit trade size of male threads of fitting		Tightening torque	
inches	(mm OD)	Pound-inches	(N·m)
1/2	(21.3)	300	(33.9)
2 3/4	(26.7)	500	(56.5)
1	(33.4)	700	(79.1)

95 Endurance Load at Elevated Temperature Test

95.1 A flexible fixture fitting shall be subjected to the endurance load at elevated temperature test described in 95.2.

95.2 A flexible fixture fitting is to be mounted in a vertical position in a heated-insulated chamber maintained at a temperature of 75 °C (167 °F) while subjected to a 500 pound force (2220 N) applied in tension to the lower end of the fitting. The upper end of the fitting is to be located outside the heated-insulated chamber and is to be threaded into a rigid support. This test is to be conducted for 100 hours.

95.3 The fitting shall be examined and measured before and after the test. After removal from the test chamber, the increase in length of the fitting shall not exceed 1/16 inch per foot (5.2 mm/m) of flexible length, and there shall be no evidence of damage to the fitting. The fitting shall not leak when subjected to the leakage test described in 93.4.

96 Tension Test

96.1 A flexible fixture fitting shall be installed in a tensile-strength testing machine and tension slowly applied to the fitting until breakage occurs.

96.2 The attachment of the end fitting to the flexible center section shall not be damaged by the tension test.

97 Moist Ammonia-Air Stress Cracking Test

97.1 After being subjected to the conditions described in 97.2 – 97.3, a pressure confining brass part containing more than 15 % zinc shall:.

a) Show no evidence of cracking, delamination, or degradation as described in 97.4; and

b) Perform as intended when tested as described in 97.5.

97.2 One test sample of each size is to be subjected to the physical stresses normally imposed on or within a part as the result of assembly with other components. Samples with female tapered pipe threads, intended to be used for installing the product in the field, are to have the threads engaged and tightened to the required torque specified in Table 97.1. Samples with female threads other than tapered pipe threads shall be torqued as specified by the manufacturer. Teflon tape or pipe compound is not to be used on any threads. Samples with male threads are evaluated in "as-received" condition.

Table 97.1
Torque Requirements for Threaded Connections

Nominal thread size		Torque	
inches	(mm OD)	pound-inches	(N·m)
1/2 – 3/4	(21.3 – 26.7)	800	(90)
1 – 1-1/2	(33.4 – 48.3)	1000	(113)
2 and larger	(60.3 and larger)	1600	(181)

97.3 Three samples are then to be tested in accordance with Apparatus, Section 6, Reagents and Materials, Section 7, Test Media, Section 8, Test Sample Preparation, 9.3 – 9.4, and Test Procedure, 10.1 – 10.4 of the Standard Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress

Corrosion Cracking in Copper Alloys, ASTM B858-06, with the test solution pH level high 10.5 ±1 °C; and with the examination in accordance with 97.4.

97.4 After the exposure period, the samples are to be examined for cracks or other signs of stress corrosion using a microscope having a magnification of 25X.

97.5 Pressure-confining brass parts exhibiting evidence of cracking, detamination, degradation, as a result of the test exposure shall withstand, without rupture, a hydrostatic test with Section 22 as is applicable.

98 Accelerated Aging of Bushing Test

98.1 A molded-rubber or -neoprene bushing provided at the cord entrance to the terminal enclosure of a cord connector shall show no greater change in hardness than five numbers [0.0005 inches (0.013 mm)] as a result of a 96-hour exposure to oxygen at a pressure of 300 ±10 psig (2070 ±69 kPa) at a temperature of 70 ±1 °C (158 ±2 °F).

98.2 If possible, the complete molded-rubber or -neoprene bushing is to be tested. The hardness of the rubber or neoprene is to be determined as the average of five readings with a gauge, such as a Rex hardness gauge or Shore durometer. The bushing is then to be exposed to oxygen for 96 hours at the pressure and temperature specified in 98.1.

98.3 The apparatus for oxygen pressure aging is to consist of a high-pressure steel vessel or bomb equipped with a removable cap and a safety release mechanism; pressure gauges, piping, and fittings for introducing oxygen into the interior of the bomb; a water bath or other means for maintaining the bomb at a controlled temperature as specified; and temperature- and pressure-recording instruments.

98.4 The bushing, or specimen thereof, is to weigh not more than 2 grams per cubic inch (122 g/dm^3) of space within the bomb. With the bushing or specimen in place, the bomb is to be sealed and then placed in a water bath or the equivalent. This bomb is then to be filled with oxygen at the required pressure and maintained at the specified temperature for the required length of time. Temperatures are to be recorded throughout the period of heating. At the end of the exposure period, the pressure within the bomb is to be reduced to atmospheric pressure at a rate not greater than 150 psig (1030 kPa) per minute. The bushing or specimen is to be removed from the bomb and then cooled at room temperature for at least 4 hours. The hardness is to be determined again as the average of five readings. The difference between the original average hardness reading and the average reading taken after exposure to oxygen is the change in hardness.

99 Cord Pull Test

99.1 There shall be no stress at the cord conductor connections of a cord connector or damage to the cord when a direct pull is applied for 1 minute to the extension of the flexible cord. A 150 pound force (670 N) shall be applied for a connector rated 30 amperes or less. If the connector is rated over 30 amperes, a 300 pound force (1340 N) shall be applied.

99.2 With the flexible cord connected to the device as intended in service, the cord clamp of the device is to be secured in place and a gradual pull is to be applied by use of a pulley and weights at the cord extension.

100 Solvent and Water Condensate Exposure Test

100.1 The installation of a fitting on mineral insulated cable shall not result in an appreciable decrease in the insulation resistance of the cable. When tested as described in 100.2 and 100.3, the insulation resistance shall be at least 250,000 ohms after 90 days of exposure.

100.2 Representative samples of the fittings are to be assembled to lengths of mineral insulated cable, approximately 1 foot (305 mm) long, in accordance with the manufacturer's instructions. The fitting-cable assemblies are to be installed in threaded openings in the side walls of conduit boxes so that the samples are in a horizontal position. Tap water is to be added to the conduit box until the sealing pots of the fittings are one-half submerged. A different solvent, representative of the Class I hazardous locations groups, is then to be added to each box so that the sealing pots are completely submerged. The conductors with sleeving within each box are to be turned upward before filling so that the ends will extend above the liquid level. Each conduit box is then to be tightly closed.

100.3 Insulation resistance measurements are to be made before adding the water and solvents and after 30 and 90 days of exposure. Before making the 30 and 90 day measurements, the water and solvents are to be removed and assemblies are to be allowed to dry at room temperature with the covers removed for 2 days and 4 days, respectively. The resistance measurements are to be made between the conductors and between each conductor and the copper sheath of the cable.

101 Secureness of Conduit Hubs Test

101.1 A conduit hub not integrally cast with a metal enclosure shall withstand the torque specified in Table 101.1 applied to a short length of rigid conduit threaded into the hub of the enclosure in the intended manner, without turning in the enclosure and without stripping of any threads.

Table 101.1
Tightening Torque for Conduit Hubs

Conduit hub trade size		Tightening torque	
Inches	(mm OD)	Pound-inches	(N·m)
1/2 – 3/4	(21.3 – 26.7)	800	(90)
1 – 1-1/2	(33.4 – 48.3)	1000	(113)
2 and larger	(60.3 and larger)	1600	(181)

102 Markings

102.1 Each outlet box or fitting shall be marked indicating the following in addition to the marking requirements in Section 59, Details.

a) Volume in cubic inches for a box having an internal volume of 100 cubic inches (1.64 L) or less.

b) The electrical rating in volts and amperes, for a cord connector.

c) Each cord connector shall be provided with marking instructions regarding the type of power supply cord to be used. The instructions shall include the following or equivalent information: "Use ___ AWG, Type _____ power supply cord only." The instructions shall be legible and permanent in nature. The instructions shall be permitted to be a paper label if located within the terminal compartment and free from mechanical damage.

d) Each cord connector employing a packing gland requiring dismantling during installation and replacement of the cord shall be provided with suitable marking instructions regarding its installation and replacement.

102.2 With reference to 102.1(d), all three elements of the marking need not be provided if:

a) The physical size, design, or shape of the product is such that there is insufficient space available for all elements of the marking; and

b) The marking includes both the signal word "CAUTION" or equal, and sufficient information to indicate the precautions to be taken.

102.3 If the physical size or shape of the product is such that there is insufficient space available for the marking permitted by 102.2, the marking required by 102.1(d) may be on a pressure-sensitive label as described in 102.6 and 102.7. The label shall be provided with the product, together with instructions that the label shall be applied to a surface, such as the connected conduit where space is available, when the product is installed.

102.4 Designation of the hazardous location group need not be marked on a fitting if the size or design of the fitting is such that there is insufficient space for this marking, and:

a) The designations of both the hazardous location class and group are on the smallest package in which the fitting is shipped; and

b) The fitting is suitable for all hazardous location groups in the hazardous location class marked on the fitting.

102.5 Except as noted in 102.1(c), 102.1(d) and 102.3, 102.6, and 102.8, all markings shall be on a metal plate or plates permanently attached to the conduit box, fitting, or the cord connector, or shall be embossed, stamped, cast, or molded in the enclosure where it will be readily visible after installation.

102.6 A nonmetallic pressure-sensitive label may be used if an investigation indicates that such marking means is permanent and suitable for the purpose. See 102.7.

102.7 The investigation mentioned in 102.6 will include exposure to the various chemical reagents likely to be encountered in use.

102.8 A conduit fitting for sealing or a box with integral sealing hubs shall be provided with the necessary installation instructions such as proper mounting position and type of sealing compound to be used. This information may be marked on the box or fitting or it may be part of the installation instructions for each box or fitting.

102.9 With reference to 37.1(d), a threaded close-up plug provided in a conduit opening or an opening for pouring sealing compound and installing a dam in a sealing fitting are not considered a removable cover.

102.10 Each fitting or each package of sealing compound shall be provided with instructions containing the following information:

a) Preparation of dams.

b) Instructions for mixing the compound including proportions of compound to water by weight or volume. The proportions by weight or volume need not be indicated if the compound and water are prepacked as a unit.

c) Filling instructions.

d) A statement including the following:

1) Specific temperature below which the seal should not be poured.

2) Period of time the fitting must be at, or above, the given temperature in order that the seal will set properly.

e) Instructions indicating that the close-up plugs provided are to be used to close the openings for pouring the sealing compound and installing dams.

102.11 The instructions shall include the number, size, and type of wires that can be properly sealed in the fitting during installation in the field, and that comply with the Leakage of Sealing Fittings Test, Section 86. For example, for instructions for a fitting intended for 25 % maximum fill, see Table 102.1.

Table 102.1
Example of Instructions for the Maximum Number of Conductors that can be Properly Sealed in a Fitting Under Normal Field Installation Conditions

	The maximum number of wires[a,b] that can be sealed in a sealing fitting are as follows:																					
Size AWG or kcmil	1/2 Inch 16 Metric Designator		3/4 Inch 21 Metric Designator		1 Inch 27 Metric Designator		1-1/4 Inch 35 Metric Designator		1-1/2 Inch 41 Metric Designator		2 Inch 53 Metric Designator		2-1/2 Inch 63 Metric Designator		3 Inch 78 Metric Designator		3-1/2 Inch 91 Metric Designator		4 Inch 103 Metric Designator		5 Inch 129 Metric Designator		6 Inch 155 Metric Designator	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
18	7	11	12	20	12	20	20	33	35	58	49	80	80	131	115									
16	6	9	10	16	17	27	17	27	30	47	41	64	68	106	98									
14	3	8	6	15	10	24	10	24	18	43	25	58	41	96	58		90			121				
12	3	6	5	11	8	18	8	18	15	32	21	43	34	71	50	102	76		103					
10	1	4	4	7	7	11	13	20	13	20	20	27	29	45	41	65	64	100	86	134	110			
8	1	2	2	4	4	6	7	11	9	16	9	16	16	26	22	37	35	58	47	78	60	100	94	
6	1	1	1	2	2	4	4	7	6	9	10	16	15	23	15	23	23	35	32	47	41	61	64	96
4	1	1	1	1	1	2	3	4	5	6	8	9	12	14	18	21	18	21	24	29	31	37	49	59
3			1	1	1	2	3	3	4	5	7	8	10	12	16	18	16	18	21	24	28	31	44	50
2			1	1	1	1	3	3	3	4	6	7	9	10	14	15	14	15	19	20	24	26	38	42
1			1	1	1	1	1	2	3	3	4	5	7	7	10	11	10	11	14	15	18	20	29	31
0					1	1	1	2	2	2	4	4	6	6	9	9	12	13	12	13	16	16	25	26
2/0					1	1	1	1	1	2	3	3	5	5	8	8	11	11	14	14	14	14	22	22
3/0					1	1	1	1	1	1	3	3	4	4	7	7	9	9	12	12	12	12	19	19
4/0							1	1	1	1	2	2	3	3	6	6	8	8	10	10	10	10	16	16
250							1	1	1	1	1	2	3	3	5	5	6	6	8	8	11	11	15	15
300							1	1	1	1	1	1	3	3	4	4	5	5	7	7	10	10	15	15
350							1	1	1	1	1	1	1	2	3	3	5	5	6	6	10	10	14	14
400									1	1	1	1	1	2	3	3	4	4	6	6	9	9	13	13
500									1	1	1	1	1	1	3	3	4	4	5	5	8	8	11	11
600											1	1	1	1	1	2	3	3	4	4	6	6	9	9
700											1	1	1	1	1	2	3	3	3	3	6	6	8	8
750											1	1	1	1	1	1	3	3	3	3	5	5	8	8
800											1	1	1	1	1	1	2	2	3	3	5	5	7	7

Table 102.1 Continued on Next Page

Table 102.1 Continued

The maximum number of wires[a,b] that can be sealed in a sealing fitting are as follows:																						
Size AWG or kcmil	1/2 Inch 16 Metric Designator		3/4 Inch 21 Metric Designator		1 Inch 27 Metric Designator		1-1/4 Inch 35 Metric Designator		1-1/2 Inch 41 Metric Designator		2 Inch 53 Metric Designator		2-1/2 Inch 63 Metric Designator		3 Inch 78 Metric Designator		3-1/2 Inch 91 Metric Designator		4 Inch 103 Metric Designator		5 Inch 129 Metric Designator		6 Inch 155 Metric Designator	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
900											1	1	1	1	1	1	1	2	3	3	4	4	7	7
1000											1	1	1	1	1	1	1	1	3	3	4	4	6	6
1250													1	1	1	1	1	1	1	2	3	3	5	5
1500															1	1	1	1	1	1	3	3	4	4
1750															1	1	1	1	1	1	2	2	4	4
2000															1	1	1	1	1	1	1	1	3	3

[a] Col. A = Types RFH-2, RH, RHH, RHW, THW, TW, XHHW (AWG 14 – 6), FEPB (AWG 6 – 2)

Col. B = FEP, THHN, THWN, TFN, PF, PGF, XHHW (AWG 4 – 2000 kcmil), FEPB (AWG 14 – 8)

[b] Any combination of these wires not exceeding 25 % of a cross section of the conduit for the fitting they fill may be used.

102.12 An outlet box intended to have sealing fittings installed in accordance with note a of Table 85.1 shall be provided with a permanent warning marking readily visible during and after installation: "WARNING – To prevent ignition of Group ____ atmospheres conduit runs must not exceed ____inch in size and all conduit runs, ____ inch size and larger, must have a sealing fitting connected within ____ inches of the enclosure," or equivalent wording. If the marking is on a removable cover, an additional marking with the same wording shall be on or in the box. This additional marking need not be permanent.

102.13 An outlet box not provided with provision for connection to threaded rigid metal conduit shall be provided with instructions for drilling and tapping conduit openings. The instructions shall include the following information:

a) Maximum number of conduit openings.

b) Maximum and minimum trade size of conduit openings.

c) Location of conduit openings.

d) Type of conduit threads.

e) Any other instructions necessary to provide acceptable provision for connection to threaded rigid metal conduit in accordance with the requirements of this standard.

102.14 In accordance with the Exceptions to 14.1.1.3 instructions to install a fitting providing a smooth, rounded inlet hole shall be provided if a conduit opening is not:

a) Provided with a conduit stop;

b) Well-rounded; or

c) Threaded as specified in Table 14.2.

PART IX – RECEPTACLE-PLUG COMBINATIONS

INTRODUCTION

103 General

103.1 Receptacle-plug combinations shall comply with the applicable requirements of Part I – Part IV of this Standard in addition to the requirements in Part IX.

103.2 These requirements cover receptacles with plugs, receptacles with plugs interlocked with circuit breakers, and receptacles with plugs interlocked with switches rated not more than 200 amperes, not more than 600 volts, alternating-current (ac), and not more than 250 volts, direct-current (dc).

CONSTRUCTION

104 General

104.1 Where reference is made to contact blades, the requirements also apply to flat, round, butt type, and similar contacts.

105 Material

105.1 A base or body in or on which live parts are mounted shall be of porcelain, phenolic, urea, or cold-molded composition or of equivalent insulating material.

105.2 Except for a raintight device, vulcanized fiber may be used for insulating washers, separators, and barriers, but shall not be used as the sole support for live parts. Hard rubber is not acceptable.

106 Live Parts

106.1 Iron or steel, plain or plated, shall not be used for a part that is depended upon to carry current or for a wire-binding nut or screw.

Exception: Stainless steel may be employed for a part not subject to arcing, if found to be acceptable.

106.2 An uninsulated live part shall be secured in place to prevent a reduction in the spacings to less than those required by 112.1.

107 Grounding

107.1 Except as indicated in 107.2, a receptacle and a plug shall have a separate contact and a blade, respectively, for interconnection of the equipment-grounding conductor.

107.2 The metal shell of a plug may be used as the grounding-contact member if:

a) The part of the plug shell that is depended upon for grounding continuity is unlikely to be painted or otherwise subjected to conditions that may result in loss of grounding continuity;

b) At least two separate grounding contact points are provided in the receptacle; and

c) The receptacle grounding contact points are protected against damage.

107.3 Unless the plug and the receptacle are of the interlocked type that requires disconnection of the supply circuit before the plug can be inserted or removed, the grounding contact in the receptacle shall be located and formed so that electrical continuity to the grounding blade or contact of the mating plug is completed before continuity is established between any other contact and its respective blade on the plug. This grounding path shall be substantial when the plug is seated in the receptacle as intended.

107.4 The grounding-contact path, other than the metal housing, shall be of copper or of a copper-base alloy. The contact surfaces in the grounding contact path may be of silver, silver alloy, or other equivalent material. Also see 107.5.

107.5 A rivet, bolt, or clamp that is used to secure parts in the grounding path, but that is not an essential conductor in the grounding path, may be of steel or of another acceptable material.

107.6 A copper-base-alloy rivet that is used to hold parts in the grounding-contact path together or that forms a part of the grounding path shall contain not less than 80 % copper.

107.7 A connection in the grounding-contact path shall be secured by riveting, bolting, welding, or equivalent means.

107.8 All dead metal parts of a receptacle that could become energized shall be conductively connected to the point of attachment of the equipment grounding conductor.

107.9 All dead metal parts of a plug enclosure that could become energized shall be conductively connected to the point of attachment of the equipment grounding conductor when the plug is inserted in the receptacle.

108 Supply Connection

108.1 Receptacle

108.1.1 The location of a terminal box or a compartment in which power-supply connections to the receptacle are to be made shall be such that the connections may be readily inspected after the device is installed as intended without the disconnection of any portion of the wiring.

108.1.2 A terminal compartment intended for the connection of a supply raceway shall be such that movement is prevented in relation to the complete receptacle assembly.

108.2 Plug

108.2.1 A plug shall have provision for connection of flexible cord with grounding conductor listed extra-hard-usage. Except for a flammable anesthetizing location plug of the construction covered in 120.1 – 120.8, the terminal enclosure shall be of a construction that will allow the cord to be readily replaced when necessary.

108.3 Plug and receptacle

108.3.1 General

108.3.1.1 A receptacle and a plug shall be provided with acceptable field-wiring terminals or leads for the connection of conductors having an ampacity, in accordance with NFPA 70, not less than the current rating of the mating parts.

108.3.1.2 For the purpose of these requirements, field-wiring terminals are considered to be the terminals to which power supply, control, or equipment-grounding connections will be made in the field when the device is installed. It is assumed that 60 °C (140 °F) wire will be used for connections to a device rated at 80 amperes or less and that 75 °C (167 °F) wire will be used with a device rated at more than 80 amperes.

108.3.2 Terminals

108.3.2.1 The wiring terminals of a receptacle shall be located or protected so that live parts will not be forced against the wiring in the terminal box or compartment during installation.

108.3.2.2 A field-wiring terminal intended solely for connection of an equipment-grounding conductor shall be capable of securing a conductor of the size acceptable for the application, in accordance with NFPA 70. Connections that depend upon solder shall not be used.

108.3.2.3 Other than as indicated in 108.3.2.2, 108.3.2.4, and 108.3.2.6, a field-wiring terminal on a receptacle shall be provided with a soldering lug or well or with a pressure wire connector securely fastened in place; for example, firmly bolted or held by a screw.

108.3.2.4 A wire-binding screw may be employed at a field-wiring terminal on a receptacle intended to accommodate a 10 AWG (5.3 mm^2) stranded or smaller conductor if upturned lugs or the equivalent are provided to hold the wire in position. See also 108.3.2.9.

108.3.2.5 Other than as indicated in 108.3.2.2, the terminals employed on a plug shall be provided with an acceptable soldering lug or well or with a pressure wire connector of the type by which the wire is clamped between two plates.

108.3.2.6 Other forms of construction may be accepted if the ampacity and mechanical features are found to be equivalent to those of one of the connections described in 108.3.2.3 – 108.3.2.5.

108.3.2.7 A field-wiring terminal shall be prevented from any turning or shifting in position that may impair the assembly by means other than friction between surfaces. This may be accomplished by:

a) Screws or rivets;

b) Square shoulders or mortices;

c) A dowel pin, lug, or offset;

d) A connecting strap or clip fitted into an adjacent part; or

e) Some other equivalent method.

108.3.2.8 The requirement specified in 108.3.2.7 does not preclude a limited degree of movement so that the blades and contacts of the mating plug and receptacle may be somewhat self-aligning.

108.3.2.9 A wire-binding screw at a field-wiring terminal shall not be smaller than No. 10 (4.8 mm), except that a No. 8 (4.2 mm) screw may be used at a terminal intended only for the connection of a 12 or 14 AWG (3.3 or 2.1 mm^2) conductor.

108.3.2.10 In accordance with NFPA 70, 14 AWG (2.1 mm^2) is the smallest conductor which may be used for branch-circuit wiring, and thus is the smallest conductor that may be anticipated at a terminal for the connection of a power-supply wire.

108.3.2.11 A terminal plate tapped for a wire-binding screw shall be metal not less than 0.050 inch (1.27 mm) thick, except that a plate not less than 0.030 inch (0.76 mm) thick is acceptable if the tapped threads have the necessary mechanical strength. There shall be two or more full threads in the metal, which may be extruded if necessary to provide the threads.

108.3.2.12 An upturned lug or a cupped washer shall retain a conductor of the size mentioned either in 108.1.1 [but not smaller than 14 AWG (2.1 mm^2)] or in 108.3.2.4, whichever is applicable, under the head of the screw or the washer.

108.3.2.13 A wire-binding screw shall thread into metal.

108.3.2.14 A field-wiring terminal intended for the connection of a grounded conductor shall be of, or plated with, a metal substantially white in color (such as nickel) and shall be distinguishable from the other terminals, or identification of that terminal shall be clearly shown in some other manner, such as on an attached wiring diagram.

Exception: This requirement does not apply to a receptacle for anesthetizing locations.

108.3.2.15 A white head of a wire-binding screw that is not removable from its terminal plate and that does not clearly relate to the improper slot or blade in the device configuration may serve as the terminal identification specified by 108.3.2.14.

108.3.2.16 A white terminal plate of a binding-screw terminal that is plainly visible after wiring and that does not clearly relate to the improper slot or blade in the device configuration may serve as the terminal identification specified in 108.3.2.14 if all of the line terminal binding screws are of the same color.

Exception: This requirement does not apply to a receptacle for anesthetizing locations.

108.3.2.17 Other than when a device is constructed so that the factory installed bond between the terminal and exposed dead metal parts is readily visible and the terminal for the connection of the grounding conductor is obvious, the terminal for the connection of an equipment-grounding conductor shall have a permanent identification that is readily identifiable during installation. The terminal marking shall be one of the following:

a) A terminal screw that is not readily removable and that has a green-colored head that is hexagonal, slotted, or both;

b) A hexagonal green-colored nut that is not readily removable from a threaded terminal stud;

c) A visible pressure wire connector that has a green-colored body or appendage that is not readily removable from the connector; or

d) A concealed pressure wire connector identified as specified in 108.3.2.18.

108.3.2.18 If a pressure wire connector at the equipment-grounding terminal is located within the insulating body and is not readily visible, the wire-entrance hole for a connection to that terminal shall be identified by one of the following:

a) A distinct green-colored area immediately adjacent to the wire-entrance hole; or

b) The letter or word "G," "GR," "GND," "Ground," "Grounding," or "Green" distinctively marked immediately adjacent to the wire-entrance hole in letters at least 1/16 inch (1.6 mm) high.

108.3.2.19 A readily removable – not staked or otherwise held captive – part of an equipment-grounding terminal, such as a setscrew or a clamping member, shall not be colored green or otherwise identified as part of the grounding terminal if the part may be interchanged with a similar part of another terminal on the device.

108.3.3 Leads

108.3.3.1 A lead intended for the connection of a grounded conductor shall be finished to show a white or grey color and shall be distinguishable from the other leads.

Exception: This requirement does not apply to a receptacle for anesthetizing locations.

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

108.3.3.3 The requirements specified in 108.3.3.1 and 108.3.3.2 relating to color coding of a lead for identification do not apply to internal wiring that is not visible in a wiring compartment in which field connections are to be made.

108.3.3.4 The free length of a lead inside an outlet box or wiring compartment shall be 4 inches (102 mm) or more if the lead is intended for field connection to an external circuit. The length of a grounding lead if provided shall not be less than 6 inches (152 mm).

109 Receptacle Employing Interlocking Switch or Circuit Breaker

109.1 An interlocking switch or circuit breaker employed in a receptacle-plug combination so that the plug cannot be withdrawn or inserted when the switch or circuit breaker is in the on position shall simultaneously break all current-carrying conductors, including the neutral conductor (if any), of the supply circuit.

110 Contact and Blade Exposure

110.1 A receptacle shall be constructed to permit the mating plug to seat as intended without exposing the blades between the plane of the plug face and the plane of the receptacle rim.

110.2 The live parts of a receptacle shall not be exposed to contact when the receptacle is assembled and installed as intended. See 110.4.

110.3 With reference to the requirement specified in 110.2:

a) An opening that will not permit the entrance of a 3/4 inch (19.1 mm) diameter rod is acceptable if a probe as illustrated in Figure 110.1 cannot be made to touch any uninsulated live part when inserted through the opening; and

b) An opening that will permit the entrance of a 3/4 inch diameter rod is acceptable under the conditions specified in Figure 110.2.

Figure 110.1

Probe for Uninsulated Live Parts

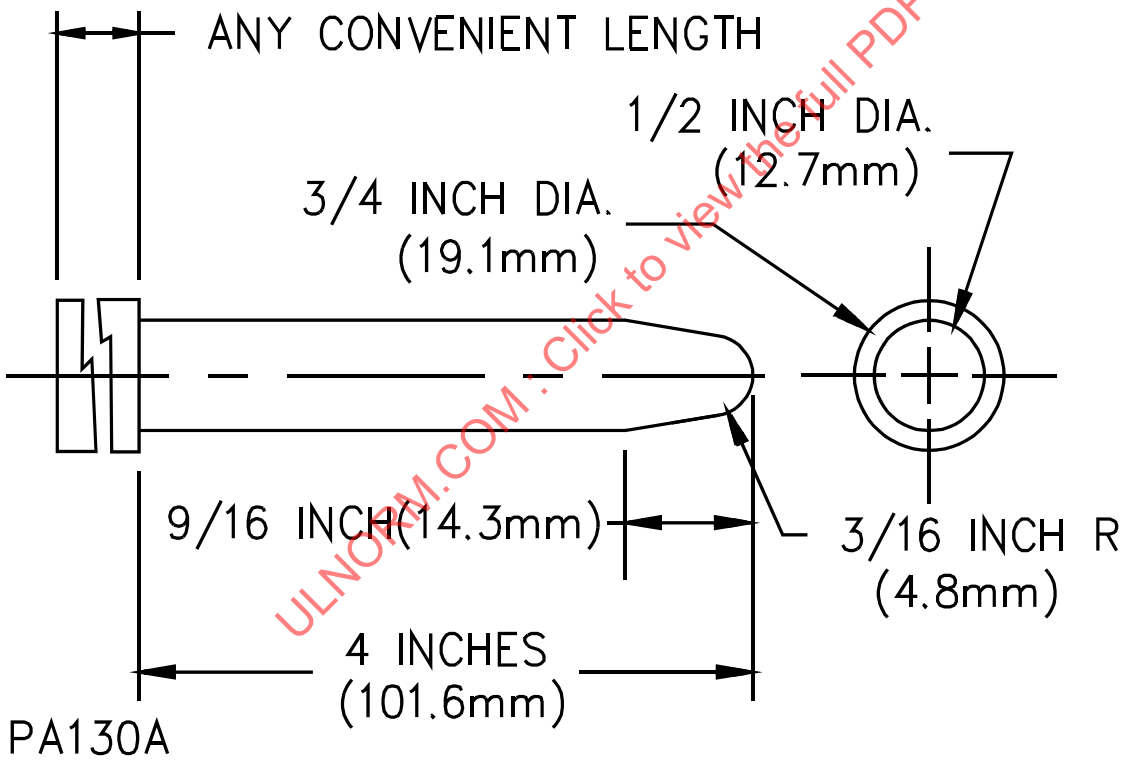
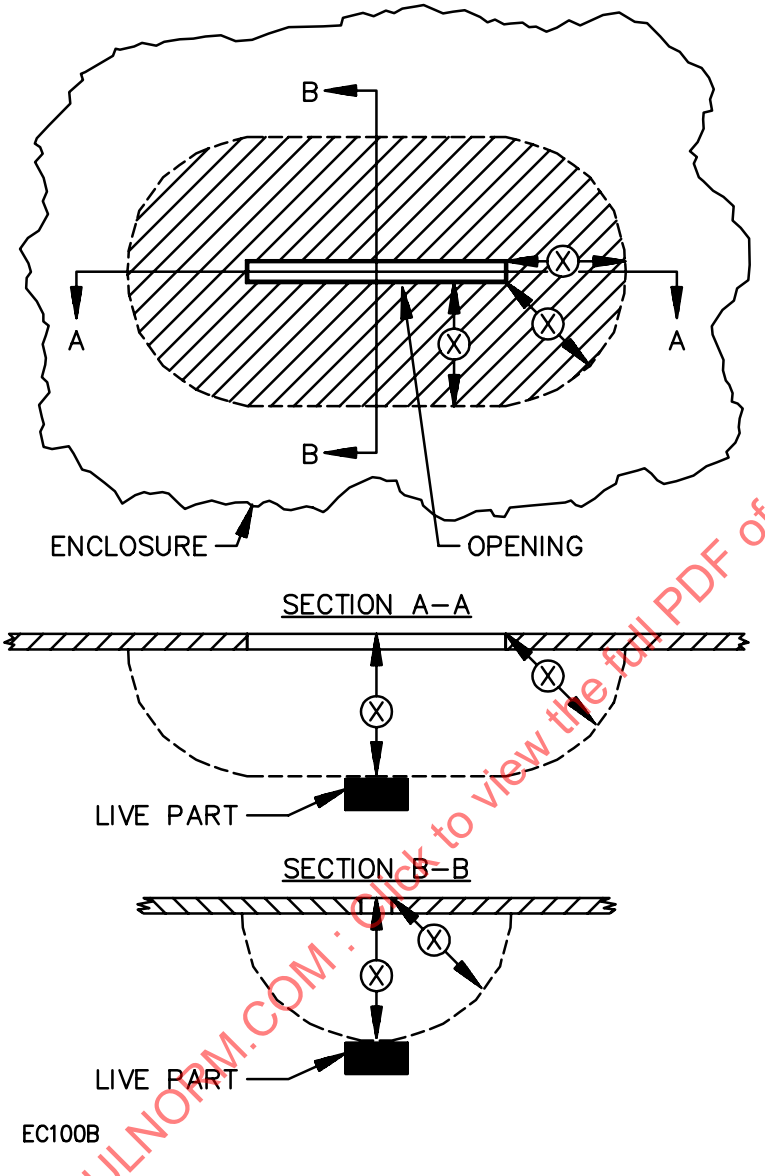


Figure 110.2

Opening in Enclosure



110.4 The requirements specified in 110.2 and 110.3 are not applicable to the following devices:

a) A receptacle interlocked with a switch or a circuit breaker where the live parts of the receptacle are deenergized when the plug is withdrawn.

b) A receptacle provided with a spring-loaded cover where the cover automatically returns to the closed position when the plug is withdrawn.

c) A receptacle provided with a manually-replaceable cover if:

1) The cover is secured to the receptacle enclosure by a chain or the equivalent; and

2) The receptacle is provided with the marking specified in 131.2.

111 Spacings

111.1 Other than as noted in 111.2, the spacings in a plug and receptacle shall not be less than the values specified in Table 111.1.

Table 111.1
Minimum Spacings in inches (mm)

Parts involved		Potential involved in volts			
		General power devices			
		0 – 250		251 – 600	
Between any uninsulated live part and an uninsulated live part of opposite polarity, an uninsulated grounded dead metal part other than the enclosure, or an exposed dead metal part which is isolated (insulated)	Through air	3/16	(4.8)	3/16	(4.8)
	Over Surface	3/16	(4.8)	3/16	(4.8)
Between any uninsulated live part and the walls of a metal enclosure	Shortest distance	1/4	(6.4)	1/4	(6.4)

111.2 The spacings specified in Table 111.1 do not apply to the inherent spacings of a component of the device. Such spacings are judged under the requirements for the component.

111.3 In measuring a spacing, an isolated dead metal part interposed between live parts of opposite polarity or between a live part and a grounded or an exposed dead metal part reduces the spacing by an amount equal to the dimension of the isolated dead metal part in the direction of the measurement.

111.4 An insulating barrier as specified in 111.5 – 111.9 may be provided as part or in place of the spacings specified in 111.1.

111.5 Other than as noted in 111.6, an insulating barrier or liner used as the sole separation between an uninsulated live part and a grounded dead metal part (including the enclosure) or between uninsulated live parts of opposite polarity, shall be of material that is acceptable for the mounting of an uninsulated live part and shall not be less than 0.028 inch (0.71 mm) thick. See also 111.6.

111.6 Fiber not less than 0.028 inch (0.71 mm) thick may be used as the sole separation between the enclosure and an uninsulated metal part electrically connected to a grounded-circuit conductor, if the operating temperature of the fiber is not more than 90 °C (194 °F).

111.7 Other than as noted in 111.8, an insulating barrier or liner that is used in addition to an air space in place of the required spacing through air shall not be less than 0.028 inch (0.71 mm) thick. If the barrier or

the liner is of fiber, the air space shall not be less than 1/32 inch (0.8 mm), and if the barrier or the liner is of a material that is not acceptable for the support of an uninsulated live part, the air space provided shall be acceptable for the particular application. See 111.8.

111.8 A barrier or liner that is used in addition to no less than one-half the required spacing through air may be less than 0.028 inch (0.71 mm) thick but shall not be less than 0.015 inch (0.38 mm) thick if the barrier or liner is of a material that is:

a) Acceptable for the mounting of an uninsulated live part;

b) Of acceptable mechanical strength if exposed or otherwise likely to be subjected to mechanical damage;

c) Held in place; and

d) Located so that it will not be impaired by operation of the equipment in service.

111.9 Insulating material having a thickness less than that specified in 111.5, 111.7, and 111.8 may be used if found to be acceptable.

112 Assembly

112.1 A device shall be capable of being readily wired as intended.

112.2 A device involving two or more pieces shall be constructed so that any intended polarization will not be defeated by improper assembly during installation.

112.3 A screw upon which the general assembly of a device depends shall, where possible, be prevented from loosening or backing by sealing, staking, or an equivalent means.

112.4 A sealing compound shall be insulating, waterproof, and shall not soften at a temperature of 93 °C (199 °F). See 118.1 and 118.2.

112.5 Positive electrical contact shall be maintained at any point where a connection is made between current-carrying parts.

112.6 A receptacle shall not accommodate a plug other than one that is specifically designed for use with the combination.

112.7 Plugs and receptacles that have different electrical ratings shall not be interchangeable with one another.

PLUG

113 General

113.1 A plug enclosure shall not have more than one cord outlet opening.

114 Enclosure

114.1 Except for openings for the contacts and for the cord and as indicated in 8.1 and 114.3, a plug shall be enclosed in an enclosure of iron, steel, copper, brass, bronze, or aluminum or its alloys containing not less than 80 % aluminum. A metal such as zinc or magnesium, or their alloys, shall not be used.

114.2 Copper or a copper alloy shall not be used for a plug enclosure for a device for Class I, Group A locations other than as noted in 22.2.

114.3 A plug enclosure may be made of a rigid polymeric material if the material has been investigated and found acceptable. Nitrocellulose-base material, proxylin, and cellulose acetate shall not be used.

114.4 The thickness of a plug enclosure shall be such that the enclosure will have the strength and rigidity necessary to resist the abuses to which it could be subjected without increasing the risk of shock, fire, and explosion due to total or partial collapse with resulting reduction in spacings, loosening, or displacement of parts, or other serious defects.

114.5 Other than as noted in 114.6, the thickness of a cast-metal plug enclosure shall not be less than 3/32 inch (2.4 mm).

114.6 At small areas for springs, at the root of threads, and at polarization alignment slots having a maximum width of 1/2 inch (12.7 mm), the thickness of a cast-metal enclosure shall not be less than 0.040 inch (1.02 mm) thick.

114.7 The thickness of a metal plug enclosure, other than cast metal, shall not be less than 0.040 inch (1.02 mm) for steel, 3/64 inch (1.2 mm) for bronze or brass, and 1/16 inch (1.6 mm) for aluminum.

114.8 An enclosure of a rigid polymeric material shall have mechanical strength and durability comparable to metal enclosures, but in no case shall the thickness of polymeric enclosures be less than that specified for cast-metal enclosures.

115 Strain Relief

115.1 A positive mechanical cord clamp shall be provided that permits the flexible supply cord to be readily replaced. See Strain Relief Test, Section 124. If the cord clamp is threaded to the plug enclosure, it shall form a tight engagement or shall be secured against turning or loosening by means of a setscrew or the equivalent. The clamp shall be smooth and free from sharp edges that may damage the jacket of the flexible cord.

115.2 If a range of flexible cord sizes is intended to be employed, the strain relief means shall be acceptable for all sizes in the range.

116 Bushings

116.1 A metal-enclosed plug shall be provided with an insulating bushing at the point where the cord enters the enclosure. The material shall be acceptable for the particular application.

116.2 A rubber or rubber-like compression-type bushing complies with the requirement in 116.1.

117 Enclosure – Material

117.1 A snap lid or screw cover that covers a receptacle opening when the device is not being used may be made of zinc or magnesium or their alloys or may be made of nonmetallic material.

118 Seal Between Electrical Enclosure and Receptacle Contacts

118.1 Lead wires or conductors shall be securely held and tightly fitted where they extend through the wall between the electrical enclosure and the receptacle contacts. If a sealing compound or a cement is used, it shall not be less than 5/8 inch (15.9 mm) deep, shall neither soften nor crack under service

conditions, shall provide a tight fit, and shall not be affected by the vapors or gases of the respective hazardous location class and groups. If the compound contacts uninsulated live parts it shall be of the nonconductive type. The sealing compound shall not flow or creep at the operating temperature of the device.

118.2 A sealing compound that softens upon the application of heat shall have a softening point of not less than 93 °C (199 °F), as determined in accordance with the Standard Test Method for Softening Point by Ring-and-Ball Apparatus, ASTM E28.

118.3 In place of sealing compound, the seal may consist of explosionproof joints between receptacle parts as specified in Joints in Enclosure, Section 10.

118.4 For a plug and receptacle interlocked with a switch or a circuit breaker, the lead wires may be sealed between the enclosure intended for field wiring and the enclosure housing the switch or circuit breaker. If the seal complies with the requirements in 118.1, the device shall be marked in accordance with 59.3(k).

119 Bonding

119.1 All exposed dead metal parts of a receptacle shall be electrically connected together.

PLUG AND RECEPTACLE FOR FLAMMABLE ANESTHETIZING LOCATIONS

120 General

120.1 A receptacle and a plug for flammable anesthetizing locations shall comply with the requirements of 120.2 – 120.8. They shall be a part of a unit device with an explosionproof interlocking switch arranged so that the plug cannot be withdrawn or inserted when the switch is in the on position, and the switch cannot be turned on until the plug is securely seated; or they shall be devices in which the current is broken in an explosionproof enclosure before the plug can be removed.

120.2 The plug and receptacle referred to in 120.1 are intended for use in accordance with Chapter 12 of NFPA 99.

120.3 A receptacle for anesthetizing locations shall not have a field-wiring terminal or lead identified as indicated in 108.3.2.14, 108.3.2.16, and 108.3.3.1.

120.4 A receptacle for anesthetizing locations shall not have a field-wiring terminal or lead identified as indicated in 108.3.2.14, 108.3.2.16, and 108.3.3.1.

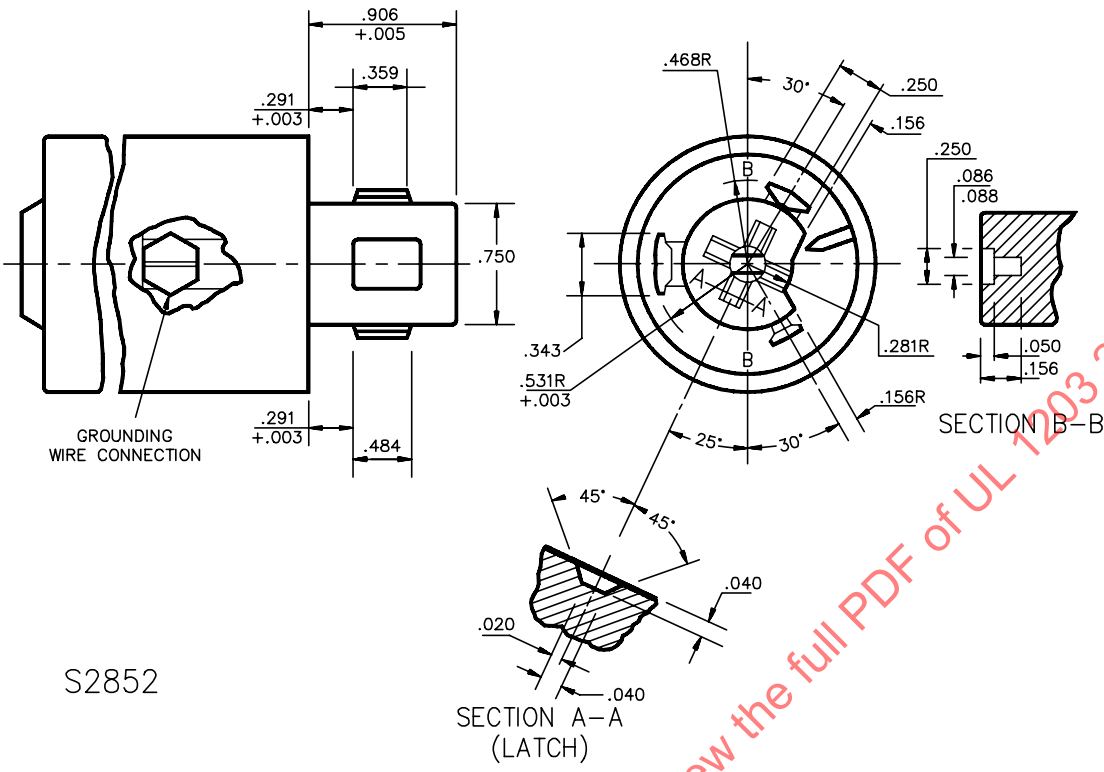
120.5 A plug and cord combination used in flammable anesthetizing locations shall be watertight (see 130.1 – 130.3) and of a design permitting easy cleaning.

120.6 Plugs for use in hazardous locations of flammable anesthetizing locations for 125-volt, 20-ampere, alternating current service shall be designed for interchangeability, for direct connection without the use of adapters, with Class I, Group C receptacles in hazardous locations and with isolated power receptacles in nonhazardous locations.

120.7 The required basic dimensions for the conforming members of plugs are illustrated in Figure 120.1.

Figure 120.1

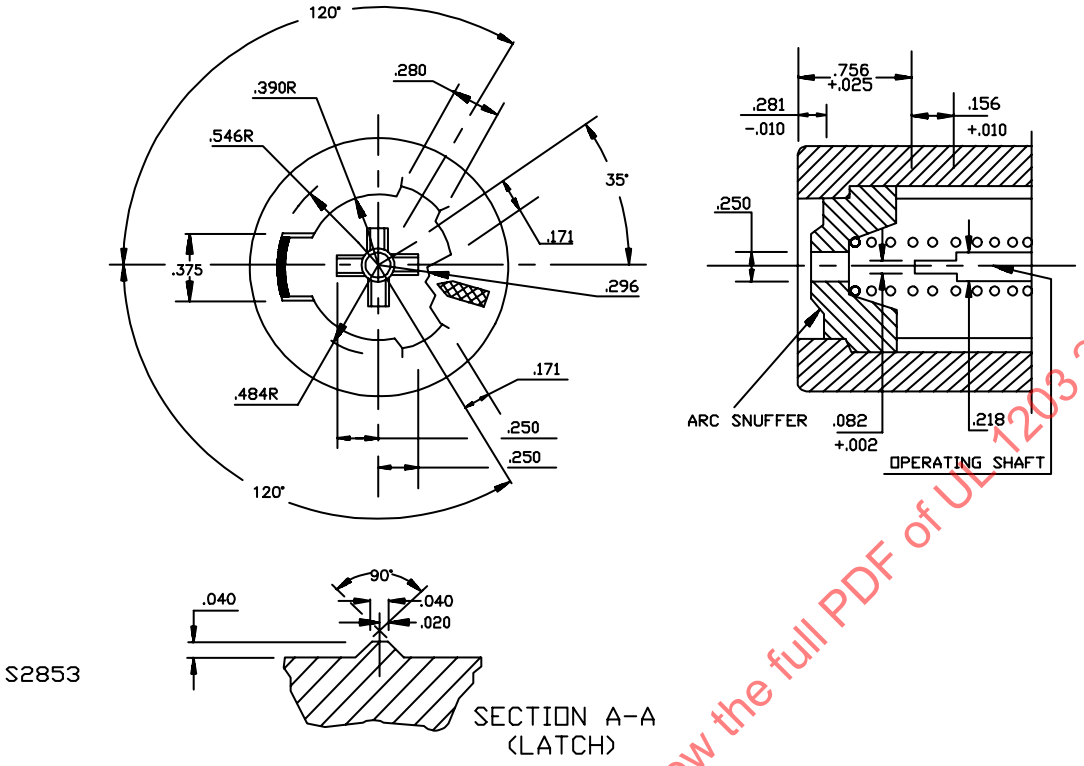
Plug for Anesthetizing Locations (Dimensions in inches)



120.8 The required basic dimensions of the receptacles are illustrated in Figure 120.2.

Figure 120.2

Receptacle for Anesthetizing Locations (Dimensions in inches)



PERFORMANCE

121 General

121.1 A plug and receptacle shall be subjected to the tests described in Sections 122 – 130.

121.2 All voltages and currents indicated in the test description are root-mean-square values. Unless otherwise indicated in the test descriptions, the voltage for tests shall be as indicated in Table 121.1.

Table 121.1
Voltage for Tests

Voltage rating of device [a]	Test potential in volts
110 – 120, ac	120, ac
110 – 125, dc	125, dc
208, ac	208, ac
220 –240, ac	240, ac
220 – 250, dc	250, dc
265 –277, ac	277, ac
440 – 480, ac	480, ac
550 – 600, ac	600, ac
550 – 600, dc	600, dc

[a] If the rating of the device does not fall within any of the indicated voltage ranges, it shall be tested at its rated voltage.

122 Overload Test

122.1 Other than as noted in 122.2, a plug and a receptacle shall perform as intended when subjected to the overload test described in 122.4 – 122.18. There shall be no electrical or mechanical malfunction of the device nor burning, pitting, or welding of the contacts that could impair intended operation.

122.2 The requirement in 122.1 does not apply to a plug and receptacle interlocked with an integral switch or circuit breaker where the switch or circuit breaker has to be automatically opened before the plug can be inserted or withdrawn.

122.3 Any additional material that is provided with the intent to reduce or confine the arcing in the contact chamber of a plug and receptacle and that decomposes or is otherwise affected by the arcing shall be removed for all of the overload tests.

122.4 The device under test is to be operated manually or mechanically by inserting the plug into the receptacle while connected to the load specified in 122.6 and 122.7 and then withdrawing the plug. The equipment grounding blade is to be connected to ground through a fuse. The device shall make and break 150 % of its rated current for 50 cycles of operation at a rate not higher than 10 cycles per minute.

122.5 A separate sample of a plug and a receptacle is to be used for each overload test, except that, upon request from the manufacturer, one sample may be used for all of the overload tests.

122.6 The potential of the test circuit is to be 100 – 105 % of the rating of the device in volts based on the voltage specified in Table 121.1.

122.7 Other than as noted in 122.8 – 122.10, the test on a plug and a receptacle that has multiple voltage and ampere ratings is to be performed at:

a) 150 % of the rated current that corresponds to the maximum rated voltage;

b) 150 % of the maximum rated current at the corresponding rated voltage; and

c) 150 % of the rated current and corresponding rated voltage that results in maximum power per pole.

122.8 A test on alternating-current may be waived if acceptable results have been obtained from an equivalent or higher volt-ampere test at a direct-current potential that is equal to or greater than the alternating-current potential rating.

122.9 One or two of the overload tests described in 122.7 may be waived, if it is obvious that it is fully represented by the other test or tests.

122.10 The overload tests specified in 122.7 may be waived, if it is obvious that they are fully represented by the tests specified in 122.15.

122.11 Neither the blades of the plug nor the contacts of the receptacle are to be adjusted, lubricated, or otherwise conditioned before or during the test.

122.12 The device is to be mounted and wired to represent service conditions. If the device is rated at 250 volts or a lower potential, exposed metal parts are to be connected through a fuse to ground, the grounded conductor of the test circuit, or a circuit conductor that differs at least 125 volts in potential from one or more of the remaining conductors in the circuit. If the device is rated at more than 250 volts, the exposed metal parts are to be connected similarly to a circuit conductor that differs by at least the rated potential from one or more of the remaining conductors in the circuit.

122.13 The fuse in the grounding conductor is to be a 15-ampere fuse if the device under test is rated at 30 amperes or less, and is to be a 30-ampere fuse if the device under test is rated at more than 30 amperes. The fuse in the test circuit is to be of the next higher commercial fuse rating than the value of the test current. Neither the line fuse nor the grounding fuse shall open during the test.

122.14 The test is to be conducted on direct-current, except that alternating-current is to be used if the device is rated for alternating-current only. If alternating-current is used for the test, the power factor of the load is to be from 0.75 to 0.80 for an ampere-rated device.

122.15 Other than as noted in 122.16, a plug and receptacle that have a horsepower rating shall perform as intended in an overload test making and breaking the locked-rotor current corresponding to the horsepower rating of the device. The test shall be conducted as specified in 122.4 – 122.14, except that the value of the test current corresponding to a horsepower rating is to be as specified in the requirements for snap switches for 2 horsepower or less in UL 20, and in UL 98, for an alternating-current rating of more than 2 horsepower. The load for an alternating-current horsepower rating is to have a power factor of 0.40 to 0.50.

122.16 Either of the overload tests mentioned in 122.15 may be omitted if it is obvious that it is fully represented by the other test.

122.17 A plug and receptacle for controlling a contactor, a relay, or other magnetically-operated device shall perform acceptably when subjected to an overload test consisting of 50 operations, making and breaking a circuit of 110 % of the overload-test potential specified in Table 122.1. The load is to consist of an electromagnet representative of the load that the device is intended to control. Other than as noted in 122.18, the load is to be that specified in Table 122.1. The test is to be conducted as described in 122.11 – 122.13.

122.18 A load other than one of those specified in Table 122.1 may be used after due consideration of the need for a device to control an electromagnet having other characteristics, the means utilized for matching the rating of the device to that of the load, and the completeness of the marking.

Table 122.1
Standard Electromagnet Loads

Test potential in volts	Standard duty		Heavy duty	
	Normal current	Current inrush	Normal current	Current inrush
120 ac[a]	3.0	30	6.0	60
240 ac[a]	1.5	15	3.0	30
480 ac[a]	0.75	7.5	1.5	15
600 ac[a]	0.6	6	1.2	12
125 dc	1.1	–	2.2	–
250 dc	0.55	–	1.1	–
600 dc	0.2	–	0.4	–

[a] Power factor 0.35 or less

123 Normal Temperature Test

123.1 When tested under the conditions described in 123.2 – 123.6, a plug and a receptacle shall not:

a) Attain a temperature at any point sufficiently high to cause a risk of fire or to damage any material employed in the device; or