

DOCUMENT NUMBER: 4L 698

ORDER OF DATA

[illegible]

Underwriters Laboratories Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096

UL Standard for Safety
for
Industrial Control Equipment for Use in Hazardous (Classified) Locations, UL 698

Twelfth Edition, Dated June 22, 1995

Revisions: This Standard contains revisions through and including July 12, 1996.

A change is indicated by a note following the affected item. The note is preceded and followed by an asterisk.

The new requirements are substantially in accordance with UL's Bulletin on this subject dated March 14, 1996. The bulletin is now obsolete and may be discarded.

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The requirements in this Standard are now in effect, except for those paragraphs, sections, tables, figures, and/or other elements of the Standard having future effective dates as indicated in the note following the affected item. The prior text for requirements that have been revised and that have a future effective date are located after the Standard, and are preceded by a "SUPERSEDED REQUIREMENTS" notice.

New product submittals made prior to a specified future effective date will be judged under all of the requirements in this Standard including those requirements with a specified future effective date, unless the applicant specifically requests that the product be judged under the current requirements. However, if the applicant elects this option, it should be noted that compliance with all the requirements in this Standard will be required as a condition of continued Listing, Recognition, Classification, and Follow-Up Services after the effective date, and understanding of this should be signified in writing.

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This Standard consists of pages dated as shown in the following checklist:

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tr1 – tr4	July 12, 1996
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3	July 12, 1996
4, 5	March 25, 1996
6	June 22, 1995
7	July 12, 1996
8	June 22, 1995
9, 10, 10A, 10B	July 12, 1996
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18 – 20, 20A, 20B	March 25, 1996
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INTRODUCTION

1 Scope

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

1.1.1 These requirements also cover explosion-proof electrical equipment for installation and use in Class I, Zone 1, Groups IIA, IIB, IIB plus Hydrogen, and IIC hazardous (classified) locations.

1.1.1 added July 12, 1996

1.2 Examples of industrial control equipment are:

- a) Manual and magnetic starters and controllers.
- b) Thermal- and magnetic-overload relays.
- c) Pushbutton stations, including selector switches and pilot lights.
- d) Control-circuit switches and relays.
- e) Float-, flow-, pressure-, and vacuum-operated switches.
- f) Resistors and rheostats.
- g) Proximity switches.
- h) Time-delay relays and switches.
- i) Resistors and rheostats intended for industrial heating and lighting, including those for motor-generator fields.
- j) Control devices intended for industrial heating and lighting.
- k) Variable-voltage autotransformers.

1.3 These requirements apply to industrial control equipment for use in hazardous locations under the following atmospheric conditions:

- a) A minimum ambient temperature of minus 25°C (minus 13°F),
- b) An oxygen concentration not greater than 21 percent by volume, and
- c) A nominal barometric pressure of one atmosphere.

1.4 These requirements do not cover intrinsically-safe electrical circuits of industrial control equipment for use in hazardous locations.

1.5 These requirements do not cover electrostatic devices, circuits, or systems.

1.6 These requirements do not cover refrigeration-system controllers or the internal construction of electrical instruments such as meters.

1.7 A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire, electric shock, or injury to persons shall be evaluated using the appropriate additional component and end-product requirements as determined necessary to maintain the acceptable level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard cannot be judged to comply with this standard. Where considered appropriate, revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

2 General

2.1 General

2.1.1 These devices shall also comply with the applicable requirements in the Standard for Industrial Control Equipment, UL 508.

2.2 Components

2.2.1 Except as indicated in 2.2.2, a component of a product covered by this standard shall comply with the requirements for that component.

2.2.2 A component need not comply with a specific requirement that:

- a) Involves a feature or characteristic not needed in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

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

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

2.3 Undated reference

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

2.4 Units of measurement

2.4.1 If a value for measurement is followed by a value in other units in parentheses, the second value may be only approximate. The first stated value is the requirement.

3 Enclosure Types

3.1 An enclosure shall comply with the applicable requirements specified in Table 3.1.

3.2 An enclosure that is intended for use in environmental conditions other than those defined in Table 3.1, and that has a marked enclosure type designation, shall also comply with the applicable requirements for each enclosure type, as specified in the Standard for Enclosures for Electrical Equipment, UL 50; for example, Type 3, 4X, or 6.

3.3 A Type 3, 3R, 3S, 4, 4X, 6, or 6P enclosure may also be marked "Raintight" if no water enters the enclosure or "Rainproof" if no water enters the enclosure at a point higher than the lowest live part. Compliance with these requirements shall be determined by the applicable tests in the Standard for Enclosures for Electrical Equipment, UL 50.

Table 3.1
Enclosure types for hazardous locations

Type number	Application	Requirements
7	Class I, Division 1, Groups A, B, C, or D – Indoor Hazardous Locations – Air-Break Equipment	Part I – Sections 4 – 25
8	Class I, Division 1, Groups A, B, C, or D – Indoor Hazardous Locations – Oil-Immersed Equipment	Part II – Sections 26 – 31
9	Class II, Division 1, Groups E, F, or G – Indoor Hazardous Locations – Air-Break Equipment	Part III – Sections 32 – 52

3A Class I, Zone, and Group Equivalency

3A.1 Class I, Zone 1, Group IIA

3A.1.1 Explosion-proof electrical equipment intended to be marked in accordance with 54.2.1 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group D hazardous (classified) locations.

3A.1.1 added July 12, 1996

3A.2 Class I, Zone 1, Group IIB

3A.2.1 Explosion-proof electrical equipment intended to be marked in accordance with 54.2.2 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group C hazardous (classified) locations.

3A.2.1 added July 12, 1996

3A.3 Class I, Zone 1, Group IIB plus Hydrogen

3A.3.1 Explosion-proof electrical equipment intended to be marked in accordance with 54.2.3 shall comply with all the requirements for explosion-proof electrical equipment for use in Class I, Group B hazardous (classified) locations.

3A.3.1 added July 12, 1996

3A.4 Class I, Zone 1, Group IIC

3A.4.1 Explosion-proof electrical equipment intended to be marked in accordance with 54.2.4 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.

3A.4.1 added July 12, 1996

PART I - CLASS I, GROUPS A, B, C, AND D AIR-BREAK TYPE

CONSTRUCTION

4 Enclosure Material

4.1 The enclosure housing the electrical components, except any portion for viewing or light transmission, shall be made of iron, steel, copper, brass, bronze, or aluminum or its alloys containing not less than 80-percent aluminum, or shall be made of acceptable nonmetallic material. A metal such as zinc or magnesium, or their alloys, is not acceptable.

4.2 Copper shall not be used for the enclosure of a device for use in Class I, Group A locations. A copper alloy may be used for an enclosure if:

- a) It is coated with tin, nickel, or other acceptable coating, or
- b) The copper content of the alloy is limited to not more than 30 percent.

4.3 Among the factors that are taken into consideration when determining the acceptability of a nonmetallic material are:

- a) Mechanical strength;
- b) Resistance to impact;
- c) Moisture-absorptive properties;

- d) Resistance to fungus;
- e) Combustibility;
- f) Resistance to repeated explosions;
- g) Resistance to solvents as covered by the hazardous location group or groups under consideration;
- h) Resistance to accumulation of electrostatic charges; and
- i) Resistance to distortion and creep at temperatures to which the material may be subjected under all conditions of use.

All of these factors are to be considered with respect to thermal aging. See Part I of Supplement A for tests on a polymeric material.

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

5 Enclosure Thickness

5.1 Except for a component as noted in 5.3 and 5.4, the minimum thickness of the metal enclosure walls shall not be less than specified in Table 5.1.

5.2 A machined or a threaded joint in the walls of a cast-metal enclosure shall have at least the thickness specified in Table 5.1 through the overlap.

Table 5.1
Thickness of metal for enclosure

External enclosure dimensions		Minimum thickness, inch (mm)			
Length or diameter, inches (mm)	Area of any one surface, square inches (dm ²)	Cast brass, bronze, copper, malleable iron	Cast iron and aluminum ^a	Sheet steel	
22 (559)	480 (31)	0.093 (2.36)	0.125 (3.18)	0.067	(1.70)
30 (762)	620 (40)	0.093 (2.36)	0.125 (3.18)	0.093	(2.36)
60 (1524)	1,500 (97)	0.125 (3.18)	0.187 (4.75)	0.125	(3.18)
Over 60 (over 1524)	Over 1,500 (over 97)	0.187 (4.75)	0.250 (6.35)	0.187	(4.75)

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

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44 Rust-Resistance Test

44.1 An enclosure of ferrous metal other than stainless steel shall comply with the requirements in Section 17.

45 Thermal-Shock Test on Glass Parts

45.1 A glass part of a device shall comply with the requirements in Section 18.

46 Secureness Test on Conduit Hubs

46.1 A conduit hub not integrally cast with a metal enclosure shall comply with the requirement in Section 19.

47 Tests on Joint Gaskets

47.1 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 if of the elastomeric or thermoplastic type.

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

48 Electrical-Resistance Test

48.1 A cord-connected device shall comply with the requirements in Section 21.1.

49 Accelerated-Aging Test on Bushings

49.1 A molded-rubber or -neoprene bushing provided at the cord entrance to the terminal enclosure of a portable device shall comply with the requirements in Section 22.

50 Strain-Relief Test

50.1 A portable device shall comply with the requirements in Section 23.

51 Rough-Usage Test

51.1 A portable device shall comply with the requirements in Section 24.

52 Drop Test

52.1 A portable device shall comply with the requirements in Section 25.

PART IV – MANUFACTURING AND PRODUCTION TESTS**53 Bonding Test for Cord-Connected Equipment**

53.1 The manufacturer shall determine by a routine production-line test that the grounding member of the attachment plug, if provided, or the grounding conductor of the supply cord is electrically connected to dead metal parts of a portable device required to be bonded in accordance with 10.2.5.1 or 37.2.5.1.

PART V – MARKING**54 Details**

54.1 These marking requirements apply to devices covered in Parts I, II, and III of this standard.

54.2 Each device shall be marked with a metal nameplate indicating the following:

- a) The manufacturer's name or trademark.
- b) The device identification.
- c) Electrical ratings.
- d) Designation of the hazardous location in which the device is intended to be used: for example, "Class _____, Group _____." A device 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."
- e) Ambient temperature rating, if more than 40°C (104°F).
- f) A cautionary statement consisting of the word "CAUTION" and the following or equivalent wording: "To reduce the risk of ignition of hazardous atmospheres, disconnect the device from the supply circuit before opening. Keep assembly tightly closed when in operation."
- g) Maximum operating temperature or temperature code as specified in Table 54.1, if the operating temperature exceeds 100°C (212°F). This marking is to be based on the maximum temperature attained in the temperature tests. The operating temperature or temperature code shall be near the marking required by (d). It shall be identified as "Operating Temperature _____," or "Operating Temperature Code _____," or the equivalent.
- h) For Class I location devices having an operating temperature over 100°C (212°F), a cautionary statement consisting of 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)."

54.2.1 In addition to, or as an alternative to, the marking requirement in 54.2(d), equipment that has been investigated and found to comply with the requirements for Class I, Group D locations may additionally or alternatively be marked Class I, Zone 1, Group IIA.

54.2.1 added July 12, 1996

54.2.2 In addition to, or as an alternative to, the marking requirement in 54.2(d), equipment that has been investigated and found to comply with the requirements for Class I, Group C locations may additionally or alternatively be marked Class I, Zone 1, Group IIB.

54.2.2 added July 12, 1996

54.2.3 In addition to, or as an alternative to, the marking requirement in 54.2(d), equipment that has been investigated and found to comply with the requirements for both Class I, Group B locations may be marked Class I, Zone 1, Group IIB plus Hydrogen.

54.2.3 added July 12, 1996

54.2.4 In addition to, or as an alternative to, the marking requirement in 54.2(d), equipment that has been investigated and found to comply with the requirements for both Class I, Group A, and Class I, Group B locations may additionally or alternatively be marked Class I, Zone 1, Group IIC.

54.2.4 added July 12, 1996

54.2.5 Equipment marked Group IIB may also be marked Group IIA.

54.2.5 added July 12, 1996

54.2.6 Equipment marked Group IIC may also be marked Group IIA, Group IIB, or both Group IIA and Group IIB.

54.2.6 added July 12, 1996

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March 25, 1996

Revision pages for

Standard for

**Industrial Control Equipment for Use in Hazardous
(Classified) Locations**

UL 698, Twelfth Edition

Attached to this transmittal notice is a revision of the Twelfth edition of UL 698.

A CHANGE ON A PAGE DATED MARCH 25, 1996 IS INDICATED BY A SMALL PRINT NOTE FOLLOWING THE AFFECTED ITEM, PRECEDED AND FOLLOWED BY AN ASTERISK.

THESE NEW AND REVISED REQUIREMENTS ARE NOW IN EFFECT.

The new and revised requirements are substantially in accordance with UL's bulletin on this subject dated November 6, 1992. The bulletin is now obsolete and may be discarded.

Revised and/or additional pages may be issued from time to time.

With the inclusion of the accompanying material, the standard consists of pages dated as shown in the following checklist:

Page	Date
1	June 22, 1995 (Reprinted: March 25, 1996)
2	—
3 – 5	March 25, 1996
6 – 17	June 22, 1995
18 – 20, 20A	March 25, 1996
21 – 29	June 22, 1995
30, 30A, 31, 32, 32A, 33	March 25, 1996
34 – 53	June 22, 1995
SA1 – SA3	March 25, 1996
SA4, SA5	June 22, 1995
SA6	March 25, 1996
SA7	June 22, 1995

JUNE 22, 1995

(Title Page Reprinted: March 25, 1996)

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UL 698

Standard for

Industrial Control Equipment for Use in Hazardous (Classified) Locations

The First through Seventh editions were titled Industrial Control Equipment for Use in Hazardous Locations. The Eighth and Ninth editions were titled Industrial Control Equipment for Use in Hazardous Locations, Class I, Groups A, B, C, & D, and Class II, Groups E, F, & G

First Edition – June, 1930
Second Edition – November, 1934
Third Edition – March, 1941
Fourth Edition – January, 1943
Fifth Edition – March, 1947
Sixth Edition – December, 1949
Seventh Edition – November, 1969
Eighth Edition – February, 1972
Ninth Edition – April, 1973
Tenth Edition – July, 1984
Eleventh Edition – April, 1991

Twelfth Edition

June 22, 1995

An effective date included as a note immediately following certain requirements is one established by Underwriters Laboratories Inc.

Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL Standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest published set of revision pages.

ISBN 1-55989-876-3

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FOREWORD

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

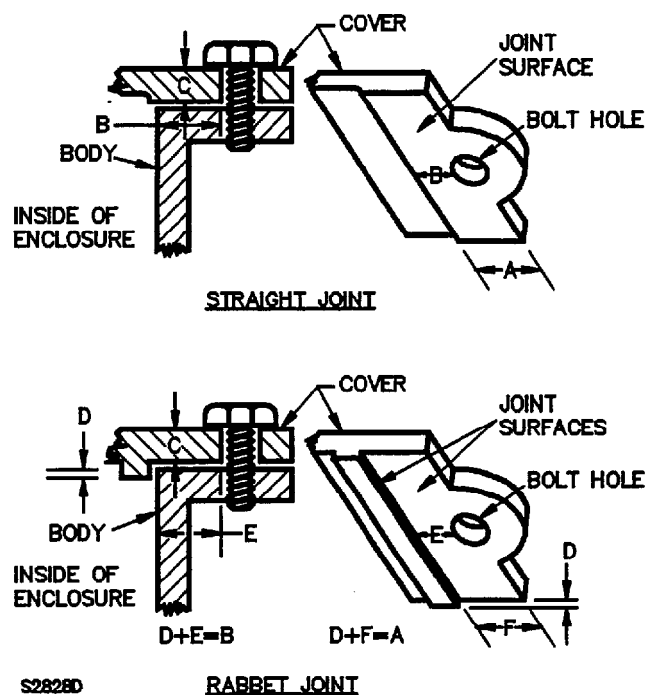
C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product employing materials or having forms of construction differing from those detailed in the requirements of this Standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with the Standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

Figure 6.4
Bolts in joint width
 (See 6.2.4.1 and 6.2.4.2)



A = Required minimum width of joint (see Figure 6.1)

B = Minimum distance from inside enclosure to bolt clearance hole

C = One-half of required minimum width of joint

D = One part of rabbit joint

E = Second part of rabbit joint to bolt clearance hole

F = Second part of rabbit joint elsewhere

6.3 Class I, Group A locations

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

- Eight fully-engaged threads with a Class 1 fit,
- Seven threads with a Class 2 fit, or
- Six threads with a Class 3 fit.

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.

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

6.4 Class I, Group B locations

6.4.1 Except as indicated in 6.4.2, 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 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 6.3.

6.4.2 The width of a joint in an enclosure having a free internal volume of not more than 6 cubic inches (0.1 dm^3) shall not be less than $5/16$ inch (7.9 mm) with a clearance between joint surfaces of not more than 0.002 inch (0.05 mm) or $3/8$ inch (9.5 mm) with a clearance between joint surfaces of not more than 0.004 inch (0.10 mm).

6.4.3 The width of a joint in an enclosure having a free internal volume of more than 30 cubic inches (0.5 dm^3) but 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 shall 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 the 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 6.2.

6.4.4 The width of a joint in an enclosure having a free internal volume of more than 100 cubic inches (1.6 dm^3) but 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).

6.4.5 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.

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.

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

7 Shaft Openings

7.1 General

7.1.1 A shaft opening in an enclosure shall be of the metal-to-metal, metal-to-polymeric or polymeric-to-ceramic type. See 6.1.1 regarding the roughness of the surfaces forming the shaft path.

7.1.1 revised March 25, 1996

7.1.2 The requirements in 7.2.1 – 7.3.5.2 apply to shaft openings in electrical enclosures for Class I, Groups C and D locations.

7.1.3 A device for Class I, Group A or B locations having a free internal volume of 30 cubic inches (0.5 dm³) or less shall comply with the requirements in 7.2.1.

7.2 Nonrotating shafts and shafts rotating at a speed of less than 100 RPM

7.2.1 Except as noted in 7.2.1.1 – 7.2.1.3, 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 6.1. The diametrical clearance for a path longer than 1-1/4 inches (31.8 mm) shall not be more than 0.0045 inch (0.114 mm). See 7.2.3.

7.2.1 revised and separated into 7.2.1, 7.2.1.1, and 7.2.1.2 March 25, 1996

7.2.1.1 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 need not comply with the requirements in 7.2.1 and 7.2.3 if it complies with the requirements in 7.3.1.1 – 7.3.5.2.

7.2.1 revised and separated into 7.2.1, 7.2.1.1, and 7.2.1.2 March 25, 1996

7.2.1.2 A device having a free internal volume of 1.0 cubic inch (0.016 dm³) or less may have a length of path of not less than 9/32 inch (7.1 mm) with a diametrical clearance of not more than 0.005 inch (0.127 mm).

7.2.1 revised and separated into 7.2.1, 7.2.1.1, and 7.2.1.2 (date of publication)

7.2.1.3 A device having a free internal volume of 6.1 cubic inches (100 cm³) or less and tested as specified in 14.24.1 may have a shaft opening with a length and diametrical clearance as follows:

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

7.2.1.3 added March 25, 1996

7.2.2 Unless otherwise noted a shaft path shall be continuous; that is, the path shall not be interrupted by an "O" ring groove or the like.

7.2.3 A shaft opening in an enclosure with a venting section may have a diametrical clearance of not more than 0.005 inch (0.127 mm) for a length of not less than 1/2 inch (12.7 mm) if the explosion pressure developed in the explosion tests does not exceed 5 psi (34.47 kPa).

7.3 Shafts rotating at a speed of 100 RPM or more

7.3.1 General

7.3.1.1 The paths at shaft openings specified in 7.3.1.2 – 7.3.3.5 and 7.3.4.1 – 7.3.5.2 shall be in addition to any protection offered by the ball bearings or the sleeve bearings on the shaft.

7.3.1.2 The length of a shaft opening or path shall be determined by measuring only the metal-to-metal path with clearance specified below. Oil or grease grooves (without any inlet or outlet openings for grease or oil) are acceptable, if not of sufficient size to affect significantly the protective value of the total length of path, but are not considered in measuring the effective metal path. A labyrinth, if of a substantial form of construction, is considered as equivalent in length to a straight metal path. Openings for oil or grease shall be located outside the path.

7.3.2 Free Internal Volume of Enclosure Not More Than 65 Cubic inches (1.1 dm³) for Class I, Group D Locations, Only

7.3.2.1 An enclosure having a free internal volume of 65 cubic inches (1.1 dm³) 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).

7.3.3 Free Internal Volume of Enclosure Not More Than 350 Cubic inches (5.7 dm³)

7.3.3.1 Except as indicated in 7.3.3.3 and 7.3.3.4, an enclosure for Class I, Group D locations having a free internal volume more than 65 cubic inches (1.1 dm³) but not more than 350 cubic inches (5.7 dm³), 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 (0.63 mm).

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

- a) Comply with the requirements in 7.3.3.1, 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.

7.3.3.3 A larger clearance at a shaft opening is acceptable on the basis of 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.

7.3.3.4 A proportional decrease in length of 1/4 inch (6.4 mm) per 0.002-inch (0.05-mm) decrease in diametrical clearance is acceptable, provided that the metal path is not less than 1 inch (25.4 mm).

7.3.3.5 If the path specified in 7.3.3.1 – 7.3.3.4 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 may be 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 no 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).

7.3.4 Free Internal Volume of Enclosure More Than 350 Cubic inches
(5.7 dm³) With Internal Length of Joint of 90 inches (2.29 m) or Less

7.3.4.1 An enclosure for Class I, Group D locations having a free internal volume more than 350 cubic inches (5.7 dm³) and an internal length (circumference) of joint less than 90 inches (2.29 m) shall have a shaft path for the arrest of flame complying with Table 7.1.

- c) A visible pressure terminal connector that has a green-colored body or appendage that is not readily removable from the connector; or
- d) A concealed pressure terminal connector identified in accordance with 10.2.5.4.

10.2.5.4 If a pressure terminal 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," "GRD," "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.

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

10.2.5.6 If provided, the grounding member of the attachment plug and the grounding conductor of the power-supply cord and dead metal parts of portable equipment required to be bonded in accordance with 10.2.5.1 shall be electrically connected as determined by test.

11 Protection Against Corrosion

11.1 All ferrous-metal parts other than stainless steel shall be protected against corrosion, except at joint surfaces and conduit threads, by zinc or cadmium coating, plating, enameling, painting, varnishing, or lacquering. Joint surfaces and conduit threads may be electroplated with zinc or cadmium. An enclosure of ferrous metal other than stainless steel shall be subjected to the Rust-Resistance Test, Section 17.

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

12 Materials Applied to Joint Surfaces

12.1 A corrosion inhibiting grease, such as petrolatum or soap-thickened mineral oils, may be applied to the metal joint surfaces before assembly.

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

- a) Harden because of aging,
- b) Contain an evaporating solvent, and
- c) Cause corrosion of the joint surfaces.

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

Exception No. 1: A sealing material may be applied to the contacting surfaces of a joint that is not intended to be and need not be opened to install or service the equipment if the application of the material complies with the requirements in 6.1.3 and 14.18.

Exception No. 2: A metallic paint or other noninsulating coating may be applied to a threaded joint surface or a threaded conduit opening if the joint surface or opening, 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 14.11; and*
- b) Complies with the requirements in 21.2.1 – 21.2.3.*

PERFORMANCE

13 Temperature Test

13.1 A device shall be subjected to a temperature test to determine the maximum temperature at any point on the external surface.

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

13.3 The operating temperature or temperature code shall be based on operation in a 40°C (104°F) ambient, or at a higher ambient temperature if the device is intended to be used in an ambient higher than 40°C. The temperature code, if provided, shall be indicated in accordance with Table 54.1. For equipment intended and marked for use where Class I and Class II conditions may exist simultaneously, the marked operating temperature or temperature code is to be based on the temperature attained during the test with dust blanket – see 41.3.

13A No-Load Endurance Test

13A.1 A manually-operated device provided with a metal-to-polymeric or polymeric-to-ceramic type shaft opening shall be subjected to the no-load endurance test specified in 13A.2. There shall be no mechanical or visible damage to any of the parts.

13A.1 added March 25, 1996

13A.2 The device shall be tested with shaft path surfaces having the maximum surface roughness to be provided in production. Following the test, the device shall comply with Explosion Tests, Section 14.

13A.2 added March 25, 1996

13A.3 The device is to be operated in its intended manner. This test may be conducted manually or mechanically. The duration of the test is to be 10,000 cycles, at a rate not greater than 10 per minute. The rate of cycling is to be greater if agreeable to all concerned.

13A.3 added March 25, 1996

14 Explosion Tests

14.1 The device shall be subjected to a series of tests conducted in the presence of the specific gas- or vapor-air mixtures over the range of flammable or explosive concentration to determine:

- a) The maximum pressure effects of the gas- or vapor-air mixtures;
- b) The maximum propagation effects of the gas- or vapor-air mixtures; and
- c) That an electrical mechanism having contacts will not fail electrically in the presence of explosive atmospheres if such tests are required — see 14.4 and 14.5.

14.2 During the explosion tests, the enclosure shall:

- a) Prevent the passage of flame and sparks capable of igniting the surrounding atmosphere; and
- b) Withstand the internal pressure from the explosions without bursting or loosening of the joints in the enclosure.

14.3 In addition to complying with the requirements in 14.1, 14.2, and 14.5, there shall be no mechanical damage to the electrical mechanism or mechanisms.

14.4 Except as indicated in 14.5 and 14.7, tests are to be conducted under stalled-rotor-load conditions. A device 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.

14.5 A device for Class I, Group C or D locations and intended for connection to a circuit with an available short-circuit current not over 10,000 rms symmetrical amperes shall be subjected to spark plug ignition tests with the intended electrical mechanisms in place. In addition, such devices for Class I, Group C locations rated over 125 volts shall be subjected to explosion tests to determine that electrical mechanisms having contacts will 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 shall be the same as the load characteristics required for ordinary-location use when the device is subjected to an endurance test. An equivalent load may be used.

14.6 A device rated more than 200 horsepower (149.2 kW output) is considered as being intended for connection to a circuit with an available short-circuit current of more than 10,000 rms symmetrical amperes.

14.7 In addition to the tests specified in 14.4, tests are to be conducted using a spark plug to ignite the flammable mixture.

14.8 A device having an internal fuse, including any device for Class I, Group C or D locations, is also to be subjected to overload and short-circuit tests to determine the electrical and pressure effects resulting from rupture of the fuse.

14.9 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.

14.9.1 The gases and test range used in the explosion tests are to be as specified in Table 14.3.

14.9.1 added March 25, 1996

Table 14.3
Gases for tests

Devices for use in Class I, Group	Gas to be used	Test range, percent by volume in air
A	Acetylene	5 – 20
B	Hydrogen	15 – 35
C	Ethylene	4 – 9
D	Propane	3 – 7

Table 14.3 added March 25, 1996

14.10 If lengths of conduit are required to be connected to a device for the explosion tests (see 14.14), 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 approximately 4 inches (102 mm) from the outer end.

14.11 If a device is intended to be provided with a metallic paint or other noninsulating 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 of 12.3(a).

14.12 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 analysis from the test chamber, within the device 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.

14.13 A series of at least ten tests is to be conducted over the flammable range on each device. 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.

14.14 A device is to be tested with lengths of conduit as specified in Table 14.4 if:

- a) It has no current-interrupting contacts, or has all current-interrupting contacts hermetically sealed (see 14.25) against the entrance of gases or vapors or immersed in oil; and
- b) It is intended for connection to 1-1/2-inch (38.1 mm) and smaller trade sizes of conduit.

Exception: A device intended to have sealing fittings attached need not be tested with lengths of conduit if it is marked in accordance with 54.16.

14.14 revised March 25, 1996

Table 14.1
Lengths of rigid metal conduit for explosion tests

Table 14.1 renumbered Table 14.4 March 25, 1996

Table 14.4
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)

Table 14.1 renumbered Table 14.4 March 25, 1996

14.15 A device having a factory-installed conduit seal shall be subjected to explosion tests on each side of the seal. Lengths of conduit, as specified in Table 14.5, are to be connected to the conduit side of the seal.

Exception: Explosion tests on the conduit side of the seal need not be conducted if the device is:

- a) *Intended for use in Group C or D locations, and*
- b) *Subjected to the hydrostatic test required by the Exception to 15.2.*

14.15 revised March 25, 1996

Table 14.2
Lengths of rigid metal conduit for explosion tests on conduit seals

Table 14.2 renumbered Table 14.5 March 25, 1996

Table 14.5
**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 or over (60.3)	5, 10, and 15 feet (1.5, 3.0, and 4.6 m)

Table 14.2 renumbered Table 14.5 March 25, 1996

14.16 Any gaskets provided in addition to the required joints are to be removed for the explosion tests.

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

14.18 If a sealing material is applied to a joint surface in accordance with the exception to 12.3, explosion tests are to be conducted both with and without the sealing material in place.