UL 823

STANDARD FOR SAFETY

Electric Heaters For Use In Hazardous (Classified) Locations

UL Standard for Safety for Electric Heaters For Use in Hazardous (Classified) Locations, UL 823

Ninth Edition, Dated October 20, 2006

Summary of Topics

This revision to ANSI/UL 823 dated January 11, 2021 includes the following changes in requirements:

> ***– Revisions to include +60°C and -60°C explosion testing with test factors using precompression explosion testing equipment; 1.7, 33.28, 33.28A, 33.28B, Table 33.4, Section 34A, SB1.29 – SB1.31 and Table SB1.6***
>
> ***– Revisions to permit the use of electronic medium for required documentation; 55.20, 55.26, and Section 56***

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

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated May 22, 2020 and October 23, 2020.

No Text on This Page

OCTOBER 20, 2006
(Title Page Reprinted: January 11, 2021)

ANSI/UL 823-2021

1

UL 823

Standard for Electric Heaters For Use in Hazardous (Classified) Locations

The First and Second editions were titled Electric Heaters for Use in Hazardous Locations, Class I, Groups C and D, Class II, Groups E, F, and G. The Third through fifth editions were titled Electric Heaters For Use In Hazardous Locations, Class I, Groups A, B, C, and D, and Class II, Groups E, F, and G.

First Edition – September, 1965
Second Edition – January, 1969
Third Edition – June, 1971
Fourth Edition – May, 1972
Fifth Edition – July, 1977
Sixth Edition – October, 1985
Seventh Edition – February, 1991
Eighth Edition – October, 1995

Ninth Edition

October 20, 2006

This ANSI/UL Standard for Safety consists of the Ninth Edition including revisions through January 11, 2021.

The most recent designation of ANSI/UL 823 as an American National Standard (ANSI) occurred on January 11, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

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

No Text on This Page

CONTENTS

INTRODUCTION

CONSTRUCTION – ALL HEATERS

INTRODUCTION

1 Scope

1.1 These requirements cover explosion-proof, dust-ignition-proof and dust-tight portable and fixed electric heaters for installation and use in hazardous (classified) locations, Class I, Divisions 1 and 2, Groups A, B, C, and D; Class II, Division 1, Groups E, F, and G; Class II, Division 2, Groups F and G; and Class III, Divisions 1 and 2, in accordance with the National Electrical Code, NFPA 70.

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

1.3 These requirements also cover explosion-proof 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 55.4.

1.4 These requirements cover electric air heaters, electric hot-water or steam radiators, and electric hot plates rated 600 volts or less.

1.5 These requirements also cover paint heaters, rated 600 volts or less, for use at pressures not exceeding 100 psig (690 kPa). Paint heaters operating at more than 100 psig may be investigated in accordance with these requirements and any additional requirements judged to be necessary.

1.6 These requirements do not cover medical equipment.

1.7 These requirements cover heaters for use only 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 percent by volume; and

c) A nominal barometric pressure of one atmosphere.

2 General

2.1 An electric heater for use in hazardous locations shall also comply with the applicable requirements for a similar product for use in ordinary locations.

2.2 An electric heater for Class III locations shall comply with requirements for Class II, Group G, except that an enclosure for Class III, Division 2 shall be of the type described in 45.3.

3 Components

3.1 Except as indicated in 3.2, a component of a product covered by this standard shall comply with the requirements for that component.

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

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

b) Is superseded by a requirement in this standard.

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

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

4 Units of Measurement

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

5 Undated References

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

6 Enclosure Types

6.1 A heater that is marked enclosure Type 7 shall comply with the applicable requirements for Class I. A heater that is marked enclosure Type 9 shall comply with the applicable requirements for Class II.

6.2 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 the Standard for Enclosures for Electrical Equipment, UL 50.

7 Class I, Zone and Group Equivalency

7.1 Class I, Zone 1, Group IIA

7.1.1 Explosion-proof electrical equipment intended to be marked in accordance with 55.2 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group D hazardous (classified) locations.

7.2 Class I, Zone 1, Group IIB

7.2.1 Explosion-proof electrical equipment intended to be marked in accordance with 55.3 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group C hazardous (classified) locations.

7.3 Class I, Zone 1, Group IIC

7.3.1 Explosion-proof electrical equipment intended to be marked in accordance with 55.5 shall comply with all the requirements for explosion-proof electrical equipment for use in both Class I, Group A and Class I, Group B hazardous (classified) locations.

7.4 Zone 20, Zone 21, and Zone 22

7.4.1 Dust-ignition-proof electric heaters intended to be marked Zone 20 and 21 in accordance with 55.8 shall comply with all the requirements for dust-ignition-proof electrical equipment for use in Class II, Division 1 hazardous (classified) locations.

7.4.2 Dusttight electric heaters intended to be marked Zone 22 in accordance with 55.9 shall comply with all the requirements for Dusttight electric heaters for use in Class II, Division 2 hazardous (classified) locations.

8 Glossary

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

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

8.3 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 11.2.

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

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

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

8.7 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 explosion-proof enclosure.

8.8 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.

8.9 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.

8.10 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.

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

8.12 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 11.3.1 and 19.4.

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

8.14 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.

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

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

CONSTRUCTION – ALL HEATERS

9 General

9.1 A portable heater shall be of the hand-held type or shall be mounted on a movable base or stand with or without casters or wheels.

10 Enclosure

10.1 Enclosure

10.1.1 The enclosure housing the electrical components, such as heater elements, switches, and thermostats, shall be made of iron, steel, copper, brass, bronze, aluminum, or an alloy containing not less than 80 percent aluminum, or shall be made of nonmetallic material which complies with the requirements in Section 32, Non-Metallic Enclosure Materials Tests. A metal such as zinc or magnesium or their alloys shall not be used.

10.1.2 Copper shall not be used for the enclosure of an electric heater for use in Class I, Group A locations. A copper alloy shall not be used for an enclosure unless it is coated with tin, nickel, or other acceptable coating, or unless the copper content of the alloy is not more than 30 percent.

10.2 Thickness

10.2.1 Except as indicated in 10.2.2 and 10.2.3, the thickness of enclosure walls shall not be less than specified in Table 10.1.

Table 10.1
Thickness of metal for enclosure

Maximum enclosure dimensions				Minimum thickness, inch (mm)					
Length or diameter,		Area of any one surface,		Cast brass, bronze, copper, of malleable iron		Cast iron and aluminum		Sheet steel	
inches	(m)	square inches	(m^2)						
22	(0.56)	480	(0.31)	0.093	(2.36)	0.125	(3.18)	0.067	(1.70)
30	(0.76)	620	(0.40)	0.093	(2.36)	0.125	(3.18)	0.093	(2.36)
60	(1.52)	1500	(0.97)	0.125	(3.18)	0.187	(4.75)	0.125	(3.18)
Over 60	(over 1.52)	Over 1500	(over 0.97)	0.187	(4.66)	0.250	(6.55)	0.187	(4.66)

10.2.2 A heating element shall be permitted to have a sheath thickness less than 3/32 inch (2.4 mm) if the element:

a) Is cast in metal, with the cast metal not less than 1/8 inch (3.2 mm) thick over the sheath; or

b) Complies with the Dielectric Voltage-Withstand Test, Section 29, and the manufacturing and production tests specified in 51.1(c).

10.2.3 A sheet-metal enclosure of a heater for use in Class II locations shall be permitted to have a thickness not less than specified in Table 10.2 if the heater is intended only for:

a) Ceiling mounting and is marked in accordance with 55.16; or

b) Wall mounting, complies with the requirements in 29.3 and 29.4, and is marked in accordance with 55.17.

Table 10.2
Thickness of sheet metal for Class II locations

Specific construction[a]		Minimum thickness of sheet metal, inch (mm)					
		Uncoated steel		Zinc-coated steel		Copper, brass, or aluminum	
At Openings for Conduit		0.032	(0.81)	0.034	(0.86)	0.040	(1.02)
Length more than 26 inches (660 mm)	Component Support	0.026	(0.66)	0.029	(0.74)	0.032	(0.81)
	No Component Support	0.020	(0.51)	0.023	(0.58)	0.025	(0.64)
Length not more than 26 inches	Component Support	0.020	(0.51)	0.023	(0.58)	0.025	(0.64)
	No Component Support	0.016	(0.41)	0.019	(0.48)	0.020	(0.51)

NOTE – This table applies only to heaters as described in 10.2.3 and 39.2.2.1.

[a] A component refers to an electrical device, such as a lampholder, switch, and the like.

10.2.4 Table 10.2 applies to any single surface of a single flat sheet. Rigid members consisting of 1/2 by 1/2 inch (12.7 by 12.7 mm), 90-degree angle strips formed of sheet steel not less than 0.032 inch (0.81 mm) thick, or flat steel bars not less than 3/8 inch (9.5 mm) thick shall be permitted to be used to reinforce and divide a large area into sections for which thinner metal shall be permitted to be used. Such reinforcement, unless along the longer dimensions of the surface, is to be additionally secured to the adjacent sides of the enclosure. A single piece of sheet metal that is corner-bent to form an angle of not more than 120 degrees is considered to be reinforced along the bend, and its thickness shall be permitted to be based on the length of the largest flat surface involved.

10.2.5 A machined or threaded joint in the wall of a cast-metal enclosure shall have at least the thickness specified in Table 10.1 through the overlap.

11 Joints in Enclosures

11.1 General

11.1.1 Joints in an enclosure shall comply with the applicable requirements in 11.1.2 – 11.7.3.1, and Section 33, Explosion Tests.

Exception: This requirement does not apply to joints that comply with the requirements in Supplement SA, Alternative Joints in Enclosures, and Supplement SB, Alternative Explosion Tests.

11.1.2 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 the Standard for Surface Texture, ANSI/ASME B46.1.

11.2 Cemented joints

11.2.1 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 sealed with a sealing compound, the sealing compound shall:

a) For Class I equipment, resist solvent action in compliance with 32.5, Tests on sealing compounds;

b) Resist moisture in compliance with UL 1203, High Humidity Tests; and

c) Comply with the requirements of 29.2, Impact test, without loosening or cracking, or showing other signs of deterioration.

11.2.2 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.

11.2.3 The cement shall contain no voids between the mating parts forming the joint.

11.2.4 The cement shall not be relied upon for mechanical security of the joint.

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

11.3.1 A sealing material applied to a joint surface in accordance with Exception No. 1 to 21.3 shall not increase the maximum clearance between joint surfaces beyond the dimensions specified in this Standard.

11.3.2 A polymeric-to-polymeric joint shall be of the labyrinth or threaded type, and shall comply with the requirements in Section 32, Non-Metallic Enclosure Materials Tests.

11.3.3 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 coilinsulation 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.

11.3.4 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.

11.3.5 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.

11.3.6 A gasket functioning as an active member in the flamepath is not prohibited from being employed in a metal-to-glass or polymeric-to-glass joint when the gasket complies with the requirements in 11.3.7 –

11.3.10. 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.

11.3.7 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.

11.3.8 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. 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. 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. 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.

11.3.9 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. 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.

11.3.10 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 which is attached by an adhesive or a cement does not comply with this Standard.

11.3.11 A joint of the labyrinth type shall comply with the requirements in 33.13.

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

11.4 Class I, Groups C and D locations

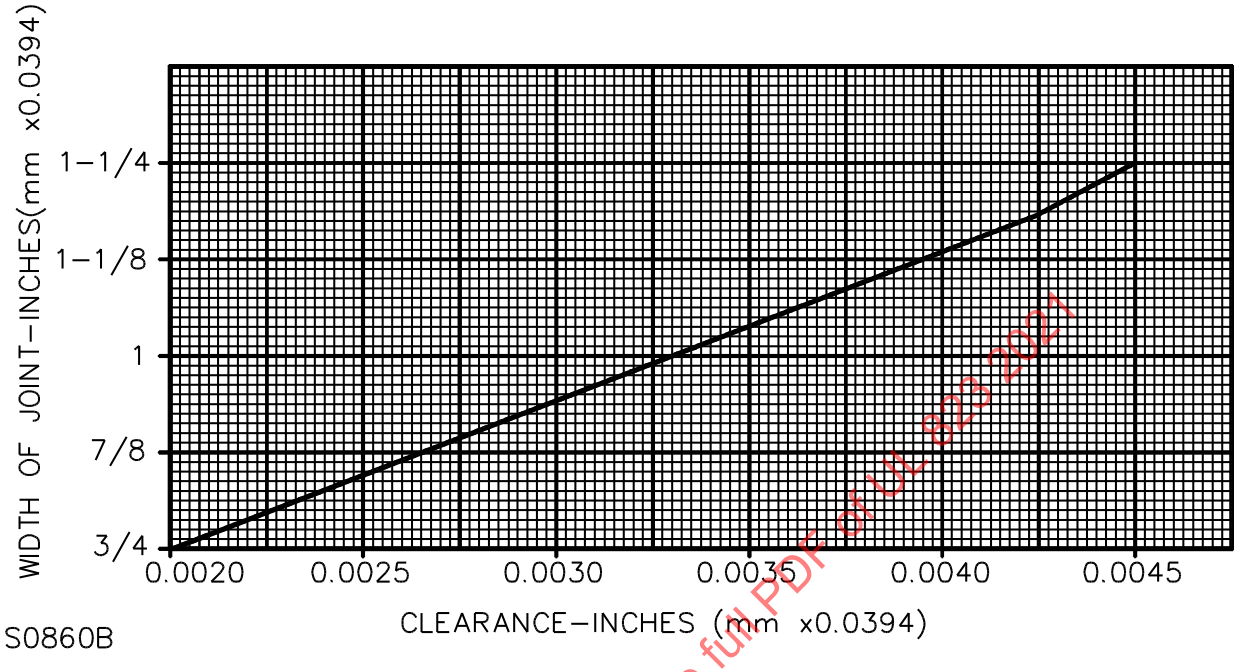
11.4.1 General

11.4.1.1 Except as indicated in 11.4.1.2 – 11.4.1.5 and 11.4.2.1, the width of a joint and the clearance, when assembled, shall be as specified in Figure 11.1. The width of the joint shall not be less than 3/4 inch (19.1 mm).

11.4.1.2 A rabbet joint is not prohibited from having a diametrical clearance at the axial section of not more than twice the clearance specified in Figure 11.1 when neither the axial nor the radial section of the joint is less than 1/16 inch (1.6 mm) wide.

Figure 11.1

Relation between clearance and width of joint



11.4.1.3 An enclosure having a free-internal volume of not more than 300 cubic inches (4.92 dm3) 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 11.2).

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 11.3).

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;

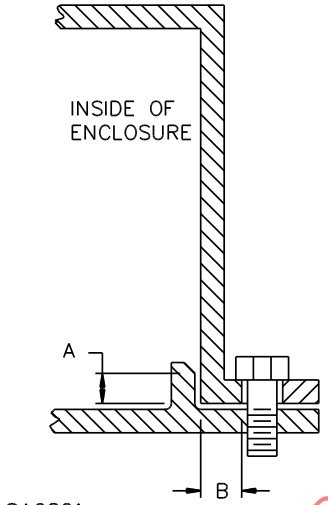
2) The thickness of the cover at the joint width is not less than 3/8 inch (9.5 mm), unless stiffened or reinforced material less thick has been found to be capable of being used when judged with respect to opening of joint clearance under internal pressures; and

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 11.2

Rabbet joint

See 11.4.1.3(a) and 11.5.1.2



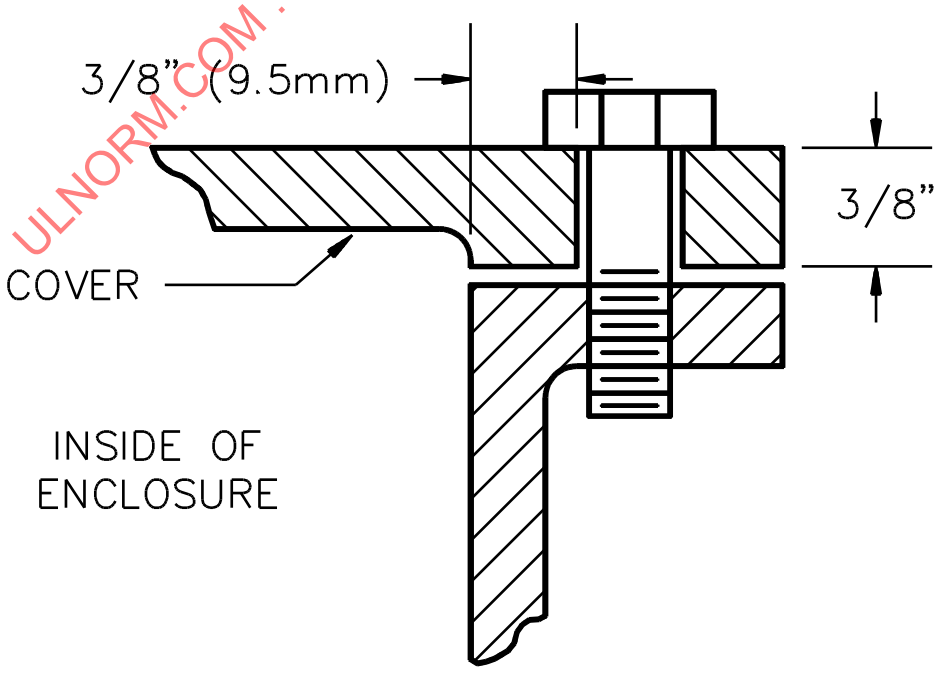
A + B = 1/2 inch (12.7 mm) for Class I, Groups C and D enclosures having free internal volume not more than 300 cubic inches (4.92 dm^3)

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 11.3

3/8-inch (9.5-mm) wide flat joint

(See 11.4.1.3(b) and 11.5.1.1)



11.4.1.4 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).

11.4.1.5 An enclosure is not prohibited from having a venting section to relieve internal explosion pressures. A joint in a vented enclosure is not prohibited from having 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), when the maximum explosion pressure developed during the explosion tests does not exceed 5 psig (34.5 kPa). A venting section shall afford protection against propagation of flame.

11.4.1.6 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.

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

11.4.2.1 A joint of the labyrinth type shall comply with the requirements in 33.25.

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

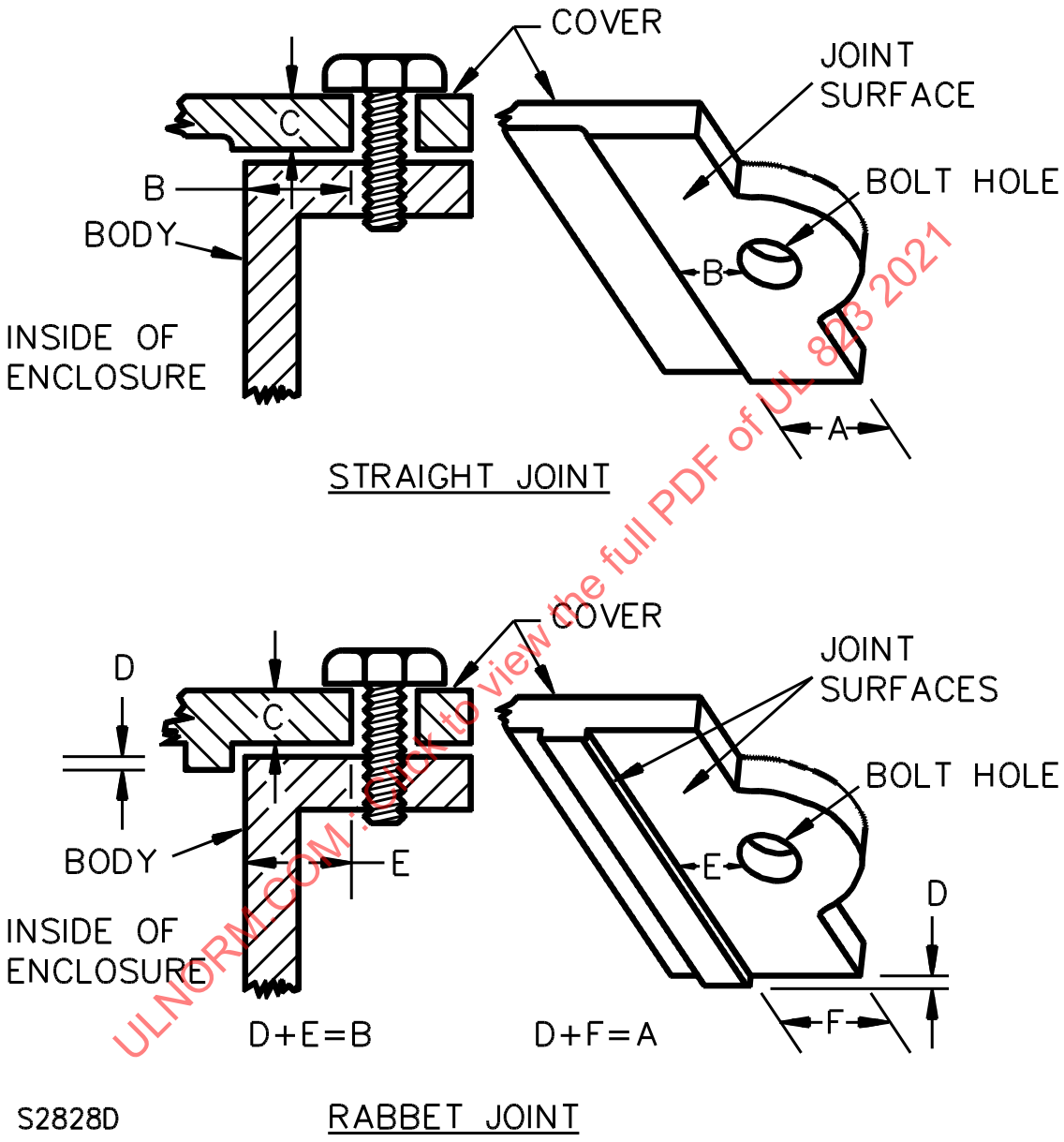
11.4.3 Bolts in joint width

11.4.3.1 A bolt is not prohibited from being 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 11.1. 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 11.4.3.4 and Figure 11.4.

Figure 11.4

Bolts in joint width

(See 11.4.3.1 and 11.5.2.2)



A = Required minimum width of joint (see Figure 11.1)

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

11.4.3.2 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.

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

11.4.3.4 The requirements in 11.4.3.1 and 11.4.3.2 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 11.4.3.1 and 11.4.3.2, 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.

11.5 Class I, Group B locations

11.5.1 General

11.5.1.1 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 11.3.

Exception: For an enclosure having a free internal volume of not more than 6 cubic inches (0.1 dm^3), the clearance between the joint surfaces is not prohibited from being not more than 0.004 inch (0.10 mm), and the cover thickness at the joint flange is not prohibited from being less than 3/8 inch .

11.5.1.2 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 11.2.

11.5.1.3 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).

11.5.2 Bolts in joint width

11.5.2.1 A bolt is not prohibited from being 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 11.5.2.2 and 11.5.2.3.

11.5.2.2 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 11.5.2.5 and Figure 11.4.

11.5.2.3 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.

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

11.5.2.5 The requirements in 11.5.2.1 – 11.5.2.3 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 11.5.2.1 – 11.5.2.3, 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.

11.6 Class I, Group A locations

11.6.1 Except for a conduit connection and a joint having tapered threads, a threaded joint in an enclosure shall have at least:

a) Eight fully engaged threads with a Class 1 fit;

b) Seven threads with a Class 2 fit; or

c) Six threads with a Class 3 fit.

11.6.2 A threaded joint in an enclosure having tapered threads shall fully engage at least five threads. Threads shall not be finer than 20 threads per inch (per 25.4 mm).

11.6.3 A joint of the serrated type with thread contour shall not have more than 20 serrations per inch (per 25.4 mm) and shall have at least five fully-engaged and tightly-clamped serrations.

11.7 Threaded joints

11.7.1 General – Class I, Groups A, B, C, and D

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

11.7.1.2 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.

11.7.1.3 All unused threaded openings through the walls of an explosion-proof enclosure shall be closed by a device or a threaded plug. The joint formed, upon assembly, shall comply with 11.7.2.1.

11.7.1.4 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.

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

11.7.1.6 Tapered threaded joints shall comply with Table 11.0.

Table 11.0
Tapered threaded joints

Pitch	≥ 0.9 mm[a]
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 ANSI/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 ANSI/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.	
Note: Gauging of female threads in IEC 60079-1 is flush to +2 turns of the plug gauge.	

11.7.2 Class I, Groups A and B

11.7.2.1 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 11.1 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 33, Explosion Tests, the minimum number of threads required shall be not less than specified in Table 11.2.

Table 11.1
Number of threads versus class of fit

Minimum number of fully engaged threads	Class of fit	
	ANSI[a]	ISO[b]
6	3	(5H/4h)
7	2	(6H/6h)
8	1	(7H/7h)
[a] See the Standard for Unified Inch Screw Threads (UN and UNR Thread Form),ANSI/ASME B1.1. [b] See the Standard for General Purpose Metric Screw Threads – Tolerances – Part 1, ISO 965-1 and the Standard for General Purpose Metric Screw Threads – Tolerances – Part 3, ISO 965-3,.		

Table 11.2
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)

11.7.3 Class I, Groups C and D

11.7.3.1 A threaded joint shall be made up with the number of fully engaged threads specified in Table 11.3. Threads shall not be finer than specified in Table 11.3.

Table 11.3
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

11.8 Shaft Openings

11.8.1 General

11.8.1.1 A shaft opening in an enclosure shall be of the metal-to-metal type. See 11.1.2 regarding the roughness of the surfaces forming the shaft path joints.

11.8.1.2 The requirements in 11.8.2.1 – 11.8.3.5.2 apply to shaft openings in electrical enclosures for Class I, Groups C and D locations.

11.8.1.3 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 11.8.2.1.

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

11.8.2.1 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 11.1. 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 11.8.2.2.

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 11.8.2.1 and 11.8.2.2 when it complies with the requirements in 11.8.3.1.3 – 11.8.3.5.2.

11.8.2.2 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).

11.8.3 Shafts rotating at a speed of 100 rpm or more

11.8.3.1 General

11.8.3.1.1 Other than as noted in 11.8.3.1.2, the path at the opening for a shaft that rotates at a speed of 100 rpm or more shall comply with the requirements in 11.8.3.1.3 – 11.8.3.1.4.

11.8.3.1.2 For products 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 11.8.2.1 and 11.8.2.2.

11.8.3.1.3 The paths at shaft openings specified in 11.8.3.1.4 – 11.8.3.3.4 and 11.8.3.4.1 – 11.8.3.5.2 shall be in addition to any protection offered by the ball bearings or the sleeve bearings on the shaft.

11.8.3.1.4 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.

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

11.8.3.2.1 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).

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

11.8.3.3.1 Except as indicated in 11.8.3.3.3 and 11.8.3.3.4, 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).

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

a) Comply with the requirements in 11.8.3.3.1; 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-degree turns.

11.8.3.3.3 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.

11.8.3.3.4 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).

11.8.3.3.5 When the path specified in 11.8.3.3.1 – 11.8.3.3.4 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-degree 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).

11.8.3.4 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

11.8.3.4.1 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 11.4.

Table 11.4
Length of shaft opening and diametrical clearance

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

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

a) Comply with the requirements in 11.8.3.4.1; 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-degree turns.

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

11.8.3.5.1 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 11.5.

Table 11.5
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 degree turns.

11.8.3.5.2 The minimum dimensions specified in Table 11.5 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.

11.9 Class II

11.9.1 General

11.9.1.1 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 11.1.2.

Exception No. 1: 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.

Exception No. 2: 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.

11.9.1.2 A sealing material applied to a joint surface in accordance with Exception No. 2 to 21.3 shall not increase the maximum required clearance between the joint surfaces.

11.9.1.3 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.

11.9.1.4 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).

11.9.1.5 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 32.3.3.

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.

11.9.1.6 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.

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

11.9.2 Shaft Openings

11.9.2.1 A shaft opening in an enclosure shall be of the metal-to-metal type or metal-to-polymeric type. See 11.1.2 regarding the roughness of surfaces that form the shaft path.

11.9.2.2 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 11.9.2.3 – 11.9.2.5.

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 35.

11.9.2.3 Shafts rotating at a speed of 100 rpm or more shall have a minimum length of path, as shown in segment "B" in Figure 11.5, 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

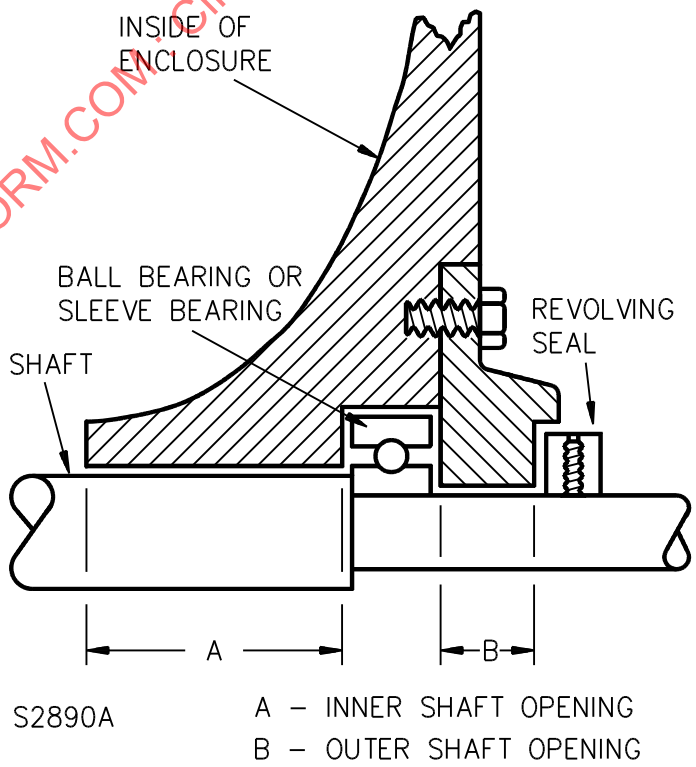
c) 0.022 inch (0.56 mm) for a 1-1/2 inch (38.1 mm) length of path.

Intermediate values are proportional. See Figure 11.5.

Exception: Equipment provided with an inner shaft opening (shown as segment "A" in Figure 11.5) complying with the dimensions specified in 11.2.1 – 11.5.2 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 35.

Figure 11.5

Shaft Openings



11.9.2.4 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 35.

11.9.2.5 With reference to the requirement in 11.9.2.4, when 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.

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

12 Holes in Enclosures

12.1 Class I locations

12.1.1 A metal pin or 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 the equivalent.

12.1.2 Holes in an enclosure for securing a part shall be:

a) Bottomed;

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

c) The screws securing the part shall engage at least five full threads and be secured against removal. A self-tapping screw shall have a minimum of five full threads engaged when seated. A screw shall not have more than 32 threads per inch (25.4 mm).

12.1.3 Unless attachment complies with the requirements in 12.1.1 or 12.1.2, holes in an enclosure for attachment of a nameplate shall be bottomed. The remaining thickness at the bottomed hole shall be sufficient to withstand the Hydrostatic-Pressure Test, Section 34, but shall not be less than 1/16 inch (1.6 mm).

12.1.4 A threaded plug, other than the enclosure cover, provided to permit replacement of a heater element shall engage at least five full threads and shall be covered or not accessible, or both.

12.2 Class II locations

12.2.1 A metal pin or part press-fitted through the wall of an electrical 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.

12.2.2 Holes in the enclosure for securing a part:

a) Shall be bottomed;

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

c) The screws securing the part shall engage three full threads and be secured against removal. A self-tapping screw shall have a minimum of three full threads engaged when seated. A screw shall not have more than 32 threads per inch (25.4 mm).

12.2.3 Unless attachment complies with the requirements in 12.2.1 or 12.2.2, holes in an 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).

13 Hot-Water or Steam Radiators

13.1 General

13.1.1 Pressure-, temperature-, and low-water-operated controls shall be of explosion-proof or dust-ignition-proof construction, or both.

13.2 Immersed heating elements

13.2.1 Unless a heating element complies with the requirements in 10.2.2, it shall be enclosed by a metal tube and shall be tightly brazed or welded to the radiator body or to a threaded metal plug.

13.3 Low-water cutoff

13.3.1 A low-water cutoff shall have no electrical parts within the radiator. All mechanical parts – such as a float and the flexible parts transmitting the float movement through the radiator to a switch enclosure that is explosion-proof, dust-ignition-proof, or both – shall be resistant to corrosion.

13.4 Parts subject to pressure

13.4.1 Parts subject to pressure shall comply with the applicable requirements for pressure vessels and parts subject to pressure in the Standard for Electric Heating Appliances, UL 499.

13.5 Water-fill opening

13.5.1 An opening for adding water to a radiator shall provide sufficient air space above the water level for intended operation. The opening shall be closed with a threaded plug.

13.6 Provisions for mounting

13.6.1 A stationary heater shall be provided with mounting feet, lugs, or the equivalent.

14 Supply Connections – Fixed Heaters

14.1 General

14.1.1 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 the National Electrical Code, ANSI/NFPA 70-2005.

Exception: The equipment enclosure is not required to comply with this requirement when instructions are provided in accordance with 55.22.

14.1.2 NPT threaded entries shall be permitted and shall use a modified National Standard Pipe Taper (NPT) thread with thread form per ANSI/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 ANSI/ASME B1.20.1 except that entries shall gauge from flush to +3-1/2 turns beyond the L-1 gauging notch in lieu of the −1 to +1 turns described in ANSI/ASME B1.20.1. Supply connection threads shall comply with Section 33, Explosion Tests.

14.1.3 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 55.22.

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)	60.65	(154.05)

Figure 14.1

Conduit opening without conduit stop

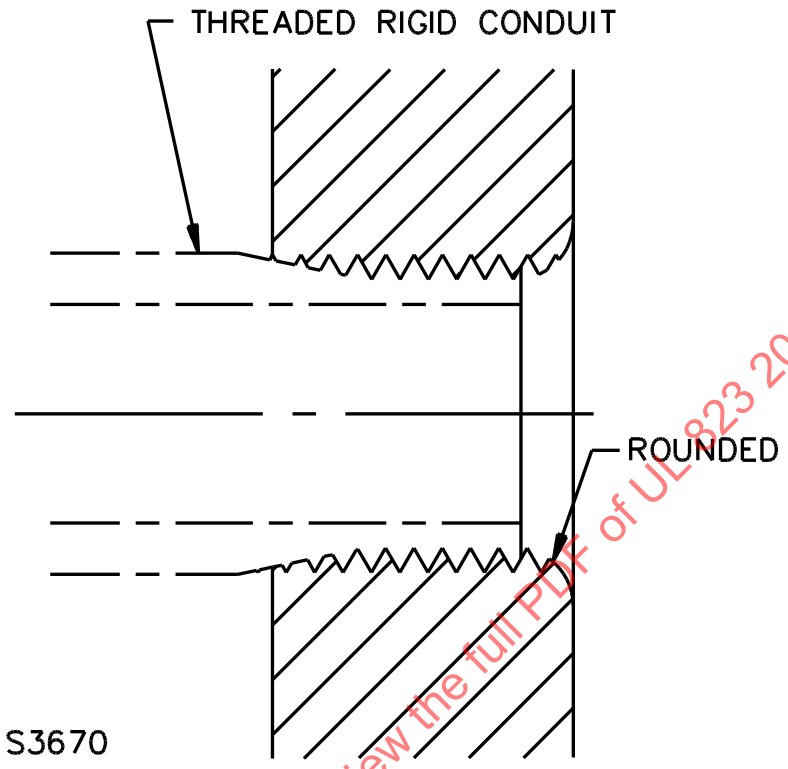


Table 14.2
Number of threads in a conduit opening without an integral stop

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

14.1.4 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.

14.1.5 Metric threaded entries shall comply with the requirements in Section 11.7, Threaded Joints, and Section 33, Explosion Tests. Means shall be provided to minimize abrasion to conductor insulation.

14.1.6 Metric threaded entries shall have a permanent marking near the supply connection opening in accordance with 55.21.

Exception: Equipment which uses a thread type other than NPT or NPS is not required to have the marking in 55.21 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 I in this Standard.

14.1.7 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.

14.1.8 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).

14.1.9 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 ANSI/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 14.2.

14.1.10 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).

14.1.11 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 11.7, Threaded joints.

14.1.12 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 36.

14.1.13 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 55.20.

14.1.14 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 ANSI/ASME B1.20.1 when measured from the end of the fitting thread to the face of a shoulder or to an interruption.

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

14.1.16 *Deleted*

14.1.17 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 of Conduit Hubs Test, Section 36.

14.2 Conduit seals

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

a) Comply with the applicable requirements in 14.2.2, 14.2.3, and Section 37.3, Leakage Test on Factory-Installed Conduit Seals; and

b) Be marked in accordance with 55.25.

14.2.2 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 32.2.3;

d) Be resistant to moisture and aging; and

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

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

14.2.4 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.

14.3 Class II locations

14.3.1 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 the National Electrical Code, ANSI/NFPA 70-2005.

Exception: The opening is not required to comply with this requirement when instructions are provided in accordance with 55.20.

14.3.2 An NPT conduit opening shall be provided with not less than 3-1/2 threads.

14.3.3 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 55.22.

14.3.4 Entries shall use a modified National Standard Pipe Taper (NPT) or National Standard Pipe Straight (NPS) thread. The pipe thread form shall comply with the Standard for Pipe Threads, ANSI/ASME B1.20.1. Entries shall not be smaller than trade size 1/2 nor larger than trade size 6 and shall provide for not less than 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 ANSI/ASME B1.20.1 except that entries shall gauge with +1/2 to + 3-1/2 turns beyond the L-1 gauging notch in lieu of the ±1 turns described in ANSI/ASME B1.20.1.

14.3.5 Metric threaded entries shall comply with the requirements in Section 11.7, Threaded Joints. Means shall be provided to minimize abrasion to conductor insulation.

14.3.6 Metric threaded entries shall have a permanent marking near the supply connection opening in accordance with 55.21.

Exception: Equipment which uses a thread type other than NPT or NPS is not required to have the marking in 55.21 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 I in this Standard.

14.3.7 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.

14.3.8 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).

14.3.9 When an integral conduit stop is provided in a conduit opening of an enclosure for Class I, Group C or D locations, the threads are to be either of the straight type or tapered 3/4 inch per foot (62.5 mm/m).

14.3.10 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).

14.3.11 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.

14.3.12 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 36.

14.3.13 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 55.22.

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

a) Comply with the applicable requirements in 14.2 and Section 37.3, Leakage Test on Factory-Installed Conduit Seals; and

b) Be marked in accordance with 55.25.

14.3.15 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.

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

14.3.17 Grounding shall comply with the requirements in Section 18, Bonding and Grounding.

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

14.4 Supply connections – Portable heaters

14.4.1 General

14.4.1.1 A portable heater shall have a provision for connection of flexible cord as described in 14.4.3.1.1 – 14.5.3.

14.4.2 Seal between heater and terminal enclosure

14.4.2.1 Lead wires or conductors shall be securely held and tightly fitted where they extend through the wall between the heater and terminal enclosure. If a sealing compound or cement is used, it shall comply with the requirements in 14.2.1 and 14.2.4.

14.4.3 Terminal enclosure

14.4.3.1 General

14.4.3.1.1 A portable heater shall have provision for connection of an extra-hard-usage flexible cord Type S, SO, ST, or STO with a grounding conductor.

14.4.3.1.2 The terminal enclosure shall be of a construction that facilitates ready replacement of the cord.

14.4.3.1.3 The enclosure that contains the terminals for connection of the flexible-cord conductors shall be of substantial construction completely enclosing the terminals.

14.4.3.1.4 The surface of the insulation on the equipment-grounding conductor shall be green with or without one or more yellow stripes, and no other conductor shall be so identified.

14.4.3.1.5 The equipment-grounding conductor shall be connected to the grounding terminal of the heater by means other than solder.

14.4.3.1.6 An attachment plug provided with a heater shall be:

a) Of the grounding type;

b) Acceptable for the same hazardous location Classes and Groups as the heater; and

c) Connected to the power-supply cord as intended.

14.4.3.1.7 If an attachment plug is not provided, the heater shall be marked in accordance with Section 55, Markings/General.

14.4.3.2 Class I locations

14.4.3.2.1 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 strands of the cord conductor, the terminal enclosure shall comply with the requirements specified in the Explosion Test, Section 33, and the Hydrostatic-Pressure Test, Section 34, and have metal-to-metal joints in accordance with 11.1.1 – 11.8.3.5.2. The terminal enclosure shall be made of metal having a thickness not less than that specified in Table 11.1.

14.4.3.2.2 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 strands of the cord conductor, the terminals shall be enclosed but the explosion-proof construction specified in 14.4.3.2.1 need not be provided. The entrance for the power-supply cord shall be permitted to be closed with a molded rubber bushing complying with the Accelerated-Aging Test on Bushings, Section 23.

14.4.3.2.3 With reference to the requirements in 14.4.3.2.2, the terminal may be of the pressure-wire-connector type in which the wiring is clamped between two plates.

14.4.3.3 Class II, Group G locations

14.4.3.3.1 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 strands of the cord conductor, the terminal enclosure shall prevent the entrance of grain dust (see Dust Penetration Test, Section 35) and have metal-to-metal, gasketed, or threaded joints in accordance with 11.5.1 – 11.7.3. The terminal enclosure shall be made of metal having a thickness of not less than that specified in Table 10.1..

14.4.3.3.2 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 strands of the cord conductor, the terminals shall be enclosed but the dust-ignition-proof construction specified in 14.4.3.3.1 need not be provided. The entrance for the power-supply cord shall be permitted to be closed with a molded rubber bushing complying with the requirements in Accelerated-Aging Test on Bushings, Section 23.

14.4.3.3.3 With reference to the requirements in 14.4.3.3.2, the terminals shall be permitted to be of the pressure-wire-connector type in which the wiring is clamped between two plates.

14.4.4 Packing gland

14.4.4.1 A packing gland – stuffing box – shall be provided at the cord entrance to the terminal enclosure if the enclosure is constructed as described in 14.4.3.2.1 or 14.4.3.3.1.

14.4.4.2 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 the tightly compressed seal shall be at least 5/8 inch (15.9 mm) if the terminal enclosure is constructed as described in 14.4.3.2.1 and at least 1/2 inch (12.7 mm) if the terminal enclosure is constructed as described in 14.4.3.3.1. The

construction and the 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 interference with parts other than the packing material. The compression nut shall be mechanically secured against loosening by means of a setscrew or the equivalent.

14.4.4.3 The diametrical clearance between the outer jacket of the power-supply cord and the surrounding cavity for the 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 1/16 inch (1.6 mm) for packing material less than 1/4 inch (6.4 mm) in diameter, or 3/16 inch (4.8 mm) for packing material 1/4 inch in diameter or larger.

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

14.5 Cord clamp

14.5.1 A positive mechanical cord clamp shall be provided that:

a) Facilitates ready replacement of the power-supply cord; and

b) Reduces the risk of strain at the cord connection within the terminal enclosure.

14.5.2 A cord clamp that is threaded to the terminal enclosure shall form a tight engagement or shall be secured against turning or loosening by means of a setscrew or the equivalent.

14.5.3 The cord clamp shall be smooth and free from sharp edges that can damage the jacket of the flexible cord.

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

14.6 Securing of threaded joints

14.6.1 A threaded joint entering an explosion-proof or dust-ignition-proof heater or a terminal enclosure of a portable heater unit shall be secured against loosening by means of a setscrew or the equivalent.

15 Hooks and Handles

15.1 A portable heater shall be provided with a hook, unless mounted on a base or a stand, and shall be provided with a handle or the equivalent.

16 Casters and Wheels

16.1 Casters or wheels, or both, provided on a floor-borne assembly of a portable heater shall be:

a) Metal;

b) Electrically conductive rubber casters; or

c) Metal wheels with electrically conductive tires.

17 External Metal Parts

17.1 To reduce the risk of percussion sparks, all external metal parts of a portable heater, including its base or stand, that may be struck by or strike against foreign objects, shall be made of brass, aluminum, or bronze.

18 Bonding and Grounding

18.1 Except as noted in 18.2, all dead metal parts of a portable heater shall be electrically bonded to the terminal intended for the connection of the equipment-grounding conductor of the power-supply cord.

18.2 A dead metal part not likely to become energized, such as a nameplate, need not be bonded if an investigation shows that after such a part has been electrostatically charged, the accumulation is not sufficient to arc to a grounded probe.

18.3 The 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 slotted, hexagonal, green-colored head;

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 in accordance with 18.4.

18.4 If a pressure wire connector at the equipment-grounding terminal is located within the device 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.

18.5 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 if the part can be interchanged with a similar part of another terminal on the heater.

18.6 The grounding member of the attachment plug, if provided, and the grounding conductor of the power-supply cord and dead metal parts of a portable electric heater, required to be bonded in accordance with 18.1, shall be electrically connected as determined by test. See Resistance Test, Section 37.

18.7 When provided, supplementary grounding or bonding connection facilities on the outside of a heater 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. The terminal shall be marked in accordance with 55.26.

19 Temperature-Limiting Devices

19.1 A thermal cutoff or a manually reset temperature-limiting control shall be secured in place and located so that replacement of the thermal cutoff or resetting of the temperature-limiting control is possible without damaging other connections or internal wiring.

19.2 Stretching or similar displacement of the heater element wire shall not cause permanent displacement or distortion that could affect the performance of the heater.

19.3 A thermal cutoff employed to reduce the risk of overheating of the exterior surface of the heater enclosure shall not be affected adversely by aging and shall open the electrical circuit under the conditions described in the Thermal-Cutoff Test, Section 30.

19.4 A thermal cutoff complying with the Standard for Thermal-Links – Requirements and Application Guide, UL 60691, is not to be considered affected adversely by aging.

20 Protection Against Corrosion

20.1 All ferrous metal parts of other than stainless steel shall be protected against corrosion, except at joint surfaces, shaft openings, and conduit threads, by zinc or cadmium coating, plating, enameling, painting, varnishing, or lacquering. Joint surfaces and conduit threads shall be permitted to be electroplated with zinc or cadmium.

20.2 Brass, copper, or lead alloy (terne) are not acceptable for coating ferrous metal parts for protection against corrosion.

21 Materials Applied to Joint Surfaces

21.1 A corrosion inhibiting grease, such as petrolatum or soap-thickened mineral oils, shall be permitted to be applied to metal joint surfaces before assembly.

21.2 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 metal joint surfaces.

21.2.1 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.

21.3 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 11.3.1 and 33.12.

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 33.7; and

b) Complies with the requirements in 37.5.2 – 37.4.3.

21.4 A sealing material applied to a joint surface in accordance with Exception No. 1 to 21.3 shall not increase the maximum clearance between the joint surfaces beyond the dimensions specified in this Standard.

21.5 When a sealing material is applied to a joint surface in accordance with the Exception No. 1 to 21.3, explosion tests are to be conducted both with and without the sealing material in place.

21.6 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 21.3, the explosion tests are also to be conducted on a sample provided with such coating.

PERFORMANCE

22 Temperature Test

22.1 General

22.1.1 Tests are to be conducted at rated frequency and, except as indicated in 22.1.2 and 22.4.2, at the voltage specified in Table 22.1.

Table 22.1
Voltage for tests

Voltage rating of device[a]	Test potential, volts
110 – 120 ac	120 dc
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

[a] If the rating of the heater does not fall within any of the specified voltage ranges, it is to be tested at its rated voltage.

22.1.2 If the application of the test voltage specified in Table 22.1 does not result in the measured wattage input to the heater being equal to or more than the marked wattage rating, the test voltage to the heater is to be increased until the measured wattage input equals the marked wattage rating.

22.1.3 If a heater employs a motor in addition to a heating element, the voltage applied to the motor is to be as specified in Table 22.1.

22.1.4 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). When thermocouples are used in determining temperatures in electrical equipment, it is common practice to employ thermocouples consisting of 30 AWG iron and constantan wire and a potentiometer-type instrument; and such equipment is to be used whenever referee temperature measurements by thermocouples are necessary. The thermocouples and related instruments are to be accurate and calibrated.

22.1.5 The thermocouple junction and the adjacent thermocouple lead wire are to be securely held in thermal contact with the surface of the material the temperature of which is being measured. In most

cases, adequate thermal contact will result from securely taping or cementing the thermocouple in place but, if a metal surface is involved, brazing, soldering, or peening the thermocouple to the metal may be necessary.

22.1.6 Except as noted in 22.2.4, the heater is to be operated continuously until constant temperatures are reached. A temperature is to be considered constant when three successive readings, taken at intervals of 10 percent of the previously elapsed duration of the test, but not less than 5-minute intervals, indicate no change.

22.1.7 The temperature tests are to be conducted at an ambient of 40°C (104°F).

Exception: In determining operating temperatures of a heater that is marked for use in an elevated ambient, the test is to be conducted at the elevated ambient for which the heater is marked.

22.1.8 A heater that is intended to be mounted in a definite position in order to function as intended is to be so tested, and instructions for mounting in the intended position shall be marked on the heater in accordance with Section 55, Markings/General.

22.1.9 When testing a paint heater, water shall be permitted to be substituted for paint, with the water flow equivalent to the rated paint flow.

22.1.10 A temperature-limiting device in a heater shall not open during normal operation. Also see 22.2.4.

22.1.11 The cheesecloth, when specified in the temperature tests, is to be bleached cheesecloth, 36 inches (914 mm) wide, running 14 – 15 yards per pound-mass (28 – 30 m/kg) and having what is known to the trade as a count of 32 by 28 – that is, for any 1 inch square, 32 threads in one direction and 28 threads in the other (for any 1 centimeter square, 13 threads in one direction and 11 in the other).

22.2 All heaters

22.2.1 A heater when operated as described in 22.2.2 – 22.2.4 shall not exceed the temperatures specified in Table 22.2.

Table 22.2
Maximum temperatures – all heaters

Point of temperature measurement		Maximum temperature[a]	
		°C	°F
1.	Insulated wire	b	b
2.	Black-painted wood on which an air heater may be mounted or to which the heater is adjacent	105	221
3.	Any point within a terminal box or a wiring compartment in which field-installed conductors are connected, including the conductors, unless the heater is marked in accordance with 55.14	75	167
4.	Exterior of a handle	70	158
5.	Insulation and jacket of a power-supply cord	75[c]	167[c]

[a] Maximum temperatures are based on 40°C (104°F) test ambient or marked elevated ambient, when applicable.

[b] 15°C (27°F) more than the temperature rating of the wire.

[c] Consideration is to be given to a temperature more than 75°C (167°F) on the insulation and jacket if the cord is rated higher than 60°C (140°F) and if the section of the cord attaining a temperature more than 75°C is within an enclosure.

22.2.2 During the test, any automatic temperature-regulating controls provided with the heater are to be placed in the maximum position.

22.2.3 When determining compliance with item 2 of Table 22.2, an air heater is to be supported in the intended manner on or adjacent to the black-painted surface of a wall consisting of nominal 3/8-inch thick plywood fastened to the shorter sides of trade size 2- by 4-inch vertical wooden studs on 16-inch (406-mm) centers. Two or more such walls are to be fastened together to form a 90-degree angle, and the height and length of the walls are to be such that they extend not less than 2 feet (610 mm) beyond the physical limits of the heater. The heater is to be located as close to the sides of the wall angle as its construction allows, and it is to be placed relative to the walls so that maximum heating occurs on the walls; except that the heater may be spaced away from the wall so that temperature rises of more than 65°C (117°F) are not attained if the heater is marked accordingly.

22.2.4 To determine that a thermal cutoff does not open during normal operation (see 22.1.10), the heater is to be operated for at least 168 hours.

22.3 Heaters for Class I locations

22.3.1 A heater for Class I locations shall be operated until constant temperatures are attained.

22.3.2 A paint heater shall not exceed 150° C (302° F) on any external surface and there shall be no apparent change in the paint coating, such as discoloration – see 22.3.5.

22.3.3 During the test, an automatic temperature-regulating control is to be shunted out of the circuit. A fan or a blower provided as part of the heater is to be disconnected.

22.3.4 The heater is to be operated in air. An air heater is also to be operated in air with two layers of cheesecloth secured over the top of the heater and draped over the entire front.

Exception: A ceiling-mounted heater is not tested with cheesecloth.

22.3.5 For the test on a paint heater, the exterior surfaces are to have three coats of nitrocellulose-base paint (containing at least 30 percent by weight of nitrocellulose). The paint is to be applied with a brush and allowed to dry between each coat. The final coat is to be allowed to dry before the temperature test is conducted.

22.4 Heaters for Class II locations

22.4.1 A heater for Class II locations shall not exceed the temperatures specified in Table 22.3. In tests conducted with dust blanket, the dust in contact with the heater shall not ignite or discolor from heat.

Table 22.3
Maximum temperatures – Class II heaters

Point of temperature measurement		Maximum temperature	
		°C	°F
1.	External surfaces of a heater for Group E or F	200	392
2.	External surfaces of a heater for Group G	165	329

22.4.2 The temperature limits in Table 22.3 apply when the heater is operated:

a) At the voltage specified in Table 22.1 while blanketed with dust; and

b) At 110 percent of the voltage specified in Table 22.1 in air (without dust blanket).

22.4.3 Opening of a temperature limiting device is acceptable during the tests specified in 22.4.2.

22.4.4 A heater for use in Class II, Group E locations only is to be blanketed with magnesium dust during the test required by 22.4.2(a).

22.4.5 A heater for use in Class II, Groups E and F; Groups E and G; Groups E, F, and G, Groups F and G, or Group G locations, is to be blanketed with grain dust during the test required by 22.4.2(a).

22.4.6 During the test, an automatic temperature-regulating control is to be shunted out of the circuit. A fan or a blower provided as part of the heater is to be disconnected.

22.4.7 With reference to 22.4.4 and 22.4.5, the heater is to be installed in a test chamber as described in 35.2 and is to be exposed to the circulating dust-air atmosphere until the dust blanket is stabilized. The dust-circulation equipment is then to be de-energized and the heater is to be operated until equilibrium temperatures are attained.

22.5 Heaters for simultaneous exposure to Class I and Class II locations

22.5.1 The exterior surface temperatures of a heater intended for use when Class I and Class II conditions may exist simultaneously shall not exceed:

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

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

22.5.2 The maximum temperatures are to be determined under the conditions specified in 22.4.2.

23 Accelerated-Aging Test on Bushings

23.1 A molded rubber bushing provided at the cord entrance to the terminal enclosure of a portable heater shall not have a change in hardness of more than five numbers as a result of exposure in an air oven for 70 hours at 100°C ±2°C (212°F ±3.6°F).

23.2 When possible, the complete molded rubber bushing is to be tested. The hardness of the rubber 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 exposed in an air oven for 70 hours at 100°C ±2°C (212°F ±3.6°F).

23.3 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 average of the original hardness readings and the average of the hardness readings taken after exposure in an air oven is the change in hardness.

24 Strain-Relief Test

24.1 There shall be no strain at the cord conductor connections or damage to the cord of a portable heater when a direct pull is applied to the extension of the power-supply cord for 1 minute.

24.2 With the power-supply cord connected to the heater as intended in service, the cord clamp of the heater is to be held firmly and a pull, provided by the use of a pulley and weights, is to be applied at the cord extension. A pull of 150 pounds (667 N) is to be applied if the heater is rated 30 amperes or less. If the heater is rated over 30 amperes, a pull of 300 pounds (1334 N) is to be applied.

25 Rough-Usage Test

25.1 A portable heater not provided with a base or stand shall be subjected to a rough-usage test. A portable heater, its terminal enclosure, and cord clamp shall not be impaired nor shall threaded engagements be loosened when subjected to the test specified in 25.3.

25.2 Following the test described in 25.3, the heater shall withstand for 1 minute without breakdown the application of a 60 hertz essentially sinusoidal potential of 1000 volts plus twice the test voltage specified in Table 22.1. The potential is to be applied between live parts and dead metal parts of the heater.

25.3 The portable heater is to be suspended in a vertical position, with cord clamp up, by means of a short loop formed from a heavy solid wire. The power-supply cord is to be removed from the heater and one end of the wire loop connected to the heater at the cord clamp. The other end of the wire loop is to be extended through a screw eye secured to a solidly mounted vertical board, 2 inches (50.8 mm) thick. The free end of the portable heater is to be pulled away from the board and then allowed to swing back against the board, or against a wooden block secured to the board, for 9000 times at a rate of about 50 times per minute. The horizontal swing distance is to be about 6 inches (152 mm). A slower cycling rate may be employed with the concurrence of those concerned.

26 Drop Test

26.1 A drop test shall be conducted on a portable heater that can be dropped while being handled. The heater, the terminal enclosure, and the cord clamp shall not be impaired when the heater is dropped to a concrete floor ten times from a height of 3 feet (0.9 m), as specified in 26.2.

26.2 For the first five drops, the heater, with cord connected as in service, is to freely fall in a manner that would normally be the case if the heater were to fall from a horizontal platform to the floor. In the remaining five drops, the heater with cord is to be held at various angles about 3 feet (0.9 m) above the concrete floor and dropped.

26.3 Following the drop test, the heater shall withstand for 1 minute without breakdown the application of a 60 hertz essentially sinusoidal potential of 1000 volts plus twice the test voltage specified in Table 22.1. The potential is to be applied between live parts and dead metal parts of the heater.

27 Overturning Test

27.1 A portable heater having a base or a stand shall be subjected to an overturning test. The heater, the terminal enclosure, and the cord clamp shall not be impaired when the heater is overturned on a concrete floor ten times in various positions of adjustment.

28 Stability Test

28.1 In the intended operating position, a portable heater having a base or a stand shall not overturn when:

a) Tilted 20 degrees from its vertical center line; and

b) Placed on a horizontal floor and a directly horizontal pull of 12 pounds (53 N) is applied the heater at 4 feet (1.2 m) above the floor, or at the maximum height of the heater if less than 4 feet.

28.2 The stability of a portable heater having a base or stand is to be determined with the heater adjusted to the most unstable condition likely to be encountered during its intended use, including swiveling and blocking of the casters and wheels with a 3/8-inch (9.5-mm) square rod.

29 Dielectric Voltage-Withstand Test

29.1 Heating elements having a sheath with a wall thickness less than 3/32 inch (2.4 mm) and not cast in metal having a thickness of not less than 1/8 inch (3.2 mm) over the sheath shall withstand without breakdown the following dielectric voltage-withstand tests:

a) A 60 hertz essentially sinusoidal potential of 1000 volts plus twice the test voltage specified in Table 22.1 for 1 minute between the live parts and the dead metal parts of three samples following 6000 cycles of 1 minute on and 4 minutes off – ambient air cooling.

b) A 60 hertz essentially sinusoidal potential of 1000 volts plus twice the test voltage specified in Table 22.1 for 1 minute between the live parts and the dead metal parts following 50 cycles of 5 minutes on and 25 minutes off. The heater element is to be immersed in water during the off period.

c) A 60 hertz essentially sinusoidal potential of 1000 volts plus twice the test voltage specified in Table 22.1 for 1 minute between the live parts and the dead metal parts of a heater following 50 cycles of 5 minutes on and 25 minutes off – 5 minutes ambient-air cooling and 20 minutes at minus 40°C (minus 40°F) air cooling.

d) A 60 hertz essentially sinusoidal potential of 1000 volts plus twice the test voltage specified in Table 22.1 for 1 minute between the live parts and the dead metal parts of a heater following a 35-hour vibration test – 1/32-inch (0.8-mm) movement at a rate of 2000 cycles per minute.

e) A 60 hertz essentially sinusoidal potential of 1000 volts plus twice the test voltage specified in Table 22.1 for 1 minute between the live parts and the dead metal parts of three heaters, while in a thoroughly heated condition, following an impact test of 50 pounds (22.7 kg) dropped from a height of 3 feet (0.9 m). See 29.2.

29.2 For the impact test specified in 29.1(e), the heating element is to be placed on a flat steel plate that is 1-1/2 inches (38.1 mm) wide. A 50-pound (22.7-kg) weight having a flat base with dimensions of approximately 6 by 4 inches (152 by 102 mm) is to fall freely through a vertical guide from a 3-foot (0.9-m) height and strike the element sheath of an unfinned element. If the element is provided with fins for its entire length, the weight is to strike the fins. If an element is partially finned, two impact tests are to be conducted: in the first test, the weight is to strike the fins and, in the second test, the weight is to strike the sheath.

29.3 Three samples of a Class II wall-mounted heater having a thickness in accordance with 10.2.3 shall be subjected to the impact test described in 29.4. Following the impact test, each heater, while in a thoroughly heated condition, shall withstand for 1 minute without breakdown the application of a 60-hertz essentially sinusoidal potential of 1000 volts plus twice the test voltage specified in Table 22.1 between live parts and dead metal parts.

29.4 For the impact test specified in 29.3, each heater is to be placed horizontally on a flat steel plate. A 50-pound (22.7-kg) weight having a flat base with dimensions of approximately 6 by 4 inches is to fall freely through a vertical guide from a height of 3 feet (0.91 m) and strike the heater. Each of the three samples is to be impacted at a different location.

30 Thermal-Cutoff Test

30.1 A thermal cutoff shall open the circuit in the intended manner without causing the short circuiting of live parts and without causing live parts to become grounded to the enclosure when the heater is connected to a circuit of voltage as specified in 22.1.1 and operated in the intended position with any other thermally operated control devices in the heater short-circuited to cause abnormal heating.

30.2 The heater is to be operated with separate thermal cutoffs five times as described in 22.1.1 – 22.1.11, and with any other thermally operated control devices in the heater short-circuited. During the test, the enclosure is to be connected through a 3-ampere fuse to ground. Each thermal cutoff shall comply with the requirement in 30.1.

31 Low-Water Cutoff Test

31.1 General

31.1.1 A low-water cutoff shall be subjected to the tests specified in 31.2.1 – 31.5.4.

31.2 Overload

31.2.1 A low-water cutoff switch is to be subjected to 50 cycles of operation at 150 percent maximum rated current at the test voltage specified in Table 22.1. As a result of these tests, there shall be no electrical or mechanical malfunction of the low-water cutoff switch, nor welding or undue pitting or burning of the contacts.

31.3 Endurance

31.3.1 The switch used in the overload test is to be subjected to 6000 cycles of operation at rated load with the enclosure connected to ground through a 6-ampere fuse. The internal pressure during the test is to equal the rating of the pressure-relief valve. As a result of these tests, there shall be no electrical or mechanical malfunction of the low-water cutoff switch, nor welding or undue pitting or burning of the contacts.

31.4 Pressure

31.4.1 With the water level lowered to the point at which the low-water cutoff switch assumes an off position and with the heating element connected as described in 22.1.1, the heater is to be draped with cheesecloth as described in 22.3.4. Upon increasing pressure, the cutoff switch shall be made to close the circuit, and then the cutoff switch shall open the circuit when the cutoff is released.

31.5 Moist ammonia-air stress cracking test

31.5.1 After being subjected to the conditions as described in 31.5.3 – 31.5.4, a brass float of a low-water cutoff containing more than 15 percent zinc, shall show no evidence of cracking, rupture, distortion, or delamination when examined using 25X magnification.

31.5.2 Each test sample is to be subjected to physical stresses normally imposed on or within a part as the result of assembly with other components. Such stresses are to be applied to the sample prior to and maintained during the test. Samples with threads intended to be used for installing the product in the field, are to have the threads engaged and tightened to the torque specified in Table 31.1. Teflon tape or pipe compound are not to be used on the threads.

Table 31.1
Torque requirements for threaded connections

Nominal thread size, inches	Torque	
	pound-inches	(N·m)
1	1200	(135.6)
1-1/4	1450	(163.8)
1-1/2	1550	(175.1)
2	1650	(186.4)
2-1/2	1750	(197.7)
3	1800	(203.4)

31.5.3 Three samples are to be degreased and then continuously exposed in a set position for ten days to a moist ammonia-air mixture maintained in a glass chamber approximately 12 by 12 by 12 inches (305 by 305 by 305 mm) having a glass cover.

31.5.4 Approximately 600 ml of aqueous ammonia having a specific gravity of 0.94 is to be maintained at the bottom of the glass chamber below the samples. The samples are to be positioned 1-1/2 inches (38.1 mm) above the aqueous ammonia solution and supported by an inert tray. The moist ammonia-air mixture in the chamber is to be maintained at atmospheric pressure with the temperature constant at 93 ±4°F (34 ±2°C).

32 Non-Metallic Enclosure Materials Tests

32.1 General

32.1.1 Non-metallic materials shall comply with the requirements in either 32.2 or 32.3, and shall comply with the requirements in 32.4.

32.1.2 Non-metallic electrical enclosures shall comply with the requirements in the Standard for Electrical Enclosures, UL 50.

32.2 Chemical compatibility by material samples

32.2.1 Samples with like dimensions are to be prepared according to the requirements in Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics, ANSI/ASTM D256, and Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ANSI/ASTM D790.

32.2.2 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 Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics, ANSI/ASTM D256;

b) Flexural properties in accordance with Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ANSI/ASTM D790; and

c) Changes in weight and dimensions.

32.2.3 For each of the following test chemicals, a set of three sets of 5 samples [5 specimens each for 32.2.2 (a) – (c)] shall be exposed to a 100 percent saturated vapor in air of the chemical at 20 – 25°C (68 – 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.

32.2.4 The physical property values after chemical exposure shall not be less than 85 percent of the values determined using as-received samples for 32.2.2 (a) and (b).

Exception: A material that has values less than 85 percent and not less than 50 percent 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.

32.2.5 With regard to 32.2.2(c), shrinkage or weight loss shall not exceed 1 percent.

Exception: A material whose shrinkage or weight loss exceeds 1 percent 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.

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

a) Accelerated aging as specified in 32.3.3; and

b) Flamepath erosion test as specified in 32.3.5.

32.3 Chemical compatibility by complete end product tests

32.3.1 Sixteen (16) complete samples are to be tested as specified in 32.3.2 – 32.4.3.5.

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

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.

32.3.3 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:

Hygroscopic materials (most notably nylons) are not prohibited from being rehydrated in an ambient of 50 ±10 percent 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.

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

$$T_2 = T_1 + 10\left(\frac{In\frac{18262.5}{D}}{In\ 2}\right)$$

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.

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.

32.3.4 The three samples subjected to the accelerated aging test of 32.3.3 and each of the samples subjected to the solvent vapor exposure tests shall be individually subjected to the Hydrostatic Pressure Test, Section 34, based on the test pressure obtained during the explosion pressure tests conducted as described in Explosion Tests, Section 33.

32.3.5 Samples subjected to the solvent vapor exposure test of 32.3.2 or accelerated aging test of 32.3.3, shall exhibit no visual erosion of any flamepath when subjected to 100 additional flame propagation tests using the test method from Explosion Tests, Section 33.

32.4 Test for accumulation of static electricity

32.4.1 General

32.4.1.1 A nonmetallic external part with an area greater than 15.5 in^2 (100 cm^2) shall comply with either the requirements in 32.4.2 or 32.4.3.

32.4.2 Method A

32.4.2.1 Any non-metallic surface with area greater than 15.5 in^2 (100 cm^2) shall have a surface resistivity of 1 GΩ or less at 23° C (73° F) and 50 percent relative humidity as defined by the material specifications or as determined by the test in 32.4.2.2.

32.4.2.2 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 percent 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.

32.4.3 Method B

32.4.3.1 A nonmetallic external part with an area greater than 15.5 in^2 (100 cm^2) shall be subjected to the test specified in 32.4.3.2 – 32.4.3.5.

32.4.3.2 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.

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

32.4.3.4 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 then 35 percent 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.

32.4.3.5 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.

32.5 Tests on sealing compounds

32.5.1 A sealing compound used in Class I equipment shall be subjected to the tests described in 32.5.2 – 32.5.7 to determine its resistance to chemicals.

32.5.2 The resistance to crushing of the sealing 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 percent 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 percent 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 33.8.

32.5.3 Cylindrical 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.

32.5.4 The specimens are to be exposed for 168 hours (7 days) to saturated vapors in air of the chemicals specified in 32.2.3.

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

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

32.5.7 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.

32.5.8 As an alternative, tests to determine resistance of the sealing 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 33, Explosion Tests, and Section 34, Hydrostatic Pressure Test, on the complete sample after the sample has been exposed to the chemicals specified in 32.3.2. There shall be no flame propagation, rupture, cracking, breakage, or other damage to the sealing compound.

33 Explosion Tests

33.1 Equipment for use in Class I locations shall comply with the applicable requirements in Section 11, Joints in Enclosures, and 33.2 – 33.15.

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

33.2 A heater for use in Class I locations shall be tested in the presence of specific gas- or vapor-air mixtures over the range of flammable or explosive concentrations to determine:

a) The maximum explosion-pressure effects; and

b) The maximum propagation effects.

33.3 During the explosion tests, there shall be no obvious damage to internal parts, and the enclosure shall prevent the passage of flame to the surrounding atmosphere and sparks capable of igniting the surrounding atmosphere. In addition, the enclosure shall not burst or its joints become loosened.

33.4 Except as indicated in 33.5, 33.6, and 33.9, 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.

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

a) The explosion-proof 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.

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

a) The explosion-proof 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.

33.7 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.

33.8 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.

33.9 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.

33.10 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 21.3.

33.11 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.

33.12 When lengths of conduit are required to be connected to the equipment for the explosion tests (see 33.16), 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.

33.13 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. Samples are to be taken for analyses from the test chamber, within the equipment enclosure, and the lines carrying the explosive mixture. 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.

33.14 A series of at least ten tests is to be conducted on each device over the flammable range shown in Table 33.3. An enclosure having a venting section is to be subjected to an additional series of ten explosion tests with 75 percent of the venting area sealed.

33.15 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.

33.16 Equipment is to be tested with lengths of conduit as specified in Table 33.1 when:

a) It has no current-interrupting contacts, or all current-interrupting contacts hermetically sealed (see 33.17) 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 55.25.

Table 33.1
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)

33.17 With reference to 33.16, 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.

33.18 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 33.2, 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 21.2.

Table 33.2
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)

Table 33.3
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

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

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

33.21 When a sealing material is applied to a joint surface in accordance with Exception No. 1 to 21.3, the explosion tests are to be conducted both with and without the sealing material in place.

33.22 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 percent of the minimum production joint width and the joints shimmed to give a clearance of 50 percent more than the maximum production clearance.

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

33.24 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 percent of the total path length.

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

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

33.27 The explosive mixtures to be used in the explosion tests are as specified in Table 33.3.

33.28 For explosion-proof 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 explosion-proof 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) degrees. 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 33.3 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 33.2(b), the equipment shall alternatively be subjected to the hydrostatic pressure test using the test factors for low ambient rated equipment found in Table 34.1, based upon room ambient explosion pressure tests, or

c) The reference pressure shall be determined at room ambient temperature 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

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

33.28A For explosion-proof equipment specified and marked for use at ambient temperatures greater than 60°C (140°F), in addition to the tests of 33.28, 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 33.4; or

c) At normal atmospheric pressure and temperature, but with the test gap increased by the factors noted in Table 33.4.

These tests are in addition to the explosion tests required to determine compliance with 33.1 and 33.2(a).

Table 33.4
Test Factors to Increase Pressure or Flamepath Test Gap

Temperature up to °C	Groups A and B 27.5% H_2 7.5% C_2H_2	Group C 37% H_2	Group D 55% H_2
60	1.00	1.00	1.00
70	1.11	1.04	1.05

Table 33.4 Continued on Next Page

Table 33.4 Continued

Temperature up to °C	Groups A and B 27.5% H_2 7.5% C_2H_2	Group C 37% H_2	Group D 55% H_2
80	1.13	1.05	1.06
90	1.15	1.06	1.07
100	1.16	1.06	1.08
110	1.18	1.07	1.09
120	1.20	1.08	1.10
130	1.22	1.09	1.11

33.28B All test sample flamepaths are to be based upon the manufacturers maximum specified gap, and tested with the minimum specified flamepath length. Specially prepared test samples having modified flamepath lengths, gaps and engagements shall be employed. For Groups A, B, or A and B, test factors per 33.23 and 33.26 are also required to be introduced into the test pressure or test gap in addition to the test factors above.

33.29 A polymeric enclosure or a polymeric enclosure part that forms a portion of an explosion-proof joint shall be subjected to the following series of explosion tests in addition to those required by Explosion Tests, Section 33:

a) At least 100 tests on an enclosure with joints as described in 33.22 – 33.26, 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 the Accelerated air-oven aging test, 32.3.3.

d) At least ten tests on selected enclosures that have been subjected to the Chemical resistance tests, 32.3.

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 the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

34 Hydrostatic Pressure Test

34.1 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.

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 34.1.

Exception No. 2: When the production-line hydrostatic pressure test specified in Section 34, 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 34.1
Safety factors for determining the strength of an enclosure

Enclosure material or part	Test factor for calculations	Test factor for equipment rated and marked as low as minus 50°C[a] (minus 58°F)	Test factor for hydrostatic pressure tests
Cast metal	5	6	4
Non-metallic	–	–	4
Fabricated steel and aluminum	4	4.5	3[b]
Cover bolts or screws	3	4.5	3

[a] For Group C or D equipment in accordance with the Exception to 33.27, 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.

34.2 A radiator shall withstand without rupture a hydrostatic pressure of not less than five times the opening pressure of the relief valve.

34.3 The hydrostatic pressure is to be applied at a rate of approximately 100 – 600 psig (690 – 4137 kPa) per minute until the required internal pressure is reached. A gasket or equivalent means may be employed to prevent leakage of water during application of pressure.

34.4 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 33.17 shall withstand without rupture or permanent distortion the applicable hydrostatic test pressure specified in Table 34.2.

Table 34.2
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)

34A Dynamic Pressure Test

34A.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. 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.

34A.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

34A.3 Following the test, there shall be no permanent deformation or damage and joints shall not be permanently enlarged.

35 Dust Penetration Test

35.1 The enclosure or enclosures of a heater for use in Class II locations shall be exposed to a circulating dust-air atmosphere to determine that the heater is dust-ignition-proof with regard to exclusion of dust. During this test, there shall be no entrance of the dust into the heater as determined by visual examination following the test described in 35.2.

35.2 The heater is to be installed in a test chamber to permit free circulation of dust-air mixtures around the device. The test chamber is to be provided with a cover and with dust-air inlet and outlet connections. The heater is to be exposed to the dust-air atmosphere that is to be produced by auxiliary apparatus and introduced into the test chamber. The test is to be continued for at least 6 heating and cooling cycles covering at least 30 hours while the heater is continuously exposed to the circulating dust-air atmosphere.

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

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

35.5 The wire cloth in 35.3 and 35.4 is to conform to the dimensional requirements of Standard Specifications for Wire-Cloth Sieves for Testing Purposes, ASTM E11.

35.6 If the equipment is intended for Class II, Group E, Groups E and F, or Groups E, F, and G locations, penetrations tests are to be conducted with magnesium dust.

36 Secureness of Conduit Hubs Test

36.1 A conduit hub not integrally cast with a metal enclosure shall withstand the torque specified in Table 36.1 applied to a short length of 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.

Table 36.1
Torque

Trade size of conduit, inches	Torque, pound-inches	(N·m)
1/2 and 3/4	800	(90.4)
1, 1-1/4, and 1-1/2	1000	(112.9)
2 and larger	1600	(180.8)

37 Resistance Test

37.1 General

37.1.1 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 the portable heater, required to be bonded in accordance with 18.1, shall not exceed 0.1 ohm.

37.1.2 The resistance may be determined by any convenient method except that, if unacceptable results are recorded, either a direct or alternating current of 15 amperes is to be passed from the grounding terminal to all exposed dead metal parts, and the resulting drop in potential is to be measured between those 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.

37.2 Leakage test on factory-installed conduit seals

37.2.1 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.

37.2.2 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.

37.3 Electrical-resistance test

37.3.1 Grounding-continuity of cord-connected equipment

37.3.1.1 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 18.1 shall not exceed 0.1 ohm.

37.3.1.2 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 18.1, 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.

37.4 Equipment having coated threaded joint surfaces or conduit openings

37.4.1 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.

37.4.2 A direct or alternating current of 50 amperes is to be passed between the two points specified in 37.3.1.2, 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.

37.4.3 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.

37.5 Tests on joint gaskets

37.5.1 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.

37.5.2 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.

PART II – HEATERS FOR CLASS I, DIVISION 2, GROUPS A, B, C, AND D LOCATIONS

GENERAL

38 Details

38.1 Other than as noted in 38.2, a heater for use in Class I, Division 2 locations shall comply with the requirements for a heater for use in ordinary locations and with the requirements in Sections 39 – 43.

38.2 A heater for use in Class I, Division 2 locations, but requiring Division 1 constructional features, shall comply with the appropriate requirements for a Division 1 heater. See 42.1.

CONSTRUCTION

39 Enclosure

39.1 General

39.1.1 The electrical components shall be totally enclosed to prevent the escape of sparks or other hot particles.

39.1.2 The enclosure shall be formed and assembled so that it will have the strength and rigidity necessary to resist the abuses to which it is likely to be subjected without increasing the risk of fire due to total or partial collapse with resulting reduction of spacings, loosening or displacement of parts, or other serious defects.

39.1.3 The heater shall be provided with an enclosure of a material acceptable for the application that shall house all electrical parts that may present a risk of fire or electric shock under any condition of use.

39.1.4 Among the factors taken into consideration when the acceptability of an enclosure is being determined are resistance to:

a) Mechanical damage;

b) Impact;

c) Moisture absorption;

d) Combustion;

e) Corrosion;

f) Distortion at temperatures to which the enclosure may be subjected under all conditions of anticipated use;

g) Solvents covered by the hazardous location group classification; and

h) The accumulation of electrostatic charges capable of igniting hazardous atmospheres.

39.2 Enclosure material

39.2.1 Cast metal

39.2.1.1 Except as noted in 39.2.1.2, a cast-metal enclosure shall not be less than 1/8 inch (3.2 mm) thick at every point and not less than 1/4 inch (6.4 mm) thick at holes tapped for conduit.

39.2.1.2 Die-cast metal, except at threaded conduit holes, shall be permiited to be:

a) Not less than 3/64 inch (1.2 mm) thick for an area of 24 square inches (155 cm^2) or less and having no dimension larger than 6 inches (152 mm). This area limitation may be obtained by the provision of reinforcing ribs subdividing a larger area; and

b) Not less than 5/64 inch (2.0 mm) thick for an area larger than 24 square inches or having any dimension larger than 6 inches.

39.2.2 Sheet metal

39.2.2.1 The thickness of a sheet-metal enclosure shall not be less than that specified in Table 10.2. Also see 10.2.4.

39.2.3 Cast iron and aluminum

39.2.3.1 The minimum thickness of polymeric enclosure walls shall be as specified for cast iron or aluminum in Table 10.1

40 Supply Connections

40.1 A heater shall have provision for connection to threaded rigid metal conduit. The construction shall comply with the requirements in 14.1.13 – 14.1.17 and 14.3.3.

Exception: A fitting for termination of a wiring system acceptable for use in Class I, Division 2 locations may be provided in lieu of a threaded conduit opening. The fitting shall be an integral part of the heater or shall be installed to provide bonding between the heater and the wiring system. Such bonding shall be equivalent to that required for field-installed wiring systems.

41 Protection Against Corrosion

41.1 All ferrous-metal parts shall be protected against corrosion by zinc or cadmium coating, plating, enameling, painting, varnishing, or lacquering. A heater shall also comply with the requirements in 20.2.

Exception: Protection against corrosion need not be provided for stainless steel parts.

42 Arcing and Sparking Parts

42.1 An arcing or sparking part – such as a switch, a circuit breaker, a starter, a fuse, a temperature-limiting device, or the like – shall be housed in an enclosure complying with the requirements for an enclosure for use in Class I, Division 1 locations unless:

a) The interruption of current occurs within a hermetically-sealed enclosure;

b) The current-interrupting contacts are oil immersed and investigated for use in Class I, Division 2 locations; or

c) The part is located in a nonincendive circuit.

42.2 An enclosure is considered to be hermetically sealed if there are no openings in the enclosure and:

a) All joints in a metal enclosure are sealed against entrance of a gas or vapor by continuous welding, brazing, or soldering; or

b) All joints in a glass enclosure are sealed against the entrance of a gas or vapor by fusing.

42.3 With reference to 42.2, the potting of components is not considered to be hermetic sealing.

PERFORMANCE

43 Temperature Test

43.1 A heater shall be tested under the conditions described in 22.1.1 – 22.2.4, 22.3.2 – 22.3.5, and 43.2 until constant temperatures are attained.

43.2 If a heater is not provided with a temperature-limiting device or is provided with a temperature-limiting device that does not operate under normal operating conditions, the test is to be conducted at 120 percent of test voltage.

PART III – HEATERS FOR CLASS II, DIVISION 2, GROUP G LOCATIONS

GENERAL

44 Details

44.1 A heater for Class II, Division 2, Group G locations shall comply with the requirements for a heater for use in ordinary locations and with the requirements in Sections 45 – 50.

45 Enclosure

45.1 Electrical components shall be totally enclosed to minimize or prevent the entrance of dust and to prevent the escape of sparks or other hot particles.

45.2 Consideration will be given to the two basic types of enclosures described in 45.3 and 45.5. Also see 47.1.

45.3 An enclosure that is of the gasketed type and is intended to prevent the entrance of dust (dust-tight) shall be tested as described in Sections 49 and 50. A gasket shall comply with the requirements in 11.5.2 – 11.8.3.5.2. The width of joints and the maximum joint clearances are not specified.

45.4 A gasket that is employed to make an enclosure dust-tight shall be mechanically secured or captive if it is at a joint that is opened for wiring or for maintenance such as replacing a thermal cutoff.

45.5 An enclosure that is not of the gasketed type and is intended to minimize the entrance of dust shall be tested as described in Section 50.

45.6 The enclosure for both types of construction shall comply with the requirements in 39.1.2 – 39.2.2.1.

46 Supply Connections

46.1 A heater shall have provision for connection of threaded rigid metal conduit. Also see 46.3.

Exception: On a heater that is intended to minimize the entrance of dust (see 45.5), a fitting for termination of a wiring system acceptable for use in Class II, Division 2 locations may be provided in lieu of a threaded conduit opening. The fitting shall be an integral part of the heater or shall be installed to provide bonding between the heater and the wiring system. Such bonding shall be equivalent to that required for field-installed wiring systems.

46.2 A conduit hub, if provided, shall comply with the requirements in 14.1.2 – 14.1.5.

46.3 A heater intended to prevent the entrance of dust (see 45.3) shall have provision for connection of threaded rigid metal conduit or other wiring systems in accordance with 14.1.2 – 14.1.4 and 14.3.3.

47 Control Devices

47.1 A control device such as a switch, a circuit breaker, or a temperature-limiting device shall be mounted within an enclosure that will prevent the entrance of dust. See 45.3.

48 Protection Against Corrosion

48.1 All ferrous metal parts shall be protected against corrosion by zinc or cadmium coating, plating, enameling, painting, varnishing, or lacquering. A heater shall also comply with the requirements in 20.2.

Exception: Protection against corrosion need not be provided for a stainless steel part.

PERFORMANCE

49 Temperature Test

49.1 A heater shall be operated at the voltage specified in 22.1.2, 22.1.3, and Table 22.1 and tested under conditions described in 22.1.4 – 22.1.11, 22.2.2, 22.2.3, 22.4.6, and 49.5. The temperatures shall not exceed the applicable values specified in Table 22.2 and not exceed 165°C (329°F) elsewhere on the heater.

49.2 If the heater is intended to prevent the entrance of dust (see 45.3), the maximum temperature specified in 49.1 applies to the exterior of the heater.

49.3 If the heater is intended to minimize the entrance of dust (see 45.5), the maximum temperature specified in 49.1 applies to all internal parts as well as the exterior of the heater.

49.4 The operating temperature or operating-temperature range is to be based on operation in a 40°C (104°F) ambient. If the operating-temperature range is used in lieu of the operating temperature, it shall be indicated by a code number as specified in Table 55.1. See 55.10.

Exception: In determining operating temperatures of a heater that is marked for use in an elevated ambient, the test is to be conducted at the elevated ambient for which the heater is marked.

49.5 The heater is to be operated in air until temperatures are constant. The heater is then to be blanketed with grain dust as described in 22.4.6 and again operated until temperatures are constant. The maximum temperature to be used for determining compliance with the requirement in 49.1 and the marked operating temperature or operating temperature range is to be calculated using the formula:

$$T = T_1 + \frac{T_2 - T_1}{2}$$

in which:

T is the calculated maximum temperature,

T_1 is the maximum temperature in air, and

T_2 is the maximum temperature with dust blanket.

50 Dust-Tight Enclosure Test

50.1 General

50.1.1 An enclosure of a heater intended to prevent the entrance of dust (dust-tight) shall be tested using the:

a) Dust-penetration method;

b) Dust-blast method; or

c) Atomized-water method.

50.1.2 The test length mentioned in 50.3.2 and 50.4.1 is the sum of the height, width, and depth of the enclosure under test.

50.2 Dust-penetration method

50.2.1 The enclosure is to be exposed for at least two heating and cooling cycles and for at least 10 hours to a circulating dust-air atmosphere to determine that the enclosure is dust-tight. There shall be no entrance of the dust into the enclosure, as determined by visual examination following the test described in 50.2.2.

50.2.2 The heater is to be installed in a test chamber that will permit free circulation of dust-air atmospheres around the heater. The test chamber is to be provided with a cover and with dust-air inlet and outlet connections. The heater is to be exposed to the dust-air atmosphere that is to be produced by auxiliary apparatus and introduced into the test chamber.

50.2.3 Grain dust that has passed through a 100-mesh screen is to be used for the dust-air atmosphere. See 35.3.

50.3 Dust-blast method

50.3.1 The enclosure is to be exposed to a blast of compressed air mixed with dry, Type 1 general-purpose Portland cement, and no dust shall enter the enclosure.

50.3.2 A suction-type sandblast gun that is equipped with a 3/16-inch (4.8-mm) diameter air jet and a 3/8-inch (9.5-mm) diameter nozzle is to be used. The air is to be at a pressure of 90 – 100 psi (620 – 690 kPa). The cement is to be supplied by a suction feed. Not less than 4 pounds of cement per linear foot (6 kg/m) of test length of the enclosure under test is to be applied at a rate of 5 pounds (2.3 kg) per minute. The nozzle is to be held 12 – 15 inches (305 – 381 mm) away from the enclosure, and the blast of air and cement is to be directed at all points of potential dust entry, such as seams, joints, external operating mechanisms, and the like. A conduit may be installed to equalize the internal and external pressure.

50.4 Atomized-water method

50.4.1 The enclosure is to be sprayed with atomized water and no water shall enter the enclosure.

50.4.2 A nozzle that produces a round pattern 3 – 4 inches (76 – 102 mm) in diameter, 12 inches (305 mm) from the nozzle, is to be used. The air pressure is to be 30 psi (207 kPa). The water is to be supplied by a suction feed with a siphon height of 4 to 8 inches (102 to 204 mm). Not less than 5 ounces per linear foot (485 mL/m) of test length of the enclosure under test is to be applied at a rate of 3 gallons (11 L) per hour. The nozzle is to be held 12 to 15 inches (305 to 381 mm) from the enclosure, and the spray of water is to be directed at all points of potential dust entry, such as seams, joints, external operating mechanisms, and the like. A conduit may be installed to equalize the internal and external pressures, but is not to serve as a drain.

MANUFACTURING AND PRODUCTION TESTS

51 General

51.1 A product shall be subjected to the applicable production-line tests specified in (a) – (c):

a) Each portable heater is to be subjected to the Bonding Test, Section 54.

b) Each electric hot water radiator with a low-water cutoff is to be subjected to water pressure, vacuum, and air leakage tests depending upon the construction and rating of the device.

c) Each heating element that has a sheath with a wall thickness less than 3/32 inch (2.4 mm) and without other explosion-proof or dust-ignition-proof enclosures is to be subjected to the tests specified in Sections 52 and 53.

51.2 When the hydrostatic pressure test specified in Section 34 is conducted in accordance with the Exception to 34.1, each explosion-proof electrical enclosure shall withstand without rupture or permanent distortion, as a routine production-line test, the hydrostatic pressure specified in 51.3.

51.3 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 not less than 10 seconds and not more than 1 minute.

52 Air-Leakage Test

52.1 Each heating element [see 51.1(c)] is to be immersed in a water bath and, on application of air at a pressure of 100 psig (690 kPa) to the open ends, there shall be no air leakage through the enclosure wall (sheath).

53 Dielectric Voltage-Withstand Test

53.1 Following the Air-Leakage Test, Section 52, each heating element shall withstand, without breakdown, a 60 hertz essentially sinusoidal potential applied between live parts and dead metal parts of the assembly. The test potential is to be:

a) 2500 volts applied for 1 second to a heating element tested in a cold condition; or

b) Twice the test voltage specified in Table 22.1, plus 1000 volts applied for 1 minute to a heating element tested with the element at its maximum normal operating temperature.

54 Bonding Test

54.1 Each portable heater shall be subjected to the Resistance Test, Section 37, or the equivalent, to determine that it includes a grounding path complying with the requirements in 18.1.

MARKINGS AND INSTRUCTIONS

55 Marking

55.1 Each electric heater shall be marked with the following:

a) The manufacturer's name, trade name, or other descriptive marking by which the organization responsible for the product may be identified.

b) A catalog or designation number to specifically identify the heater.

c) The electrical rating in volts, amperes, and either volt-amperes or watts. The ratings shall include the number of phases if the heater is intended for use on a polyphase circuit, and shall include the frequency if necessary because of a motor, a relay coil, or other control device. A heater intended for use on alternating current only or direct current only shall be so marked.

d) The maximum operating pressure in pounds per square inch (kPa), if a paint heater.

e) Designation of the hazardous location in which the heater is intended to be used – for example, "Class ___, Group ___." In addition, a product for Division 2 only shall bear the wording: "Division 2," for example, "Class ..., Division 2, Group ..." Also see 55.18.

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

g) Maximum operating temperature or temperature identification number or code as specified in Table 55.1. This marking shall be:

1) Based on the maximum temperature attained in the temperature tests;

2) One of the values in Table 55.1; and

3) Identified as "Operating Temperature ____," "Operating Temperature Code ____," or the equivalent. See 55.11 and 55.12.

For a heater marked for use in an elevated ambient, the operating temperature or operating temperature code shall be based on operation in the elevated ambient for which the heater is marked.

Exception: A heater having a maximum external operating temperature of not more than 100°C (212°F) need not be so marked.

h) Ambient temperature rating, when over 40°C (104°F).

Table 55.1
Temperature marking

Maximum operating temperature		Temperature identification or code number
°C	°F	
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

55.2 In addition to, or as an alternative to, the marking requirement in 55.1(e), equipment that has been investigated and found to comply with the requirements for Class I, Group D locations shall be permitted to be additionally or alternatively marked Class I, Zone 1, Group IIA.

55.3 In addition to, or as an alternative to, the marking requirement in 55.1(e), equipment that has been investigated and found to comply with the requirements for Class I, Group C locations shall be permitted to be additionally or alternatively marked Class I, Zone 1, Group IIB.

55.4 In addition to, or as an alternative to, the marking requirement in 55.1(e), equipment that has been investigated and found to comply with the requirements for Class I, Group B locations shall be permitted to be marked Class I, Zone 1, Group IIB plus Hydrogen.

55.5 In addition to, or as an alternative to, the marking requirement in 55.1(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 _____."

55.6 Equipment marked Group IIB shall be permitted to also be marked Group IIA.

55.7 Equipment marked Group IIC shall be permitted to also be marked Group IIA, Group IIB, or both Group IIA and Group IIB.

55.8 In addition to, or as an alternative to, the marking requirement in 55.1(e), equipment that has been investigated and found to comply with the requirements for Class II, Division 1, Groups E, F and G shall be permitted to be additionally or alternatively marked Zone 20 and or Zone 21.

55.9 In addition to, or as an alternative to, the marking requirement in 55.1(e), equipment that has been investigated and found to comply with the requirements for Class II, Division 2 shall be permitted to be additionally or alternatively marked Zone 22.

55.10 The marked operating temperature need not be one of the temperatures specified in Table 55.1 on a heater for Class I, Division 1 or Class I, Division 2 locations if:

a) The heater is marked to indicate that it is for use only in a specific gas or vapor atmosphere;

b) The specific gas or vapor is identified in the marking;

c) The ignition temperature of the specified gas or vapor is more than 5°C (9°F) below the next higher temperature specified in Table 55.1; and

d) The exposed surface temperature and marked operating temperature do not exceed the ignition temperature of the specific gas or vapor.

55.11 The marked maximum operating temperature or operating temperature code for a Class I, Division 1 or 2, heater shall be based on the maximum external temperature attained when tested:

a) For air heaters, with a cheesecloth drape as described in 22.3.4.

b) For all other heaters, in air.

55.12 If the operating temperature of a Class I heater exceeds 100°C (212°F), the heater shall be marked with the word "CAUTION" and the following or equivalent wording: "To reduce the risk of fire or explosion, do not install where the marked operating temperature exceeds the ignition temperature of the hazardous atmosphere(s)."

55.13 Except as noted in 55.1 (h), (i), and (j) and in 55.14, all markings shall be on a metal plate or plates permanently attached to the heater or shall be embossed, stamped, or molded in the enclosure.

55.14 If any point within a terminal box or wiring compartment of a permanently connected heater in which the power-supply conductors are intended to be connected, including such conductors themselves, attains a temperature of more than 75°C (167°F) during the Temperature Test, Section 22, the heater shall be marked "For supply connection, use wires rated for at least ___C (___F)" or with an equivalent statement and the temperature shall be in accordance with Table 55.2. This statement shall be located at or near the point at which the supply connections are to be made, and shall be clearly visible both during and after installation of the heater.

Table 55.2
Terminal-box marking

Temperature attained during test in terminal box or compartment[a]		Temperature marking	
76 – 90°C	(169 – 194°F)	75°C	(167°F)
91 – 105°C	(195 – 221°F)	90°C	(194°F)
106 – 165°C	(222 – 329°F)	150°C	(302°F)
166 – 215°C	(330 – 419°F)	200°C	(392°F)

[a] Based on a 40°C (104°F) ambient or marked elevated ambient, when applicable.

55.15 If a manufacturer produces electric heaters at more than one factory, each heater shall have a distinctive marking to identify it as the product of a particular factory.

55.16 A Class II, Division 1 heater that is intended for ceiling mounting and has a thickness in accordance with 10.2.3 shall be marked: "For ceiling mounting only," or with an equivalent statement.

55.17 A Class II, Division 1 heater that is intended for wall mounting and has a thickness in accordance with 10.2.3 shall be marked: "For wall mounting not less than 6 feet above floor," or with an equivalent statement.

55.18 A heater that has been investigated and found acceptable for exposure to Class I and Class II location conditions at the same time shall be marked with the following or equivalent wording: "Suitable for simultaneous use in Class I, Group ___ and Class II, Group ___ locations," together with the operating temperature or code number indicating operating temperature range. The operating temperature shall not exceed the appropriate limit specified in 22.4.7 when determined as specified in 22.5.1.

55.19 In accordance with the Exception to 14.1.2, 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.

55.20 In accordance with 14.1.1, 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 the thread type; and

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.

55.21 Equipment having metric supply connection openings in accordance with 14.1.5 shall have a permanent marking which includes the supply connection thread size, type, and class of fit.

55.22 In accordance with the Exceptions to 14.1.3 and 14.3.1, 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.

55.23 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.

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

55.25 Equipment intended to have sealing fittings installed as specified in the Exception to 33.16 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."

55.26 If a supplementary external grounding or bonding terminal is provided on the outside of a heater, and is identified by being either colored green or by being marked G, GR, Ground, Grounding, Protective Earth, PE, or ⏚; the instructions shall indicate that the internal grounding terminal shall be used for the equipment grounding connection to complete the effective ground-fault current path and that the external terminal is for a supplementary bonding connection where local codes or authorities permit or require such connection.

56 Instructions

56.1 General

56.1.1 Electric heaters shall be provided with documentation that includes all the instructional material required by this standard.

56.2 Electronic medium for required instructions

56.2.1 The required instructional material of this standard may be provided additionally or alternatively 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, indicates 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.